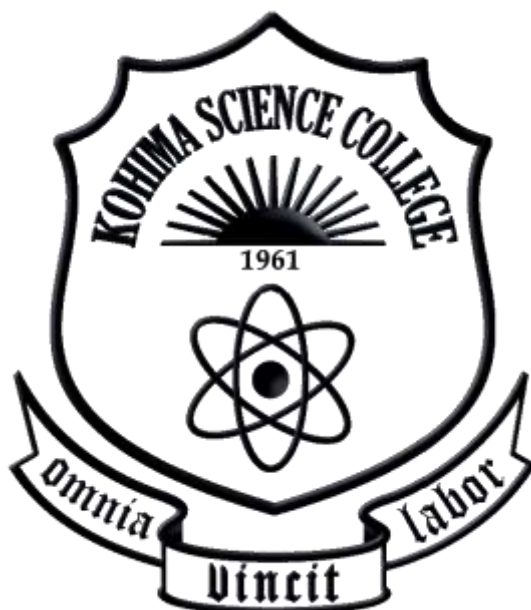


# KOHIMA SCIENCE COLLEGE

(An Autonomous Government P.G. College)

JOTSOMA, NAGALAND



*Revised*

## **SYLLABI OF B.SC. AND M.SC. PROGRAMMES**

Under New UGC CBCS Guidelines

**2018**



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**SCHEME FOR CHOICE BASED CREDIT SYSTEM IN B.A. & B.Sc. Honours**

<b>SEMESTER</b>	<b>CORE COURSE</b>	<b>ABILITY ENHANCEMENT COMPULSORY COURSE (AECC)</b>	<b>SKILL ENHANCEMENT COURSE (SEC)</b>	<b>DISCIPLINE SPECIFIC ELECTIVE (DSE)</b>	<b>GENERIC ELECTIVE (GE)</b>
<b>I</b>	C1	English/Hindi/MIL Communication	---	---	GE-1
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	C9	---		---	
	C10	---		---	
<b>V</b>	C11	---	---	DSE-1	---
	C12	---	---	DSE-2	---
<b>VI</b>	C13	---	---	DSE-3	---
	C14	---	---	DSE-4	---



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**B.A. / B.Sc.**

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*Revised*  
SYLLABUS FOR  
Bachelor of Science (Honours)

**ANTHROPOLOGY**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)



## COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Introduction to Biological Anthropology (Theory)	ANC 1.11	4
		Introduction to Biological Anthropology (Practical)	ANC 1.12	2
	Core 2	Introduction to Social Anthropology (Theory)	ANC 1.21	4
		Introduction to Social Anthropology (Practical)	ANC 1.22	2
II	Core 3	Archaeological Anthropology (Theory)	ANC 2.11	4
		Archaeological Anthropology (Practical)	ANC 2.12	2
	Core 4	Fundamentals of Human Origin & Evolution (Theory)	ANC 2.21	4
		Fundamentals of Human Origin & Evolution (Practical)	ANC 2.22	2
III	Core 5	Tribes and Peasants in India (Theory)	ANC 3.11	4
		Tribes and Peasants in India (Practical)	ANC 3.12	2
	Core 6	Human Ecology: Biological & Cultural Dimensions (Theory)	ANC 3.21	4
		Human Ecology: Biological & Cultural Dimensions (Practical)	ANC 3.22	2
	Core 7	Biological Diversity in Human Populations (Theory)	ANC 3.31	4
		Biological Diversity in Human Populations (Practical)	ANC 3.32	2
	Skill Enhancement Course 1	Tourism Anthropology	ANS 3.11	2
IV	Core 8	Theories of Culture & Society (Theory)	ANC 4.11	4
		Theories of Culture & Society (Practical)	ANC 4.12	2
	Core 9	Human Growth and Development (Theory)	ANC 4.21	4
		Human Growth and Development (Practical)	ANC 4.22	2
	Core 10	Research Methods (Theory)	ANC 4.31	4
		Research Methods (Practical)	ANC 4.32	2
	Skill Enhancement Course 2	Anthropology of Disaster	ANS 4.11	2
V	Core 11	Human Population Genetics (Theory)	ANC 5.11	4
		Human Population Genetics (Practical)	ANC 5.12	2
	Core 12	Anthropology in Practice (Theory)	ANC 5.21	4
		Anthropology in Practice (Practical)	ANC 5.22	2
	Discipline Specific Elective 1	Sports and Nutritional Anthropology (Theory) OR Forensic Dermatoglyphics (Theory)	AND 5.11(a) AND 5.11(b)	4

		Sports and Nutritional Anthropology (Practical) OR Forensic Dermatoglyphics (Practical)	AND 5.12(a) AND 5.12(b)	2
	Discipline Specific Elective 2	Anthropology of Health (Theory) OR Tribal Cultures of India (Theory)	AND 5.21(a) AND 5.21(b)	4
		Anthropology of Health (Practical) OR Tribal Cultures of India (Practical)	AND 5.22(a) AND 5.22(b)	2
VI	Core 13	Forensic Anthropology (Theory)	ANC 6.11	4
		Forensic Anthropology (Practical)	ANC 6.12	2
	Core 14	Anthropology of India (Theory)	ANC 6.21	4
		Anthropology of India (Practical)	ANC 6.22	2
	Discipline Specific Elective 3	Indian Archaeology (Theory) OR Palaeo-anthropology (Theory)	AND 6.11(a) AND 6.11(b)	4
		Indian Archaeology (Practical) OR Palaeo-anthropology (Practical)	AND 6.12(a) AND 6.12(b)	2
		Discipline Specific Elective 4	Dissertation / Project Work	AND 6.21

*Note: Student will opt either dissertation or project work or one paper from the elective discipline course in 6<sup>th</sup> Semester. He will be attached with one supervisor or guide.*

## SEMESTER - I

### CORE 1 (ANC 1.11)

#### INTRODUCTION TO BIOLOGICAL ANTHROPOLOGY

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** History of Physical Anthropology and development of Modern Biological Anthropology, aim, scope and its relationship with allied disciplines.  
1. Difference in the approaches of modern and traditional Biological Anthropology, with emphasis on human evolution.
- UNIT II** History and development of understanding human variation and evolutionary thought.  
1. Theories of evolution. Lamarckism, Neo Lamarckism, Darwinism, Synthetic theory, Mutation and Neo-Mutation theory.
- UNIT III** Position of Mans place in animal Kingdom,  
1. Classification and characteristics of living primates.  
2. Comparative anatomy and behavior of human and non-human primates.
- UNIT IV** Human Morphology:  
i) Human skeletal anatomy & functional morphology of bones as part of total skeleton, functions, classification of bones, anatomical positions, articulations of bones & their functions.
- UNIT V** Human genetics:  
Concept of cell & cell division, Mendel's law of inheritance, single & multiple factor inheritance, sex-linked inheritance, ABO & Rh inheritance.

### CORE 1 (ANC 1.12)

#### INTRODUCTION TO BIOLOGICAL ANTHROPOLOGY

*Practical Credit: 2*

*Teaching Hours: 30*

#### 1. Somatometry

1. Maximum head length
2. Maximum head breadth
3. Maximum bizygomatic breadth
4. Bigonial breadth
6. Nasal length
5. Nasal height
7. Nasal breadth
8. Morphological facial height
9. Morphological upper facial height
10. Head circumference

**2. Cephalic indices:** cephalic, nasal, upper facial height, total facial height, jugo-mandibular.

**3. Somatoscopy:** skin, hair, forehead, ear, eye, eyebrow, nose, chin, and malar prominence

**Recommended Books and References:**

1. Jurmain R., Kilgore L., Trevathan W., Ciochon R.L. (2012). Introduction to Physical Anthropology. Wadsworth Publ., USA
2. Kroeber A. L. (1948). Anthropology. Oxford & IBH Publishing Co., New Delhi.
3. Stanford C., Allen J.S. and Anton S.C. (2010). Exploring Biological Anthropology. The Essentials. Prentice Hall Publ, USA.
4. Statement on Race: Annotated Elaboration and Exposition of the Four Statements on Race (1972). Issued by UNESCO. Oxford University Press.
5. Das, B.M & Ranjan – Physical Anthropology Practical
6. Jannusch, J. Buettner – origins of Man
7. Hootan, E.A - up from the Ape
8. Comas, J – Manual of Physical Anthropology
9. Sarkar, R.M – Fundamentals of Physical Anthropology

**CORE 2 (ANC 1.21)****INTRODUCTION TO SOCIO-CULTURAL ANTHROPOLOGY**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I** Definition, scope and relevance of socio-cultural Anthropology; Relationship of socio cultural Anthropology with other disciplines.

**UNIT II** Concept of society and culture: status and role, social groups and institutions, social stratification and civil society.

**UNIT III** Social Institution (Basic concepts: Family, Marriage and Kinship)  
Family: Definition, function, types of family.  
Marriage: Definition, function and types of marriage.  
Kinship: Definition, usages, classification, terminology, descent group, kin group, lineage, clan, phratry and moiety

**UNIT IV** Social and Culture change: Definition, characteristics and factors of change.

**UNIT V** Religion and Magic:  
Religion: Functions and Theories of religion, Animism. Manaism, Totemism.  
Magic: Functions, types and principles of magic.  
Magico-religious functionaries- priests, shamans, sorcerer and witch.  
Science, religion and magic.

**CORE 2 (ANC 1.22)****INTRODUCTION TO SOCIO-CULTURAL ANTHROPOLOGY**

*Practical Credit: 2*

*Teaching Hours: 30*

**Genealogical studies.**

Students will learn how to structure genealogical ties like marriage, family, inheritance pattern etc

**Recommended Books and References:**

1. Ember C. R. et al. (2011). *Anthropology*. New Delhi: Dorling Kindersley.
2. Ferraro G. and Andreatta S. (2008). In *Cultural Anthropology: An Applied Perspective*. Belmont: Wadsworth.
3. Rapport N. and Overing J. (2004). *Key Concepts in Social and Cultural Anthropology*. London: Routledge.
4. Frazer James (1911). *The Golden Bough*. London: Macmillan
5. Madan T. N. and Majumdar D.N. (1987) *An Introduction to Social Anthropology*. New Delhi: National Publishing House.
6. Mair Lucy (1972). *An Introduction to Social Anthropology*. New Delhi: Oxford University Press
7. Malinowski Bronislaw (). *Magic, Science and Religion*.
8. Kroeber A.L. (1923). *Anthropology*. New York: Harcourt, Brace.
9. Roy Indrani Basu (2003). *Anthropology The Study of Man*. New Delhi: S. Chand & Company Ltd.
10. Scupin Raymond and DeCorse Christopher R. (). *Anthropology: A Global Perspective*.
11. Sharma R.N. *Social and Cultural Anthropology*. Delhi: Surjeet Publications
12. Tylor E.B. (1871). *Primitive Culture: Researches into the Development of Mythology, Philosophy, Religion, Language, Art and Customs*. London: J. Murray.

## SEMESTER -II

### CORE 3 (ANC 2.11) ARCHAEOLOGICAL ANTHROPOLOGY

Theory Credit: 4

Teaching Hours: 60

#### UNIT I Introduction:

- Definition and scope of archaeological anthropology
- Relation with other disciplines
- Methods of studying archaeological anthropology

**UNIT II** Methods of Estimation of Time and Reconstruction of the Past  
Absolute dating methods, radio-carbon, potassium argon, thermoluminescent, dendrochronology, paleomagnetism.  
Relative dating methods- fluorine-nitrogen analysis, stratigraphy, typology, patination

**UNIT III** Geochronology of Pleistocene Epoch:  
Glacial and Interglacial  
Pluviation and Inter Pluviation

**UNIT IV** Technology & Typology of pre-historic tools:  
Technique of tool manufacture  
Typology and cultural nomenclature

**UNIT V** Earliest Evidence of Culture in the World: Olduvai Gorge, Dmanisi & Attirampakkam,

### CORE 3 (ANC 2.12) ARCHAEOLOGICAL ANTHROPOLOGY

Practical Credit: 2

Teaching Hours: 30

Typo-technological Analysis of Prehistoric Tools: Identification, Interpretation and Drawings of the tool Types (2 tools from each type)

1. Core Tool Types,
2. Flake Tool Types,
3. Microlithic Tool Type,
4. Neolithic Tool Type

#### **Recommended Books and References:**

1. Allchin and Allchin (1993). *The Rise of Civilization of India and Pakistan*. Cambridge University Press
2. Bhattacharya D.K. (1978). *Emergence of Culture in Europe*, Delhi, B.R. Publication.
3. Bhattacharya D.K. (1979). *Old Stone Age Tools and Techniques*. Calcutta, K.P. Bagchi Company
4. Bhattacharya D.K. (1996). *Palaeolithic Europe*. Netherlands, Humanities Press.
5. Champion et al. (1984). *Prehistoric Europe*. New York, Academic Press.
6. Fagan B.M. (1983). *People of Earth: An Introduction*. Boston, Little, Brown & Company.
7. Phillipson D. W. (2005). *African Archaeology*. Cambridge, Cambridge University Press.
8. Sankalia H.D. (1964). *Stone Age Tools*. Poona Deccan College



**CORE 4 (ANC 2.21)**  
**FUNDAMENTALS OF HUMAN ORIGIN & EVOLUTION**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Primate origins and radiation with special reference to Miocene hominoids: Ramapithecus, distribution, features and their phylogenetic relationships.
- UNIT II** 1. Australopithecines: distribution, features and their phylogenetic relationships.  
2. Appearance of genus Homo (*Homo habilis*) and related finds.
- UNIT III** *Homo erectus* from Asia, Europe and Africa: Distribution, features and their phylogenetic status.
- UNIT IV** The origin of *Homo sapiens*: Fossil evidences of Neanderthals and Archaic *Homo sapiens sapiens*
- UNIT V** Origin of modern humans (*Homo sapiens sapiens*): Distribution and features, hominisation process.

**CORE 4 (ANC 2.22)**  
**FUNDAMENTALS OF HUMAN ORIGIN & EVOLUTION**

*Practical Credit: 2*

*Teaching Hours: 30*

- 1. Osteology:** Drawing and studying of bones.

**Recommended Books and References:**

1. Buettner-Janusch, J. (1966). *Origins of Man: Physical Anthropology*. John Wiley & Sons, Inc., New York, London, Sydney.
2. Conroy, G.C. (1997). *Reconstructing Human Origins: A Modern Synthesis*. W. W. Norton & Company, New York, London.
3. Howell F.C. (1977). *Horizons of Anthropology*. Eds. S. Tax and L.G. Freeman, Aldine Publishing House, Chicago.
4. Nystrom P. and Ashmore P. (2011). *The Life of Primates*. PHI Learning Private Limited, New Delhi.
5. Seth P. K. and Seth S. (1986). *The Primates*. Northern Book Centre, New Delhi, Allahabad.
6. Singh I. P. and Bhasin M.K. (1989). *Anthropometry: A Laboratory Manual on Biological Anthropology*. Kamla-Raj Enterprises, Chawri Bazar, Delhi.
7. Stanford C.; Allen J.S. and Anton S.C. (2012). *Biological Anthropology: The Natural History of Mankind*. PHI Learning Private Limited, New Delhi.
8. Swindler D. R. (2009). *Introduction to the Primates*. Overseas Press India Pvt. Ltd., N. Delhi

## SEMESTER - III

### CORE 5 (ANC 3.11)

#### TRIBES AND PEASANTS IN INDIA

Theory Credit: 4

Teaching Hours: 60

- UNIT I** Anthropological concept of Tribe:
- Problems of nomenclature, definition.
  - Features of tribes in India.
  - Classification of Indian tribes
- UNIT II** Tribes and Wider world:
- The history of tribal administration.
  - Tribal development schemes and programme.
- UNIT III** Anthropological concept of Village and peasantry.
- Significance of village study in India
  - Impact of globalization on Indian village.
- UNIT IV** Characteristics of Indian Village; social organization; economy and changes
- Caste system and changes.
- UNIT V** Ethnicity and Identity Issues: causes and types of Tribal and peasant movements.

### CORE 5 (ANC 3.12)

#### TRIBES AND PEASANTS IN INDIA

Practical Credit: 2

Teaching Hours: 30

Reading of Ethnography: (a) How to review a book. Students are required to read and analyze any part of the ethnographies (as listed below)/any Naga Monograph and prepare a report based upon it.

#### List of Ethnographies:

- Walker A. (1986). *The Todas*. Delhi: Hindustan Publishing Corporation Verrier
- Elwin (1992). *The Muria and their Ghotul*. USA: Oxford University Press.
- Malinowski M. (1922). *Argonauts of the Western Pacific*. London: Routledge and Kegan Paul Ltd.
- Furer-Haimendorf C.V. (1939). *The Naked Nagas*. London: Methuen and Co.
- Evans-Pritchard E.E. (1940). *The Nuer: A Description of the Modes of Livelihood and Political Institutions of a Nilotic People*. Oxford: Clarendon Press.
- Majumdar D. N. (1950). *Affairs of tribes*. Lucknow: Universal Publishers Ltd.
- Dube S.C. (1955). *Indian Village*. London: Routledge and Kegan Paul Ltd.
- Berreman G.D. (1963). *Hindus of the Himalayas*. Berkeley: California University Press.
- Hutton, J.H. *The Angami Nagas*.
- Hutton, J.H. *The Lotha Nagas*.
- Hutton, J.H. *The Sema Nagas*.
- Mills, J.P. *The Ao Nagas*.
- Mills, J.P. *The Rengma Nagas*.

**Recommended Books and References:**

1. Gupta D. (1991). Social Stratification. Oxford University Press: Delhi.
2. Madan V. (2002). The Village in India. Oxford University Press: Delhi.
3. Nathan D. (1998). Tribe-Caste Question. Simla: IAS.
4. National Tribal Policy (draft). (2006). Ministry of Tribal Affairs. Government of India.
5. Patnaik S.M. (1996). Displacement, Rehabilitation and Social change. Inter India Publication, Delhi.
6. Shah G. (2002). Social Movement and the State. Delhi: Sage.
7. Shanin T. (1987). Peasants and Peasantry. New York, Blackwell.
8. Vidyarthi L.P. and Rai B.K. (1985) Tribal Culture in India, New Delhi, Concept Publishing Company.
9. Wolf E. (1966). Peasants. NJ, Prentice Hall.

**CORE 6 (ANC 3.21)**

**HUMAN ECOLOGY: BIOLOGICAL & CULTURAL DIMENSIONS**

*Theory Credit: 4*

*Teaching Hours: 60*

**Biological Dimensions**

**UNIT I** Concepts in Ecology: Definition, ecosensitivity adaptation, acclimation, acclimatization, biotic and abiotic component.

**UNIT II** Methods of studying human ecology, Adaptation to various ecological stresses; Ecological rules and their applicability to human populations.

**UNIT III** Impact of urbanization and industrialization on Man.

**Cultural Dimensions**

**UNIT IV** Culture as a tool of adaptation; Various modes of human adaptation in pre-statesocieties.

i. Hunting and food gathering

ii. Pastoralism

iii. Shifting cultivation

**UNIT V** Industrial civilization and growth of urban societies

**CORE 6 (ANC 3.22)**

**HUMAN ECOLOGY: BIOLOGICAL & CULTURAL DIMENSIONS**

*Practical Credit: 2*

*Teaching Hours: 30*

**Biological Dimensions**

*Size and Shape Measurements*

1. Stature

2. Sitting Height

3. Body Weight

4. Total Upper Extremity Length

5. Total Lower Extremity Length

6. Nasal Breadth
7. Nasal Height

*Size and Shape Indices*

1. Body Mass Index
2. Ponderal Index.
3. Relative Sitting Height
4. Relative Upper Extremity Length
5. Relative Total Lower Extremity Length
6. Nasal Index

**Cultural Dimensions**

1. Drawing, identification & description of technological implements from the department collection. (Implements for food gathering, hunting, fishing & agriculture)

**Recommended Books and References:**

1. Human ecology: biocultural adaptation in human communities. (2006) Schutkowski, H. Berlin. Springer Verlag.
2. Human ecology and cognitive style: comparative studies in cultural and physical adaptation. (1976) Berry, J.B. New York: John Wiley.
3. Human ecology. (1964) Stapledon. Faber & Faber.
4. Studies in Human Ecology. (1961) Theodorson, G.A. Row, Peterson & Company Elmsford, New York.
5. Human ecology: (1973) Problems and Solutions. Paul R. Ehrlich, Anne H. Ehrlich and John P. Holdress. W.H. Freeman & Company, San Francisco.
6. Cohen, Yehudi A. 1968. Man in adaptation; the cultural present. Chicago: Aldine Pub. Co.
7. Redfield, Robert. (1965). Peasant society and culture an anthropological approach to civilization. Chicago [u.a.]: Univ. of Chicago Press.
8. Symposium on Man the Hunter, Richard B. Lee, and Irven DeVore. 1969. Man the hunter. Chicago: Aldine Pub. Co.

**CORE 7 (ANC 3.31)**

**BIOLOGICAL DIVERSITY IN HUMAN POPULATIONS**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Concept of race & racism, criteria for racial classification,  
 1. Major races of the world, UNESCO Statement on Race.  
 2. A comparative account of various racial classifications (Risley and Guha)
- UNIT II** Concept of Biological Variability; Sources of Genetic Variation; Genetic Polymorphism (Serological, Biochemical and DNA Markers); Human Adaptability –Adaptive Mechanisms determining the types of adaptation.
- UNIT III** Pre and Proto historic racial elements in India. Linguistic classification of Indian population.
- UNIT IV** Cultural Biology; Role of Bio-cultural factors influencing the diseases and nutritional status. Biological perspectives of ageing process among different populations.

**UNIT V** Demographic Perspective  
Demographic Anthropology; Sources of Demographic Data, Demographic Processes  
Inbreeding and Consanguinity – Biological consequences of inbreeding, frequency of  
inbreeding in world populations; Methods of counseling.

**CORE 7 (ANC 3.32)**  
**BIOLOGICAL DIVERSITY IN HUMAN POPULATIONS**

*Practical Credit: 2*

*Teaching Hours: 30*

1. Craniometric Measurements (Skull)
2. Analysis and interpretation of finger ball pattern types, palmar main lines and pattern index; Finger print classification of the data collected (Five Subjects)

***Recommended Books and References:***

1. Baker P.T. and J.S. Weiner (ed.) (1996) *The Biology of Human Adaptability*. Oxford & New York, Oxford University Press.
2. Bhende A. and T. Kantikar (2006) *Principles of Population Studies*. Himalayan Publishing House, Mumbai
3. Bogin B. (1999). *Pattern of Human Growth*. 2nd edition CUP.
4. Cameron Noel and Barry Bogin (2012) *Human Growth and development*. Second edition, Academic Press Elsevier.
5. Eckhardt R.B. (1979) *The Study of Human Evolution*. McGrand Hill Book Company, USA.
6. Frisancho R. (1993) *Human Adaptation and Accommodation*. University of Michigan press
7. Harrison G.A., Tanner, J.M., Pilbeam, D.R., Baker, P.T. (1988) *Human Biology*. Oxford University Press.
8. Jurmain Robert Lynn kilgore Wenda Trevathan and Ciochon (2010). *Introduction to Physical Anthropology*. Wadsworth Publishing, USA.
9. Kapoor A.K. and Satwanti Kapoor (ed) (1995). *Biology of Highlanders*. Jammu, Vinod Publisher & Distributor.
10. Kapoor A.K. and Satwanti Kapoor (eds) (2004) *India's Elderly-A Multidisciplinary Dimension*. Mittal Publication, New Delhi.
11. Klepinger L.L. (2006). *Fundamentals of Forensic Anthropology*. John Wiley & Sons., New Jersey.
12. Malhotra K.C. and B. Balakrishnan (1996) *Human Population Genetics in India*
13. Malina Robert M., Claude. Bouchard, Oded. Bar-Or. (2004) Growth, and Physical Activity. *Human Kinetics*.
14. Stanford C., Allen, S.J. and Anton, C.S. (2013): *Biological Anthropology*. 3rd edition, Pearson, USA.

## SEMESTER - IV

### **CORE 8 (ANC 4.11) THEORIES OF CULTURE AND SOCIETY**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Evolutionary theory, changing perspective of Evolutionism (Taylor, Morgan, Steward & white)
- UNIT II** Diffusionism: Basic postulates of diffusionism: British, American & German school of diffusionism (Rivers, G.E. Smith, Franz Boas, A.L. Kroeber, Friedrich Ratzel, Leo Frobenius)
- UNIT III** Durkheim and social integration, Functionalism, and Structural- Functionalism.
- UNIT IV** Culture & personality, (Benedict, Mead, Kardiner, R. Linton, Cora DuBois)
- UNIT V** Symbolic and Interpretative approach. (Clifford Geertz, Victor Turner, and Mary Douglas.)

### **CORE 8 (ANC 4.12) THEORIES OF CULTURE AND SOCIETY**

*Practical Credit: 2*

*Teaching Hours: 30*

As a part of the practical the students will be made to write a term paper on any one of the theories they have learned.

#### **Recommended Books and References:**

1. Applebaum H.A. (1987) *Perspectives in Cultural Anthropology*. Albany: State University of New York.
2. Barnard A. (2000). *History and Theory in Anthropology*. Cambridge: Cambridge University.
3. McGee R.J. and Warms R.L. (1996) *Anthropological Theories: An Introductory History*.
4. Moore M. and Sanders T. (2006). *Anthropology in Theory: Issues in Epistemology*, Malden, MA: Blackwell Publishing.

### **CORE 9 (ANC 4.21) HUMAN GROWTH AND DEVELOPMENT**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Concept of human growth, development, differentiation and maturation. Evolutionary perspective on human growth
- UNIT II** Prenatal (conception till birth) and postnatal (birth till senescence) period of growth, pattern of normal growth curves, variation from normal growth (catch-up growth and catch-down growth), gender differences in growth curves, secular trend

- UNIT III** Bio-cultural factors (genetic, social, and ecological factors) influencing patterns of growth and variation, methods and techniques to study growth, significance/applicability of growth studies,
- UNIT IV** Nutritional epidemiology-concept of balanced diet, impact of malnutrition (over and under) with special reference to obesity, Kwashiorkor and Marasmus. Assessment of nutritional status.
- UNIT V** Human physique and body composition – models and techniques; gender and differences, Somatotyping and human physique with reference to Sheldon, Parnell, and Carter methods

**CORE 9 (ANC 4.22)**  
**HUMAN GROWTH AND DEVELOPMENT**

*Practical Credit: 2*

*Teaching Hours: 30*

1. Somatometry (stature, body weight, mid upper arm circumference etc.), assessment of chronological age, height for age, weight for age, BMI for age.
2. Estimation of body composition with skinfold thickness.

**Recommended Books and References:**

1. Bogin B. (1999) Patterns of human growth. Cambridge University Press.
2. Frisancho R. (1993) Human Adaptation and Accommodation. University of Michigan Press.
3. Cameron N and Bogin B. (2012) Human Growth and Development. Second edition, Academic press Elsevier.
4. Harrison GA and Howard M. (1998). Human Adaptation. Oxford University Press.
5. Harrison GA, Tanner JM, Pibeam DR, Baker PT. (1988). Human Biology. Oxford University Press.
6. Jurmain R, Kilgore L, Trevathan W. Essentials of physical anthropology. Wadsworth publishing.
7. Kapoor AK and Kapoor S. (1995) Biology of Highlanders. Vinod Publisher and Distributor.
8. Kathleen K. (2008). Encyclopedia of Obesity. Sage.
9. Malina RM, Bouchard C, Oded B. (2004) Growth, Maturation, and Physical Activity. Human Kinetics.
10. McArdle WD, Katch FI, Katch VL. (2001) Exercise Physiology: Energy, Nutrition and Human Performance.
11. Singh I, Kapoor AK, Kapoor S. (1989). Morpho-Physiological and demographic status of the Western Himalayan population. In Basu and Gupta (eds.). Human Biology of Asian Highland Populations in the global context.
12. Sinha R and Kapoor S. (2009). Obesity: A multidimensional approach to contemporary global issue. Dhanraj Publishers. Delhi.

**CORE 10 (ANC 4.31)  
RESEARCH METHODS**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Research Design  
Review of literature, conceptual framework, formulation of research problem, formulation of hypothesis.
- UNIT II** Field work tradition in Anthropology  
Ethnographic approach, ethnocentrism, etic and emic perspectives, comparative and historical methods, techniques of rapport establishment, identification of informants, maintenance of field diary and logbook
- UNIT III** Tools and technique of data collection:  
Sampling, Concept of survey, relationship of survey method with ethnographic method, questionnaire and interview method, Focussed Group Discussion, key informant, Case Study and life history, Genealogy.
- UNIT IV** Analysis and Writing Up  
1. Chapterization, preparing a text for submission and publication, concepts of preface, notes (end and footnotes), glossary, prologue and epilogue, appendix, bibliography (annotated) and references cited, index.  
2. Similarities and differences between qualitative and quantitative data analysis.
- UNIT V** Bio-Statistics  
1. Uses of statistics in Anthropology: mean, median Mode, standard deviation, test of significance.  
2. Types of variables, presentation and summarization of data (tabulation and illustration).

**CORE 10 (ANC 4.32)  
RESEARCH METHODS**

*Practical Credit: 2*

*Teaching Hours: 30*

1. Preparation of questionnaire and schedule.
2. Graphical and diagrammatic presentation of data.

***Recommended Books and References:***

1. Garrard E and Dawson A. What is the role of the research ethics committee? Paternalism, inducements, and harm in research ethics. *Journal of Medical Ethics* 2005; 31: 419-23.
2. Bernard H.R. *Research Methods in Anthropology, Qualitative and Quantitative Approaches*. Jaipur: Rawat Publications. 2006.
3. Madrigal L. *Statistics for Anthropology*. Cambridge: Cambridge University Press. 2012.
4. Zar JH. *Biostatistical Analysis*. Prentice Hall. 2010.
5. Michael A. *The Professional Stranger*. Emerald Publishing. 1996.
6. Bernard R. *Research Methods in Anthropology: Qualitative and Quantitative Approaches*. AltaMira Press. 2011.
7. Emerson RM, Fretz RI and Shaw L. *Writing Ethnographic Fieldnotes*. Chicago, University of Chicago Press. 1995.



8. Lawrence NW. Social Research Methods, Qualitative and Quantitative Approaches. Boston: Allyn and Bacon. 2000.
9. O'reilly K. Ethnographic Methods. London and New York: Routledge. 2005.
10. Patnaik S.M. Culture, Identity and Development: An Account of Team Ethnography among the Bhil of Jhabua. Jaipur: Rawat Publications. 2011.
11. Pelto PJ and Pelto GH. Anthropological Research, The Structure of Inquiry. Cambridge: Cambridge University Press. 1978.
12. Sarantakos S. Social Research. London: Macmillan Press. 1998.

## SEMESTER - V

### CORE 11 (ANC 5.11) HUMAN POPULATION GENETICS

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Essentials of Genetics: principles in human genetics, chromosome theory of inheritance (segregation and independent assortment) Mendelian inheritance (single factor and multifactorial inheritance, polygenic inheritance), Non- Mendelian inheritance (multiple allelism, Co-dominance; sex linked, epistasis; penetrance and expressivity;
- UNIT II** Ecological Genetics and Polymorphism, phenotypic & genotypic polymorphisms, transient polymorphism, balanced polymorphisms, Relationship between sickle cell and malaria, X-linked polymorphism, selection due to infectious diseases and its association with blood groups and other.
- UNIT III** Hardy-Weinberg principle: Genotypic and allelic frequencies, assumptions of Hardy-Weinberg equilibrium, its applications and exceptions.
- UNIT IV** Mechanism for dynamics in Gene Frequency, mutation, selection (pattern and mechanism), Genetic drift (bottle neck and founder effect), Gene flow/migration, inbreeding.
- UNIT V** Population structure and admixture in human populations, random & non-random mating (positive and negative assortative mating), eugenics and genetic counseling.

### CORE 11 (ANC 5.12) HUMAN POPULATION GENETICS

*Practical Credit: 2*

*Teaching Hours: 30*

1. Blood group typing-ABO and Rh (D) blood groups.
2. Color Blindness
3. Blood pressure and sugar level variation (random)

#### **Recommended Books and References:**

1. Brooker R.J. (2012). Genetics: analysis & principles. The McGraw-Hill Companies, Inc 4th ed.
2. Cavalli-Sforza, L.L. and Bodmer, W.F (1971). The Genetics of Human Population. San Francisco: Freeman
3. Cooper DN and Kehrer-Sawatzki H. (2008). Handbook of Human Molecular Evolution. John Wiley & Sons, volume-2.
4. Crawford MH (2007). *Anthropological Genetics Theory, Methods and Applications*. Cambridge University Press
5. Cummings M.R. (2011). Human Heredity: Principles and Issues. Ninth Edition. Brooks/Cole, Cengage Learning
6. Jobling, M.A. Hurlst M. and Tyler-Smith C. (2004). *Human Evolutionary Genetics: Origins, Peoples & Disease*. GS. NY

7. Lewis R. (2009). *Human Genetics: Concepts and Applications* 9th Edition. The McGraw-Hill Companies, Inc.
8. Patch C. (2005). *Applied Genetics in Healthcare*. Taylor & Francis Group
9. Relethford J.H. (2012). *Human Population Genetics*. Wiley-Blackwell, USA
10. Snustad .D.P. and Simmons M.J. (2006). *Principles of Genetics*, Fourth Edition, John Wiley & Sons USA, Hoboken NJ
11. Strachan T, Read A.P. (2004). *Human Molecular Genetics*. Garland Science/Taylor & Francis Group.
12. Vogel F. and Motulsky A.G. (1996). *Human Genetics*. Springer, 3rd revised edition.

## **CORE 12 (ANC 5.21)**

### **ANTHROPOLOGY IN PRACTICE**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Concept of Applied Anthropology, Action Anthropology and Development.
- UNIT II** Role of Anthropology in Need of Assessment and Community Development, Environment and Community Health, Social and economic sustainability, Cultural resource Management.
- UNIT III** Trends in Anthropology: Anthropology of Tourism, Anthropology in Census.
- UNIT IV** Human Rights, Interrelationships of Rights and Duties, protection and enforcement of human rights and duties, National and State Human Rights Commission and other grievance redressal mechanism, Emerging trends of human rights respective to terrorism, environment.
- UNIT V** **A.** Biosocial anthropology in practice; Bio-social elements of human development at national and international level, application of conceptual framework of Forensic Anthropology in judicial settings of both criminal and civil,  
**B.** Population Dynamics and relationship between population growth and various aspects of culture such as means of subsistence, kinship, social complexity, social stratification.

## **CORE 12 (ANC 5.22)**

### **ANTHROPOLOGY IN PRACTICE**

*Practical Credit: 2*

*Teaching Hours: 30*

1. Seminar presentation.

#### **Recommended Books and References:**

1. Arya A and Kapoor AK. (2012). *Gender and Health Management in Afro-Indians*. Global Vision Publishing House, New Delhi.
2. Kertzer DI and Fricke T. (1997). *Anthropological Demography*. University of Chicago Press.
3. Basu, A. and P. Aaby (1998). *The Methods and the Uses of Anthropological Demography*. 329 pp. Oxford, Clarendon Press

4. Carter A. (1998). Cultural Models and Demographic Behavior. In *The Methods and the Uses of Anthropological Demography* edited by Basu A and Aaby P. Oxford: Clarendon Press. pp 246-268.
5. Census of India (2001, 2011) and National Family Health Survey (2006,2010).
6. Ervic, Alexander M., (2000). *Applied Anthropology: Tools and Perspectives for Contemporary Practise*, Boston, MA: Allyn and Bacon.
7. Erwin A. (2004). *Applied Anthropology Tools and Practice*, Allyn and Bacon.
8. Gupta S and Kapoor AK. (2009). *Human Rights among Indian Populations: Knowledge,Awareness and Practice*. Gyan Publishing House, New Delhi.
9. Willen SS. (2012). *Anthropology and Human Rights: Theoretical Reconsiderations andPhenomenological Explorations*. *Journal of Human Rights*. 11:150–159.
10. Goodale M. (2009). *Human Rights: An Anthropological Reader*. Wiley Blackwell.
11. Gupta S and Kapoor AK. (2007). *Human Rights, Development and Tribe*. In: *Genes,Environment and Health – Anthropological Prespectives*. K. Sharma, R.K. Pathak, S.Mehra and Talwar I (eds.). Serials Publications, New Delhi.
12. Margaret AG. (2003). *Applied Anthropology: A Career-Oriented Approach*, Boston, MA: Allyn and Bacon.
13. Halbar BG and Khan CGH. (1991). *Relevance of Anthropology – The Indian Scenario*. Rawat Publications, Jaipur.
14. Kapoor AK (1998). *Role of NGO's in Human Development: A Domain of Anthropology*. *J Ind Anthropol Soc*; 33:283-300.
15. Kapoor AK and Singh D. (1997). *Rural Development through NGO's*. Rawat Publications, Jaipur.
16. Klepinger LL (2006). *Fundamentals of Forensic Anthropology*. Wiley-Liss Publications
17. Kumar RK and Kapoor AK. (2009). *Management of a Primitive Tribe: Role ofDevelopment Dynamics*. Academic Excellence, Delhi.
18. Mehrotra N and Patnaik SM. (2008). *Culture versus Coercion: The Other Side of Nirmal Gram Yojna*, Economic and Political weekly. pp 25-27.
19. Mishra RC (2005). *Human Rights in a Developing Society*, Mittal Publications, Delhi.
20. Noaln RW. (2002). *Anthropology in Practice: Building a Career outside the Academy*. Publishing Lynne Reinner.
21. Patnaik SM (1996). *Displacement, Rehabilitation & Social Change*. Inter IndiaPublications, New Delhi.
22. Patnaik SM (2007). *Anthropology of Tourism: Insights from Nagaland*. *The EasternAnthropologist*. 60(3&4):455-470
23. Srivastav OS (1996). *Demographic and Population Studies*. Vikas Publishing House, India
24. Vidyarthi LP and BN Sahay (2001). *Applied Anthropology and Development in India*,National Publishing House, New Delhi.
25. Vidyarthi LP. (1990). *Applied Anthropology in India – Principles, Problems and CaseStudies*. Kitab Mahal, U.P.
26. Vidyarthi V (1981). *Tribal Development and its Administration*. Concept PublishingCompany, New Delhi.

## SEMESTER - VI

### CORE 13 (ANC 6.11) FORENSIC ANTHROPOLOGY

Theory Credit: 4

Teaching Hours: 60

- UNIT I** Introduction to Forensic Anthropology: Definition, Brief History, Scope, Applications and Integration of Forensic Anthropology.
- UNIT II** Identification of Human and Non-Human Skeletal Remains, Ancestry, age, sex and stature estimation from bones.
- UNIT III** Personal Identification, Complete and Partial Identification, Methods of Identification in Living Persons: Somatometry, Somatoscopy, dermatoglyphics of palm prints and Fingerprints, Deformities and Others.
- UNIT IV** Serology: Identification and Individualization of bloodstain, urine, semen and saliva. Patterns of Bloodstains.
- UNIT V** Individualization: Forensic Odontology-Tooth Structure and Growth, Bite Marks, Facial Reconstruction, DNA Profiling.

### CORE 13 (ANC 6.12) FORENSIC ANTHROPOLOGY

Practical Credit: 2

Teaching Hours: 30

1. Study of Human Long Bones. Estimation of age, sex and stature from bones.
2. Analysis of Fingerprints & palm prints

#### **Recommended Books and References:**

1. Bass W.M. (1971). Human Osteology: A Laboratory and Field manual of the Human Skeleton. Columbia: Special Publications Missouri Archaeological Society.
2. Black S. and Ferguson E. (2011). *Forensic Anthropology 2000 to 2010*. CRC Press, London.
3. Byers, S. N. (2008). *Forensic Anthropology*. Boston: Pearson Education LTD.
4. Gunn A. (2009) *Essential Forensic Biology* (2nd ed). Chichester: Wiley-Blackwell
5. Modi, R. B. J. P. (2013). *A Textbook of Medical Jurisprudence and Toxicology*. Elsevier.
6. Reddy V. R. (1985). *Dental Anthropology*, Inter-India Publication, New Delhi.
7. Spencer, C. (2004). *Genetic Testimony: A Guide to Forensic DNA Profiling*, Pearson, New Delhi.
8. Vats Y., Dhall J.K. and Kapoor A.K. (2011). Gender Variation in Morphological Patterns of Lip Prints among some North Indian Population. *J. Forensic Odontology*, 4: 11-15.
9. Wilkinson, C. (2004). *Forensic facial reconstruction*. Cambridge University Press.

**CORE 14 (ANC 6.21)**  
**ANTHROPOLOGY OF INDIA**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Emergence and growth of Anthropology in India, approaches to study Indian society and culture.
- UNIT II** Understanding the diversity of Indian social structure- concept of varna, jati/caste. Theories of origin of caste system, Ashram or purusharatha.
- UNIT III** Impact of culture-contact, urbanization and industrialization on tribal and rural population.
- UNIT IV** Basic concepts- Great tradition and little tradition, sacred complex, Universalization and parochialization, Sanskritization and Westernization, Dominant caste, Nature-Man-Spirit complex,
- UNIT V** Problems of exploitation and deprivation of scheduled caste/tribe and Other Backward Classes.

**CORE 14 (ANC 6.22)**  
**ANTHROPOLOGY OF INDIA**

*Practical Credit: 2*

*Teaching Hours: 30*

1. Write a report highlighting the contributions of any one contemporary Indian anthropologists.

***Recommended Books and References:***

1. Nicholas D. (2001). *Castes of Mind: Colonialism and the Making of Modern India*. Princeton University Press.
2. Bernard CS. (2000). *India: The Social Anthropology of Civilization*. Delhi: Oxford University Press.
3. Bhasin MK, Watter H and Danker-Hopfe H. (1994). *People of India – An Investigation of Biological variability in Ecological, Ethno-economic and Linguistic Groups*. Kamla Raj Enterprises, Delhi
4. Lopez DS. (1995). *Religions of India in Practice*. Princeton University Press
5. Gupta D. *Social Stratification*. Delhi: Oxford University Press.
6. Karve I. (1961). *Hindu Society: An Interpretation*. Poona : Deccan College
7. Guha BS. (1931). *The racial attributes of people of India*. In: *Census of India, 1931, voll, Part III (BPO, Simla)*
8. Trautmann TR (2011). *India: Brief history of Civilization*. Oxford University Press :Delhi
9. Vidyarthi LP and Rai BK. (1976). *The tribal culture of India*. Concept Publishing Co, Delhi.
10. Haddon AC. (1929). *Races of man*. Cambridge University, London.
11. Kapoor A.K. (1992). *Genetic Diversity among Himalayan Human Populations*. M/S Vinod Publishers, Jammu
12. Majumdar DN. (1901). *Races and Culture of India*. Asia Publishing House, Bombay
13. Dube SC. (1992). *Indian Society*. National Book Trust, India: New Delhi.
14. Dumont L. (1980). *Homo Hierarchicus*. University of Chicago Press.

15. Guha B.S. (1931). The racial attributes of people of India. In: Census of India, 1931,vol I, Part III (BPO, Simla)
16. Malhotra K.C. (1978). Morphological Composition of people of India. J. HumanEvolution.

## **DISCIPLINE SPECIFIC ELECTIVE (DSE)**

### **DISCIPLINE SPECIFIC ELECTIVE 1 (AND 5.11(a)) SPORTS AND NUTRITIONAL ANTHROPOLOGY**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Anthropology of sports- Physical fitness, component of physical fitness.
- UNIT II** Physical conditioning, training-techniques and physiological effects, Environmental effects on physical performance: effect of heat stress, cold stress and high altitude on physiological response and performance.
- UNIT III** Body composition and Athletes, sports selection and monitoring.
- UNIT IV** Human biological variability, health and nutrition; doping and performance.
- UNIT V** Cultural constructions and physiologic implications of food across time, space and society; an integrated bio-behavioral perspective towards food preference.

### **DISCIPLINE SPECIFIC ELECTIVE 1 (AND 5.12(a)) SPORTS AND NUTRITIONAL ANTHROPOLOGY**

*Practical Credit: 2*

*Teaching Hours: 30*

#### **Practical**

1. Survey Assessment of daily nutrient intake/ Evaluate association of nutritional status and physical performance/ Demonstrate cultural perspective for preference of specific food of a population

#### **Recommended Books and References:**

1. Stinson S. (1992). Nutritional Adaptation. Annual Review of Anthropology 21:143-170.
2. Brughart R. (1990). The Cultural Context of Diet, Disease and the Body. In Diet and Disease in Traditional and Developing Societies. GA Harrison and JC Waterlow, eds. P. 307-325. Cambridge University Press. Cambridge.
3. Rozin P. (1987). Psychobiological Perspectives on Food Preferences. In Food and Evolution: Toward a Theory of Food Habits. M. Harris and EB Ross (eds.). Temple University Press. Philadelphia, pp. 181-205.
4. Quandt SA. (1987). Methods for Determining Dietary Intake. In Nutritional Anthropology. FE Johnston, ed. Pp. 67-84. Liss. NY.
5. Ulijasek SJ and Strickland SS. (1993). Introduction. In Nutritional Anthropology: Prospects and Perspectives. Pp. 1-5. Smith Gordon. London.



**DISCIPLINE SPECIFIC ELECTIVE 1 (AND 5.11(b))  
FORENSIC DERMATOGLYPHICS**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Introduction to Dermatoglyphics: History and Development, scope and Applications.
- UNIT II** Formation of fingerprint ridges, pattern types and patterns area. Classification of Fingerprints- Galton & Henry Classification.
- UNIT III** Types of Fingerprints: Plastic, Visible and Latent Prints. Conventional and Modern methods for development of latent fingerprints-, Powder Methods, Metal Deposition Method, Small Particle Reagent and Laser Techniques.
- UNIT IV** Basis of Fingerprint Comparison: Class Characteristics and Individual Characteristics, Determination of Identity. Other Dermatoglyphic Patterns: Palm Print, Sole Prints and Toe Prints.
- UNIT V** Recent advances: Fingerprint and Palm-print Recognition, Automated Fingerprint Identification System.

**DISCIPLINE SPECIFIC ELECTIVE 1 (AND 5.12(b))  
FORENSIC DERMATOGLYPHICS**

*Practical Credit: 2*

*Teaching Hours: 30*

**Practical**

1. Recording and Study of Finger and Palm Prints
2. Determination of palmar main line formula, Ridge count and indices
3. Comparison of Fingerprints and Palmprints on the basis of class and individual ridge Characteristics

**Recommended Books and References:**

1. Cowger, J. F. (1992). *Friction ridge skin: comparison and identification of fingerprints*(Vol. 8) CRC Press.
2. Cummins, H., & Midlo, C. (1961). *Finger prints, palms and soles: An introduction to dermatoglyphics*(Vol. 319). New York: Dover Publications.
3. Jain, A. K., Flynn, P., & Ross, A. A. (2007). *Handbook of biometrics*. Springer Science & Business Media.
4. Lee, H. C., Ramotowski, R., & Gaensslen, R. E. (Eds.). (2001). *Advances in fingerprint technology*. CRC press.
5. Berry, J., & Stoney, D. A. (2001). The history and development of fingerprinting. *Advances in fingerprint Technology*, 2, 13-52.
6. Mehta, M. K. (1980). Identification of thumb impression and cross examination of fingerprints. N. M. Tripathi Publication, Bombay.

**DISCIPLINE SPECIFIC ELECTIVE 2 (AND 5.21(a))  
ANTHROPOLOGY OF HEALTH**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Introduction and overview of the Field of Anthropology and Health: Defining Health and Illness in Cross- Cultural Perspectives. Looking at 'health', 'illness' and related concepts in western culture, some important variations in the process of seeking health care.
- UNIT II** Measuring Health: Concept of Morbidity & Mortality, Epidemiology: Meaning, scope and methods. Epidemiology of common communicable diseases: Malaria, Tuberculosis, Leprosy, Diabetes, Cardiovascular disease and Sexually Transmitted Diseases (STDs), HIV/AIDS.
- UNIT III** Healing and Healers in Cross-Cultural Perspectives: Shamanism, Magic and Healing. Shaman, magic, witchcraft and sorcery.
- UNIT IV** Healing and Healers in Cross-Cultural Perspectives: Folk Healers and "Alternative medicine". Types of healers and healing, problems in evaluating efficacy, sources of dissatisfaction with mainstream medicine.
- UNIT V** Rules and regulations of international health policy, Medico-Legal Problems in relation to health administration, International health organization/ NGOs, Medical Ethics, Critical issues in global health.

**DISCIPLINE SPECIFIC ELECTIVE 2 (AND 5.22(a))  
ANTHROPOLOGY OF HEALTH**

*Practical Credit: 2*

*Teaching Hours: 30*

1. Case Studies of Traditional and Modern healers.

***Recommended Books and References:***

1. Rajesh Khanna and A.K. Kapoor. 2007. Ethnic Groups and Health Dimensions. Discovery Publishing House, New Delhi.
2. Chin, James, M.D., M.P.H. (ed.) 2000. Control of Communicable Diseases Manual. 17th Edition. American Public Health Association. *Anyone interested in field work in less developed areas should own this book for reference.*
3. Helman, Cecil G. 2001. Culture, Health, and Illness. 4th ed. London: Arnold. *This book is written for health care practitioners and clearly explains the relevance of culture to health.*
4. Mann, Jonathon M., et al. (eds.) 1999. Health and Human Rights. New York: Routledge.
5. Albrecht, Gary L., Ray Fitzparick, and Susan C. Scrimshaw (eds.) 2000. The Handbook of Social Studies in Health and Medicine, SAGE. Publications.
6. Bannerman, Robert, J. Burton, and Ch'en Wen-Chieh (eds.) 1983. Traditional Medicine and Health Care Coverage. Geneva: World Health Organization.
7. Chen, Lincoln C. Arthur Kleinman, and Norma C. Ware 1994. Health and Social Change in International Perspective. Harvard University Press.
8. Coreil, Jeannine and J. Dennis Mull (eds.) 1990. Anthropology and Primary Health Care, Boulder: Westview Press.

9. Hahn, Robert A. 1999. Anthropology in Public Health. Bridging Differences in Culture and Society. New York: Oxford University Press.
10. Helman, Cecil G. 1994. Culture, Health, and Illness. 3rd ed. Oxford: Butterworth-Heinemann.
11. Inhorn, Marcia C. and Peter J. Brown 1997. The Anthropology of Infectious Disease. International health Perspectives. Gordon and Breach Publishers.
12. Koop, C. Everett, Clarence E. Pearson, and M. Roy Schwartz (eds.) 2001. Critical Issues in Global Health. San Francisco: Jossey-Bass. A Wiley Company.
13. Mayer, Kenneth H. and H.F. Pizer (eds.) 2000. The Emergence of AIDS. The Impact on Immunology, Microbiology, and Public Health. Washington, D.C.: American Public Health Association.
14. Nichter, Mark and Mimi Nichter 1996. Anthropology and International Health. Asian Case Studies. Gordon and Breach Publishers.
15. Paul, Benjamin D. (ed.) 1955. Health, Culture, and Community. Case Studies of Public Reactions to Health Programs.
16. Williams, Cicely D., Naomi Baumslag, and Derrick B. Jelliffe 1994. Mother and Child Health. Delivering the Services. 3rd Edition. New York: Oxford University Press  
Basch, Paul F. Textbook of International Health 1999. New York: Oxford University Press.
17. Tsui, Amy O., Judith N. Wasserheit, and John G. Haaga (eds.) 1997. Reproductive Health in Developing Countries. Washington, D.C.: National Academy Press.

**DISCIPLINE SPECIFIC ELECTIVE 2 (AND5.21(b))  
TRIBAL CULTURES OF INDIA**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Tribes in India: historical, academic, administrative and anthropological importance.
- UNIT II** Tribe- caste continuum, Constitutional safeguard/provisions, Gender and Tribe,
- UNIT III** Scheduled and non-scheduled categories of tribes, Denotified tribes.
- UNIT IV** Problems of tribal communities: land alienation, poverty, unemployment and underemployment, low literacy, health and nutrition, lack of educational facilities, shifting cultivation etc.
- UNIT V** Forest policies and tribes, Migration and occupational shift, Tribal arts and aesthetics  
Displacement, rehabilitation and social change Globalization among Indian tribes.

**DISCIPLINE SPECIFIC ELECTIVE 2 (AND 5.22(b))  
TRIBAL CULTURES OF INDIA**

*Practical Credit: 2*

*Teaching Hours: 30*

**Practical**

Distribution of Indian Tribes: PTG, ST/Location of different tribes on the map of India/Write an annotated bibliography on any one tribe.

**Recommended Books and References:**

1. Behera, D.K and Georg pfeffer. Contemporary Society Tribal Studies, Volume I to VII.New Delhi: Concept Publishing Company
2. Georg Pfeffer. Hunters, Tribes and Peasant: Cultural Crisis and Comparison. Bhubaneswar: Niswas.
3. Vidarthy, L.P. and Rai. Applied Anthropology in India.
4. Vidarrthy.L.P. and B.N. Sahay. Applied Anthropology and Development in India. NewDelhi: National Publishing House

**DISCIPLINE SPECIFIC ELECTIVE 3 (AND 6.11(a))  
INDIAN ARCHAEOLOGY**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I** History of Indian Archeology pre & post independence.

**UNIT II** Methods of climatic reconstruction: palynology, paleontology, soil pH estimation.

**UNIT III** Character, distribution and interpretation of habitat and economy of :  
i Lower palaeolithic  
ii Middle palaeolithic  
iii Upper palaeolithic  
iv Mesolithic culture

**UNIT IV** Neolithic revolution – emergence of human settlement and farming in India.

**UNIT V** Megalithic cultures in India salient feature and types

**DISCIPLINE SPECIFIC ELECTIVE 3 (AND 6.12(a))  
INDIAN ARCHAEOLOGY**

*Practical Credit: 2*

*Teaching Hours: 30*

1. Sketching, description, identification and functions of prehistoric tools (5 tools from each period)
  - i Palaeolithic (lower, middle, upper)
  - ii Mesolithic
  - iii Neolithic
2. Identification of lithic technology.

**Recommended Books and References:**

1. Agrawal, D.P. 1982. *The Archaeology of India*. New Delhi: Select Books Syndicate.
2. Allchin, B and R. Allchin. 1983. *The Rise of Civilization in India and Pakistan*. New Delhi: SBS.
3. Bhattacharya, D. K. (1996) *An Outline of Indian Prehistory*. Delhi, Palika Prakashan.
4. Jamir, T. and M. Hazarika (eds.). 2014. *50 Years After Gaojali-Hading: Emerging Perspectives in the Archaeology of Northeast India*. Research India Press.

5. Sankalia, H. D. (1974) Prehistory and Protohistory of India and Pakistan. Poona, Deccan College.
6. Sankalia, H. D. (1982) Stone Tool Type and Technology. Delhi, B.R. Publication.

**DISCIPLINE SPECIFIC ELECTIVE 3 (AND 6.11(b))  
PALEO-ANTHROPOLOGY**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Geological time scale, taphonomy and interpretation of the paleontological and archaeological records, taxonomic and chronological problems of fossils records.
- UNIT II** Primate Speciation and extinctions: a geological perspective, adaptive primate Radiation.
- UNIT III** Evolutionary biology: Origins and evolution of stone age technology (Human origins: Development, distribution and fossilized evidence of Australopithecines, Paranthropus (Zinjanthropus), Homo habilis, Homo erectus, Archaic H. sapiens.
- UNIT IV** Primate and Non-Primate Models for Early Hominid Behaviour; hominization process- Evolution of hominid-human bipedalism
- UNIT V** Palaeopathology- bioarchaeological approach of disease; effects of agriculture, urbanization; dispersion of modern humans - molecular and morphological patterns of relationship

**DISCIPLINE SPECIFIC ELECTIVE 3 (AND 6.12(b))  
PALEO-ANTHROPOLOGY**

*Practical Credit: 2*

*Teaching Hours: 30*

**Practical**

1. Seminar

**Recommended Books and References:**

1. Napier JR and Napier PH. (1985). The Natural History of the Primates. Cambridge, MA: The MIT Press
2. Boyd R and Silk JB. (2009). How Humans Evolved. London: WW Norton.
3. Tattersall I. (2009). The Fossil Trail: How We Know What We Think We Know about Human Evolution. New York: Oxford University Press.
4. Waldron T. (2008): Palaeopathology. Cambridge University Press.
5. Cela-conde CJ and Frisancho J. (2007). Human Evolution: Trails from the past. Ayala Oxford University Press.
6. Barnes E. Diseases and Human Evolution. (2005). University of New Mexico Press.
7. Pinhasi R and Mays S (2008). Advances in Human Palaeopathology. Chichester: John Wiley & Sons, Inc. (PM).
8. Hoppa RD and Vaupel JW. (2002). Paleodemography: Age Distributions from Skeletal Samples. Cambridge University Press.

9. Lansen CS, Matter RM and Gebo DL. (1998). Human Origin: The fossil Record. Waveland Press.
10. Cameron DW and Colin P. Groves CP. (2004). Bone, Stones and Molecules: "Out of Africa" and Human Origins. Elsevier Inc.
11. Stringer C. (2011). The Origin of Our Species. London: Allen Lane.
12. Conroy GC. (2005). Reconstructing Human Origins. WW Norton and Company.

**DISCIPLINE SPECIFIC ELECTIVE 4 (AND 6.21)  
DISSERTATION**

*Theory Credit: 4*

*Teaching Hours: 60*

**DISSERTATION: Student will opt either dissertation or project work or one paper from the elective discipline course in 6th Semester. He will be attached with one supervisor or guide.**

## **SKILL ENHANCEMENT COURSE (SEC)**

### **SKILL ENHANCEMENT COURSE 1 (ANS 3.11) TOURISM ANTHROPOLOGY**

*Theory Credit: 2*

*Teaching Hours: 30*

**UNIT I** Concept and historical background of tourism anthropology, aspects and prospects of tourism anthropology, tourism and the co modification of culture or cultural degradation.

**UNIT II** (a). Relationship between heritage making enterprises, revival n preservation projects, role of museum and other branches of the cultural industries (including music art and food) in tourism economies.  
(b). New direction of anthropology in tourism, tourism and terrorism, tourism and global mobility, ecotourism and sustainable development.

#### **Recommended Books and References:**

1. Chambers E. (2000). *Native Tours: The Anthropology of Travel and Tourism*. Prospect Heights: Waveland.
2. Crick M. (1995). *The Anthropologist as Tourist: An Identity in Question*. In Lanfant MF, Allcock JB, Bruner EM (eds.) *International Tourism: Identity and Change*. London: Sage. pp. 205-223.
3. Dann GMS, Nash D and Pearce PL. (1988). *Methodology in Tourism Research*. *Annals of Tourism Research*. 15:1-28.
4. Gmelch SB. (2004). *Tourists and Tourism: A Reader*. Long Grove: Waveland.
5. Graburn NHH. (1977). *Tourism: The Sacred Journey. Hosts and Guests: The Anthropology of Tourism*. Valene L. Smith, ed. Philadelphia: University of Pennsylvania Press. Pp. 33-47.
6. Dann G. (2002). *The Tourist as a Metaphor of the Social World*. Wallingford: CAB International.
7. Nash D. (1996). *Anthropology of Tourism*. New York: Pergamon.
8. Kirshenblatt-Gimblett B. (1998). *Destination Culture: Tourism, Museums, and Heritage*. University of California Press.
9. Lippard LR. (1999). *On the Beaten Track: Tourism, Art and Place*. New Press.
10. Picard M and Wood R. (1997). *Tourism, Ethnicity, and the State in Asian and Pacific Societies*. University of Hawai Press.
11. Crick M. (1994). *Anthropology and the Study of Tourism: Theoretical and Personal Reflections*. In Crick M (eds.). *Resplendent Sites, Discordant Voices: Sri Lanka and International Tourism*. Chur, Switzerland: Harwood Publishers.
12. Wood R. (1997). *Tourism and the State: Ethnic Options and the Construction of Otherness*. In Picard and Wood *Tourism, Ethnicity and the State in Asian and Pacific Societies*. University of Hawai Press.
13. Richard B. (1992). *Alternative Tourism: The Thin Edge of the Wedge*. In Valene Smith and Eadington *Tourism* (eds.). *Alternatives: Potentials and Problems in the Development of Tourism*. University of Pennsylvania Press.
14. Hitchcock. (1997). *Cultural, Economic and Environmental Impacts of Tourism Among the Kalahari*. In Chambers E (eds.) *Tourism and Culture: An Applied Perspective*. SUNY Press.

**SKILL ENHANCEMENT COURSE 2 (ANS 4.11)**  
**ANTHROPOLOGY OF DISASTER**

*Practical Credit: 2*

*Teaching Hours: 30*

**UNIT I** a) Introduction to Disaster: Definition and concept, types, vulnerability, risk, coping  
b) Anthropological approaches to study disasters - archaeological/historical, political ecology, socio-cultural behavioral, gendered perspective.

**UNIT II** a) Methods for studying disasters, Health, social and economic impacts of disaster.  
b) Plans and National policies concerning disasters, disaster risk mitigation, disasters management.

**Note:** *Students are to write and assignment or a project on a recent disaster (local, state, national level)*

**Recommended Books and References:**

1. The Angry Earth: Disasters in Anthropological perspectives. A. Oliver-Smith and SM Hoffman. Routledge.1999.
2. Community in Disaster. WH Form and S. Nosow. Harper. 1958.
3. Environmental Disaster and the Archaeology of Human Response. G. Bawden and RM Reycraft. Univesity of New Mexico Press. 2000.
4. The Northridge Earthquake: Vulnerability and Disasters. RC Bolin! Stanford. 2000.
5. Disasters, Relief and the Media. J Benthall. IB Tauris and Company Ltd. 1993.
6. Mapping Vulnerability. J Bankoff and G Frerks. Earthscan. 2004.
7. Natural Disasters. A. Alexander. Routledge Taylor and Francesbrip. 1993.
8. Confronting Catastrophe: New perspective on Natural Disasters. DE Alexander. Terra Publishing. 2000.
9. Terrorism and Disasters: New threats, new ideas. LB Clarke. JAI Press. 2003.
10. Methods for Disaster Mental Health Research. FH Norris, S galea, MT Friedman, PJ Watson, Guilford Press. 2006.
11. Phenomenology of Disasters: Towards a Rhetoric of Tragedy. Pennsylvanias State University Press. 2006.



*Revised*  
SYLLABUS FOR  
Bachelor of Science (Honours)

**BOTANY**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)



## COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Phycology and Microbiology (Theory)	BOC 1.11	4
		Phycology and Microbiology (Practical)	BOC 1.12	2
	Core 2	Biomolecules and Cell Biology (Theory)	BOC 1.21	4
		Biomolecules and Cell Biology (Practical)	BOC 1.22	2
II	Core 3	Mycology and Phytopathology (Theory)	BOC 2.11	4
		Mycology and Phytopathology (Practical)	BOC 2.12	2
	Core 4	Archegoniate (Theory)	BOC 2.21	4
		Archegoniate (Practical)	BOC 2.22	2
III	Core 5	Morphology and Anatomy (Theory)	BOC 3.11	4
		Morphology and Anatomy (Practical)	BOC 3.12	2
	Core 6	Economic Botany (Theory)	BOC 3.21	4
		Economic Botany (Practical)	BOC 3.22	2
	Core 7	Genetics (Theory)	BOC 3.31	4
		Genetics (Practical)	BOC 3.32	2
	Skill Enhancement Course 1	Floriculture	BOS 3.11	2
	IV	Core 8	Molecular Biology (Theory)	BOC 4.11
Molecular Biology (Practical)			BOC 4.12	2
Core 9		Plant Ecology and Phytogeography (Theory)	BOC 4.21	4
		Plant Ecology and Phytogeography (Practical)	BOC 4.22	2
Core 10		Plant Systematics (Theory)	BOC 4.31	4
		Plant Systematics (Practical)	BOC 4.32	2
Skill Enhancement Course 2		Mushroom Culture Technology	BOS 4.11	2
V		Core 11	Reproductive Biology of Angiosperms (Theory)	BOC 5.11
	Reproductive Biology of Angiosperms (Practical)		BOC 5.12	2
	Core 12	Plant Physiology (Theory)	BOC 5.21	4
		Plant Physiology (Practical)	BOC 5.22	2
	Discipline Specific Elective 1	Plant Breeding (Theory)	BOD 5.11	4
		Plant Breeding (Practical)	BOD 5.12	2
	Discipline Specific Elective 2	Natural Resource Management (Theory)	BOD 5.21	4
		Natural Resource Management (Practical)	BOD 5.22	2
VI	Core 13	Plant Metabolism (Theory)	BOC 6.11	4
		Plant Metabolism (Practical)	BOC 6.12	2
	Core 14	Plant Biotechnology (Theory)	BOC 6.21	4
		Plant Biotechnology (Practical)	BOC 6.22	2
	Discipline Specific Elective 3	Research Methodology (Theory)	BOD 6.11	4
		Research Methodology (Practical)	BOD 6.12	2
	Discipline Specific Elective 4	Biostatistics (Theory)	BOD 6.21	4
		Biostatistics (Practical)	BOD 6.22	2

## SEMESTER-I

### CORE 1 (BOC 1.11) PHYCOLOGY AND MICROBIOLOGY

Theory Credits: 4

Teaching Hours: 60

#### UNIT I Introduction to microbial world (12 Hours)

General account of the Darwin's theory of evolution; the evolution of populations, concepts of species, Mechanism of speciation; Microbial nutrition, growth and metabolism. Economic importance and scope of viruses and bacteria.

#### UNIT II Viruses(12 Hours)

Discovery, general structure, physiochemical and biological characteristics; classification (Baltimore), viroids and prions; replication (general account), DNA virus (T-phage), lytic (*T4 phage*) and lysogenic cycle (*Lambda phage*); RNA types: RNA virus (TMV), Retro virus (*HIV*), DNA virus (*coliphage*).

#### UNIT III Bacteria(12 Hours)

Discovery, general characteristics; Bergey's classification of bacteria; Shapes of bacteria; Types-archaebacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Nutritional types; Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction), bacterial genome and plasmid, gram positive and gram negative bacteria.

#### UNIT IV Algae I(12 Hours)

General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; methods of reproduction; Classification; criteria, system of Fritsch; Significant contributions of important phycologists (F.E. Fritsch, G.M. Smith). Economic importance of algae.

#### UNIT V AlgaeII(12 Hours)

General characteristics, occurrence, range of thallus organization, reproduction and life cycle of Cyanophyta (*Nostoc*), Xanthophyta (*Vaucheria*), Chlorophyta (*Oedogonium*), Charophyta (*Chara*), Phaeophyta (*Ectocarpus*) and Rhodophyta (*Polysiphonia*)

### CORE 1 (BOC 1.12) PHYCOLOGY AND MICROBIOLOGY

Practical Credit: 2

#### Microbiology

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs.
3. Gram staining.
4. Endospore staining with malachite green using the (endospores taken from soil bacteria).

## Phycology

5. Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas* (electronmicrographs), *Volvox*, *Oedogonium*, *Coleochaete*, *Chara*, *Vaucheria*, *Ectocarpus*, *Fucus* and *Polysiphonia*, *Prochloron* through electron micrographs, temporary preparations and permanent slides.

### Recommended Books and References:

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
6. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

## CORE 2 (BOC 1.21)

### BIOMOLECULES AND CELL BIOLOGY

Theory Credit: 4

Teaching Hours: 60

#### UNIT I Biomolecules1(12 Hours)

Types and significance of chemical bonds; Structure and properties of water; pH and buffers.

**Carbohydrates:** Nomenclature and classification; Monosaccharides; Disaccharides; Oligosaccharides and polysaccharides.

**Lipids:** Definition and principle classes of lipids. Storage, metabolic and structural lipids; Fatty acids Types, structure and functions; Essential fatty acids; Triacyl glycerols structure, functions and properties; Phosphoglycerides.

#### UNIT II Biomolecules2(12 Hours)

**Proteins:** Structure and classification of amino acids; Levels of protein structure- primary, secondary, tertiary and quaternary; Protein denaturation and biological roles of proteins.

**Nucleic acids:** Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, C and Z types of DNA; Types of RNA; Structure of tRNA.

#### UNIT III Bio energetic & enzymes(12 Hours)

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule.

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theory), Michaelis - Menten equation, enzyme inhibition and factors affecting enzyme activity.

#### UNIT IV The cell(12 Hours)

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Chemistry, structure and function of Plant cell wall. Overview of membrane

function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis. Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle- checkpoints, role of protein kinases.

#### **UNIT V Cell organelles (12 Hours)**

**Nucleus:** Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus.

**Cytoskeleton:** Role and structure of microtubules, microfilaments and intermediary filament.

**Chloroplast, mitochondria and peroxisomes:** Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.

**Endomembrane system:** Endoplasmic Reticulum – Structure and function. Golgi Apparatus – structure and function. Lysosomes- structure and function.

#### **CORE 2 (BOC 1.22)**

#### **BIOMOLECULES AND CELL BIOLOGY**

*Practical Credit: 2*

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion/ *Rhoeo/ Crinum*.
3. Measurement of cell size by the technique of micrometry.
4. Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollengrains).
5. Study the effect of organic solvent and temperature on membrane permeability.
6. Study different stages of mitosis and meiosis.

#### **Recommended Books and References:**

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H. Freeman
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H. Freeman and Company
5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.
6. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
7. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
8. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
9. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7<sup>th</sup> edition. Pearson Benjamin Cummings Publishing, San Francisco.

## SEMESTER-II

### CORE3 (BOC 2.11)

#### MYCOLOGY AND PHYTOPATHOLOGY

Theory Credit: 4

Teaching Hours:60

- UNIT I Introduction to true fungi, Chytridiomycota and Zygomycota(12 Hours)**  
General characteristics; Ecology, Nutrition; Classification, economic importance of fungi, Mushroom Cultivation  
**Chytridiomycota and Zygomycota:** Characteristic features; significance; Reproduction; Life cycle with reference to *Synchytrium*, *Rhizopus*.
- UNIT II Ascomycota & Basidiomycota(12 Hours)**  
**Ascomycota:** General characteristics (asexual and sexual fruiting bodies); Life cycle of *Saccharomyces*, *Aspergillus*, *Penicillium* and *Alternaria*  
**Basidiomycota:** General characteristics; Life cycle of *Puccinia* (Physiological Specialization), *Agaricus* life cycle; Bioluminescence, Fairy Rings.
- UNIT III Allied Fungi, Oomycota & Symbiotic associations(12 Hours)**  
General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.  
Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.
- UNIT V Applied Mycology(12 Hours)**  
Role of fungi in biotechnology; Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.
- UNIT V Phytopathology (12 Hours)**  
Terms and concepts; General symptoms; Geographical distribution of diseases; Etiology; Symptomology; Host-Pathogen relationships; Disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine.  
Bacterial diseases – Citrus canker Viral diseases – Tobacco Mosaic viruses.  
Algal disease- tea rust  
Fungal diseases – Early & late blight of potato, Black stem rust of wheat.  
Loose and covered smut (symptoms only)

### CORE 3 (BOC 2.12)

#### MYCOLOGY AND PHYTOPATHOLOGY

Practical Credit: 2

1. Introduction to the world of fungi (Unicellular, coenocytic/ septate mycelium, ascocarps & basidiocarps).

2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus* and *Penicillium*: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. *Alternaria*: Specimens/photographs and temporary mounts.
5. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
6. *Agaricus*: Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*, fairy rings and bioluminescent mushrooms to be shown.
7. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs)
8. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Viral diseases: TMV, Fungal diseases: Early blight of potato, Black stem rust of wheat, Tea rust.

**Recommended Books and References:**

1. Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
3. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
4. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
5. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

**CORE 4 (BOC 2.21)  
ARCHEGONIATE**

Theory Credits: 4

Teaching Hours: 60

**UNIT I Introduction to Bryophytes & Pteridophytes (12 Hours)**

Unifying features of archegoniates; Transition to land habit; Alternation of generations. Bryophytes-General characteristics; Adaptations to land habit; Classification; Range of thallus organization. Pteridophytes- General characteristics; Classification; Early land plants (*Cooksonia* and *Rhynia*).

**UNIT II Type Studies- Bryophytes (12 Hours)**

Classification (up to family), morphology, anatomy, reproduction and evolutionary trends of *Marchantia*, *Anthoceros*, *Sphagnum* and *Funaria*; Ecological and economic importance of bryophytes with special reference to *Sphagnum*.

**UNIT III Type Studies- Pteridophytes (12 Hours)**

Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris* (Developmental details not to be included). Apogamy and apospory, heterospory and seed habit, telome theory, Stellar evolution; Ecological and economic importance.



**UNIT IV Gymnosperms(12 Hours)**

General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum* (Developmental details not to be included); Ecological and economic importance.

**UNIT V Paleobotany(12 Hours)**

Geological time scale, fossil types and their formation, general account of dominant fossil flora of different ages, paleobotany in relation to exploration of fossil fuels

**CORE 4 (BOC 2.22)****ARCHEGONIATE**

*Practical Credit: 2*

1. **Marchantia**- Morphology of thallus, whole mount of rhizoids & Scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).
2. **Anthoceros**- Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).
3. **Sphagnum**- Morphology of plant, whole mount of leaf (permanent slide only).
4. **Funaria**- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.
5. **Psilotum**- Study of specimen, transverse section of synangium (permanent slide).
6. **Selaginella**- Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
7. **Equisetum**- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
8. **Pteris**- Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
9. **Cycas**- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll, transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).
10. **Pinus**- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), transverse section of Needle, transverse section of stem, longitudinal section of / transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone, tangential longitudinal section & radial longitudinal sections stem (permanent slide).
11. **Gnetum**- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide)
12. **Botanical excursion (Local).**

## SEMESTER-III

### CORE 5 (BOC 3.11) ANATOMY OF ANGIOSPERMS

*Theory Credits: 4*

*Teachings Hours: 60*

#### **UNIT I Introduction, Structure and Development of Plant Body**(12 Hours)

Internal organization of plant body: The three tissue systems, types of cells and tissues. Development of plant body: Polarity, Cyto-differentiation and organogenesis during embryonic development.

#### **UNIT II Tissues**(12 Hours)

Classification of tissues; Simple and complex tissues (no phylogeny); cyto-differentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Wall ingrowths and transfer cells, Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.

#### **UNIT III Apical meristems**(12 Hours)

Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory); Types of vascular bundles; Structure of dicot and monocot stem. Origin, development, arrangement and diversity in size and shape of leaves; Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

#### **UNIT IV Vascular Cambium and Wood**(12 Hours)

Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Axially and radially oriented elements; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm, rhytidome and lenticels.

#### **UNIT V Adaptive and Protective Systems**(12 Hours)

Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni- and multicellular, glandular and nonglandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

### CORE 5 (BOC 3.12) ANATOMY OF ANGIOSPERMS

*Practical Credit: 2*

1. Study of anatomical details through permanent slides/ temporary stain mounts/ macerations/ museum specimens with the help of suitable examples.
2. Apical meristem of root, shoot and vascular cambium.
3. Distribution and types of parenchyma, collenchyma and sclerenchyma.
4. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
5. Wood: ring porous; diffuse porous; tyloses; heart- and sapwood.

6. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
7. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
8. Root: monocot, dicot, secondary growth. Anomalous secondary growth.
9. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.
10. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
11. Adaptive Anatomy: xerophytes, hydrophytes.
12. Secretory tissues: cavities, lithocysts and laticifers.

**Recommended Books and References:**

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
4. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.

**CORE 6 (BOC 3.21)  
ECONOMIC BOTANY**

*Theory Credits: 4*

*Teaching Hours: 60*

- UNIT I      Origin of Cultivated Plants; Sources of sugars and starches** (12 Hours)  
 Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity. sugars and starches -Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses.
- UNIT II      Cereals & Legumes: Spices & Beverages** (12 Hours)  
 Wheat and Rice (origin, morphology, processing & uses); Brief account of millets. Legumes- Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes. Importance to man and ecosystem.  
 Listing of important spices, their family and part used. Economic importance with special reference to black pepper, ginger, turmeric and chillies.  
 Beverages- Tea, Coffee (morphology, processing & uses)
- UNIT III     Agro ecosystem** (12 Hours)  
 Agro-ecosystem in Nagaland. Jhum cultivation, terrace cultivation, water harvesting methods, irrigation methods, types of crops grown, cropping system, land use pattern and its importance to ecosystem.
- UNIT IV     Sources of oils and fats; Natural Rubber** (12 Hours)  
 General description, classification, extraction, their uses and health implications of groundnut, linseed, soyabean, mustard and coconut (Botanical name, family & uses). Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.  
 Natural Rubber -Para-rubber: tapping, processing and uses.
- UNIT V      Drug-yielding plants, Timber plants & Fibers** (12 Hours)  
 Therapeutic and habit-forming drugs with special reference to *Cinchona*, *Digitalis*, *Papaver* and *Cannabis*; Tobacco (Morphology, processing, uses and health hazards).

*Timberplants*-General account with special reference to teak and pine.  
Fibers-Classification based on the origin of fibers; Cotton, Nettle, Coir and Jute (morphology, extraction and uses).

## **CORE 6 (BOC 3.22) ECONOMIC BOTANY**

*Practical Credit: 2*

1. **Cereals:** Wheat (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests) Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. **Legumes:** Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. **Sources of sugars and starches:** Sugarcane (habit sketch; cane juice- micro-chemical tests), Potato(habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains, micro-chemical tests).
4. **Spices:** Black pepper, Fennel and Clove (habit and sections).
5. **Beverages:** Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. **Sources of oils and fats:** Coconut- T.S. nut, Mustard-plant specimen, seeds; tests for fats in crushed seeds.
7. **Essential oil-yielding plants:** Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and *Eucalyptus* (specimens/photographs).
8. **Rubber:** specimen, photograph/model of tapping, samples of rubber products.
9. **Drug-yielding plants:** Specimens of *Digitalis*, *Papaver* and *Cannabis*.
10. **Tobacco:** specimen and products of Tobacco.
11. **Woods:** *Tectona*, *Pinus*: Specimen, Section of young stem.
12. **Fiber-yielding plants:** Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Nettle, Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

### **Recommended Books and References:**

1. Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
2. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
3. Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett\_Publishers.

## **CORE 7 (BOC 3.31) GENETICS**

*TheoryCredits: 4*

*Teaching Hours: 60*

### **UNIT I Mendelian genetics and its extension(12 Hours)**

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and co-dominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Numericals; Polygenic inheritance.

**UNIT II Extrachromosomal Inheritance** (12 Hours)

Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects- shell coiling in snail; Infective heredity- Kappa particles in *Paramecium*.

**UNIT III Linkage, crossing over and chromosome mapping** (12 Hours)

Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.

**UNIT IV Variation in chromosome number and structure; Gene mutations** (12 Hours)

Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy *Gene mutations* -Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Baseanalog, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method. Role of Transposons in mutation. DNA repair mechanisms.

**UNIT V Fine structure of gene; Population and Evolutionary Genetics** (12 Hours)

Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.

*Population and Evolutionary Genetics* - Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

**CORE 7 (BOC 3.32)**

**GENETICS**

*Practical Credit: 2*

1. Meiosis through temporary squash preparation.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
3. Chromosome mapping using point test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Blood Typing: ABO groups & Rh factor.
7. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
8. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
9. Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red-green Colour blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached ear lobe.

**Recommended Books and References:**

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

## SEMESTER -IV

### CORE 8 (BOC 4.11) MOLECULAR BIOLOGY

Theory Credit: 4

Teaching Hours: 60

#### UNIT I **Nucleic acids: Structures of DNA and RNA** (12 Hours)

Historical perspective; DNA as the carrier of genetic information DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure\_Organelle DNA - mitochondria and chloroplast DNA. The Nucleosome\_Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.  
Central dogma, Genetic code (deciphering & salient features)

#### UNIT II **The replication of DNA** (12 Hours)

Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semiconservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle,  $\theta$  (theta) mode of replication, replication of linear ds-DNA, replication of the 5' end of linear chromosome; Enzymes involved in DNA replication.

#### UNIT III **Transcription**(12 Hours)

Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli*. Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing.

#### UNIT IV **Processing and modification of RNA**(12 Hours)

Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport.

#### UNIT V **Translation**(12 Hours)

Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

### CORE 8 (BOC 4.12) MOLECULAR BIOLOGY

Practical Credit: 2

1. Preparation of LB medium and raising *E.Coli*.
2. Isolation of genomic DNA from *E.Coli*.
3. DNA isolation from cauliflower head.
4. DNA estimation by diphenylamine reagent/ UV Spectrophotometry.
5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).

6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
7. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.
9. Nucleic acid separation through chromatography paper
10. Estimation of DNA size through electrophoresis

**Recommended Books and References:**

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). *Molecular Biology of the Gene*, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). *Principles of Genetics*. John Wiley and Sons Inc., U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). *Concepts of Genetics*. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). *i-Genetics- A Molecular Approach*. Benjamin Cummings, U.S.A. 3rd edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). *Introduction to Genetic Analysis*. W. H. Freeman and Co., U.S.A. 10th edition.

**CORE 9 (BOC 4.21)**

**PLANT ECOLOGY AND PHYTOGEOGRAPHY**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Introduction; soil & water (12 Hours)**

Basic concepts; Levels of organization. Inter-relationships between the living world and the environment, the components and dynamism, homeostasis. Soil- Importance; Origin; Formation, Composition; Physical, Chemical and Biological components. Soil profile; Role of climate in soil development. Water- Importance: States of water in the environment, Atmospheric moisture, Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle, Water in soil, Water table.

**UNIT II Light, temperature, wind and fire. Biotic interactions (12 Hours)**

Light, temperature, wind and fire- adaptations of plants to their variation. *Biotic interactions*- Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism, parasitism.

**UNIT III Population ecology and plant communities (12 Hours)**

Characteristics and Dynamics. Ecological Speciation *Plant communities*-Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

**UNIT IV Ecosystems & Functional aspects of ecosystem (12 Hours)**

Structure; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids. *Functional aspects of ecosystem*- Principles and models of energy flow, Productivity, biomass, standing crop. Ecological efficiencies, Biogeochemical cycles- Cycling of Carbon, Nitrogen and Phosphorus.

## **UNIT V    Phytogeography**(12 Hours)

Principles of Continental drift, Theory of tolerance, Endemism. Brief description of major terrestrial biomes (one each from tropical, temperate & tundra). Phytogeographical division of India with special reference to North East region of India.

### **CORE 9 (BOC 4.22)**

#### **PLANT ECOLOGY AND PHYTOGEOGRAPHY**

*Practical Credit: 2*

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.
5. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
6. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
7. (a) Study of morphological adaptations of hydrophytes and xerophytes (four each).  
(b) Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*) Epiphytes, Predation (Insectivorous plants).
8. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
11. Local field visit to familiarize students with ecology of different sites.

#### **Recommended Books and References:**

1. Odum, E. P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5<sup>th</sup> edition.
2. Singh, J. S., Singh, S. P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
3. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
5. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.

### **CORE 10 (BOC 4.31)**

#### **PLANT SYSTEMATICS**



**UNIT I Significance of Plant systematics (12 Hours)**

Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from palynology, cytology, phytochemistry and molecular data. Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access.

**UNIT II Angiosperm taxonomy (12 Hours)**

Critical study of the following families with emphasis on identification of local members using flora, economic importance, interrelationship and evolutionary trends- *Dicots*; Magnoliaceae, Brassicaceae, Ranunculaceae, Rutaceae, Fabaceae, Meliaceae, Lamiaceae, Euphorbiaceae, Solanaceae, Cucurbitaceae, Asteraceae. *Monocots*; Orchidaceae, Poaceae, Zingiberaceae

**UNIT III Taxonomic hierarchy & Taxonomical nomenclature (12 Hours)**

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary). *Botanical nomenclature*- Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.

**UNIT IV Systems of classification (12 Hours)**

Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (upto series) and Engler and Prantl (upto series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.

**UNIT V Phylogeny of Angiosperms & Biometrics, numerical taxonomy and cladistics (12 Hours)**

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Co-evolution of angiosperms and animals. Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences). Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

**CORE 10 (BOC 4.32)  
PLANT SYSTEMATICS**

Practical Credit: 2

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):

Ranunculaceae - *Ranunculus*, *Delphinium*

Asteraceae - *Sonchus*/*Launaea*, *Vernonia*/*Ageratum*, *Eclipta*/*Bidens*

Solanaceae - *Solanum* / *Withania*

Brassicaceae- *Brassica* sp.

Fabaceae- *Phaseolus*/ *Vigna*/ *Trifolium*/ *Pisum*

Lamiaceae - *Salvia*/*Leucus*

Euphorbiaceae – *Euphorbia/Ricinus/Jatropha*

Poaceae – *Oryza/Triticum/Hordeum/Avena*

Zingiberaceae- *Zingiber/Curcuma/ Hedychium*

2. Field visit (local) – Subject to grant of funds from the university.
3. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

**Recommended Books and References:**

1. Singh, (2012). *Plant Systematics: Theory and Practice* Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
2. Jeffrey, C. (1982). *An Introduction to Plant Taxonomy*. Cambridge University Press, Cambridge.
3. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). *Plant Systematics-A Phylogenetic Approach*. Sinauer Associates Inc., U.S.A. 2nd edition.
4. Maheshwari, J.K. (1963). *Flora of Delhi*. CSIR, New Delhi.
5. Radford, A.E. (1986). *Fundamentals of Plant Systematics*. Harper and Row, New York.

## SEMESTER-V

### CORE 11 (BOC 5.11) REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

Theory Credit: 4

Teaching Hours: 60

#### UNIT I **Introduction; reproductive biology** (12 Hours)

History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope. *Reproductive development*-Induction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects.

#### UNIT II **Anther and pollen biology** (12 Hours)

Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

#### UNIT III **Ovule** (12 Hours)

Structure; Types; Special structures—endothelium, obturator, aril, caruncle and hypostase; Female gametophyte— megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac.

#### UNIT IV **Pollination and fertilization; self incompatibility** (12 Hours)

Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization. *Self incompatibility* -Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization; Cybrids, *in vitro* fertilization.

#### UNIT V **Embryo, Endosperm, Seed, Polyembryony and apomixis** (12 Hours)

Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Endosperm haustoria, Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia*. Seed structure, importance and dispersal mechanisms *Polyembryony and apomixis* -Introduction; Classification; Causes and applications.

### CORE 11 (BOC 5.12) REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

Practical Credit: 2

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.

2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs, fresh material), ultrastructure of pollen wall (micrograph);  
Pollen viability: Tetrazolium test. germination: Calculation of percentage germination in different media using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
4. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
5. Intra-ovarian pollination; Test tube pollination through photographs.
6. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
7. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

**Recommended Books and References:**

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
2. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
3. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
4. Johri, B.M. (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

**CORE 12 (BOC 5.21)  
PLANT PHYSIOLOGY**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Plant-water relations (12 Hours)**

Water Potential and its components, water absorption by roots, pathway of water movement- symplast, apoplast, transmembrane pathways, aquaporins. Ascent of sap-cohesion-tension transpirational pull theory, Root pressure. Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement, guttation.

**UNIT II Mineral nutrition (12 Hours)**

Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.

**UNIT III Nutrient Uptake & translocation in the phloem (12 Hours)**

Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport. *Translocation in the phloem* -Experimental evidence in support of phloem as the site of sugar translocation. Pressure-Flow Model; Phloem loading and unloading; Source-sink relationship.

**UNIT IV Plant growth regulators (12 Hours)**

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.

**UNIT V Physiology of flowering: Phytochrome, cryptochromes and phototropins (12 Hours)**

Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy. *Phytochrome, cryptochromes and phototropins* -Discovery, chemical nature, role in photomorphogenesis, Low Energy Responses (LER) and High Irradiance Responses (HIR), mode of action.

**CORE 12 (BOC 5.22)  
PLANT PHYSIOLOGY**

*Practical Credit: 2*

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/ leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the effect of different concentrations of IAA on *Avena* coleoptile elongation (IAA Bioassay).
8. To study the induction of amylase activity in germinating barley grains.

**Demonstration experiments**

1. To demonstrate suction due to transpiration.
2. Fruit ripening/Rooting from cuttings (Demonstration).
3. Bolting experiment/ *Avena* coleoptile bioassay (demonstration).

**Recommended Books and References:**

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.

## SEMESTER-VI

### CORE 13 (BOC 6.11) PLANT METABOLISM

Theory Credit: 4

Teaching Hours: 60

#### UNIT I **Concept of metabolism: Carbohydrate metabolism** (12 Hours)

Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes).

*Carbohydrate metabolism-* Synthesis and catabolism of sucrose and starch.

#### UNIT II **Carbon assimilation** (12 Hours)

Historical background, photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO<sub>2</sub> reduction, photorespiration, C<sub>3</sub>& C<sub>4</sub> pathways; Crassulacean acid metabolism; Factors affecting CO<sub>2</sub> reduction.

#### UNIT III **Carbon Oxidation** (12 Hours)

Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

#### UNIT IV **ATP-Synthesis & Mechanisms of signal transduction**(12 Hours)

Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers.

*Mechanisms of signal transduction-* Receptor-ligand interactions; Second messenger concept, Calcium calmodulin, MAP kinase cascade.

#### UNIT V **Lipid & nitrogen metabolism** (12 Hours)

Synthesis and breakdown of triglycerides,  $\beta$ -oxidation,  $\alpha$ -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination.

*Nitrogen metabolism-* Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

### CORE 13 (BOC 6.12) PLANT METABOLISM

Practical Credit: 2

1. Chemical separation of photosynthetic pigments.
2. Experimental demonstration of Hill's reaction.
3. To study the effect of light intensity on the rate of photosynthesis.
4. Effect of carbon dioxide on the rate of photosynthesis.

5. To compare the rate of respiration in different parts of a plant.
6. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
7. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
8. Demonstration of fluorescence by isolated chlorophyll pigments.
9. Demonstration of absorption spectrum of photosynthetic pigments.

**Recommended Books and References:**

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.

**CORE 14 (BOC 6.21)**

**PLANT BIOTECHNOLOGY**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Plant Tissue Culture (12 Hours)**

Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).

**UNIT II Recombinant DNA technology (12 Hours)**

Restriction Endonucleases (History, Types, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic; Eukaryotic Vectors (YAC).

**UNIT III Gene Cloning (12 Hours)**

Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR

**UNIT IV Methods of gene transfer (12 Hours)**

*Agrobacterium*-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP).

**UNIT V Applications of Biotechnology (12 Hours)**

Pest resistant (Bt-cotton); herbicide resistant plants (Round-Up Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

**CORE 14 (BOC 6.22)**  
**PLANT BIOTECHNOLOGY**

*Practical Credit: 2*

1. (a) Preparation of MS medium.  
(b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
3. Isolation of protoplasts.
4. Construction of restriction map of circular and linear DNA from the data provided.
5. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
6. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
7. Isolation of plasmid DNA.
8. Restriction digestion and gel electrophoresis of plasmid DNA.

***Recommended Books and References:***

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
5. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.



## DISCIPLINE SPECIFIC ELECTIVE COURSES

### DISCIPLINE SPECIFIC ELECTIVE 1 (BOD 5.11) PLANT BREEDING

*Theory Credit: 4*

*Teaching Hours: 60*

#### **UNIT I Plant Breeding (12 Hours)**

Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.

#### **UNIT II Methods of crop improvement (12 Hours)**

Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.

#### **UNIT III Quantitative inheritance (12 Hours)**

Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings. Monogenic vs polygenic Inheritance.

#### **UNIT IV Inbreeding depression and heterosis (12 Hours)**

History, genetic basis of inbreeding depression and heterosis; Applications.

#### **UNIT V Crop improvement and breeding(12 Hours)**

Role of mutations; Polyploidy, Distant hybridization and role of biotechnology in crop improvement.

### DISCIPLINE SPECIFIC ELECTIVE 1 (BOD 5.12) PLANT BREEDING

*Practical Credit: 2*

1. Self pollination experiment
2. cross pollination experiment
3. emasculation, bagging and tagging
4. Grafting and layering experiment
5. Effect of light and temperature in pollen germination
6. Seed viability test

#### **Recommended Books and References:**

1. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7<sup>th</sup> edition.
2. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH. 2<sup>nd</sup> edition.
3. Acquaah, G. (2007). Principles of Plant Genetics & Breeding. Blackwell Publishing.

**DISCIPLINE SPECIFIC ELECTIVE 2 (BOD 5.21)  
NATURAL RESOURCE MANAGEMENT**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Natural resources & Sustainable utilization (12 Hours)**

Definition and types. Sustainable utilization- Concept, approaches (economic, ecological and socio-cultural) with special reference to sustainable agricultural methods and Jhum cultivation.

**UNIT II Land & water (12 Hours)**

Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management. *Water*- Fresh water (rivers, lakes, groundwater, aquifers, catchment area, watershed); Marine, Estuarine, Wetlands. Threats and management strategies.

**UNIT III Biological Resources (12 Hours)**

Biodiversity-definition and types, Significance, Threats, Management strategies, Bioprospecting, IPR, CBD, National Biodiversity Action Plan.

**UNIT IV Forests & Energy (12 Hours)**

Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion, Management.

*Energy*- Renewable and non-renewable sources of energy

**UNIT V Contemporary practices in resource management (12 Hours)**

EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.

**DISCIPLINE SPECIFIC ELECTIVE 2 (BOD 5.22)  
NATURAL RESOURCE MANAGEMENT**

*Practical Credit: 2*

1. Estimation of solid waste generated by a domestic system (biodegradable and nonbiodegradable) and its impact on land degradation.
2. Collection of data on forest cover of specific area.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Ecological modeling.
6. Field report

***Recommended Books and References:***

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.

**DISCIPLINE SPECIFIC ELECTIVE 3 (BOD 6.11)  
RESEARCH METHODOLOGY**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Basic concepts of research (12 Hours)**

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs empirical). Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.

**UNIT II General laboratory practices (12 Hours)**

Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases. Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

**UNIT III Data collection and documentation of observations: Methods to study plant cell/ tissue structure (12 Hours)**

Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

Methods to study plant cell/tissue structure-Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning; Tissue preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulant fixatives; tissue dehydration using graded solvent series; Paraffin and plastic infiltration; Preparation of thin and ultrathin sections.

**UNIT IV Plant microtechniques (12 Hours)**

Staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and fluorochromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials.

**UNIT V The art of scientific writing and its presentation (12 Hours)**

Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Powerpoint presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright-academic misconduct/ plagiarism.

**DISCIPLINE SPECIFIC ELECTIVE 3 (BOD 6.12)  
RESEARCH METHODOLOGY**

*Practical Credit: 2*

1. Experiments based on chemical calculations.
2. Plant microtechnique experiments.
3. The art of imaging of samples through microphotography and field photography.
4. Poster presentation on defined topics.
5. Technical writing on topics assigned.

**Recommended Books and References:**

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Ruzin, S.E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

**DISCIPLINE SPECIFIC ELECTIVE 4 (BOC 6.21)  
BIostatISTICS**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Biostatistics (12 Hours)**

Definition - statistical methods - basic principles. Variables - measurements, functions, limitations and uses of statistics.

**UNIT II Collection of data primary and secondary (12 Hours)**

Types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data - sampling methods.

**UNIT III Measures of central tendency (12 Hours)**

Mean, median, mode, geometric mean- merits & demerits. Measures of dispersion - range, standard deviation, mean deviation, quartile deviation - merits and demerits; Co- efficient of variations.

**UNIT IV Probability(12 Hours)**

Priori probability, addition rule, multiplication rule

**UNIT V Statistical inference (12 Hours)**

Hypothesis- Simple hypothesis - student 't' test, chi square test.

**DISCIPLINE SPECIFIC ELECTIVE 4 (BOC 6.22)  
BIostatISTICS**

*Practical Credit: 2*

1. Calculation of mean, standard deviation and standard error
2. Calculation of correlation coefficient values and finding out the probability
3. Calculation of 'F' value and finding out the probability value for the F value.

**Recommended Books and References:**

1. Biostatistic, Danniel, W.W., 1987. New York, John Wiley Sons.
2. An introduction to Biostatistics, 3rd edition, Sundarrao, P.S.S and Richards, J. Christian Medical College, Vellore
3. Statistical Analysis of epidemiological data, Selvin, S., 1991. New York University Press.
4. Statistics for Biology, Boston, Bishop, O.N. Houghton, Mifflin.
5. The Principles of scientific research, Freedman, P. New York, Pergamon Press.
6. Statistics for Biologists, Campbell, R.C., 1998. Cambridge University Press.

## SKILL ENHANCEMENT COURSE

### SKILL ENHANCEMENT COURSE 1 (BOS 3.11) FLORICULTURE

*Theory Credits: 2*

*Teaching Hours: 30*

- UNIT I** Introduction: History of gardening; Importance and scope of floriculture and landscape gardening. Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators. (6 Hours)
- UNIT II** Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai. (6 Hours)
- UNIT III** Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India. (6 Hours)
- UNIT IV** Landscaping Places of Public Importance: Landscaping highways and Educational institutions. (6 Hours)
- UNIT V** Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers and foliages (Carnation, Chrysanthemum, Alstromeria, Gerbera, Gladiolous, Marigold, Rose, Liliun, Orchids). Diseases and Pests of Ornamental Plants (6 Hours)

#### **Recommended Books and References:**

1. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied Publishers.

### SKILL ENHANCEMENT COURSE 2 (BOS 4.11) MUSHROOM CULTURE TECHNOLOGY

*Theory Credits: 2*

*Teaching Hours: 30*

- UNIT I** Introduction, history. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India - *Volvariella volvacea*, *Pleurotus citrinopileatus*, *Agaricus bisporus*. (6 Hours)
- UNIT II** Cultivation Technology : Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparation of spawn, multiplication. (6 Hours)

- UNIT III** Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation- Low cost technology, Composting technology in mushroom production. (6 Hours)
- UNIT IV** Storage and nutrition: Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins. (6 Hours)
- UNIT V** Food Preparation: Types of foods prepared from mushroom. Research Centres - National level and Regional level. Cost benefit ratio - Marketing in India and abroad, Export Value. (6 Hours)

***Recommended Books and References:***

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
3. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol. II.

*Revised*  
SYLLABUS FOR  
Bachelor of Science (Honours)

**CHEMISTRY**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)





## COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Inorganic Chemistry I (Theory)	CHC 1.11	4
		Inorganic Chemistry I (Practical)	CHC 1.12	2
	Core 2	Physical Chemistry I (Theory)	CHC 1.21	4
		Physical Chemistry I (Practical)	CHC 1.22	2
II	Core 3	Organic Chemistry I (Theory)	CHC 2.11	4
		Organic Chemistry I (Practical)	CHC 2.12	2
	Core 4	Physical Chemistry II (Theory)	CHC 2.21	4
		Physical Chemistry II (Practical)	CHC 2.22	2
III	Core 5	Inorganic Chemistry II (Theory)	CHC 3.11	4
		Inorganic Chemistry II (Practical)	CHC 3.12	2
	Core 6	Organic Chemistry II (Theory)	CHC 3.21	4
		Organic Chemistry II (Practical)	CHC 3.22	2
	Core 7	Physical Chemistry III (Theory)	CHC 3.31	4
		Physical Chemistry III (Practical)	CHC 3.32	2
	Skill Enhancement Course 1	Pesticide Chemistry (Theory & Practical) or Fuel Chemistry (Theory & Practical)	CHS 3.11(a)  CHS 3.11(b)	2
	IV	Core 8	Inorganic Chemistry III (Theory)	CHC 4.11
Inorganic Chemistry III (Practical)			CHC 4.12	2
Core 9		Organic Chemistry III (Theory)	CHC 4.21	4
		Organic Chemistry III (Practical)	CHC 4.22	2
Core 10		Physical Chemistry IV (Theory)	CHC 4.31	4
		Physical Chemistry IV (Practical)	CHC 4.32	2
Skill Enhancement Course 2		Chemical Technology & Society (Theory & Practical) or Pharmaceutical Chemistry (Theory & Practical) or Chemistry of Cosmetics & Perfumes (Theory & Practical)	CHS 4.11(a)  CHS 4.11(b)  CHS 4.11(c)	2
V		Core 11	Organic Chemistry IV (Theory)	CHC 5.11
	Organic Chemistry IV (Practical)		CHC 5.12	2
	Core 12	Physical Chemistry V (Theory)	CHC 5.21	4
		Physical Chemistry V (Practical)	CHC 5.22	2
	Discipline Specific Elective 1	Analytical Methods in Chemistry (Theory) or Polymer Chemistry (Theory)	CHD 5.11(a)	4
			CHD 5.11(b)	
		Analytical Methods in Chemistry (Practical) or Polymer Chemistry (Practical)	CHD 5.12(a)	2
			CHD 5.12(b)	
	Discipline Specific Elective 2	Green Chemistry (Theory) or Novel Inorganic Solids (Theory)	CHD 5.21(a)	4
			CHD 5.21(b)	
Green Chemistry (Practical) or		CHD 5.22(a)	2	

		Novel Inorganic Solids (Practical)	CHD 5.22(b)	
VI	Core 13	Inorganic Chemistry IV (Theory)	CHC 6.11	4
		Inorganic Chemistry IV (Practical)	CHC 6.12	2
	Core 14	Organic Chemistry V (Theory)	CHC 6.21	4
		Organic Chemistry V (Practical)	CHC 6.22	2
	Discipline Specific Elective 3	Industrial Chemicals & Environment (Theory) or Research Methodology in Chemistry (Theory)	CHD 6.11(a)  CHD 6.12(b)	4
		Industrial Chemicals & Environment (Practical) or Research Methodology in Chemistry (Practical)	CHD 6.12(a)  CHD 6.12(b)	2
	Discipline Specific Elective 4	Inorganic Materials of Industrial Importance (Theory) or Instrumental Method of Chemicals (Theory)	CHD 6.21(a)  CHD 6.21(b)	4
		Inorganic Materials of Industrial Importance (Practical) or Instrumental Method of Chemicals (Practical)	CHD 6.22(a)  CHD 6.22(b)	2

## SEMESTER - I

### CORE 1 (CHC 1.11) INORGANIC CHEMISTRY-I

Theory Credit: 4

Teaching Hours: 60

#### UNIT I **Atomic Structure:** (12 Hours)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de-Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of  $\psi$  and  $\psi^2$ . Quantum numbers and their significance. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Pauli's Exclusion Principle, Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. Hund's rule of maximum multiplicity, Aufbau's principle. Electronic configurations.

#### UNIT II **Periodicity of Elements:** (12 Hours)

Modern periodic law; *s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.

- Electropositive character
- Atomic and Ionic radii
- Covalent radii
- Ionization enthalpy; Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
- Electron gain enthalpy; trends of electron gain enthalpy.
- Electronegativity; Pauling's/ Mulliken's electronegativity scales. Variation of electronegativity with bond order, group electronegativity.
- Isoelectronic species.

#### UNIT III **Chemical Bonding:** (12 Hours)

- Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Derivation of Madelung constant, Born-Haber cycle and its applications, Solvation energy.
- Metallic Bond:* Qualitative idea of valence bond and band theories. Conductors, Semiconductors and insulators.
- Weak Chemical Forces:* van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding by valence bond treatment); Effects of melting, boiling points and solubility, energetics of dissolution process.
- Coordinate covalent bond;* General ideas.

#### UNIT IV **Chemical Bonding-II**(12 Hours)

(ii) *Covalent bond:* Lewis structure, Valence Bond theory (Heitler-London approach). Hybridisation; types of hybridization. Energetics of hybridization, equivalent and non-equivalent hybrid orbitals, Resonance and resonance energy, Resonance structures of  $\text{CO}_3^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{SO}_2$ ,  $\text{SO}_3$ ,  $\text{CO}_2$  Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules  $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{F}_2$ ,  $\text{CO}$ ,  $\text{NO}$ , and their ions; Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of

simple molecules and ions containing lone pairs and bond pairs of electrons,  $\text{BeF}_2$ ,  $\text{BF}_3$ ,  $\text{H}_3\text{O}^+$ ,  $\text{NH}_3$ ,  $\text{H}_2\text{O}$ ,  $\text{H}_2\text{S}$ ,  $\text{O}_3$ ,  $\text{BO}_3^{3-}$ ,  $\text{PCl}_5$ ,  $\text{SF}_4$ ,  $\text{SF}_6$

#### UNIT V **Chemical Bonding-III and Oxidation-Reduction:** (12 Hours)

**[a] Chemical Bonding:** Covalent character in ionic compounds, polarizing power and polarizability, consequences of polarization. Fajan's rule and its applications. Ionic character in covalent compounds: Dipole moment, Calculation of dipole moment, Percentage ionic character from dipole moment and electronegativity difference.

**[b] Oxidation-Reduction:** General concept, Electrochemical series and its applications, Hydrogen over voltage and oxygen over voltage, redox stability in water, Frost diagram (Nitrogen), Latimer diagram (chlorine in acidic and basic medium), disproportionation of  $\text{H}_2\text{O}_2$  into  $\text{O}_2$  and  $\text{H}_2\text{O}$  under acidic conditions and Pourbaix diagram (iron species in natural water).

#### **Recommended Books and References:**

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970
3. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002
6. Madan, Tuli and Malik, selected topics of inorganic, organic & physical chemistry
7. R.L Madan Chemistry for degree Students S.Chand & Company Ltd New Delhi

#### **CORE 1 (CHC 1.12)**

#### **INORGANIC CHEMISTRY-I**

*Practical Credit: 2*

Qualitative semi micro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

$\text{CO}_3^{2-}$ ,  $\text{NO}_2^-$ ,  $\text{S}_2^-$ ,  $\text{SO}_3^{2-}$ ,  $\text{S}_2\text{O}_3^{2-}$ ,  $\text{CH}_3\text{COO}^-$ ,  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ ,  $\text{NO}_3^-$ ,  $\text{BO}_3^{3-}$ ,  $\text{C}_2\text{O}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  $\text{NH}_4^+$ ,  $\text{K}^+$ ,  $\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Bi}^{3+}$ ,  $\text{Sn}^{2+}$ ,  $\text{Sb}^{3+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$

Mixtures should preferably contain one interfering anion, **or** insoluble component ( $\text{BaSO}_4$ ,  $\text{SrSO}_4$ ,  $\text{PbSO}_4$ ,  $\text{CaF}_2$  or  $\text{Al}_2\text{O}_3$ ) **or** combination of anions e.g.  $\text{CO}_3^{2-}$  and  $\text{SO}_3^{2-}$ ,  $\text{NO}_2^-$  and  $\text{NO}_3^-$ ,  $\text{Cl}^-$  and  $\text{Br}^-$ ,  $\text{Cl}^-$  and  $\text{I}^-$ ,  $\text{Br}^-$  and  $\text{I}^-$ ,  $\text{NO}_3^-$  and  $\text{Br}^-$ ,  $\text{NO}_3^-$  and  $\text{I}^-$ .

#### **Oxidation-Reduction Titrimetry**

- (i) Estimation of Fe(II) and oxalic acid using standardized  $\text{KMnO}_4$  solution.
- (ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
- (iii) Estimation of Fe(II) with  $\text{K}_2\text{Cr}_2\text{O}_7$  using internal (diphenylamine, anthranilic acid) and external indicator.

#### **Recommended Books and References:**

Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

**CORE 2 (CHC 1.21)**  
**PHYSICAL CHEMISTRY-I**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Gaseous state-I:(12 Hours)**

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of  $\sigma$  from  $\eta$ ; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities

**UNIT II Gaseous state-II and Liquid state:(12 Hours)**

**[a]Gaseous state:** van der Waals equation of state, its derivation and application in explaining real gas behaviour, Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor,  $Z$ , and its variation with pressure for different gases. Causes of deviation from ideal behaviour. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

**[b]Liquid state:** Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and viscosity, and their determination (Iostenioscopic method, drop weight method, Capillary rise method and the Ostwald visocometer method). Effect of addition of various solutes on surface tension and viscosity.

**UNIT III Solid state: (12 Hours)**

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, determination of crystal structure ( Laue's and powder pattern method). Defects in crystals. Glasses and liquid crystals.

**UNIT IV Ionic equilibria-I:(12 Hours)**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and triprotic acids (exact treatment). Different types of salt; Salt hydrolysis-calculation of hydrolysis constant, Relation between  $K_a$ ,  $K_b$  and  $K_w$ , degree of hydrolysis and pH for different salts; of (1) strong acid and weak base (2) weak acid and strong base. (Numerical problems on relevant topics)

**UNIT V Ionic equilibria-II (12 Hours)**

Qualitative treatment of acid – base titration curves. Theory of acid–base indicators; selection of indicators and their limitations. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and Bio-chemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

**Recommended Books and References:**

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 10th Ed., Oxford University
2. 12 Press (2014).
3. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
4. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
5. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
6. Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed. Pearson (2013). Madan R.L Chemistry for Degree students S.Chand & Company
7. Arun Bahl & B.S Bahl Text book of Organic Chemistry S. Chand & Company

**CORE 2 (CHC 1.22)****PHYSICAL CHEMISTRY-I**

Practical Credit: 2

1. **Surface tension measurements.**
  - a. Determine the surface tension by (i) drop number (ii) drop weight method.
  - b. Study the variation of surface tension of detergent solutions with concentration.
2. **Viscosity measurement using Ostwald's viscometer.**
  - a. Determination of viscosity of aqueous solutions of (i) ethanol and (ii) sugar at room temperature.
  - b. Study the variation of viscosity of sucrose solution with the concentration of solute.
3. **pH metry**
  - a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
  - b. Preparation of buffer solutions of different pH
    - i. Sodium acetate-acetic acid
    - ii. Ammonium chloride-ammonium hydroxide
  - c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
  - d. Determination of dissociation constant of a weak acid.
4. **Determination of the Heat of displacement.**
5. **Determination of the Heat of Precipitations.**

**Recommended Books and References:**

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.*; W.H. Freeman & Co.: New York (2003).

## SEMESTER - II

### CORE 3 (CHC 2.11) ORGANIC CHEMISTRY- I (Basic & Hydrocarbon)

Theory Credit: 4

Teaching Hours: 60

#### UNIT I **Basics of Organic Chemistry:** (12 Hours)

*Organic Compounds:* Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

*Electronic Displacements:* Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Homolytic and Heterolytic fission with suitable examples; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

#### UNIT II **Stereochemistry:**(12 Hours)

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis-trans and, syn-anti isomerism E/Z notations with C.I.P rules.

*Optical Isomerism:* Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

#### UNIT III **Chemistry of Aliphatic Hydrocarbons:**(12 Hours)

**[a]** Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions:

**[b]** Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, reactions. Saytzeff and Hofmann eliminations.

*Reactions of alkenes:* Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical) 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene.

#### UNIT IV **Alkynes, Cycloalkanes and Conformational Analysis**(12 Hours)

**[a]** Reactions of alkynes:Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes

**[b]** Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane:

**[c]** Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

#### UNIT V **Aromatic Hydrocarbons** (12 Hours)

*Aromaticity:* Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and

Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

**Recommended Books and References:**

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
5. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
6. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

**CORE 3 (CHC 2.12)  
ORGANIC CHEMISTRY- I**

*Practical Credit: 2*

1. Detection of extra elements.
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

**Recommended Books and References:**

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press (2000).
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press (2000).

**CORE 4 (CHC 2.21)  
PHYSICAL CHEMISTRY- II  
(Thermodynamic and its Application)**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Chemical Thermodynamics-I:(12 Hours)**

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

*First law:* Concept of heat,  $q$ , work,  $w$ , internal energy,  $U$ , and statement of first law; enthalpy,  $H$ , relation between heat capacities, calculations of  $q$ ,  $w$ ,  $U$  and  $H$  for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.



*Second Law:* Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

**UNIT II Chemical Thermodynamics-II: (12 Hours)**

*Third Law:* Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

*Thermochemistry:* Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; Hess law of constant summation, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

**UNIT III Free Energy Functions and Systems of Variable Composition: (12 Hours)**

**[a]**Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

**[b]**Systems of Variable Composition: Partial molar quantities; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

**UNIT IV Chemical Equilibrium: (12 Hours)**

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants  $K_p$ ,  $K_c$  and  $K_x$ . Le Chatelier principle (quantitative treatment);

**UNIT V Solutions and Colligative Properties: (12 Hours)**

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic criteria for ideal solution. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

**Recommended Books and References:**

1. Peter, A. & Paula, J. de. *Physical Chemistry* 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. *Physical Chemistry* 4th Ed., Narosa (2004).
3. Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed., Prentice-Hall (2012).
4. McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics*. CRC Press: NY (2011).
6. Levine, I. N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).
7. Metz, C.R. *2000 solved problems in chemistry*, Schaum Series (2006).

**CORE 4 (CHC 2.22)**  
**PHYSICAL CHEMISTRY- II**

*Practical Credit: 2*

- (a) Determination of enthalpy of hydration of copper sulphate.
- (b) Study of the solubility of benzoic acid in water and determination of  $\Delta H$ .
- (c) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
- (d) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
- (e) Calculation of the enthalpy of ionization of ethanoic acid.
- (f) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
- (e) *Any other experiment carried out in the class.*

**Recommended Books and References:**

1. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
2. Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).

## SEMESTER - III

### CORE 5 (CHC 3.11) INORGANIC CHEMISTRY-II (s- & p- Blocks elements)

Theory Credit: 4

Teaching Hours: 60

#### UNIT I **General Principles of Metallurgy:** (6 Hours)

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic process, Parking process, van Arkel-de Boer process and Mond's process, Zone refining, oxidative process, Amalgamation process, Poling process.

#### UNIT II **Acids and Bases:** (8 Hours)

Arrhenius concept of acids and bases, Brønsted-Lowry concept of acids-bases, Lux-Flood concept of acids-bases, solvent systems, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept and its limitations, Pearsons classification of Lewis acids and Lewis bases, Hard and Soft Acids and Bases (HSAB) Principle and applications.

#### UNIT III **Chemistry of s and p Block Elements:** (30 Hours)

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy, catenation, isomorphism. Complex formation tendency of s and p block elements. Hydrides and their classification-ionic, covalent and interstitial.

#### UNIT IV **Chemistry of s and p Block Elements:** (8 Hours)

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses: Boric acid and borates, boron nitrides, borohydrides (diborane), silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine, Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and properties of halogens

#### UNIT V **Noble Gases and Inorganic Polymers:** (8 Hours)

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation, properties and structures of  $\text{XeF}_2$ ,  $\text{XeF}_4$ ,  $\text{XeF}_6$ ,  $\text{XeO}_3$ ,  $\text{XeOF}_4$  and  $\text{XeOF}_2$ ; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for  $\text{XeF}_2$  and  $\text{XeF}_4$ ). Molecular shapes of noble gas compounds (VSEPR theory).

*Inorganic Polymers:* Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes.

#### **Recommended Books and References:**

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth- Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
5. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.

- Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed. Pearson, 2010. 19
- Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

**CORE 5 (CHC 3.12)**  
**INORGANIC CHEMISTRY-II**

*Practical Credit: 2*

**(a) Inorganic preparations**

- Cuprous Chloride,  $\text{Cu}_2\text{Cl}_2$
- Preparation of Manganese(III) phosphate,  $\text{MnPO}_4 \cdot \text{H}_2\text{O}$
- Preparation of Aluminium potassium sulphate  $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$  (Potash alum) or Chrome alum.
- Preparation of potassium dichromate.
- Preparation of Mohr's salt.
- Preparation of Ferrous sulphate.
- Preparation of Magnesium sulphate.

**(b) Iodometric / Iodimetric Titrations**

- Estimation of Cu (II) using  $\text{K}_2\text{Cr}_2\text{O}_7$  and sodium thiosulphate solution (Iodometrically).
- Estimation of available chlorine in bleaching powder iodometrically.  
( more practicals based on the availability of chemicals)

**Recommended Books and References:**

- Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

**CORE 6 (CHC 3.21)**  
**ORGANIC CHEMISTRY-II**  
**(Oxygen containing functional groups)**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Chemistry of Halogenated Hydrocarbons: (12 Hours)**

*Alkyl halides:* Methods of preparation, nucleophilic substitution reactions –  $\text{SN}_1$ ,  $\text{SN}_2$  mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

*Aryl halides:* Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution;  $\text{SN}_\text{Ar}$ . Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

**UNIT II Alcohols, Phenols:(12 Hours)**

*Alcohols:* preparation, properties and relative reactivity of  $1^\circ$ ,  $2^\circ$ ,  $3^\circ$  alcohols; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;

*Phenols:* Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer-Tiemann and Kolbe's-Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

**UNIT III Ethers, Epoxides and Sulphur containing compounds: (12 Hours)**

*Ethers*: Preparation and reactions with acids

*Epoxides* :Reactions of epoxides with alcohols, ammonia derivatives and LiAlH<sub>4</sub>

Preparation and reactions of thiols, thioethers and sulphonic acids.

#### **UNIT IV Carbonyl Compounds:(12 Hours)**

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction,  $\alpha$ -substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH<sub>4</sub>, NaBH<sub>4</sub>, MPV. Addition reactions of unsaturated carbonyl compounds: Michael addition.

#### **UNIT V Carboxylic Acids and their Derivatives: (12 Hours)**

Preparation, physical properties and reactions of monocarboxylic acids: Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Simple reactions of dicarboxylic acids and hydroxy acids; maleic and fumaric acids.

#### **Recommended Books and References:**

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
4. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

### **CORE 6 (CHC 3.22)**

#### **ORGANIC CHEMISTRY-II**

*Practical Credit: 2*

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations:
  - i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p* toluidines and *o*-, *m*-, *p*-anisidine) and phenols ( $\beta$ -naphthol, vanillin, salicylic acid) by any one method:
    - a. Using conventional method.
    - b. Using green approach
  - ii. Benzoylation of one of the following amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols ( $\beta$ -naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.
  - iv. Bromination of any one of the following:
    - a. Acetanilide by conventional methods
    - b. Acetanilide using green approach (Bromate-bromide method)
  - v. Nitration of any one of the following:
    - a. Acetanilide/nitrobenzene by conventional method
    - b. Salicylic acid by green approach (using ceric ammonium nitrate).
  - vi. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.
  - vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

**Recommended Books and References:**

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press (2000). 22
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press (2000).

**CORE 7 (CHC 3.31)**

**PHYSICAL CHEMISTRY-III**

**(Phase Equilibria and Chemical Kinetics)**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Phase Equilibria-I (12 Hours)**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, Reduced phase rule (definition), phase diagram for one component systems, ( $H_2O$  system) with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, KI- $H_2O$  system congruent Mg-Zn system and incongruent melting points. NaCl- $H_2O$  system

**UNIT II Phase Equilibria-II (12 Hours)**

Two component system of solid solution (Pb-Ag) Three component systems, water-chloroform-acetic acid system, triangular plots.

*Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, Lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

**UNIT III Chemical Kinetics:(12 Hours)**

Order and molecularity of a reaction, factors affecting rate of reaction, determination of rate laws, derivation of integrated rate law expression upto second order reactions. Determination of order of reaction (integrated, differential, graphical and half life period method) up to first order reactions, experimental methods of the determination of rate laws.

**UNIT IV Chemical Kinetics (12 Hours)**

Kinetics of complex reactions ; Opposing reactions, parallel reactions, consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms), chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Activated complex Theory (Eyring equation)

**UNIT V Catalysis and Surface chemistry: (12 Hours)**

**[a]** Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

**[b]** Surface chemistry: Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state. Factors affecting adsorption, Freundlich adsorption isotherm derivation, Langmuir adsorption (eliminating idea only)

**Recommended Books and References:**

1. Peter Atkins & Julio De Paula, *Physical Chemistry* 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.: New Delhi (2004).
4. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics*. CRC Press: NY (2011). Zundhal, S.S. *Chemistry concepts and applications* Cengage India (2011).
6. Ball, D. W. *Physical Chemistry* Cengage India (2012).
7. Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
8. Levine, I. N. *Physical Chemistry 6th Ed.*, Tata McGraw-Hill (2011).
9. Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill (2009).

**CORE 7 (CHC 3.32)****PHYSICAL CHEMISTRY-III**

*Practical Credit: 2*

- I. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.
- II. Distribution of acetic/ benzoic acid between water and cyclohexane
- III. Study the kinetics of the following reactions.
  - a. Acid hydrolysis of methyl acetate with hydrochloric acid.
  - b. Saponification of ethyl acetate.
  - c. Compare the strengths of HCl and H<sub>2</sub>SO<sub>4</sub> by studying kinetics of hydrolysis of methyl acetate.
- IV. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
- V. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:
  - a. simple eutectic and
  - b. congruently melting systems.

**Recommended Books and References:**

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).

3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.*; W.H. Freeman & Co.: New York (2003).



## SEMESTER - IV

### CORE 8 (CHC 4.11) INORGANIC CHEMISTRY-III (Coordination Chemistry)

Theory Credit:4

Teaching Hours: 60

#### UNIT I Coordination Chemistry-I (12 Hours)

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes. Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding.

#### UNIT II Coordination Chemistry: (12 Hours)

Crystal field theory, measurement of  $10 Dq$  ( $\Delta_o$ ), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of  $10 Dq$  ( $\Delta_o$ ,  $\Delta_t$ ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

#### UNIT III Transition Elements: (12 Hours)

General group trends with special reference to electronic configuration: atomic and ionic radii, colouration, variable valency, magnetic, catalytic properties, ability to form alloys, interstitial compounds and ability to form complexes. Differences between the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy)

#### UNIT IV Lanthanoids and Actinoids: (12 Hours)

Introduction, Electronic configuration, oxidation states, ionic radii, colour, complex formation tendency, spectral and magnetic properties, lanthanide contraction: Causes and consequences, separation of lanthanides (ion-exchange method and from monazite sand). Comparison of lanthanides and actinides, chemistry of separation of Np, Pu and Am from U. Preparation, reactions, structure and uses of uranium hexafluoride.

#### UNIT V Bioinorganic Chemistry: (12 Hours)

Essential and trace elements in biological system. Sodium/Potassium pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems; Storage and transfer of iron. Metalloporphyrins (chlorophyll), heme-proteins (Haemoglobin, Myoglobin) and crown-ethers. Biological role of alkaline earth metal ions with reference to  $Ca^{+2}$ .

#### Recommended Books and References:

1. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977.
2. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
3. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
4. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
5. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
6. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

**CORE 8 (CHC 4.12)**  
**INORGANIC CHEMISTRY-III**

*Practical Credit: 2*

**Gravimetric Analysis:**

- i. Estimation of nickel (II) using Dimethylglyoxime (DMG).
- ii. Estimation of copper as CuSCN
- iii. Estimation of iron as Fe<sub>2</sub>O<sub>3</sub> by precipitating iron as Fe(OH)<sub>3</sub>.

**Inorganic Preparations:**

- i. Tetraamminecopper (II) sulphate, [Cu(NH<sub>3</sub>)<sub>4</sub>]SO<sub>4</sub>.H<sub>2</sub>O
- ii. Tetraamminecarbonatocobalt (III) ion
- iii. Potassium tris(oxalate)ferrate(III)
- iv. Sodium ferrioxalate or sodium trioxalato Ferrate.
- v. Cuprammonium sulphate or tetraamminocupric sulphate

**Recommended Books and References:**

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

**CORE 9 (CHC 4.21)**  
**ORGANIC CHEMISTRY-III**  
**(Heterocyclic Compound)**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Nitrogen Containing Functional Groups: (12 Hours)**

Preparation and important reactions of nitro and compounds, nitriles and isonitriles  
Amines: Effect of substituent and solvent on basicity; Preparation and properties:  
Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's  
exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and  
3° amines with Hinsberg reagent and nitrous acid. Diazonium Salts: Preparation and  
their synthetic applications

**UNIT II Polynuclear Hydrocarbons: (12 Hours)**

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and  
structure elucidation and important derivatives of naphthalene and anthracene.

**UNIT III Heterocyclic Compounds: (12 Hours)**

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-  
membered rings containing one heteroatom; Synthesis, reactions and mechanism of  
substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole  
synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine,  
Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis),  
Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Knorr  
quinoline synthesis, Bischler-Napieralski reaction,

**UNIT IV Alkaloids: (12 Hours)**

Natural occurrence, General structural features, Isolation and their physiological  
action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation

and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

**UNIT V Terpenes: (12 Hours)**

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and  $\alpha$ -terpineol.

**Recommended Books and References:**

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Welly & Sons (1976).
5. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
6. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
7. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford
9. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan

**CORE 9 (CHC 4.22)**

**ORGANIC CHEMISTRY-III**

*Practical Credit: 2*

- 1 Purification of organic compounds by crystallization using the following solvents:  
a. Water                      b. Alcohol                      c. Alcohol-Water
2. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
3. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
4. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
5. Chromatography
  - a. Separation of a mixture of two amino acids by ascending paper chromatography
  - b. Separation of a mixture of two sugars by ascending paper chromatography
  - c. Separation of a mixture of o- and p-nitrophenol or o- and p-aminophenol by thin layer chromatography (TLC)

**Recommended Books and References:**

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson (2012)

**CORE 10 (CHC 4.31)**  
**PHYSICAL CHEMISTRY-IV**  
**(Electrochemistry-I, Quantum Chemistry-I & Spectroscopy-I)**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I     **Conductance-I:** (12 Hours)**

Arrhenius theory of electrolytic dissociation and its limitations. Conduction in metals and in electrolyte solutions, electrolysis, Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Measurement of conductance, Kohlrausch law of independent migration of ions. Ostwald's dilution law, its uses and limitations, Debye-Hückel-Onsager equation. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transport numbers using Hittorf and Moving Boundary methods.

**UNIT II     **Electrochemistry-I:**(12 Hours)**

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Electrolytic and Galvanic cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Polarization, decomposition potential, overvoltage, polarography, corrosion.

**UNIT III    **Quantum Chemistry-I:**(12 Hours)**

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-1 D-box" quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

**UNIT IV     **Molecular Spectroscopy-I:**(12 Hours)**

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear tri-atomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

**UNIT V     **Electrical & Magnetic Properties of Atoms and Molecules:** (12 Hours)**

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Debye equation, dependence of polarizability on frequency, bond moments Dipole moment, molecular polarizabilities and their measurements. Dielectric polarization and dielectric constant, electric polarization of molecules, determination of dielectric constant, determination of dipole moments,

molar refraction and molar polarization. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

**Recommended Books and References:**

1. Atkins, P.W & Paula, J.D. *Physical Chemistry*, 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. *Physical Chemistry 4th Ed.*, Narosa (2004).
3. Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
4. Barrow, G. M., *Physical Chemistry 5th Ed.*, Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
6. Rogers, D. W. *Concise Physical Chemistry* Wiley (2010).
7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. *Physical Chemistry 4th Ed.*, John Wiley & Sons, Inc. (2005).
8. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
9. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
10. House, J. E. *Fundamentals of Quantum Chemistry* 2<sup>nd</sup> Ed. Elsevier: USA (2004).
11. Kakkar, R. *Atomic & Molecular Spectroscopy: Concepts & Applications*, Cambridge University Press (2015).
12. Lowe, J. P. & Peterson, K. *Quantum Chemistry*

**CORE 10 (CHC 4.32)**

**PHYSICAL CHEMISTRY-IV**

*Practical Credit: 2*

**1. Conductometry**

- I. Determination of cell constant
- II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
- III. Perform the following conductometric titrations:
  - i. Strong acid vs. strong base
  - ii. Weak acid vs. strong base
  - iii. Mixture of strong acid and weak acid vs. strong base
  - iv. Strong acid vs. weak base

**2. Potentiometry**

- I. Perform the following potentiometric titrations:
  - i. Strong acid vs. strong base
  - ii. Weak acid vs. strong base
  - iii. Dibasic acid vs. strong base
  - iv. Potassium dichromate vs. Mohr's salt
3. Determination of the heat of solution of solid calcium chloride by the Born-Haber cycle.
4. Determination of the molecular weight by Rast's method.
5. Verification of Hardy-Schulze law: Preparation and coagulation of arsenic sulphide ( $As_2S_3$ ) sol using NaCl,  $BaCl_2$  and  $AlCl_3$  solutions.
6. To study the kinetics of iodination of acetone.
7. Study the equilibrium of at least one of the following reactions by the distribution method:
  - (i)  $I_2(aq) + I^- \rightarrow I_3^-(aq)^{2+}$
  - (ii)  $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

*Any other experiment carried out in the class.*

**Recommended Books and References:**

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.*; W.H.Freeman & Co.: New York (2003).

## SEMESTER - V

### CORE 11 (CHC 5.11) ORGANIC CHEMISTRY-IV (Biomolecules)

Theory Credit: 4

Teaching Hours: 60

#### UNIT I **Nucleic Acids:** (12 Hours)

Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

#### UNIT II **Amino Acids, Peptides and Proteins:** (12 Hours)

Amino acids, Peptides and their classification.  $\alpha$ -Amino Acids - Synthesis, ionic properties and reactions. Zwitterions,  $pK_a$  values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

#### UNIT III **Enzymes:** (12 Hours)

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

#### UNIT IV **Lipids:** (12 Hours)

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Rancidity.

#### UNIT V **Pharmaceutical Compounds: Structure and Importance:** (12 Hours)

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of vitamin C and antacid (ranitidine).

#### **Recommended Books and References:**

1. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) *Biochemistry*. 6th Ed. W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) *Principles of Biochemistry*. IV Edition. W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) *Harper's Illustrated Biochemistry*. XXVIII edition. Lange Medical Books/ McGraw-Hill.

**CORE 11 (CHC 5.12)**  
**ORGANIC CHEMISTRY-IV**

*Practical Credit: 2*

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

**Recommended Books and References:**

1. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
2. Arthur, I. V. *Quantitative Organic Analysis*, Pearson.

**CORE 12 (CHC 5.21)**  
**PHYSICAL CHEMISTRY V**  
**(Electrochemistry-II, Quantum Chemistry-II & Spectroscopy-II)**

*Theory Credit: 4*

*Teaching Hours:60*

**UNIT I A. Conductance-II: (12 Hours)**

Theory of strong electrolytes, Relaxation effect, Electrophoretic effect, Wien effect, Debye-Falkenhagen effect, Walden's rules. Activity coefficients of electrolytes, Mean Ionic activity coefficients, Ionic strength, Concentration cells with and without transference, liquid junction potential; Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

**UNIT II Electrochemistry-II: (12 Hours)**

Types of electrodes: Metal-metal ion electrodes, metal-metal insoluble salt electrodes, metal-amalgam electrodes, redox electrodes, calomel-electrode. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes, Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). The structures of electrified interfaces, The Helmholtz-Perrin model, Stern model; Electrocatalysis.

**UNIT III Quantum Chemistry-II: (12 Hours)**

Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems; Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of  $H_2^+$ . Bonding and antibonding orbitals. Qualitative extension to  $H_2$ . Comparison of LCAO-MO and VB treatments of  $H_2$ .

**UNIT IV Molecular Spectroscopy-II: (12 Hours)**



Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre-dissociation, calculation of electronic transitions of polyenes using free electron model. Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules. Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

#### **UNIT V Photochemistry: (12 Hours)**

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

#### **Recommended Books and References:**

1. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
3. House, J. E. *Fundamentals of Quantum Chemistry* 2<sup>nd</sup> Ed. Elsevier: USA (2004).
4. Kakkar, R. *Atomic & Molecular Spectroscopy: Concepts & Applications*, Cambridge University Press (2015).
5. Lowe, J. P. & Peterson, K. *Quantum Chemistry*

#### **CORE 12 (CHC 5.22)**

#### **PHYSICAL CHEMISTRY V**

*Practical Credit: 2*

##### **1. Colourimetry**

- I. Verify Lambert-Beer's law and determine the concentration of  $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  in a solution of unknown concentration
- II. Determine the concentrations of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  in a mixture.
- III. Study the kinetics of iodination of propanone in acidic medium.
- IV. Determine the amount of iron present in a sample using 1,10-phenanthroline.
- V. Determine the dissociation constant of an indicator (phenolphthalein).
- VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
- VII. Analysis of the given vibration-rotation spectrum of  $\text{HCl(g)}$

##### **2. UV/Visible spectroscopy**

- I. Study the 200-500 nm absorbance spectra of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  (in 0.1 M  $\text{H}_2\text{SO}_4$ ) and determine the  $\lambda_{\text{max}}$  values. Calculate the energies of the two transitions in different units ( $\text{J molecule}^{-1}$ ,  $\text{kJ mol}^{-1}$ ,  $\text{cm}^{-1}$ , eV).
- II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of  $\text{K}_2\text{Cr}_2\text{O}_7$ .
- III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

3. Determine the Heat of Formation of Magnesium Oxide.

4. Heating and Cooling Curve of Sodium Thiosulfate.
5. Determination of the Phase Diagram of three component system (ethyl acetate-ethyl alcohol-water).
6. Determination of the Phase Diagram for three component system (acetic acid-chloroform-water).
7. To study the effect of electrolyte and non-Electrolyte solutes on the freezing point depression of water.
8. To determine the partial molar volumes of sodium chloride solution.
9. Catalytic Decomposition of Hydrogen Peroxide on Metal Oxide Catalysts.
10. To find the critical point for colloidal mixtures composed of different types of starches.

**Recommended Books and References:**

1. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.*; W.H. Freeman & Co.: New York (2003).

## SEMESTER - VI

### CORE 13 (CHC 6.11) INORGANIC CHEMISTRY-IV (Organometallic Chemistry)

Theory Credit: 4

Teaching Hours: 60

- UNIT I Theoretical Principles in Qualitative Analysis (H<sub>2</sub>S Scheme): (12 Hours)**  
Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.
- UNIT II Organometallic Compounds: (12 Hours)**  
Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. pi-acceptor behaviour of CO (MO diagram of CO to be discussed).
- UNIT III Organometallic Compounds: (12 Hours)**  
*Zeise's salt*: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.  
*Metal Alkyls*: Important structural features of methyl lithium (tetramer) and trialkylaluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures.  
*Ferrocene*: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.
- UNIT IV Reaction Kinetics and Mechanism: (12 Hours)**  
Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.
- UNIT V Catalysis by Organometallic Compounds: (12 Hours)**  
Study of the following industrial processes and their mechanism:  
1. Alkene hydrogenation (Wilkinson's Catalyst)  
2. Hydroformylation (Co salts)  
3. Wacker Process  
4. Synthetic gasoline (Fischer Tropsch reaction)  
5. Synthesis gas by metal carbonyl complexes

#### **Recommended Books and References:**

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall, 1996.
2. Cotton, F.A.G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.*; Wiley India,

- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed.*, Harper Collins 1993, Pearson, 2006.
- Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005
- Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry 3rd Ed.*, John Wiley and Sons, NY, 1994.
- Greenwood, N.N. & Earnshaw, A. *Chemistry of the Elements, Elsevier 2nd Ed*, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
- Lee, J.D. *Concise Inorganic Chemistry 5th Ed.*, John Wiley and sons 2008.
- Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
- Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.*, Oxford University Press, 1994.
- Basolo, F. & Pearson, R. *Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed.*, John Wiley & Sons Inc; NY.
- Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co. 1977
- Miessler, G. L. & Tarr, D.A. *Inorganic Chemistry 4th Ed.*, Pearson, 2010.
- Collman, J. P. *et al. Principles and Applications of Organotr Chemistry*. Mill Valley, CA: University Science Books, 1987.

### **CORE 13 (CHC 6.12)**

#### **INORGANIC CHEMISTRY-IV**

*Practical Credit: 2*

- Estimate the amount of nickel present in a given solution as bis(dimethylglyoximate) nickel(II) or aluminium as oximate in a given solution gravimetrically.
- Estimation of (i)  $Mg^{2+}$  or (ii)  $Zn^{2+}$  by complexometric titrations using EDTA.
- Estimation of total hardness of a given sample of water by complexometric titration.

#### **Preparation of inorganic compound**

- Preparation of acetylacetonato complexes of  $Cu^{2+}/Fe^{3+}$ . Find the  $\lambda_{max}$  of the complex.
- Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

#### **Recommended Books and References:**

- Vogel's *Qualitative Inorganic Analysis*, Revised by G. Svehla. Pearson Education, 2002.
- Marr & Rockett *Practical Inorganic Chemistry*. John Wiley & Sons 1972.

### **CORE14 (CHC 6.21)**

#### **ORGANIC CHEMISTRY-V**

#### **(Organic spectroscopy)**

*Theory Credit: 4*

*Teaching Hours: 60*

#### **UNIT I Organic Spectroscopy-I: (12 Hours)**

*UV Spectroscopy:* Types of electronic transitions,  $\lambda$  max, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of  $\lambda$  max for the following systems:  $\alpha$ ,  $\beta$  unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes:

alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes).

*IR Spectroscopy:* Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and IR absorptions; Fingerprint region and its significance; application in functional group analysis.

**UNIT II Organic Spectroscopy-II: (12 Hours)**

*NMR Spectroscopy:* Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

**UNIT III Carbohydrates: (12 Hours)**

Occurrence, classification and their biological importance. Monosaccharides: Constitution of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Disaccharides – Structure elucidation of maltose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose.

**UNIT IV Dyes: (12 Hours)**

Classification, Colour and constitution; Mordant and Vat Dyes; Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin.

**UNIT V Polymers: (12 Hours)**

Number average molecular weight, Weight average molecular weight, Polydispersity Index. Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Biodegradable with examples.

**Recommended Books and References:**

1. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India)Pvt. Ltd. (Pearson Education).
3. Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
4. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.
5. Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
7. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
8. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan (2010).
9. Kemp, W. *Organic Spectroscopy*, Palgrave.

10. Pavia, D. L. *et al. Introduction to Spectroscopy* 5th Ed. Cengage Learning India Ed. (2015).

**CORE14 (CHC 6.22)**  
**ORGANIC CHEMISTRY-V**

*Practical Credit: 2*

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

**Recommended Books and References:**

1. Vogel, A.I. *Quantitative Organic Analysis*, Part 3, Pearson (2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry*, 5th Ed., Pearson (2012)
4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press (2000).
5. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press (2000).

## DISCIPLINE SPECIFIC ELECTIVE

### DISCIPLINE SPECIFIC ELECTIVE 1 (CHD 5.11(a)) ANALYTICAL METHODS IN CHEMISTRY

Theory Credit: 4

Teaching Hours: 60

#### **Qualitative and quantitative aspects of analysis:** (5 Lectures)

evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data.

#### **Optical methods of analysis:** (25 Lectures)

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

*UV-Visible Spectrometry:* Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;

*Infrared Spectrometry:* Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution.

*Flame Atomic Absorption and Emission Spectrometry:* Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction, Techniques for the quantitative estimation of trace level of metal ions from water samples.

#### **Thermal methods of analysis:** (5 Lectures)

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

#### **Electro analytical methods:** (10 Lectures)

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points.

Techniques used for the determination of pKa values.

#### **Separation techniques:** (15 Lectures)

Solvent extraction: Classification, principle and efficiency of the technique.

Mechanism of extraction: extraction by solvation and chelation.

Technique of extraction: batch, continuous and counter current extractions.

Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique.

Mechanism of separation: adsorption, partition & ion exchange.

Development of chromatograms: frontal, elution and displacement methods.

Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR.

#### **Recommended Books and References:**

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Willard, H.H. *et al.: Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.

3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
7. Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
8. Ditts, R.V. *Analytical Chemistry; Methods of separation*, van Nostrand, 1974.

**DISCIPLINE SPECIFIC ELECTIVE 1 (CHD 5.12(a))  
ANALYTICAL METHODS IN CHEMISTRY**

*Practical Credit: 2*

**1. Separation Techniques**

1. Chromatography:
  - (a) Separation of mixtures
    - (i) Paper chromatographic separation of  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ , and  $\text{Cr}^{3+}$ .
    - (ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the  $R_f$  values.
  - (b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their  $R_f$  values.
  - (c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

**2. Solvent Extractions:**

- (i) To separate a mixture of  $\text{Ni}^{2+}$  &  $\text{Fe}^{2+}$  by complexation with DMG and extracting the  $\text{Ni}^{2+}$ -DMG complex in chloroform, and determine its concentration by spectrophotometry.
- (ii) Solvent extraction of zirconium with amberliti LA-1, separation from a mixture of irons and gallium.
3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.
5. Analysis of soil:
  - (i) Determination of pH of soil.
  - (ii) Total soluble salt
  - (iii) Estimation of calcium, magnesium, phosphate, nitrate
6. Ion exchange:
  - (i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
  - (ii) Separation of metal ions from their binary mixture.
  - (iii) Separation of amino acids from organic acids by ion exchange chromatography.

**Recommended Books and References:**

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.



5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition.
7. Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic & Allied Methods*, Elles Harwood Ltd. London.
8. Ditts, R.V. *Analytical Chemistry: Methods of separation*. Van Nostrand, New York, 1974.

**DISCIPLINE SPECIFIC ELECTIVE 1 (CHD 5.11(b))  
POLYMER CHEMISTRY**

*Theory Credit: 4*

**DISCIPLINE SPECIFIC ELECTIVE 1 (CHD 5.12(b))  
POLYMER CHEMISTRY**

*Practical Credit: 2*

**DISCIPLINE SPECIFIC ELECTIVE 2 (CHD 5.21(a))  
GREEN CHEMISTRY**

*Theory Credit: 4*

*Teaching Hours: 60*

**Introduction to Green Chemistry (4 Hours)**

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

**Principles of Green Chemistry and Designing a Chemical synthesis (30 Hours)**

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

- Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products , Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.
- Prevention/ minimization of hazardous/ toxic products reducing toxicity. risk = (function) hazard × exposure; waste or pollution prevention hierarchy.
- Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, solventless processes, immobilized solvents and how to compare greenness of solvents.
- Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy.
- Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups.
- Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
- Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD “What you don’t have cannot harm you”, greener alternative to Bhopal Gas

Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol), minimization, simplification, substitution, moderation and limitation.

- Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

#### **Examples of Green Synthesis/ Reactions and some real world cases (16 Hours)**

1. Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)
2. Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction
3. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO<sub>2</sub> for precision cleaning and dry cleaning of garments.
4. Designing of Environmentally safe marine antifoulant.
5. Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments.
6. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

#### **Future Trends in Green Chemistry (10 Hours)**

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C<sub>2</sub>S<sub>3</sub>); Green chemistry in sustainable development.

#### **Recommended Books and References:**

1. Ahluwalia, V.K. & Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
2. Anastas, P.T. & Warner, J.K.: *Green Chemistry - Theory and Practical*, Oxford University Press (1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
4. Cann, M.C. & Connely, M.E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington (2000).
5. Ryan, M.A. & Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.

### **DISCIPLINE SPECIFIC ELECTIVE 2 (CHD 5.22(a)) GREEN CHEMISTRY**

Practical Credit: 2

Teaching Hours: 60

#### **1. Safer starting materials**

- Preparation and characterization of nanoparticles of gold using tea leaves.

#### **2. Using renewable resources**

- Preparation of biodiesel from vegetable/ waste cooking oil.

#### **3. Avoiding waste**

Principle of atom economy.

- Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
- Preparation of propene by two methods can be studied

(I) Triethylamine ion + OH<sup>-</sup> → propene + trimethylpropene + water

(II) 1-propanol H<sub>2</sub>SO<sub>4</sub>/ propene + water

- Other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

#### 4. Use of enzymes as catalysts

- Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

#### 5. Alternative Green solvents

Extraction of D-limonene from orange peel using liquid CO<sub>2</sub> prepared from dry ice.  
Mechanochemical solvent free synthesis of azomethines

#### 6. Alternative sources of energy

- Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).
- Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

#### **Recommended Books and References:**

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice*, Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
4. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN 978-93-81141-55-7* (2013).
5. Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society (2008).
6. Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry*, American Chemical Society (2008).
7. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.
8. Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach*, W.B.Saunders, 1995.

#### **DISCIPLINE SPECIFIC ELECTIVE 2 (CHD 5.21(b))**

##### **NOVEL INORGANIC SOLIDS**

*Theory Credit: 4*

#### **DISCIPLINE SPECIFIC ELECTIVE 2 (CHD 5.22(b))**

##### **NOVEL INORGANIC SOLIDS**

*Practical Credit: 2*

**DISCIPLINE SPECIFIC ELECTIVE 3 (CHD 6.11(a))  
INDUSTRIAL CHEMICALS AND ENVIRONMENT**

*Theory Credit: 4*

*Teaching Hours: 60*

**Industrial Gases (10 Hours)**

**Industrial Gases:** Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

**Industrial Metallurgy (4 Hours)**

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

**Environment and its segments (30 Hours)**

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur

**Air Pollution:** Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, Photochemical smog: its constituents and photochemistry. Pollution by SO<sub>2</sub>, CO<sub>2</sub>, CO, NO<sub>x</sub>, H<sub>2</sub>S and other foul smelling gases. Methods of estimation of CO, NO<sub>x</sub>, SO<sub>x</sub> and control procedures. Greenhouse effect and Global warming, Ozone depletion.

**Water Pollution:** Hydrological cycle, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petrochemicals, agro, fertilizer, etc. Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

**Energy & Environment (10 Hours)**

**Sources of energy:** Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc.

**Nuclear Pollution:** Disposal of nuclear waste, nuclear disaster and its management.

**Biocatalysis (6 Hours)**

Introduction to biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

**Recommended Books and References:**

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
7. S.E. Manahan, *Environmental Chemistry*, CRC Press (2005).
8. G.T. Miller, *Environmental Science* 11th edition. Brooks/ Cole (2006).
9. A. Mishra, *Environmental Studies*. Selective and Scientific Books, New Delhi (2005).

**DISCIPLINE SPECIFIC ELECTIVE 3 (CHD 6.12(a))  
INDUSTRIAL CHEMICALS & ENVIRONMENT**

*Practical Credit: 2*

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgNO<sub>3</sub> and potassium chromate).
6. Estimation of total alkalinity of water samples (CO<sub>3</sub><sup>2-</sup>, HCO<sub>3</sub><sup>-</sup>) using double titration method.
7. Measurement of dissolved CO<sub>2</sub>.
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

**Recommended Books and References:**

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.

**DISCIPLINE SPECIFIC ELECTIVE 3 (CHD 6.11(b))  
RESEARCH METHODOLOGY IN CHEMISTRY (THEORY)**

*Theory Credit: 4*

**DISCIPLINE SPECIFIC ELECTIVE 3 (CHD 6.12(b))  
RESEARCH METHODOLOGY IN CHEMISTRY (PRACTICAL)**

*Practical Credit: 2*

**DISCIPLINE SPECIFIC ELECTIVE 4 (CHD 6.21(a))  
INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE**

*Theory Credit: 4*

*Teaching Hours: 60*

**Silicate Industries (16 Hours)**

*Glass*: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

*Ceramics*: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

**Cements:** Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

**Fertilizers: (8 Hours)**

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

**Surface Coatings: (10 Hours)**

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

**Batteries: (6 Hours)**

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

**Alloys: (10 Hours)**

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

**Catalysis: (6 Hours)**

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts.

**Chemical explosives: (4 Hours)**

Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

**Recommended Books and References:**

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics*, Wiley Publishers, New Delhi.
4. J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry*, Vikas Publications, New Delhi.
7. Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).

**DISCIPLINE SPECIFIC ELECTIVE 4 (CHD 6.22(a))  
INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE**

*Practical Credit: 2*

*Teaching Hours: 60*

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide).

***Recommended Books and References:***

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics*, Wiley Publishers, New Delhi.
4. J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry*, Vikas Publications, New Delhi. Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).

**DISCIPLINE SPECIFIC ELECTIVE 4 (CHD 6.21(b))  
INSTRUMENTAL METHOD OF CHEMICALS (THEORY)**

*Theory Credit: 4*

**DISCIPLINE SPECIFIC ELECTIVE 4 (CHD 6.22(b))  
INSTRUMENTAL METHOD OF CHEMICALS (PRACTICAL)**

*Practical Credit: 2*

## SKILL ENHANCEMENT COURSE

### SKILL ENHANCEMENT COURSE 1 (CHS 3.11(a)) PESTICIDE CHEMISTRY

Credit: 2

Teaching Hours: 30

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones Chloranil, Anilides (Alachlor and Butachlor).

#### Practicals

- 1 To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications.
- 2 Preparation of simple organophosphates, phosphonates and thiophosphates

#### Recommended Books and References:

1. Cremllyn, R. *Pesticides. Preparation and Modes of Action*, John Wiley & Sons, New York, 1978.

### SKILL ENHANCEMENT COURSE 1 (CHS 3.11(b)) FUEL CHEMISTRY

Credit: 2

Teaching Hours: 30

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.

*Coal:* Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

*Petroleum and Petrochemical Industry:* Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

*Lubricants:* Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

#### Recommended Books and References:

1. Stocchi, E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK (1990).
2. Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).



**SKILL ENHANCEMENT COURSE 2 (CHS 4.11(A))  
CHEMICAL TECHNOLOGY & SOCIETY**

*Credit: 2*

*Teaching Hours: 30*

**Chemical Technology**

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption. An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Scaling up operations in chemical industry. Introduction to clean technology.

**Society**

Exploration of societal and technological issues from a chemical perspective. Chemical and scientific literacy as a means to better understand topics like air and water (and the trace materials found in them that are referred to as pollutants); energy from natural sources (i.e. solar and renewable forms), from fossil fuels and from nuclear fission; materials like plastics and polymers and their natural analogues, proteins and nucleic acids, and molecular reactivity and interconversions from simple examples like combustion to complex instances like genetic engineering and the manufacture of drugs.

**Recommended Books and References:**

1. John W. Hill, Terry W. McCreary & Doris K. Kolb, *Chemistry for changing times* 13th Ed, Prentice-Hall (2012).

**SKILL ENHANCEMENT COURSE 2 (CHS 4.11(b))  
PHARMACEUTICAL CHEMISTRY**

*Credit: 2*

*Teaching Hours: 30*

**Drugs & Pharmaceuticals**

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

**Fermentation**

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

**Practicals**

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium bisilicate (Antacid).

**Recommended Books and References:**

1. Patrick, G. L. *Introduction to Medicinal Chemistry*, Oxford University Press, UK, 2013.
2. Singh, H. & Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, Pitampura, New Delhi, 2012.
3. Foye, W.O., Lemke, T.L. & William, D.A.: *Principles of Medicinal Chemistry*, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.

**SKILL ENHANCEMENT COURSE 2 (CHS 4.11(c))  
CHEMISTRY OF COSMETICS & PERFUMES**

Credit: 2

Teaching Hours: 30

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

**Practicals**

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of enamels.
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of nail polish and nail polish remover.

**Recommended Books and References:**

1. Stocchi, E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK (1990).
2. Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).

SYLLABUS FOR  
Bachelor of Science (Honours)

**COMPUTER SCIENCE**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)



## COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Programming Fundamentals using C(Theory)	CSC 1.11	4
		Programming Fundamentals using C (Practical)	CSC 1.12	2
	Core2	Computer System Architecture(Theory)	CSC 1.21	4
		Computer System Architecture(Practical)	CSC 1.22	2
II	Core 3	Data Structures(Theory)	CSC 2.11	4
		Data Structures(Practical)	CSC 2.12	2
	Core 4	Programming in Java(Theory)	CSC 2.21	4
		Programming in Java(Practical)	CSC 2.22	2
III	Core 5	Object Oriented Programming in C++ (Theory)	CSC 3.11	4
		Object Oriented Programming in C++(Practical)	CSC 3.12	2
	Core 6	Operating Systems(Theory)	CSC 3.21	4
		Operating Systems(Practical)	CSC 3.22	2
	Core 7	Computer Networks(Theory)	CSC 3.31	4
		Computer Networks(Practical)	CSC 3.32	2
	Skill Enhancement Course 1	HTML	CSS 3.11	2
	IV	Core 8	Design and Analysis of Algorithms(Theory)	CSC 4.11
Design and Analysis of Algorithms(Practical)			CSC 4.12	2
Core 9		Software Engineering(Theory)	CSC 4.21	4
		Software Engineering(Practical)	CSC 4.22	2
Core 10		Database Management Systems(Theory)	CSC 4.31	4
		Database Management Systems(Practical)	CSC 4.32	2
Skill Enhancement Course 2	Programming in MATLAB	CSS 4.11	2	
V	Core 11	Internet Technologies(Theory)	CSC 5.11	4
		Internet Technologies(Practical)	CSC 5.12	2
	Core 12	Theory of Computation (Theory)	CSC 5.21	5
		Theory of Computation(Tutorial)	CSC 5.22	1
	Discipline Specific Elective 1	PHP Programming (Theory)	CSD 5.11	4
		PHP Programming(Practical)	CSD 5.11	2
	Discipline Specific Elective 2	Programming in Visual Basic(Theory)	CSD 5.21	4
		Programming in Visual Basic(Practical)	CSD 5.22	2
VI	Core 13	Artificial Intelligence(Theory)	CSC 6.11	5
		Artificial Intelligence(Tutorial)	CSC 6.12	1
	Core 14	Computer Graphics(Theory)	CSC 6.21	4
		Computer Graphics(Practical)	CSC 6.22	2
	Discipline Specific Elective 3	Cloud Computing (Theory)	CSD 6.11	4
		Cloud Computing (Practical)	CSD 6.12	2
	Discipline Specific Elective 4	Project Work / Dissertation	CSD 6.21	6

## SEMESTER – I

### CORE 1 (CSC 1.11) PROGRAMMING FUNDAMENTALS USING C

Theory Credit: 4

Teaching Hours: 60

- UNIT I** Overview of Procedure oriented programming, Data types, Defining and Initializing Variables, Scope of Variables, Keywords, Casting of Data Types, Operators (Arithmetic, Relational, and Logical), main() function, Compiling and Executing a program, Using Comments in programs, Character I/O (getc, getchar, putc), printf(), scanf(), Basic Header Files (stdio.h, conio.h, math.h, string.h, etc).
- UNIT II** Simple Expressions in C, Understanding precedence of Operators in Expressions, Conditional Statements (IF, IF... ELSE, Nested IF, Switch-Case), Iterative Statements (FOR, WHILE, and DO-WHILE), Use of BREAK and CONTINUE in Loops, Nested loops.
- UNIT III** Use of functions, Call by Value, Call by Reference, Functions returning value, Void function, One Dimensional Arrays (Declaring an Array, Initializing an Array, Accessing individual elements in an Array, Manipulating array elements using loops), Use Various types of arrays (integer, float and character arrays / Strings), Two-dimensional Arrays, Working with Rows and Columns of a matrix.
- UNIT IV** **Understanding** use of structures, declaring, initializing and using simple structures, Manipulating individual members of structures, Array of Structures
- UNIT V** Understanding Pointer Variable, Simple use of Pointers, Pointer arithmetic, Differentiating between static and dynamic memory allocation, use of malloc and calloc functions, Simple file handling operations.

#### **Recommended Books and References:**

1. Programming in ANSI C - E. Balguruswamy, TMH
2. Let us C - Yaswant Kanitkar, BPB

### CORE 1 (CSC 1.12) C PROGRAMMING LAB

1. Write a program to find the maximum among three numbers.
2. Write a program to find factorial of a number.
3. Write a program to print the Fibonacci series.
4. Write a program to print the prime numbers between 1 to n.
5. Write a program to check if it a Palindrome (e.g., madam).
6. Write a program to check if it is an Armstrong number. (An Armstrong number of three digits is an integer such that the sum of the cubes of its digits is equal to the number itself)
7. Write program to reverse the digits of an input number.
8. Write a program to find the sum of digits of a number.
9. Write a program to find the GCD and LCM of two numbers.
10. Write a program to perform different arithmetic operations using switch....case.
11. Write a program to count the number bits "1" in a given binary number.
12. Write a program to find the factorial of a number using function.
13. Write a program to perform the arithmetic operations using function.

14. Write a program to find the largest element in an array.
15. Write a program to add two matrices.
16. Write a program to multiply two matrices.
17. Write a program to find the position of a given character in a string.
18. Write a program to count the number of times a character occurs in a string.
19. Write a program to create records of 10 students using structure.

**CORE 2 (CSC 1.21)**  
**COMPUTER SYSTEM ARCHITECTURE**

*Theory Credit: 4*

*Teaching Hours: 60*

**1. Introduction:** Logic gates, boolean algebra, combinational circuits, circuit simplification, flip-flops and sequential circuits, decoders, multiplexers, registers, counters and memory units.

**2. Data Representation and Basic Computer Arithmetic:** Number systems, complements, fixed and floating point representation, character representation, addition, subtraction, magnitude comparison, multiplication and division algorithms for integers

**3. Basic Computer Organization and Design:** Computer registers, bus system, instruction set, timing and control, instruction cycle, memory reference, input-output and interrupt, Interconnection Structures, Bus Interconnection design of basic computer.

**4. Central Processing Unit:** Register organization, arithmetic and logical micro-operations, stack organization, micro programmed control. Instruction formats, addressing modes, instruction codes, machine language, assembly language, input output programming, RISC, CISC architectures, pipelining and parallel architecture.

**5. Input-Output Organization:** Input / Output: External Devices, I/O Modules, Programmed I/O, Interrupt-Driven I/O, Direct Memory Access, I/O Channels.

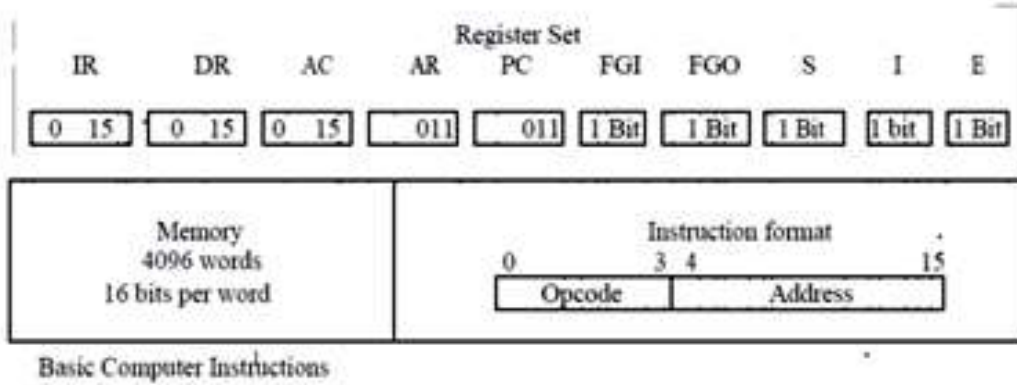
***Recommended Books and References:***

1. M. Mano, Computer System Architecture, Pearson Education 1992
2. A. J. Dos Reis, Assembly Language and Computer Architecture using C++ and JAVA, Course Technology, 2004th
3. W. Stallings, Computer Organization and Architecture Designing for Performance, 8 Edition, Prentice Hall of India, 2009
4. M.M. Mano , Digital Design, Pearson Education Asia, 2013.
5. Carl Hamacher, Computer Organization, Fifth edition, McGrawHill, 2012.

**CORE 1 (CSC 1.22)**  
**COMPUTER SYSTEM ARCHITECTURE LAB**

1. Create a machine based on the following architecture:

I. Create a machine based on the following architecture:



Memory Reference		Register Reference		Input-Output	
Symbol	Hex	Symbol	Hex	Symbol	Hex
AND	0xxx	CLA	E800	INP	F800
ADD	2xxx	CLE	E400	OUT	F400
LDA	4xxx	CMA	E200	SKI	F200
STA	6xxx	CME	E100	SKO	F100
BUN	8xxx	CIR	E080	ION	F080
BSA	Axxx	CIL	E040	IOF	F040
ISZ	Cxxx	INC	E020		
AND_I	1xxx	SPA	E010		
ADD_I	3xxx	SNA	E008		
LDA_I	5xxx	SZA	E004		
STA_I	7xxx	SZE	E002		
BUN_I	9xxx	HLT	E001		
BSA_I	Bxxx				
ISZ_I	Dxxx				

**Optional**

Refer to Chapter-5 of Morris Mano for description of instructions.

2. Create the micro operations and associate with instructions as given in the chapter (except interrupts). Design the register set, memory and the instruction set. Use this machine for the assignments of this section.
3. Create a Fetch routine of the instruction cycle.
4. Simulate the machine to determine the contents of AC, E, PC, AR and IR registers in hexadecimal after the execution of each of following register reference instructions:
  - a. CLA
  - b. CLE
  - c. CMA
  - e. CIR
  - f. CIL
  - g. INC
  - i. SNA
  - j. SZA
  - k. SZE



- d. CME                                      h. SPA                                      i. HLT
5. Simulate the machine for the following memory-reference instructions with I= 0 and address part = 082. The instruction to be stored at address 022 in RAM. Initialize the memory word at address 082 with the operand B8F2 and AC with A937. Determine the contents of AC, DR, PC, AR and IR in hexadecimal after the execution.
- a. ADD                                      f. BSA
  - b. AND                                      g. ISZ
  - c. LDA
  - d. STA
  - e. BUN
6. Simulate the machine for the memory-reference instructions referred in above question with I= 1 and address part = 082. The instruction to be stored at address 026 in RAM. Initialize the memory word at address 082 with the value 298. Initialize the memory word at address 298 with operand B8F2 and AC with A937. Determine the contents of AC, DR, PC, AR and IR in hexadecimal after the execution.

## SEMESTER – II

### CORE 3 (CSC 2.11) DATA STRUCTURES

*Theory Credit:*

*Teaching Hours: 60*

- 1. Arrays** Single and Multi-dimensional Arrays, Sparse Matrices (Array and Linked Representation).
- 2. Stacks** Implementing single / multiple stack/s in an Array; Prefix, Infix and Postfix expressions, Utility and conversion of these expressions from one to another; Applications of stack; Limitations of Array representation of stack.
- 3. Linked Lists:** Singly, Doubly and Circular Lists (Array and Linked representation); Normal and Circular representation of Stack in Lists; Self Organizing Lists; Skip Lists.
- 4. Trees:** Introduction to Tree as a data structure; Binary Trees (Insertion, Deletion , Recursive and Iterative Traversals on Binary Search Trees); Threaded Binary Trees (Insertion, Deletion, Traversals); Height-Balanced Trees (Various operations on AVL Trees).
- 5. Searching and Sorting:** Linear Search, Binary Search, Comparison of Linear and Binary Search, Selection Sort, Insertion Sort, Insertion Sort, Shell Sort, Comparison of Sorting Techniques.

#### **Recommended Books and References:**

1. Adam Drozdek, "Data Structures and algorithm in C++", Third Edition, Cengage Learning, 2012.
2. SartajSahni, Data Structures, "Algorithms and applications in C++", Second Edition, Universities Press, 2011.
3. Aaron M. Tenenbaum, Moshe J. Augenstein, YedidiahLangsam, "Data Structures Using C and C++:", Second edition, PHI, 2009.
4. Robert L. Kruse, "Data Structures and Program Design in C++", Pearson,1999.
5. D.S Malik, Data Structure using C++,Second edition, Cengage Learning, 2010.
6. Mark Allen Weiss, "Data Structures and Algorithms Analysis in Java", Pearson Education, 3rd edition, 2011
7. Aaron M. Tenenbaum, Moshe J. Augenstein, YedidiahLangsam, "Data Structures Using Java, 2003.
8. Robert Lafore, "Data Structures and Algorithms in Java, 2/E", Pearson/ Macmillan Computer Pub,2003
9. John Hubbard, "Data Structures with JAVA", McGraw Hill Education (India) Private Limited; 2 edition, 2009
10. Goodrich, M. and Tamassia, R. "Data Structures and Algorithms Analysis in Java", 4th Edition, Wiley,2013
11. Herbert Schildt, "Java The Complete Reference (English) 9th Edition Paperback", Tata McGraw Hill, 2014.
12. D. S. Malik, P.S. Nair, "Data Structures Using Java", Course Technology, 2003.

**CORE 3 (CSC 2.12)**  
**DATA STRUCTURES LAB**

1. Write a program to search an element from a list. Give user the option to perform Linear or Binary search. Use Template functions.
2. WAP using templates to sort a list of elements. Give user the option to perform sorting using Insertion sort, Bubble sort or Selection sort.
3. Implement Linked List using templates. Include functions for insertion, deletion and search of a number, reverse the list and concatenate two linked lists (include a function and also overload operator +).
4. Implement Doubly Linked List using templates. Include functions for insertion, deletion and search of a number, reverse the list.
5. Implement Circular Linked List using templates. Include functions for insertion, deletion and search of a number, reverse the list.
6. Perform Stack operations using Linked List implementation.
7. Perform Stack operations using Array implementation. Use Templates.
8. Perform Queues operations using Circular Array implementation. Use Templates.
9. Create and perform different operations on Double-ended Queues using Linked List implementation.
10. WAP to scan a polynomial using linked list and add two polynomial.
11. WAP to calculate factorial and to compute the factors of a given no. (i)using recursion, (ii) using iteration
12. (ii) WAP to display fibonacci series (i)using recursion, (ii) using iteration
13. WAP to calculate GCD of 2 number (i) with recursion (ii) without recursion
14. WAP to create a Binary Search Tree and include following operations in tree:
  - (a) Insertion (Recursive and Iterative Implementation)
  - (b) Deletion by copying
  - (c) Deletion by Merging
  - (d) Search a no. in BST
  - (e) Display its preorder, postorder and inorder traversals Recursively
  - (f) Display its preorder, postorder and inorder traversals Iteratively
  - (g) Display its level-by-level traversals
  - (h) Count the non-leaf nodes and leaf nodes
  - (i) Display height of tree
  - (j) Create a mirror image of tree
  - (k) Check whether two BSTs are equal or not
15. WAP to convert the Sparse Matrix into non-zero form and vice-versa.
16. WAP to reverse the order of the elements in the stack using additional stack.
17. WAP to reverse the order of the elements in the stack using additional Queue.
18. WAP to implement various operations on AVL Tree.

**CORE 4 (CSC 2.21)**  
**PROGRAMMING IN JAVA**

*Theory Credit:*

*Teaching Hours: 60*

**1. Introduction to Java:** Java Architecture and Features, Understanding the semantic and syntax differences between C++ and Java, Compiling and Executing a Java Program, Variables, Constants, Keywords Data Types, Operators (Arithmetic, Logical and Bitwise) and Expressions, Comments, Doing Basic Program Output, Decision Making Constructs (conditional statements

and loops) and Nesting, Java Methods (Defining, Scope, Passing and Returning Arguments, Type Conversion and Type and Checking, Built-in Java Class Methods),

**2. Arrays, Strings and I/O:** Creating & Using Arrays (One Dimension and Multi-dimensional), Referencing Arrays Dynamically, Java Strings: The Java String class, Creating & Using String Objects, Manipulating Strings, String Immutability & Equality, Passing Strings To & From Methods, String Buffer Classes. Simple I/O using System.out and the Scanner class, Byte and Character streams, Reading/Writing from console and files.

**3. Object-Oriented Programming Overview:** Principles of Object-Oriented Programming, Defining & Using Classes, Controlling Access to Class Members, Class Constructors, Method Overloading, Class Variables & Methods, Objects as parameters, final classes, Object class, Garbage Collection.

**3. Inheritance, Interfaces, Packages, Enumerations, Autoboxing and Metadata:** Inheritance: (Single Level and Multilevel, Method Overriding, Dynamic Method Dispatch, Abstract Classes), Interfaces and Packages, Extending interfaces and packages, Package and Class Visibility, Using Standard Java Packages (util, lang, io, net), Wrapper Classes, Autoboxing/Unboxing, Enumerations and Metadata.

**4. Exception Handling, Threading, Networking and Database Connectivity:** Exception types, uncaught exceptions, throw, built-in exceptions, Creating your own exceptions; Multi-threading: The Thread class and Runnable interface, creating single and multiple threads, Thread prioritization, synchronization and communication, suspending/resuming threads. Using java.net package, Overview of TCP/IP and Datagram programming. Accessing and manipulating databases using JDBC.

**5. Applets and Event Handling:** Java Applets: Introduction to Applets, Writing Java Applets, Working with Graphics, Incorporating Images & Sounds. Event Handling Mechanisms, Listener Interfaces, Adapter and Inner Classes. The design and Implementation of GUIs using the AWT controls, Swing components of Java Foundation Classes such as labels, buttons, textfields, layout managers, menus, events and listeners; Graphic objects for drawing figures such as lines, rectangles, ovals, using different fonts. Overview of servlets.

#### **Recommended Books and References:**

1. Ken Arnold, James Gosling, David Homes, "The Java Programming Language", 4<sup>th</sup> Edition, 2005.
2. James Gosling, Bill Joy, Guy L Steele Jr, Gilad Bracha, Alex Buckley "The Java Language Specification, Java SE 8 Edition (Java Series)", Published by Addison Wesley, 2014.
3. Joshua Bloch, "Effective Java" 2nd Edition, Publisher: Addison-Wesley, 2008.
4. Cay S. Horstmann, Gary Cornell, "Core Java 2 Volume 1 ,9th Edition, Printice Hall.2012
5. Cay S. Horstmann, Gary Cornell, "Core Java 2 Volume 2 - Advanced Features)", 9th Edition, Printice Hall.2013
6. Bruce Eckel, "Thinking in Java", 3rd Edition, PHI, 2002.
7. E. Balaguruswamy, "Programming with Java", 4th Edition, McGraw Hill.2009.
8. Paul Deitel, Harvey Deitel, "Java: How to Program", 10th Edition, Prentice Hall, 2011.
9. "Head First Java", Orielly Media Inc. 2nd Edition, 2005.

**CORE 4 (CSC 2.22)**  
**PROGRAMMING IN JAVA LAB**

1. To find the sum of any number of integers entered as command line arguments
2. To find the factorial of a given number
3. To learn use of single dimensional array by defining the array dynamically.
4. To learn use of .length in case of a two dimensional array
5. To convert a decimal to binary number
6. To check if a number is prime or not, by taking the number as input from the keyboard
7. To find the sum of any number of integers interactively, i.e., entering every number from the keyboard, whereas the total number of integers is given as a command line argument
8. Write a program that show working of different functions of String and StringBuffer classes like setCharAt(), setLength(), append(), insert(), concat() and equals().
9. Write a program to create a `Distance` class with methods where distance is computed in terms of feet and inches, how to create objects of a class and to see the use of this pointer
10. Modify the `Distance` class by creating constructor for assigning values (feet and inches) to the distance object. Create another object and assign second object as reference variable to another object reference variable. Further create a third object which is a clone of the first object.
11. Write a program to show that during function overloading, if no matching argument is found, then java will apply automatic type conversions (from lower to higher data type).
12. Write a program to show the difference between public and private access specifiers. The program should also show that primitive data types are passed by value and objects are passed by reference and to learn use of final keyword.
13. Write a program to show the use of static functions and to pass variable length arguments in a function.
14. Write a program to demonstrate the concept of boxing and unboxing.
15. Create a multi-file program where in one file a string message is taken as input from the user and the function to display the message on the screen is given in another file (make use of Scanner package in this program).
16. Write a program to create a multilevel package and also creates a reusable class to generate Fibonacci series, where the function to generate Fibonacci series is given in a different file belonging to the same package.
17. Write a program that creates illustrates different levels of protection in classes/subclasses belonging to same package or different packages.
18. Write a program `DivideByZero` that takes two numbers a and b as input, computes a/b, and invokes Arithmetic Exception to generate a message when the denominator is zero.
19. Write a program to show the use of nested try statements that emphasizes the sequence of checking for catch handler statements.
20. Write a program to create your own exception types to handle situation specific to your application (Hint: Define a subclass of Exception which itself is a subclass of Throwable).
21. Write a program to demonstrate priorities among multiple threads.

## SEMESTER – III

### CORE 5 (CSC 3.11)

#### OBJECT ORIENTED PROGRAMMING IN C++

*Theory Credit:*

*Teaching Hours: 60*

**UNIT I** Object Oriented Programming concept, Procedural vs OOP programming, OOP terminology and features, Tokens, Character set, Keywords, Data-types, Constants and variables, expressions, Standard Library and header files. Operator and Expressions: Arithmetic Operator, Increment/Decrement Operator, Relational Operator, Logical Operator and conditional operators, library functions, Logical Expressions.

**UNIT II** Control statements, IF, IF ...ELSE, Nested IF, Switch....Case, Looping statements, While, Do-while, For statements, nested loops.  
Classes and Objects: Need for Classes, Declaration of Classes, referencing class Members, Data members and member Functions, Inline Functions, Creation of objects

**UNIT III** Use of access specifiers, Public and Private, Function Overloading, use of Constructors and Destructors, Types of constructors: default, parameterized, and copy constructors, Operator overloading, Friend function, Arrays of objects.

**UNIT IV** Understanding utility of structures and unions, Declaring, initializing and using simple structures and unions, Manipulating individual members of structures and unions, Array of Structures, Individual data members as structures, Passing and returning structures from functions, Structure with union as members, Union with structures as members.

**UNIT V** Concept of Inheritance, Types of inheritance: Single level, multi-level, multiple, hybrid, Use of protected access specifier, Function overriding, Exception handling, Simple file handling.

#### **Recommended Books and References:**

1. Object Oriented Programming with C++ -E. Balaguruswamy, TMH
2. Let us C++ -YashavantKanetkar, BPB
3. Object Oriented Programming with C++ -Sourav Sahay, Oxford University Press
4. The C++ Programming Language - Bjarne Stroustrup, Addison-Wesley

### CORE 5 (CSC 3.12)

#### C++ PROGRAMMING LAB

1. Define a class called STUDENT with the data members Roll No., Name, Marks secured in five subjects. Write member functions to do the following:
  - i. Read data
  - ii. Find the total mark and division
  - iii. Display Roll No., Name, Total mark, and Division
2. Define a class called SHAPE with appropriate data members. Find the area of different geometrical shapes using function overloading.

3. Define a class called ACCOUNT with the data members Account no. Customer name, Amount and initialize with suitable constructor. Write member functions to do the following:
  - i. Deposit amount
  - ii. Withdraw amount
  - iii. Check balance
4. Using operator overloading add two given Lengths expressed as Feet and Inch.
5. Using operator overloading add two given TIMEs expressed as Hour : Minute : Second.

## **CORE 6 (CSC 3.21) OPERATING SYSTEMS**

*Theory Credit: 4*

*Teaching Hours: 60*

**1 Introduction:** Basic OS functions, resource abstraction, types of operating systems—multiprogramming systems, batch systems , time sharing systems; operating systems for personal computers & workstations, process control & real time systems.

**2. Operating System Organization:** Processor and user modes, kernels, system calls and system programs.

**3. Process Management:** System view of the process and resources, process abstraction, process hierarchy, threads, threading issues, thread libraries; Process Scheduling, non-pre-emptive and pre-emptive scheduling algorithms; concurrent and processes, critical section, semaphores, methods for inter-process communication; deadlocks.

**4. Memory Management:** Physical and virtual address space; memory allocation strategies -fixed and variable partitions, paging, segmentation, virtual memory

**5. File and I/O Management:** Directory structure, file operations, file allocation methods, device management.

### **Recommended Books and References:**

1. A Silberschatz, P.B. Galvin, G. Gagne, Operating Systems Concepts, 8th Edition, John Wiley Publications 2008.
2. A.S. Tanenbaum, Modern Operating Systems, 3rd Edition, Pearson Education 2007.
3. G. Nutt, Operating Systems: A Modern Perspective, 2nd Edition Pearson Education 1997.
4. W. Stallings, Operating Systems, Internals & Design Principles, 5th Hall of India. 2008. Edition, Prentice.
5. M. Milenkovic, Operating Systems- Concepts and design, Tata McGraw Hill 1992.

## **CORE 6 (CSC 3.22) OPERATING SYSTEMS LAB**

### **C/ C++ programs**

1. WRITE A PROGRAM (using *fork()* and/or *exec()* commands) where parent and child execute:
  - a) same program, same code.
  - b) same program, different code.
  - c) before terminating, the parent waits for the child to finish its task.

2. WRITE A PROGRAM to report behavior of Linux kernel including kernel version, CPU type and model. (CPU information)
3. WRITE A PROGRAM to report behavior of Linux kernel including information on configured memory, amount of free and used memory. (memory information)
4. WRITE A PROGRAM to print file details including owner access permissions, file access time, where file name is given as argument.
5. WRITE A PROGRAM to copy files using system calls.
6. Write program to implement FCFS scheduling algorithm.
7. Write program to implement Round Robin scheduling algorithm.
8. Write program to implement SJF scheduling algorithm.
9. Write program to implement non-preemptive priority based scheduling algorithm.
10. Write program to implement preemptive priority based scheduling algorithm.
11. Write program to implement SRJF scheduling algorithm.
12. Write program to calculate sum of n numbers using *thread* library.
13. Write a program to implement first-fit, best-fit and worst-fit allocation strategies.

**CORE 7 (CSC 3.31)**  
**COMPUTER NETWORKS**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Introduction to Computer Networks, Network Hardware, Network Software, Network Topologies (Star, Ring, Bus, Mesh), Network Classifications, Network Protocol, Layered Network Architecture, Overview of OSI Reference Model, Overview of TCP/IP protocol suite, Data
- UNIT II** Communication Fundamentals and Techniques, Analog and Digital Signal, Data-rate limits, Multiplexing Techniques - FDM, TDM, Transmission Media, Networks Switching Techniques and Access Mechanisms, Circuit Switching, Packet Switching-Connectionless Datagram Switching, Connection-Oriented, Virtual Circuit Switching.
- UNIT III** Dial-up Modems, Digital Subscriber Line, Cable TV for data transfer, CSMA/CD protocols, Ethernet LANs, Connecting LAN and Back-bone Networks - Repeaters, Hubs, Switches, Bridges, Router and Gateways, Routing protocols, IP Addressing.
- UNIT IV** Transport Layer Functions and Protocols, Error and flow control, Connection establishment and release, Three-way handshaking, Overview of Application Layer Protocol, DNS,
- UNIT V** Overview of WWW & HTTP Protocols, Electronic Mail.

**Recommended Books and References:**

1. B. A. Forouzan: Data Communications and Networking, Fourth edition, THM ,2007.
2. A. S. Tanenbaum: Computer Networks, Fourth edition, PHI , 2002



**CORE 7 (CSC 3.32)**  
**COMPUTER NETWORKS LAB**

1. Simulate Cyclic Redundancy Check (CRC) error detection algorithm for noisy channel.
2. Simulate and implement stop and wait protocol for noisy channel.
3. Simulate and implement go back n sliding window protocol.
4. Simulate and implement selective repeat sliding window protocol.
5. Simulate and implement distance vector routing algorithm
6. Simulate and implement Dijkstra algorithm for shortest path routing.

## SEMESTER – IV

### CORE 8 (CSC 4.11) DESIGN AND ANALYSIS OF ALGORITHMS

*Theory Credit: 4*

*Teaching Hours: 60*

- 1. Introduction:** Basic Design and Analysis techniques of Algorithms, Correctness of Algorithm.
- 2. Algorithm Design Techniques:** Iterative techniques, Divide and Conquer, Dynamic Programming, Greedy Algorithms.
- 3. Sorting and Searching Techniques:** Elementary sorting techniques–Bubble Sort, Insertion Sort, Merge Sort, Advanced Sorting techniques - Heap Sort, Quick Sort, Sorting in Linear Time - Bucket Sort, Radix Sort and Count Sort, Searching Techniques, Medians & Order Statistics, complexity analysis;
- 4. Decision Trees Red-Black Trees Amortized analysis**
- 5. Graphs:** Graph Algorithms–Breadth First Search, Depth First Search and its Applications, Minimum Spanning Trees.

#### **Recommended Books and References:**

1. T.H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein Introduction to Algorithms, PHI, 3rd Edition 2009
2. Sarabasse& A.V. Gelder Computer Algorithm – Introduction to Design and Analysis, Publisher – Pearson 3rd Edition 1999

### CORE 8 (CSC 4.12) DESIGN AND ANALYSIS OF ALGORITHMS LAB

1. i. Implement Insertion Sort (The program should report the number of comparisons)  
ii. Implement Merge Sort (The program should report the number of comparisons)
2. Implement Heap Sort (The program should report the number of comparisons)
3. Implement Randomized Quick sort (The program should report the number of comparisons)
4. Implement Radix Sort
5. Create a Red-Black Tree and perform following operations on it:
  - i. Insert a node
  - ii. Delete a node
  - iii. Search for a number & also report the color of the node containing this number.
6. Write a program to determine the LCS of two given sequences
7. Implement Breadth-First Search in a graph
8. Implement Depth-First Search in a graph
9. Write a program to determine the minimum spanning tree of a graph

For the algorithms at S.No 1 to 3 test run the algorithm on 100 different inputs of sizes varying from 30 to 1000. Count the number of comparisons and draw the graph. Compare it with a graph of  $n \log n$ .

**CORE 9 (CSC 4.21)  
SOFTWARE ENGINEERING THEORY**

Theory Credit: 4

Teaching Hours: 60

**1. Introduction:** The Evolving Role of Software, Software Characteristics, Changing Nature of Software, Software Engineering as a Layered Technology, Software Process Framework, Framework and Umbrella Activities, Process Models, Capability Maturity Model Integration (CMMI).

**2. Requirement Analysis:** Software Requirement Analysis, Initiating Requirement Engineering Process, Requirement Analysis and Modeling Techniques, Flow Oriented Modeling, Need for SRS, Characteristics and Components of SRS.

**3. Quality Management:** Quality Concepts, Software Quality Assurance, Software Reviews, Metrics for Process and Projects.

**4. Design Engineering:** Design Concepts, Architectural Design Elements, Software Architecture, Data Design at the Architectural Level and Component Level, Mapping of Data Flow into Software Architecture, Modeling Component Level Design.

**5. Testing Strategies & Tactics:** Software Testing Fundamentals, Strategic Approach to Software Testing, Test Strategies for Conventional Software, Validation Testing, System testing, Black-Box Testing, White-Box Testing and their type, Basis Path Testing.

**Recommended Books and References:**

1. R.S. Pressman, Software Engineering: A Practitioner’s Approach (7th Edition), McGraw- Hill, 2009.
2. P. Jalote, An Integrated Approach to Software Engineering (2nd Edition), Narosa Publishing House, 2003.
3. K.K. Aggarwal and Y. Singh, Software Engineering ( 2nd Edition), New Age International Publishers, 2008.
4. I. Sommerville, Software Engineering (8th edition), Addison Wesley, 2006.
5. D. Bell, Software Engineering for Students (4th Edition), Addison-Wesley, 2005.
6. R. Mall, Fundamentals of Software Engineering (2nd Edition), Prentice-Hall of India, 2004.

**CORE 9 (CSC 4.22)  
SOFTWARE ENGINEERING LAB**

SL NO.	Practical Title
1	<ul style="list-style-type: none"> <li>• Problem Statement,</li> <li>• Process Model</li> </ul>
2	Requirement Analysis: <ul style="list-style-type: none"> <li>• Creating a Data Flow</li> <li>• Data Dictionary, Use Cases</li> </ul>
3	Project Management:    Computing FP Effort <ul style="list-style-type: none"> <li>• Schedule, Risk Table, Timeline chart</li> </ul>
4	Design Engineering: <ul style="list-style-type: none"> <li>• Architectural Design</li> </ul>

	<ul style="list-style-type: none"> <li>• Data Design, Component Level Design</li> </ul>
5	Testing: <ul style="list-style-type: none"> <li>• Basis Path Testing</li> </ul>

**Sample Projects:**

1. **Criminal Record Management:** Implement a criminal record management system for jailers, police officers and CBI officers
2. **DTC Route Information:** Online information about the bus routes and their frequency and fares
3. **Car Pooling:** To maintain a web based intranet application that enables the corporate employees within an organization to avail the facility of carpooling effectively.
4. Patient Appointment and Prescription Management System
5. Organized Retail Shopping Management Software
6. Online Hotel Reservation Service System
7. Examination and Result computation system
8. Automatic Internal Assessment System
9. Parking Allocation System
10. Wholesale Management System

**CORE 10 (CSC 4.31)**

**DATABASE MANAGEMENT SYSTEMS**

*Theory Credit: 4*

*Teaching Hours: 60*

**1. Introduction:** Characteristics of database approach, data models, database system architecture and data independence.

**2. Entity Relationship(ER) Modeling:** Entity types, relationships, constraints.

**3. Relation data model:** Relational model concepts, relational constraints, relational algebra, SQL queries

**4. Database design:** Mapping ER/EER model to relational database, functional dependencies, Lossless decomposition, Normal forms (upto BCNF).

**5. File Structure and Indexing:** Operations on files, File of Unordered and ordered records, overview of File organizations, Indexing structures for files ( Primary index, secondary index, clustering index), Multilevel indexing using B and B+ trees.

**Recommended Books and References:**

1. R. Elmasri, S.B. Navathe, Fundamentals of Database Systems 6th Edition, Pearson Education, 2010.
2. R. Ramakrishanan, J. Gehrke, Database Management Systems 3rd Edition, McGraw-Hill, 2002.
3. A. Silberschatz, H.F. Korth, S. Sudarshan, Database System Concepts 6th Edition, McGraw Hill, 2010.
4. R. Elmasri, S.B. Navathe Database Systems Models, Languages, Design and application Programming, 6th Edition, Pearson Education,2013.

**CORE 10 (CSC 4.32)**  
**DATABASE MANAGEMENT SYSTEMS LAB PRACTICAL**

1. Create and use the following database schema to answer the given queries.

**EMPLOYEE Schema**

Field	Type	NULL	KEY	DEFAULT
Eno	Char(3)	NO	PRI	NIL
Ename	Varchar(50)	NO		NIL
Job_type	Varchar(50)	NO		NIL
Manager	Char(3)	Yes	FK	NIL
Hire_date	Date	NO		NIL
Dno	Integer	YES	FK	NIL
Commission	Decimal(10,2)	YES		NIL
Salary	Decimal(7,2)	NO		NIL

**DEPARTMENT Schema**

Field	Type	NULL	KEY	DEFAULT
Dno	Integer	No	PRI	NULL
Dname	Varchar(50)	Yes		NULL

**Query List**

- Query to display Employee Name, Job, Hire Date, Employee Number; for each employee with the Employee Number appearing first.
- Query to display unique Jobs from the Employee Table.
- Query to display the Employee Name concatenated by a Job separated by a comma.
- Query to display all the data from the Employee Table. Separate each Column by a comma and name the said column as THE\_OUTPUT.
- Query to display the Employee Name and Salary of all the employees earning more than \$2850.
- Query to display Employee Name and Department Number for the Employee No= 7900.
- Query to display Employee Name and Salary for all employees whose salary is not in the range of \$1500 and \$2850.
- Query to display Employee Name and Department No. of all the employees in Dept 10 and Dept 30 in the alphabetical order by name.
- Query to display Name and Hire Date of every Employee who was hired in 1981.
- Query to display Name and Job of all employees who don't have a current Manager.
- Query to display the Name, Salary and Commission for all the employees who earn commission.
- Sort the data in descending order of Salary and Commission.
- Query to display Name of all the employees where the third letter of their name is \_A'.
- Query to display Name of all employees either have two \_R's or have two \_A's in their name and are either in Dept No = 30 or their Manger's Employee No = 7788.
- Query to display Name, Salary and Commission for all employees whose Commission Amount is 14 greater than their Salary increased by 5%.

## SEMESTER – V

### CORE 11 (CSC 5.11) INTERNET TECHNOLOGIES

Theory Credit: 4

Teaching Hours: 60

- 1. Java:** Use of Objects, Array and Array List class
- 2. JavaScript:** Data types, operators, functions, control structures, events and event handling.
- 3. JDBC:** JDBC Fundamentals, Establishing Connectivity and working with connection interface, Working with statements, Creating and Executing SQL Statements, Working with Result Set Objects.
- 4. JSP:** Introduction to Java Server Pages, HTTP and Servlet Basics, The Problem with Servlets, The Anatomy of a JSP Page, JSP Processing, JSP Application Design with MVC, Setting Up the JSP Environment, Implicit JSP Objects, Conditional Processing, Displaying Values, Using an expression to Set an Attribute, Declaring Variables and Methods, Error Handling and Debugging, Sharing Data Between JSP Pages, Requests, and Users, Database Access.
- 5. Java Beans:** Java Beans Fundamentals, JAR files, Introspection, Developing a simple Bean, Connecting to DB

#### **Recommended Books and References:**

1. Ivan Bayross, Web Enabled Commercial Application Development Using Html, Dhtml, javascript, Perl Cgi , BPB Publications, 2009.
2. Cay Horstmann, BIG Java, Wiley Publication , 3rd Edition., 2009
3. Herbert Schildt , Java 7, The Complete Reference, , 8th Edition, 2009.
4. Jim Keogh ,The Complete Reference J2EE, TMH, , 2002.
5. O'Reilly , Java Server Pages, Hans Bergsten, Third Edition, 2003.

### CORE (CSC 5.12) INTERNET TECHNOLOGIES LAB

Create event driven program for following:

1. Print a table of numbers from 5 to 15 and their squares and cubes using alert.
2. Print the largest of three numbers.
3. Find the factorial of a number n.
4. Enter a list of positive numbers terminated by Zero. Find the sum and average of these numbers.
5. A person deposits Rs 1000 in a fixed account yielding 5% interest. Compute the amount in the account at the end of each year for n years.

Read n numbers. Count the number of negative numbers, positive numbers and zeros in the list

**CORE 12 (CSC 5.21)**  
**THEORY OF COMPUTATION**

*Theory Credit: 4*  
*Tutorial Credit: 1*

*Teaching Hours: 60*

1. **Languages:** Alphabets, string, language, Basic Operations on language, Concatenation, KleeneStar
2. **Finite Automata and Regular Languages:** Regular Expressions, Transition Graphs, Deterministic and non-deterministic finite automata, NFA to DFA Conversion, Regular languages and their relationship with finite automata, Pumping lemma and closure properties of regular languages.
3. **Context Free Languages:** Context free grammars, parse trees, ambiguities in grammars and languages, Pushdown automata (Deterministic and Non-deterministic), Pumping Lemma, Properties of context free languages, normal forms.
4. **Turing Machines and Models of Computation**  
RAM, Turing Machine as a model of computation, Universal Turing Machine, Language acceptability, decidability, halting problem,
5. Recursively enumerable and recursive languages, insolvability problems.

***Recommended Books and References:***

1. Daniel I.A.Cohen, Introduction to computer theory, John Wiley,1996
2. Lewis & Papadimitriou, Elements of the theory of computation, PHI 1997.
3. Hoperoft, Aho, Ullman, Introduction to Automata theory, Language & Computation **-3rd** Edition, Pearson Education. 2006
4. P. Linz, An Introduction to Formal Language and Automata 4th edition Publication Jones Bartlett, 2006

## SEMESTER – VI

### CORE 13 (CSC 6.11) ARTIFICIAL INTELLIGENCE

*Theory Credit: 4*

*Teaching Hours: 60*

**1. Introduction:** Introduction to Artificial Intelligence, Background and Applications, Turing Test and Rational Agent approaches to AI, Introduction to Intelligent Agents, their structure, behavior and environment.

**2. Problem Solving and Searching Techniques:** Problem Characteristics, Production Systems, Control Strategies, Breadth First Search, Depth First Search, Hill climbing and its Variations, Heuristics Search Techniques: Best First Search, A\* algorithm, Constraint Satisfaction Problem, Means-End Analysis, Introduction to Game Playing, Min-Max and Alpha-Beta pruning algorithms.

**3. Knowledge Representation:** Introduction to First Order Predicate Logic, Resolution Principle, Unification, Semantic Nets, Conceptual Dependencies, Frames, and Scripts, Production Rules, Conceptual Graphs.

Programming in Logic (PROLOG)

**4. Dealing with Uncertainty and Inconsistencies:** Truth Maintenance System, Default Reasoning, Probabilistic Reasoning, Bayesian Probabilistic Inference, Possible World Representations.

**5. Understanding Natural Languages:** Parsing Techniques, Context-Free and Transformational Grammars, Recursive and Augmented Transition Nets.

#### **Recommended Books and References:**

1. DAN.W. Patterson, Introduction to A.I and Expert Systems – PHI, 2007.
2. Russell & Norvig, Artificial Intelligence-A Modern Approach, LPE, Pearson Prentice Hall, 2nd edition, 2005.
3. Rich & Knight, Artificial Intelligence – Tata McGraw 2<sup>nd</sup> Hill,
4. W.F. Clocksin and Mellish, Programming in PROLOG, Narosa Publishing edition, 1991. House, 3rd edition, 2001.
5. Ivan Bratko, Prolog Programming for Artificial Intelligence, Addison-Wesley, Pearson Education, 3rd edition, 2000.

### CORE 12 (CSC 6.12) ARTIFICIAL INTELLIGENCE LAB

1. Write a prolog program to calculate the sum of two numbers.
2. Write a prolog program to find the maximum of two numbers.
3. Write a prolog program to calculate the factorial of a given number.
4. Write a prolog program to calculate the nth Fibonacci number.
5. Write a prolog program, insert\_nth(item, n, into\_list, result) that asserts that result is the list into\_list with item inserted as the n<sup>th</sup> element into every list at all levels.
6. Write a Prolog program to remove the Nth item from a list.
7. Write a Prolog program, remove\_nth(Before, After) that asserts the After list is the Before list with the removal of every n<sup>th</sup> item from every list at all levels.



8. Write a Prolog program to implement append for two lists.
9. Write a Prolog program to implement palindrome(List).
10. Write a Prolog program to implement max(X,Y,Max) so that Max is the greater of two numbers X and Y.
11. Write a Prolog program to implement maxlist(List,Max) so that Max is the greatest number in the list of numbers List.
12. Write a Prolog program to implement sumlist(List,Sum) so that Sum is the sum of a given list of numbers List.
13. Write a Prolog program to implement two predicates evenlength(List) and oddlength(List) so that they are true if their argument is a list of even or odd length respectively.
14. Write a Prolog program to implement reverse(List,ReversedList) that reverses lists.
15. Write a Prolog program to implement maxlist(List,Max) so that Max is the greatest number in the list of numbers List using cut predicate.
16. Write a Prolog program to implement GCD of two numbers.
17. Write a prolog program that implements Semantic Networks/Frame Structures.

**CORE 14 (CSC 6.21)  
COMPUTER GRAPHICS**

*Theory Credit: 4*

*Teaching Hours: 60*

- 1. Introduction:** Basic elements of Computer graphics, Applications of Computer Graphics.
- 2. Graphics Hardware:** Architecture of Raster and Random scan display devices, input/output devices.
- 3. Fundamental Techniques in Graphics:** Raster scan line, circle and ellipse drawing, thick primitives, Polygon filling, line and polygon clipping algorithms, 2D and 3D Geometric Transformations, 2D and 3D Viewing Transformations (Projections- Parallel and Perspective), Vanishing points.
- 4. Geometric Modeling:** Representing curves & Surfaces.
- 5.** Hidden surface elimination. Illumination and shading models. Basic color models and Computer Animation

***Recommended Books and References:***

1. J.D.Foley, A.Van Dan, Feiner, Hughes Computer Graphics Principles & Practice 2<sup>nd</sup> edition Publication Addison Wesley 1990.
2. D.Hearn, Baker: Computer Graphics, Prentice Hall of India 2008.
3. D.F.Rogers Procedural Elements for Computer Graphics, McGraw Hill 1997.
4. D.F.Rogers, Adams Mathematical Elements for Computer Graphics, McGraw Hill 2<sup>nd</sup> edition 1989.

**CORE 14 (CSC 6.22)**  
**COMPUTER GRAPHICS LAB**

1. Write a program to implement Bresenham's line drawing algorithm.
2. Write a program to implement mid-point circle drawing algorithm.
3. Write a program to clip a line using Cohen and Sutherland line clipping algorithm.
4. Write a program to clip a polygon using Sutherland Hodgeman algorithm.
5. Write a program to apply various 2D transformations on a 2D object (use homogenous coordinates).
6. Write a program to apply various 3D transformations on a 3D object and then apply parallel and perspective projection on it.
7. Write a program to draw Hermite/Bezier curve.

## DISCIPLINE SPECIFIC ELECTIVES

### DISCIPLINE SPECIFIC ELECTIVES 1 (CSD 5.11)

#### PHP PROGRAMMING

*Theory Credit: 4*

- UNIT I Introduction to PHP:** PHP introduction, inventions and versions, important tools and software requirements (like Web Server, Database, Editors Basic Syntax, PHP variables PHP with other technologies, scope of PHP etc.) and constants Types of data in PHP , Expressions, scopes of a variable (local, global) PHP Operators : Arithmetic, Assignment, Relational , Logical operators, Bitwise , ternary and MOD operator. PHP operator Precedence and associativity
- UNIT II Handling HTML form with PHP:** GET and Capturing Form Data Redirecting a form after Dealing with multi value fields POST form methods submission
- UNIT III PHP conditional events and Loops:** PHP IF Else conditional Switch case, while, For and Do While Loop statements (Nested IF and Else) Goto , Break ,Continue and exit
- UNIT IV PHP Functions:** Function, Need of Function, declaration and calling of a Function PHP Function with arguments, Default Arguments in Function function Scope of Function Global and argument with call by value, call by reference Local
- UNIT V String Manipulation and Regular Expression:** Creating and accessing String , Searching & Replacing String Formatting, joining and splitting String , String Use and advantage of regular expression over inbuilt Related Library functions Use of preg\_match(), preg\_replace(), preg\_split() functions in function regular expression

#### **Recommended Books and References:**

1. Steven Holzner, "PHP: The Complete Reference Paperback", McGraw Hill Education (India), 2007.
2. Timothy Boronczyk, Martin E. Psinas, "PHP and MYSQL (Create-Modify-Reuse)", Wiley India Private Limited, 2008.
3. Robin Nixon, "Learning PHP, MySQL, JavaScript, CSS & HTML5", 3rd Edition Paperback, O'reilly, 2014.

### DISCIPLINE SPECIFIC ELECTIVES 1 (CSD 5.12)

#### SOFTWARE LAB BASED ON PHP

1. Create a PHP page using functions for comparing three integers and print the largest number.
2. Write a function to calculate the factorial of a number (non-negative integer). The function accept the number as an argument.
3. WAP to check whether the given number is prime or not.
4. Create a PHP page which accepts string from user. After submission that page displays the reverse of provided string.
5. Write a PHP function that checks if a string is all lower case.

6. Write a PHP script that checks whether a passed string is palindrome or not? (A palindrome is word, phrase, or sequence that reads the same backward as forward, e.g., madam or nurses run)
7. WAP to sort an array.
8. Write a PHP script that removes the whitespaces from a string.  
Sample string : 'The quick " " brown fox' Expected Output : Thequick""brownfox

## **DISCIPLINE SPECIFIC ELECTIVES 2 (CSD 5.21)**

### **PROGRAMMING IN VISUAL BASIC**

- UNIT I    Overview Environment:** *Overview:* Visual Basic Application Types, Visual Basic Application Components- (Projects, Forms, Controls, Code modules, Class modules, User controls, Property pages)  
*VB Environment:* Menu Bar, Toolbar, Toolbox, Form, Project explorer, Property window, Immediate window, Form layout window. Creating a project, Forms, Naming a project, Saving a project.  
*Controls:* Label control, TextBox control, Command Button, Frames, Option Buttons, Check Boxes, Picture control, Image Control, Shape control, Line control, Timer control, HscrollBar control, VscrollBar control, FileListBox control, DirListBox, DriveListBox control.  
*List and Menus:* List Box control, Combo Box Control, Menu editor.
- UNIT II    Programming:** *Variables:* Data types, Declaring variables, Scope and lifetime of a variable, Examples of variables, Variant datatypes.    *Arrays:* Different Array types, Control Array.  
*Conditional Logic and Looping:* If... Then, Select... Case, Do...While, While...Wend, Loop...While, Do...Until, Loop...Until, For... Next, Nested constructs, Exit For/Exit Do, Exit Sub/Exit Function
- UNIT III    Built in Functions:** *Built-in Functions:* String Functions, Date Functions, MsgBox, InputBox, Common Dialog Control.
- UNIT IV    Data control and Programming:** JET database Engine, ADODC, DAO Data Control  
*Data Entry with ADO:* Creating a new ADO project, Adding data, Editing data, Deleting data.
- UNIT V    Creating Reports:** Data Report and crystal Report.

#### **Recommended Books and References:**

1. Paul D Sheriff Sheriff, Paul Sheriff Teaches Visual Basic 6, Prentice Hall of India
2. Evangelos Petroutsos, Mastering Visual Basic 6, BPB Publication,
3. Michel C Amundsen and Curties L Smith Smith, Teach Yourself Database Programming with Visual Basic 5 in 21 Days, TechMedia
4. Peter Norton, Peter Norton's Guide to Visual Basic 6, Techmedia

**DISCIPLINE SPECIFIC ELECTIVES 2 (CSD 5.22)**  
**VISUAL BASIC (PRACTICAL)**

1. Design a form and place a TextBox in it. Call it (assign its name property) txtInput. Place a Command Button and call it cmdExtract. Assign the caption property of the Command button as "Extract". Write a program to extract each digit or letter of a number, word or sentence that is entered in txtInput and display them in a second Text Box called txtOutput, one at a time on the click of a button.
2. Design a form with suitable controls to input a single digit number and write appropriate event handlers to check if the number is automorphic or not. A number is called automorphic if the last digit of the square of the number is same as the number itself.(e.g. 6).
3. Design a form with suitable controls and write appropriate event handlers to take in a string and determine whether the given string is palindrome or not.
4. Design a form with suitable controls and write appropriate event handlers to generate the calendar of agiven month. The user must enter the month and the year. Assume that 1st January 1900 was a Monday. Do not use the standard Visual Basic functions to generate the calendar.
5. Write a program to calculate and display the factorial of a given number, using a recursive function.
6. The following information is to be maintained regarding the users of electricity: Name, code and units consumed. Write a program that will take the name and units consumed and hence generate a bill. For the first 20 units cost is 30p/unit, for the next 20 units, 40p/unit, for the rest, 50p/unit. Make provisions for reading, editing and deleting data. Make provisions to keep the rates alterable. Use ADO data control.

**DISCIPLINE SPECIFIC ELECTIVES 3 (CSD 6.11)**  
**CLOUD COMPUTING**

- UNIT I** Recent trends in Computing: Grid Computing, Cluster Computing, Distributed Computing, Utility Computing, Cloud Computing, Cloud service providers, Benefits and limitations of Cloud Computing
- UNIT II** Cloud Computing Architecture, Comparison with traditional computing architecture (client/server), Services provided at various levels,
- UNIT III** Service Models- Infrastructure as a Service(IaaS), Platform as a Service(PaaS), Software asa Service(SaaS), How Cloud Computing Works, Deployment Models- Public cloud, Private cloud, Hybrid cloud, Community cloud
- UNIT IV** Service Management in Cloud Computing, Service Level Agreements(SLAs), Billing & Accounting, Comparing Scaling Hardware: Traditional vs. Cloud, Economics of scaling.  
Examples of cloud systems like Google App Engine, Microsoft Azure, AmazonEC2
- UNIT V** Cloud Security, Infrastructure Security, Network level security, Host level security, Application level security, Data security and Storage- Data privacy and security Issues, Jurisdictional issues raised by Data location, Authentication in cloud computing

**Recommended Books and References:**

1. Cloud Computing – U S Pandey and K Choudhary, S Chand
2. Cloud Computing: Principles and Paradigms - Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wiley

**DISCIPLINE SPECIFIC ELECTIVES 3 (CSD 6.12)  
SOFTWARE LAB BASED ON CLOUD COMPUTING**

1. Create virtual machines that access different programs on same platform.
2. Create virtual machines that access different programs on different platforms.
3. Exploring Google cloud **for the following**
  - a) **Storage**
  - b) **Sharing of data**
  - c) Manage your calendar, to-do lists,
  - d) A document editing tool
4. Exploring Microsoft cloud
5. Exploring Amazon cloud

**DISCIPLINE SPECIFIC ELECTIVES 1 (CSD 6.21)  
SOFTWARE DEVELOPMENT PROJECT WORK**

*Credit: 6*

A student has to undertake a software development project work under the guidance of a teacher during the 6th semester. After completion of the project, the student has to submit a project report which will be evaluated by an External Examiner.

## SKILL ENHANCEMENT COURSE

### SKILL ENHANCEMENT COURSE 1 (CSS 3.11) HTML PROGRAMMING

*Theory Credit: 2*

- UNIT I Introduction** •The Head, the BodyColors, Attributes Lists, ordered and unordered
- UNIT II Links**Introduction Relative Links, Absolute Links Link Attributes Using the ID Attribute to Link Within a Document
- UNIT III Images** (2L) o Putting an Image on a Page Using Images as Links Putting an Image in the Background
- UNIT IV Tables** (4L) o Creating a Table Table HeadersCaptions Spanning Multiple Columns Styling Table
- UNIT V Forms** Basic Input and Attributes Other Kinds of InputsStyling forms with CSS Where To Go From Here

#### **Recommended Books and References:**

1. Introduction to **HTML** and CSS -- O'Reilly , 2010
2. Jon Duckett, HTML and CSS, John Wiely, 2012

#### **SOFTWARE LAB BASED ON HTML**

Q.1 Create an HTML document with the following formatting options:

- I. Bold
- II. Italics
- III. Underline
- IV. Headings (Using H1 to H6 heading styles)
- V. Font (Type, Size and Color)
- VI. Background (Colored background/Image in background)
- VII. Paragraph
- VIII. Line Break
- IX. Horizontal Rule
- X. Pre tag

Q.2 Create an HTML document which consists of:

- I. Ordered List
- II. Unordered List
- III. Nested List
- IV. Image

Q.3 Create a form using HTML which has the following types of controls:

- I. Text Box
- II. Option/radio buttons
- III. Check boxes
- IV. Reset and Submit buttons

Q4 Create an HTML document which implements Internal linking as well as External linking.

**SKILL ENHANCEMENT COURSE 2 (CSS 4.11)**  
**PROGRAMMING IN MATLAB**

- UNIT I** Introduction to Programming: Components of a computer, working with numbers, Machine code, Software hierarchy
- UNIT II** Programming Environment: MATLAB Windows, A First Program, Expressions, Constants, Variables and assignment statement, Arrays.
- UNIT III** Graph Plots: Basic plotting, Built in functions, Generating waveforms, Sound replay, load and save. Procedures and Functions: Arguments and return values, M-files Formatted console input-output, String handling
- UNIT IV** Control Statements: Conditional statements: If, Else, Else-if, Repetition statements: While, for loop
- UNIT V** Manipulating Text: Writing to a text file, Reading from a text file, Randomising and sorting a list, searching a list. GUI Interface: Attaching buttons to actions, Getting Input, Setting Output

***Recommended Books and References:***

1. MATLAB: An Introduction with Applications, by Amos Gilat, 2nd edition, Wiley, 2004,
2. C.B. Moler, Numerical Computing with MATLAB, SIAM, 2004.

**SOFTWARE LAB BASED ON MATLAB**

1. Celsius temperatures can be converted to Fahrenheit by multiplying by 9, dividing by 5, and adding 32. Assign a variable called C the value 37 and implement this formula to assign a variable F the Fahrenheit equivalent of 37 Celsius.
2. supermarket conveyor belt holds an array of groceries. The price of each product (in pounds) is [ 0.6, 1.2 ,0.5, 1.3 ] ; while the numbers of each product are [ 3, 2 ,1 ,5 ]. Use MATLAB to calculate the total bill.
3. The sortrows(x) function will sort a vector or matrix X into increasing row order. Use this function to sort a list of names into alphabetical order.
4. The  $-identity$  matrix is a square matrix that has ones on the diagonal and zeros elsewhere. You can generate one with the eye() function in MATLAB. Use MATLAB to find a matrix B, such that when multiplied by matrix  $A = \begin{bmatrix} 1 & 2 \\ -1 & 0 \end{bmatrix}$  the identity matrix  $I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$  is generated. That is  $A*B=I$ .
5. Create an array of N numbers. Now find a single MATLAB statement that picks out from that array the 1,4,9,16,...,Nth entries, i.e. those numbers which have indices that are square numbers.
6. Draw a graph that joins the points (0,1), (4,3), (2,0) and (5,-2).



SYLLABUS FOR  
Bachelor of Arts (Honours)

**ECONOMICS**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)



### COURSE STRUCTURE

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
I	Core 1	Introductory Microeconomics	ECC 1.11	6
	Core 2	Mathematical Methods for Economics-I	ECC 1.21	6
II	Core 3	Introductory Macroeconomics	ECC 2.11	6
	Core 4	Mathematical Methods for Economics-II	ECC 2.21	6
III	Core 5	Intermediate Microeconomics-I	ECC 3.11	6
	Core 6	Intermediate Macroeconomics-I	ECC 3.21	6
	Core 7	Statistical Methods for Economics	ECC 3.31	6
	Skill Enhancement Course 1	Skill Enhancement Course I	ECS 3.11	2
IV	Core 8	Intermediate Microeconomics-II	ECC 4.11	6
	Core 9	Intermediate Macroeconomics-II	ECC 4.21	6
	Core 10	Introductory Econometrics	ECC 4.31	6
	Skill Enhancement Course 2	Skill Enhancement Course II	ECS 4.11	2
V	Core 11	Indian Economy-I	ECC 5.11	6
	Core 12	Development Economics-I	ECC 5.21	6
	Discipline Specific Elective 1	Discipline Specific Elective I	ECD 5.11	6
	Discipline Specific Elective 2	Discipline Specific Elective II	ECD 5.21	6
VI	Core 13	Indian Economy-II	ECC 6.11	6
	Core 14	Development Economics-II	ECC 6.21	6
	Discipline Specific Elective 3	Discipline Specific Elective III	ECD 6.11	6
	Discipline Specific Elective 4	Discipline Specific Elective IV	ECD 6.21	6

## SEMESTER - I

### CORE 1 (ECC 1.11) INTRODUCTORY MICROECONOMICS

*Theory Credit: 6*

#### **1. Exploring the subject matter of Economics**

Why study economics? Scope and method of economics; the economic problem: scarcity and choice; the question of what to produce, how to produce and how to distribute output; science of economics; the basic competitive model; prices, property rights and profits; incentives and information; rationing; opportunity sets; economic systems; reading and working with graphs.

#### **2. Supply and Demand: How Markets Work, Markets and Welfare**

Markets and competition; determinants of individual demand/supply; demand/supply schedule and demand/supply curve; market versus individual demand/supply; shifts in the demand/supply curve, demand and supply together; how prices allocate resources; elasticity and its application; controls on prices; taxes and the costs of taxation; consumer surplus; producer surplus and the efficiency of the markets.

#### **3. The Households**

The consumption decision - budget constraint, consumption and income/price changes, demand for all other goods and price changes; description of preferences (representing preferences with indifference curves); properties of indifference curves; consumer's optimum choice; income and substitution effects; labour supply and savings decision - choice between leisure and consumption.

#### **4. The Firm and Perfect Market Structure**

Behaviour of profit maximizing firms and the production process; short run costs and output decisions; costs and output in the long run.

#### **5. Imperfect Market Structure**

Monopoly and anti-trust policy; government policies towards competition; imperfect competition.

#### **6. Input Markets**

Labour and land markets - basic concepts (derived demand, productivity of an input, marginal productivity of labour, marginal revenue product); demand for labour; input demand curves; shifts in input demand curves; competitive labour markets; and labour markets and public policy.

#### **Recommended Books and References:**

1. Karl E. Case and Ray C. Fair, *Principles of Economics*, Pearson Education Inc., 8<sup>th</sup> Edition, 2007.
2. N. Gregory Mankiw, *Economics: Principles and Applications*, India edition by South Western, a part of Cengage Learning, Cengage Learning India Private Limited, 4<sup>th</sup> edition, 2007.
3. Joseph E. Stiglitz and Carl E. Walsh, *Economics*, W.W. Norton & Company, Inc., New York, International Student Edition, 4<sup>th</sup> Edition, 2007.

**CORE 2 (ECC 1.21)**  
**MATHEMATICAL METHODS IN ECONOMICS-I**

*Theory Credit: 6*

**1. Preliminaries**

Logic and proof techniques; sets and set operations; relations; functions and their properties; number systems.

**2. Functions of one real variable**

Graphs; elementary types of functions: quadratic, polynomial, power, exponential, logarithmic; sequences and series: convergence, algebraic properties and applications; continuous functions: characterizations, properties with respect to various operations and applications; differentiable functions: characterizations, properties with respect to various operations and applications; second and higher order derivatives: properties and applications.

**3. Single-variable optimization**

Geometric properties of functions: convex functions, their characterizations and applications; local and global optima: geometric characterizations, characterizations using calculus and applications.

**4. Integration of functions**

**5. Difference equations**

***Recommended Books and References:***

1. K. Sydsaeter and P. Hammond, *Mathematics for Economic Analysis*, Pearson Educational Asia: Delhi, 2002.

## SEMESTER – II

### CORE 3 (ECC 2.11)

#### INTRODUCTORY MACROECONOMICS

*Theory Credit: 6*

##### **1. Introduction to Macroeconomics and National Income Accounting**

Basic issues studied in macroeconomics; measurement of gross domestic product; income, expenditure and the circular flow; real versus nominal GDP; price indices; national income accounting for an open economy; balance of payments: current and capital accounts.

##### **2. Money**

Functions of money; quantity theory of money; determination of money supply and demand; credit creation; tools of monetary policy.

##### **3. Inflation**

Inflation and its social costs; hyperinflation.

##### **4. The Closed Economy in the Short Run**

Classical and Keynesian systems; simple Keynesian model of income determination; IS-LM model; fiscal and monetary multipliers.

##### **Recommended Books and References:**

1. Dornbusch, Fischer and Startz, *Macroeconomics*, McGraw Hill, 11<sup>th</sup> edition, 2010.
2. N. Gregory Mankiw. *Macroeconomics*, Worth Publishers, 7<sup>th</sup> edition, 2010.
3. Olivier Blanchard, *Macroeconomics*, Pearson Education, Inc., 5<sup>th</sup> edition, 2009.
4. Richard T. Froyen, *Macroeconomics*, Pearson Education Asia, 2<sup>nd</sup> edition, 2005.
5. Andrew B. Abel and Ben S. Bernanke, *Macroeconomics*, Pearson Education, Inc., 7<sup>th</sup> edition, 2011.
6. Errol D'Souza, *Macroeconomics*, Pearson Education, 2009.
7. Paul R. Krugman, Maurice Obstfeld and Marc Melitz, *International Economics*, Pearson Education Asia, 9<sup>th</sup> edition, 2012.

### CORE 4 (ECC 2.21)

#### MATHEMATICAL METHODS IN ECONOMICS - II

*Theory Credit: 6*

##### **1. Differential equations**

##### **2. Linear algebra**

Vector spaces: algebraic and geometric properties, scalar products, norms, orthogonality; linear transformations: properties, matrix representations and elementary operations; systems of linear equations: properties of their solution sets; determinants: characterization, properties and applications.

##### **3. Functions of several real variables**

Geometric representations: graphs and level curves; differentiable functions: characterizations, properties with respect to various operations and applications; second order derivatives:

properties and applications; the implicit function theorem, and application to comparative statics problems; homogeneous and homothetic functions: characterizations and applications.

#### **4. Multi-variable optimization**

Convex sets; geometric properties of functions: convex functions, their characterizations, properties and applications; further geometric properties of functions: quasiconvex functions, their characterizations, properties and applications; unconstrained optimization: geometric characterizations, characterizations using calculus and applications; constrained optimization with equality constraints: geometric characterizations, lagrange characterization using calculus and applications; properties of value function: envelope theorem and applications.

#### ***Recommended Books and References:***

1. K. Sydsaeter and P. Hammond, *Mathematics for Economic Analysis*, Pearson Educational Asia: Delhi, 2002.

## SEMESTER – III

### CORE 5 (ECC 3.11)

#### INTERMEDIATE MICROECONOMICS - I

*Theory Credit: 6*

##### 1. Consumer Theory

Preference; utility; budget constraint; choice; demand; Slutsky equation; buying and selling; choice under risk and intertemporal choice; revealed preference.

##### 2. Production, Costs and Perfect Competition

Technology; isoquants; production with one and more variable inputs; returns to scale; short run and long run costs; cost curves in the short run and long run; review of perfect competition.

##### **Recommended Books and References:**

1. Hal R. Varian, *Intermediate Microeconomics, a Modern Approach*, W.W. Norton and Company/Affiliated East-West Press (India), 8<sup>th</sup> edition, 2010. The workbook by Varian and Bergstrom may be used for problems.
2. C. Snyder and W. Nicholson, *Fundamentals of Microeconomics*, Cengage Learning (India), 2010.
3. B. Douglas Bernheim and Michael D. Whinston, *Microeconomics*, Tata McGraw-Hill (India), 2009.

### CORE 6 (ECC 3.21)

#### INTERMEDIATE MACROECONOMICS - I

*Theory Credit: 6*

##### 1. Aggregate Demand and Aggregate Supply Curves

Derivation of aggregate demand and aggregate and supply curves; interaction of aggregate demand and supply.

##### 2. Inflation, Unemployment and Expectations

Phillips curve; adaptive and rational expectations; policy ineffectiveness debate.

##### 3. Open Economy Models

Short-run open economy models; Mundell-Fleming model; exchange rate determination; purchasing power parity; asset market approach; Dornbusch's overshooting model; monetary approach to balance of payments; international financial markets.

##### **Recommended Books and References:**

1. Dornbusch, Fischer and Startz, *Macroeconomics*, McGraw Hill, 11<sup>th</sup> edition, 2010.
2. N. Gregory Mankiw. *Macroeconomics*, Worth Publishers, 7<sup>th</sup> edition, 2010.
3. Olivier Blanchard, *Macroeconomics*, Pearson Education, Inc., 5<sup>th</sup> edition, 2009.
4. Steven M. Sheffrin, *Rational Expectations*, Cambridge University Press, 2<sup>nd</sup> edition, 1996.
5. Andrew B. Abel and Ben S. Bernanke, *Macroeconomics*, Pearson Education, Inc., 7<sup>th</sup> edition, 2011.
6. Errol D'Souza, *Macroeconomics*, Pearson Education, 2009



7. Paul R. Krugman, Maurice Obstfeld and Marc Melitz, *International Economics*, Pearson Education Asia, 9<sup>th</sup> edition, 2012.

**CORE 7 (ECC 3.31)**  
**STATISTICAL METHODS FOR ECONOMICS**

*Theory Credit: 6*

**1. Introduction and Overview**

The distinction between populations and samples and between population parameters and sample statistics; the use of measures of location and variation to describe and summarize data; population moments and their sample counterparts.

**2. Elementary Probability Theory**

Sample spaces and events; probability axioms and properties; counting techniques; conditional probability and Bayes' rule; independence.

**3. Random Variables and Probability Distributions**

Defining random variables; probability distributions; expected values of random variables and of functions of random variables; properties of commonly used discrete and continuous distributions (uniform, binomial, normal, poisson and exponential random variables).

**4. Random Sampling and Jointly Distributed Random Variables**

Density and distribution functions for jointly distributed random variables; computing expected values; covariance and correlation coefficients.

**5. Sampling**

Principal steps in a sample survey; methods of sampling; the role of sampling theory; properties of random samples.

**6. Point and Interval Estimation**

Estimation of population parameters using methods of moments and maximum likelihood procedures; properties of estimators; confidence intervals for population parameters.

**Recommended Books and References:**

1. Jay L. Devore, *Probability and Statistics for Engineers*, Cengage Learning, 2010.
2. John E. Freund, *Mathematical Statistics*, Prentice Hall, 1992.
3. Richard J. Larsen and Morris L. Marx, *An Introduction to Mathematical Statistics and its Applications*, Prentice Hall, 2011.
4. William G. Cochran, *Sampling Techniques*, John Wiley, 2007.

## SEMESTER – IV

### CORE 8 (ECC 4.11)

#### INTERMEDIATE MICROECONOMICS - II

*Theory Credit: 6*

##### 1. General Equilibrium, Efficiency and Welfare

Equilibrium and efficiency under pure exchange and production; overall efficiency and welfare economics.

##### 2. Market Structure and Game Theory

Monopoly; pricing with market power; price discrimination; peak-load pricing; two-part tariff; monopolistic competition and oligopoly; game theory and competitive strategy.

##### 3. Market Failure

Externalities; public goods and markets with asymmetric information.

##### **Recommended Books and References:**

1. Hal R. Varian, *Intermediate Microeconomics, a Modern Approach*, 8<sup>th</sup> edition, W.W. Norton and Company/Affiliated East-West Press (India), 2010. The workbook by Varian and Bergstrom could be used for problems.
2. C. Snyder and W. Nicholson, *Fundamentals of Microeconomics*, Cengage Learning (India), 2010.

### CORE 9 (ECC 4.21)

#### INTERMEDIATE MACROECONOMICS - II

*Theory Credit: 6*

##### 1. Economic Growth

Harrod-Domar model; Solow model; golden rule; technological progress and elements of endogenous growth.

##### 2. Microeconomic Foundations

- a. Consumption: Keynesian consumption function; Fisher's theory of optimal intertemporal choice; life-cycle and permanent income hypotheses; rational expectations and random-walk of consumption expenditure.
- b. Investment: determinants of business fixed investment; residential investment and inventory investment.
- c. Demand for money.

##### 3. Fiscal and Monetary Policy

Active or passive; monetary policy objectives and targets; rules versus discretion: time consistency; the government budget constraint; government debt and Ricardian equivalence.

##### 4. Schools of Macroeconomic Thoughts

Classicals; Keynesians; New-Classicals and New-Keynesians.

##### **Recommended Books and References:**

1. Dornbusch, Fischer and Startz, *Macroeconomics*, McGraw Hill, 11<sup>th</sup> edition, 2010.
2. N. Gregory Mankiw. *Macroeconomics*, Worth Publishers, 7<sup>th</sup> edition, 2010.

3. Olivier Blanchard, *Macroeconomics*, Pearson Education, Inc., 5<sup>th</sup> edition, 2009.
4. Charles I. Jones, *Introduction to Economic Growth*, W.W. Norton & Company, 2<sup>nd</sup> edition, 2002.
5. Andrew B. Abel and Ben S. Bernanke, *Macroeconomics*, Pearson Education, Inc., 7<sup>th</sup> edition, 2011.
6. Errol D'Souza, *Macroeconomics*, Pearson Education, 2009.
7. Robert J. Gordon, *Macroeconomics*, Prentice-Hall India Limited, 2011.

**CORE 10 (ECC 4.31)**  
**INTRODUCTORY ECONOMETRICS**

*Theory Credit: 6*

**1. Nature and Scope of Econometrics**

**2. Statistical Concepts**

Normal distribution; chi-sq, t- and F-distributions; estimation of parameters; properties of estimators; testing of hypotheses: defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors; power of a test; tests for comparing parameters from two samples.

**3. Simple Linear Regression Model: Two Variable Case**

Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit; tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem; forecasting.

**4. Multiple Linear Regression Model**

Estimation of parameters; properties of OLS estimators; goodness of fit -  $R^2$  and adjusted  $R^2$ ; partial regression coefficients; testing hypotheses – individual and joint; functional forms of regression models; qualitative (dummy) independent variables.

**5. Violations of Classical Assumptions: Consequences, Detection and Remedies**

Multicollinearity; heteroscedasticity; serial correlation.

**6. Specification Analysis**

Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors.

**Recommended Books and References:**

1. Jay L. Devore, *Probability and Statistics for Engineers*, Cengage Learning, 2010.
2. John E. Freund, *Mathematical Statistics*, Prentice Hall, 1992.
3. Richard J. Larsen and Morris L. Marx, *An Introduction to Mathematical Statistics and its Applications*, Prentice Hall, 2011.
4. D. N. Gujarati and D.C. Porter, *Essentials of Econometrics*, McGraw Hill, 4th edition, International Edition, 2009.
5. Christopher Dougherty, *Introduction to Econometrics*, Oxford University Press, 3rd edition, Indian edition, 2007.
6. Jan Kmenta, *Elements of Econometrics*, Indian Reprint, Khosla Publishing House, 2nd edition, 2008.

## SEMESTER – V

### CORE 11 (ECC 5.11) INDIAN ECONOMY-I

Theory Credit: 6

#### 1. Economic Development since Independence

Major features of the economy at independence; growth and development under different policy regimes—goals, constraints, institutions and policy framework; an assessment of performance—sustainability and regional contrasts; structural change, savings and investment.

#### 2. Population and Human Development

Demographic trends and issues; education; health and malnutrition.

#### 3. Growth and Distribution

Trends and policies in poverty; inequality and unemployment.

#### 4. International Comparisons

#### **Recommended Books and References:**

1. Jean Dreze and Amartya Sen, Jean Dreze and Amartya Sen, 2013. *An Uncertain Glory: India and its Contradictions*, Princeton University Press.
2. Pulapre Balakrishnan, 2007, The Recovery of India: Economic Growth in the Nehru Era, *Economic and Political Weekly*, November.
3. Rakesh Mohan, 2008, —Growth Record of Indian Economy: 1950-2008. A Story of Sustained Savings and Investment, *Economic and Political Weekly*, May.
4. S.L. Shetty, 2007, —India's Savings Performance since the Advent of Planning, in K.L. Krishna and A. Vaidyanathan, editors, *Institutions and Markets in India's Development*.
5. Himanshu, 2010, Towards New Poverty Lines for India, *Economic and Political Weekly*, January.
6. Jean Dreze and Angus Deaton, 2009, Food and Nutrition in India: Facts and Interpretations, *Economic and Political Weekly*, February.
7. Himanshu. 2011, —Employment Trends in India: A Re-examination, *Economic and Political Weekly*, September.
8. Rama Baru et al, 2010, —Inequities in Access to Health Services in India: Caste, Class and Region, *Economic and Political Weekly*, September.
9. Geeta G. Kingdon, 2007, —The Progress of School Education in India, *Oxford Review of Economic Policy*.
10. J.B.G. Tilak, 2007, —Post Elementary Education, Poverty and Development in India, *International Journal of Educational Development*.
11. T. Dyson, 2008, —India's Demographic Transition and its Consequences for Development in Uma Kapila, editor, *Indian Economy Since Independence*, 19<sup>th</sup> edition, Academic Foundation.
12. Kaushik Basu, 2009, —China and India: Idiosyncratic Paths to High Growth, *Economic and Political Weekly*, September.
13. K. James, 2008, —Glorifying Malthus: Current Debate on Demographic Dividend in India, *Economic and Political Weekly*, June.
14. Reetika Khera, 2011, —India's Public Distribution System: Utilisation and Impact *Journal of Development Studies*.

15. Aniruddha Krishna and Devendra Bajpai, 2011, –Lineal Spread and Radial Dissipation: Experiencing Growth in Rural India, 1992-2005, *Economic and Political Weekly*, September.
16. Kaushik Basu and A. Maertens, eds, 2013, *The New Oxford Companion to Economics*, Oxford University Press.

**CORE 12 (ECC 5.21)**  
**DEVELOPMENT ECONOMICS-I**

*Theory Credit: 6*

**1. Conceptions of Development**

Alternative measures of development, documenting the international variation in these measures, comparing development trajectories across nations and within them.

**2. Growth Models and Empirics**

The Harrod-Domar model, the Solow model and its variants, endogenous growth models and evidence on the determinants of growth.

**3. Poverty and Inequality: Definitions, Measures and Mechanisms**

Inequality axioms; a comparison of commonly used inequality measures; connections between inequality and development; poverty measurement; characteristics of the poor; mechanisms that generate poverty traps and path dependence of growth processes.

**4. Political Institutions and the Functioning of the State**

The determinants of democracy; alternative institutional trajectories and their relationship with economic performance; within-country differences in the functioning of state institutions; state ownership and regulation; government failures and corruption.

**Recommended Books and References:**

1. Debraj Ray, *Development Economics*, Oxford University Press, 2009.
2. Partha Dasgupta, *Economics, A Very Short Introduction*, Oxford University Press, 2007.
3. Abhijit Banerjee, Roland Benabou and Dilip Mookerjee, *Understanding Poverty*, Oxford University Press, 2006.
4. Kaushik Basu, *The Oxford Companion to Economics in India*, OUP, 2007.
5. Amartya Sen, *Development as Freedom*, OUP, 2000.
6. Daron Acemoglu and James Robinson, *Economic Origins of Dictatorship and Democracy*, Cambridge University Press, 2006.
7. Robert Putnam, *Making Democracy Work: Civic Traditions in Modern Italy*, Princeton University Press, 1994

## SEMESTER – VI

### CORE 13 (ECC 6.11) INDIAN ECONOMY-II

Theory Credit: 6

#### 1. Macroeconomic Policies and Their Impact

Fiscal Policy; trade and investment policy; financial and monetary policies; labour regulation.

#### 2. Policies and Performance in Agriculture

Growth; productivity; agrarian structure and technology; capital formation; trade; pricing and procurement.

#### 3. Policies and Performance in Industry

Growth; productivity; diversification; small scale industries; public sector; competition policy; foreign investment.

#### 4. Trends and Performance in Services

#### **Recommended Books and References:**

1. Shankar Acharya, 2010, —Macroeconomic Performance and Policies 2000-8, in Shankar Acharya and Rakesh Mohan, editors, *India's Economy: Performances and Challenges: Development and Participation*, Oxford University Press.
2. Rakesh Mohan, 2010, —India's Financial Sector and Monetary Policy Reforms, in Shankar Acharya and Rakesh Mohan, editors, *India's Economy: Performances and Challenges: Development and Participation*, Oxford University Press.
3. Pulapre Balakrishnan, Ramesh Golait and Pankaj Kumar, 2008, —Agricultural Growth in India Since 1991, *RBI DEAP Study no. 27*.
4. B.N. Goldar and S.C. Aggarwal, 2005, —Trade Liberalisation and Price-Cost Margin in Indian Industries, *The Developing Economics*, September.
5. P. Goldberg, A. Khandelwal, N. Pavcnik and P. Topalova, 2009, —Trade Liberalisation and New Imported Inputs, *American Economic Review, Papers and Proceedings*, May.
6. Kunal Sen, 2010, —Trade, Foreign Direct Investment and Industrial Transformation in India, in Premachandra Athukorala, editor, *The Rise of Asia*, Routledge.
7. A. Ahsan, C. Pages and T. Roy, 2008, —Legislation, Enforcement and Adjudication in Indian Labour Markets: Origins, Consequences and the Way Forward, in D. Mazumdar and S. Sarkar, editors, *Globalization, Labour Markets and Inequality in India*, Routledge.
8. Dipak Mazumdar and Sandeep Sarkar, 2009, —The Employment Problem in India and the Phenomenon of the 'Missing Middle', *Indian Journal of Labour Economics*.
9. J. Dennis Rajakumar, 2011, —Size and Growth of Private Corporate Sector in Indian Manufacturing, *Economic and Political Weekly*, April.
10. Ramesh Chand, 2010, —Understanding the Nature and Causes of Food Inflation, *Economic and Political Weekly*, February.
11. Bishwanath Goldar, 2011, —Organised Manufacturing Employment: Continuing the Debate, *Economic and Political Weekly*, April.
12. Kaushik Basu and A. Maertens, eds, 2013, *The New Oxford Companion to Economics in India*, Oxford University Press.

**CORE 14 (ECC 6.21)**  
**DEVELOPMENT ECONOMICS-II**

*Theory Credit: 6*

**1. Demography and Development**

Demographic concepts; birth and death rates, age structure, fertility and mortality; demographic transitions during the process of development; gender bias in preferences and outcomes and evidence on unequal treatment within households; connections between income, mortality, fertility choices and human capital accumulation; migration.

**2. Land, Labor and Credit Markets**

The distribution of land ownership; land reform and its effects on productivity; contractual relationships between tenants and landlords; land acquisition; nutrition and labor productivity; informational problems and credit contracts; microfinance; inter-linkages between rural factor markets.

**3. Individuals, Communities and Collective Outcomes**

Individual behavior in social environments, multiple social equilibria; governance in organizations and in communities; individual responses to organizational inefficiency.

**4. Environment and Sustainable Development**

Defining sustainability for renewable resources; a brief history of environmental change; common-pool resources; environmental externalities and state regulation of the environment; economic activity and climate change.

**5. Globalization**

Globalization in historical perspective; the economics and politics of multilateral agreements; trade, production patterns and world inequality; financial instability in a globalized world.

**Recommended Books and References:**

1. Debraj Ray, *Development Economics*, Oxford University Press, 2009.
2. Partha Dasgupta, *Economics, A Very Short Introduction*, Oxford University Press, 2007.
3. Abhijit Banerjee, Roland Benabou and Dilip Mookerjee, *Understanding Poverty*, Oxford University Press, 2006.
4. Thomas Schelling, *Micromotives and Macrobehavior*, W. W. Norton, 1978.
5. Albert O. Hirschman, *Exit, Voice and Loyalty: Responses to Decline in Firms, Organizations and States*, Harvard University Press, 1970.
6. Raghuram Rajan, *Fault Lines: How Hidden Fractures Still Threaten the World Economy*, 2010.
7. Elinor Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press, 1990.
8. Dani Rodrik, *The Globalization Paradox: Why Global Markets, States and Democracy Can't Coexist*, Oxford University Press, 2011.
9. Michael D. Bordo, Alan M. Taylor and Jeffrey G. Williamson (ed.), *Globalization in Historical Perspective*, University of Chicago Press, 2003.

**DISCIPLINE SPECIFIC ELECTIVE**  
**(ECD 5.11, ECD 5.21, ECD 6.11, ECD 6.21)**

**DISCIPLINE SPECIFIC ELECTIVE (i)**  
**ECONOMICS OF HEALTH AND EDUCATION**

*Theory Credit: 6*

**1. Role of Health and Education in Human Development**

Importance in poverty alleviation; health and education outcomes and their relationship with macroeconomic performance.

**2. Microeconomic Foundations of Health Economics**

Demand for health; uncertainty and health insurance market; alternative insurance mechanisms; market failure and rationale for public intervention; equity and inequality.

**3. Evaluation of Health Programs**

Costing, cost effectiveness and cost-benefit analysis; burden of disease.

**4. Health Sector in India: An Overview**

Health outcomes; health systems; health financing.

**5. Education: Investment in Human Capital**

Rate of return to education: private and social; quality of education; signaling or human capital; theories of discrimination; gender and caste discrimination in India.

**6. Education Sector in India: An Overview**

Literacy rates, school participation, school quality measures.

**Recommended Books and References:**

1. William, Jack, *Principles of Health Economics for Developing Countries*, WorldBank Institute Development Studies, 1999.
2. World Development Report, *Investing in Health*, The World Bank, 1993.
3. Ronald G., Ehrenberg and Robert S., Smith, *Modern Labor Economics: Theory and Public Policy*, Addison Wesley, 2005.

**DISCIPLINE SPECIFIC ELECTIVE (ii)**  
**APPLIED ECONOMETRICS**

*Theory Credit: 6*

**1. Stages in Empirical Econometric Research**

**2. Regression Diagnostics and Specification**

Misspecification; functional forms; model selection.

**3. Advanced Topics in Regression Analysis**

Selected Topics:

Dynamic Econometric Models: distributed lag models; autoregressive models; instrumental variable estimation; simultaneous equation models.



#### **4. Panel Data Models**

Methods of estimation; fixed effects model; random effects model.

#### **5. Introduction to Econometric Software Package**

GRET; E-VIEWS; STATA (any one).

#### **Recommended Books and References:**

1. Jeffrey M. Wooldridge, *Econometrics*, CENGAGE learning, India Edition, 2009.
2. Dimitrios Asteriou and Stephen Hall, *Applied Econometrics: A Modern Approach*, Palgrave Macmillan, 2007.
3. Damodar Gujarati, *Econometrics by Example*, Palgrave Macmillan, 2011.

### **DISCIPLINE SPECIFIC ELECTIVE (iii) ECONOMIC HISTORY OF INDIA (1857-1947)**

*Theory Credit: 6*

#### **1. Introduction: Colonial India: Background and Introduction**

Overview of colonial economy.

#### **2. Macro Trends**

National Income; population; occupational structure.

#### **3. Agriculture**

Agrarian structure and land relations; agricultural markets and institutions – credit, commerce and technology; trends in performance and productivity; famines.

#### **4. Railways and Industry**

Railways; the de-industrialisation debate; evolution of entrepreneurial and industrial structure; nature of industrialisation in the interwar period; constraints to industrial breakthrough; labor relations.

#### **5. Economy and State in the Imperial Context**

The imperial priorities and the Indian economy; drain of wealth; international trade, capital flows and the colonial economy – changes and continuities; government and fiscal policy.

#### **Recommended Books and References:**

1. Lakshmi Subramanian, “*History of India 1707-1857*”, Orient Blackswan, 2010, Chapter
2. Sumit Guha, 1991, Mortality decline in early 20<sup>th</sup> century India’, *Indian Economic and Social History Review (IESHR)*, pp 371-74 and 385-87.
3. Tirthankar Roy, *The Economic History of India 1857-1947*, Oxford University Press, 3rd edition, 2011.
4. J. Krishnamurty, *Occupational Structure*, Dharma Kumar (editor), The Cambridge Economic History of India, Vol. II, (henceforth referred to as CEHI), 2005, Chapter 6.
5. Irfan Habib, *Indian Economy 1858-1914*, A People’s History of India, Vol.28, Tulika, 2006.
6. Ira Klein, 1984, –When Rains Fail: Famine relief and mortality in British India, *IESHR*.
7. Jean Dreze, *Famine Prevention in India in Dreze and Sen (eds.) Political Economy of Hunger*, WIDER Studies in Development Economics, 1990, pp.13-35.
8. John Hurd, *Railways*, CEHI, Chapter 8, pp.737-761.

9. Rajat Ray (ed.), *Entrepreneurship and Industry in India*, 1994.
10. AK Bagchi, –Deindustrialization in India in the nineteenth century: Some theoretical implications, *Journal of Development Studies*, 1976.
11. MD Morris, *Emergence of an Industrial Labour Force in India*, OUP 1965, Chapter 11, Summary and Conclusions.
12. K.N. Chaudhuri, *Foreign Trade and Balance of Payments*, CEHI, Chapter 10.
13. B.R. Tomlison, 1975, *India and the British Empire 1880-1935*, IESHR, Vol.XII.
14. Dharma Kumar, *The Fiscal System*, CEHI, Chapter 12.
15. Basudev Chatterjee, *Trade, Tariffs and Empire*, OUP 1992, Epilogue.

**Background reading for students:**

- Irfan Habib, *Indian Economy 1858-1914* (A People's History of India), Vol.28, Tulika 2006.
- Daniel Thorner, *Agrarian Prospect in India*, 1977.
- L. Visaria and P. Visaria, *Population*. CEHI, Chapter 5.

**DISCIPLINE SPECIFIC ELECTIVE (iv)  
TOPICS IN MICROECONOMICS - I**

*Theory Credit: 6*

**1. Normal form games**

The normal form; dominant and dominated strategies; dominance solvability; mixed strategies; Nash equilibrium; symmetric single population games; applications.

**2. Extensive form games with perfect information**

The game tree; strategies; subgame perfection; backward induction in finite games; commitment; bargaining; other applications.

**Recommended Books and References:**

1. Martin J. Osborne, *An Introduction to Game Theory*, Oxford University Press, New Delhi, 2004.

**DISCIPLINE SPECIFIC ELECTIVE (v)  
POLITICAL ECONOMY-I**

*Theory Credit: 6*

**1. Introduction and Historical Overview**

Perspective on political economy with a historical overview: capitalist development in the pre-second world war period, the 'golden age' and later.

**2. Changing Dynamics of Capitalist Production, Organisational Form and Labour Process**

Fordist and post-fordist production; changing dynamics of organisation of production, markets and labour process; the changing nature of job security and labour rights.

**3. The State in the Era of Globalisation: Welfare, Development and Autonomy**

Globalisation and the limits of the welfare state, development and state autonomy.

#### **4. The Changing Role of Finance**

The changing role of finance in capital accumulation and corporate structure; finance and globalisation - financialisation, financial liberalisation and financial crisis.

#### **5. The Social Dimension**

Globalisation and uneven development – growth, inequality and exclusion.

#### **6. New Perspectives**

Gender in work, accumulation and globalisation; issues in environment and sustainability; alternatives ahead.

#### **Recommended Books and References:**

1. Michel Beaud, *A History of Capitalism, 1500-2000*, trans. by Tom Dickman and Anny Lefebvre, New York: Monthly Review Press, 2001.
2. Ash Amin (ed.), *Post-Fordism: A Reader*, Blackwell, 1994.
3. Fran Tonkiss, *Contemporary Economic Sociology: Globalisation, Production, Inequality*, Chapter 4 (Fordism and After), Routledge India 2008 reprint, 2006.
4. S. Hymer, "The Multinational Corporation and the Law of Uneven Development", in H. Radice (ed.) *International Firms and Modern Imperialism*, Penguin Books, 1975.
5. G. Gereffi, J. Humphrey and T. Sturgeon, 2005, –The Governance of Global Value Chains, *Review of International Political Economy*, Volume 12: 78–104.
6. Narasimha Reddy, –Economic Globalisation, Past and Present – The Challenges to Labour, in Jomo K.S. & Khoo KhayJin (ed.) *Globalization and Its Discontents, Revisited*, Sepsis - Tulika Books, 2003.
7. David Harvey, *A Brief History of Neoliberalism*, OUP, 2005.
8. Andrew Glyn, –Challenges to Capital, in *Capitalism Unleashed: Finance, Globalization and Welfare*, Oxford: Oxford University Press, (Ch. One, pp. 1-24), 2006.
9. G Dumenil and D Levy, *The Crisis of Neoliberalism*, Harvard University Press, 2011.
10. K.S. Jomo (ed.), *The Long Twentieth Century: The Great Divergence: Hegemony, Uneven Development and Global Inequality*, OUP, 2006.
11. Gary Dymksy, 2005, –Financial Globalization, Social Exclusion and Financial Crisis, *International Review of Applied Economics*, Vol. 19: 439–457.
12. E. Stockhammer, –Financialization and the Global Economy, in G. Epstein and M.H. Wolfson (ed.) *The Political Economy of Financial Crises*, Oxford University Press, 2010. [Also in Working Paper Series, No. 240, Political Economy Research Institute, University of Massachusetts Amherst]
13. J.P. Smith and M.P. Ward, 1989, –Women in the Labour Market and in the Family, *Journal of Economic Perspectives*, Volume 3: 9-23.
14. Marilyn Power, 2004, –Social Provisioning as a Starting Point for Feminist Economics, *Feminist Economics*, Volume 10: 3-19.
15. John Bellamy Foster, *Ecology against Capitalism*, Monthly Review Press, 2002

#### **DISCIPLINE SPECIFIC ELECTIVE (vi)**

#### **MONEY AND FINANCIAL MARKETS**

*Theory Credit: 6*

#### **1. Money**

Concept, functions, measurement; theories of money supply determination.

## **2. Financial Institutions, Markets, Instruments and Financial Innovations**

- a. Role of financial markets and institutions; problem of asymmetric information – adverse selection and moral hazard; financial crises.
- b. Money and capital markets: organization, structure and reforms in India; role of financial derivatives and other innovations.

## **3. Interest Rates**

Determination; sources of interest rate differentials; theories of term structure of interest rates; interest rates in India.

## **4. Banking System**

- a. Balance sheet and portfolio management.
- b. Indian banking system: Changing role and structure; banking sector reforms.

## **5. Central Banking and Monetary Policy**

Functions, balance sheet; goals, targets, indicators and instruments of monetary control; monetary management in an open economy; current monetary policy of India.

### **Recommended Books and References:**

1. F. S. Mishkin and S. G. Eakins, *Financial Markets and Institutions*, Pearson Education, 6<sup>th</sup> edition, 2009.
2. F. J. Fabozzi, F. Modigliani, F. J. Jones, M. G. Ferri, *Foundations of Financial Markets and Institutions*, Pearson Education, 3<sup>rd</sup> edition, 2009.
3. M. R. Baye and D. W. Jansen, *Money, Banking and Financial Markets*, AITBS, 1996. Rakesh Mohan, *Growth with Financial Stability- Central Banking in an Emerging Market*, Oxford University Press, 2011.
4. L. M. Bhole and J. Mahukud, *Financial Institutions and Markets*, Tata McGraw Hill, 5<sup>th</sup> edition, 2011.
5. M. Y. Khan, *Indian Financial System*, Tata McGraw Hill, 7<sup>th</sup> edition, 2011.
6. N. Jadhav, *Monetary Policy, Financial Stability and Central Banking in India*, Macmillan, 2006.
7. R.B.I. – *Report of the Working Group: Money Supply Analytics and Methodology of Compilation*, 1998.
8. R.B.I. Bulletin, Annual Report and Report on Currency and Finance (latest).

## **DISCIPLINE SPECIFIC ELECTIVE (vii)**

### **PUBLIC ECONOMICS**

*Theory Credit: 6*

#### **1. Public Economic Theory**

- a. Fiscal functions: an overview.
- b. Public Goods: definition, models of efficient allocation, pure and impure public goods, free riding.
- c. Externalities: the problem and its solutions, taxes versus regulation, property rights, the Coase theorem.
- d. Taxation: its economic effects; dead weight loss and distortion, efficiency and equity considerations, tax incidence, optimal taxation.

#### **2. Indian Public Finances**

- a. Tax System: structure and reforms
- b. Budget, deficits and public debt
- c. Fiscal federalism in India

**Recommended Books and References:**

1. J. Hindriks, G. Myles: *Intermediate Public Economics*, MIT Press, 2006.
2. H. Rosen, T. Gayer: *Public Finance*, 9<sup>th</sup> ed., McGraw-Hill/Irwin, 2009.
3. Joseph E. Stiglitz, *Economics of the Public Sector*, W.W. Norton & Company, 3<sup>rd</sup> edition, 2000.
4. R.A. Musgrave and P.B. Musgrave, *Public Finance in Theory & Practice*, McGraw Hill Publications, 5<sup>th</sup> edition, 1989.
5. John Cullis and Philip Jones, *Public Finance and Public Choice*, Oxford University Press, 1<sup>st</sup> edition, 1998.
6. Harvey Rosen, *Public Finance*, McGraw Hill Publications, 7<sup>th</sup> edition, 2005.
7. Mahesh Purohit, *Value Added Tax: Experiences of India and Other Countries*, 2007.
8. Kaushik Basu and A. Maertens (ed.), *The New Oxford Companion to Economics in India*, Oxford University Press, 2013.
9. M.M. Sury, *Government Budgeting in India*, 1990.
10. M. Govinda Rao, *Changing Contours of Federal Fiscal Arrangements in India*, Amaresh Bagchi (ed.), *Readings in Public Finance*, Oxford University Press, 2005.
11. Paul Samuelson, 1955, —Diagrammatic Exposition of a theory of Public Expenditure, *Review of Economics and Statistics*, Volume 37.
12. Shankar Acharya, 2005, —Thirty Years of Tax Reform in India, *Economic and Political Weekly*, May 14-20.
13. Rangarajan and D.K. Srivastava, 2005, —Fiscal Deficit and Government Debt: Implications for Growth and Stabilization”, *Economic and Political Weekly*, July 2-8.
14. M. Govinda Rao, 2011, —Goods and Services Tax: A Gorilla, Chimpanzee or a Genius like Primates? *Economic and Political Weekly*, February 12-18.
15. Report of the 13<sup>th</sup> Finance Commission, 2010-15.
16. *Economic Survey*, Government of India (Latest).
17. *State Finances: A Study of Budgets*, Reserve Bank of India (Latest).

**DISCIPLINE SPECIFIC ELECTIVE (viii)  
POLITICAL ECONOMY-II**

*Theory Credit: 6*

**1. Analysing Social Change in Historical Perspective**

The method of historical materialism; the transition from feudalism to capitalism; capitalism as a historical process – alternative perspectives.

**2. Capitalism as an Evolving Economic System**

Basic features; accumulation and crisis; the modern corporation; monopoly capitalism—alternative perspectives.

**3. The State in Capitalism**

The state and the economy – contestation and mutual interdependence; the state as an arena of conflict; imperialism – the basic foundations.

### **Recommended Books and References:**

1. J. Gurley, "The Materialist Conception of History", Ch.2.1 in R. Edwards, M. Reich and T. Weisskopf (ed.), *The Capitalist System*, 2nd edition, 1978.
2. O. Lange, *Political Economy*, vol. 1, 1963, Chapters 1 and 2.
3. E.K. Hunt, *History of Economic Thought*, M.E. Sharpe, Indian edn, Shilpi Publications, 2004.
4. Irfan Habib, 1995, "Capitalism in History", *Social Scientist*, Vol. 23: 15-31.
5. R.L. Heilbroner, "Capitalism", in *The New Palgrave Dictionary of Modern Economics*, Macmillan, 1987. Also reprinted as Chapter 2 in *Behind the Veil of Economics* by R.L. Heilbroner, W.W. Norton, 1988.
6. P. Sweezy, *The Theory of Capitalist Development*, Monthly Review Press, 1942, chapters 2, 4, 5, 6, 8 and 10.
7. Anwar Shaikh, Entries on "Economic Crises" and "Falling Rate of Profit" in T. Bottomore et al (eds.), *The Dictionary of Marxist Thought*, OUP, Indian edition, Maya Blackwell, 2000.
8. Vamsi Vakulabharanam, 2009, "The Recent Crisis in Global Capitalism: Towards a Marxian Understanding", *Economic and Political Weekly*, March 28, Vol. 44: 144-150.
9. J. Schumpeter, *Capitalism, Socialism and Democracy*, George Allen and Unwin 1976, Chapters 6, 7 and 8.
10. P. Baran (1957), *The Political Economy of Growth*, Chapter 3, Pelican edition, 1973.
11. R. Heilbroner, "The Role of the State", Ch.4 in *The Nature and Logic of Capitalism*, 1985.
12. M. Kalecki, "Political Aspects of Full Employment", in E.K. Hunt and J.G. Schwarz (eds.), *A Critique of Economic Theory*, Penguin Books, 1972.
13. Amit Bhaduri, "Nationalism and Economic Policy in the Era of Globalization", Ch. 2 in Deepak Nayyar (ed), *Governing Globalization: Issues and Institutions*, OUP, 2002 [also WIDER Working Paper no.188, WIDER website (2000)].
14. Prabhat Patnaik, "Lenin's Theory of Imperialism Today", in K.S. Jomo (ed.) *The Long Twentieth Century: The Great Divergence: Hegemony, Uneven Development and Global Inequality*, OUP.
15. James O'Connor, "The Meaning of Economic Imperialism," in Robert Rhodes, ed., *Imperialism and Underdevelopment*, New York: Monthly Review Press, 1970, pages 101 to 111.

### **DISCIPLINE SPECIFIC ELECTIVE (ix)**

#### **COMPARATIVE ECONOMIC DEVELOPMENT (1850-1950)**

*Theory Credit: 6*

#### **1. Introduction and Perspectives on Comparative Economic Development**

#### **2. An Overview of Economic Development of the countries selected for case studies**

#### **3. Agriculture**

Agrarian surplus and the role of the peasantry in economic development.

#### **4. Industry**

The industrial revolution in Britain; Industrialisation in late industrialisers.

#### **5. The Factory System and Making of the Industrial Working Class**

Division of labour, structure of industrial authority, organisation of work and industrial production, relationship between workers and managers.

#### **6. The Role of the State in Industrial and Developmental Transition**

**Recommended Books and References:**

1. E.J. Hobsbawm, *World of Labour: Further studies in the history of labour*, London Weidenfeld & Nicholson, 1984.
2. E.J. Hobsbawm, *Industry and Empire: An Economic History of Britain since 1750*, Weidenfeld & Nicholson, 1968.
3. Peter Mathias, *The First Industrial Nation, An Economic History of Britain, 1700-1914*. 2<sup>nd</sup> edition Methuen, 1983.
4. T. Nakamura, *Economic Growth in Pre-War Japan*, Tr. by Robert A Feldman, Yale University Press, 1983.
5. Okochi, Karsh and Levine, *Workers and Employees in Japan, The Japanese Employment Relations System*, University of Tokyo, 1965.
6. Y. Hayami, *A Century of Agricultural Growth in Pre-War Japan: Its Relevance to Asian Development*, University of Minnesota Press, 1975.
7. Chalmers Johnson, *MITI and the Japanese Miracle: The Growth of Industrial Policy 1925-1975*, Stanford University Press, 1982.
8. W.W. Lockwood, *Economic Development of Japan*, Expanded edition, Princeton University Press, 1966.
9. Dobb M., *Soviet Economic Development Since 1917*, Universal Book Stall, New Delhi, 1995.
10. Paul R. Gregory and Robert C. Stuart, *Soviet Economic Structure and Performance*, Harper & Row, 3<sup>rd</sup> edition, 1986.
11. Timothy W. Guinnane, 2002, –Delegated Monitors, Large and Small: Germany’s banking System, 1800 –1914, *Journal of Economic Literature*, Volume XL: 73-124.
12. Richard A. Easterlin, Davis and Parker, *American Economic Growth: An economist’s History of the United States*, Harper & Row, 1972.
13. Hughes and Cain, *American Economic History*, HarperCollins College Publishers, 4<sup>th</sup> edition, 1994.

**Background Recommended Books and References: for teachers:**

- Angus Maddison, *Dynamic Forces in Capitalist Development, A Long-Run Comparative View*, Oxford University Press, 1991.
- P.K.O’Brien, 1986, –Do we have a Typology for the Study of European Industrialization in the XIXth Century?, *Journal of European Economic History*, XV 3:291-333.

**DISCIPLINE SPECIFIC ELECTIVE (x)  
FINANCIAL ECONOMICS**

*Theory Credit: 6*

**1. Investment Theory and Portfolio Analysis****a. Deterministic cash-flow streams**

Basic theory of interest; discounting and present value; internal rate of return; evaluation criteria; fixed-income securities; bond prices and yields; interest rate sensitivity and duration; immunisation; the term structure of interest rates; yield curves; spot rates and forward rates.

**b. Single-period random cash flows**

Random asset returns; portfolios of assets; portfolio mean and variance; feasible combinations of mean and variance; mean-variance portfolio analysis: the Markowitz model and the two-fund theorem; risk-free assets and the one-fund theorem.

### **c. CAPM**

The capital market line; the capital asset pricing model; the beta of an asset and of a portfolio; security market line; use of the CAPM model in investment analysis and as a pricing formula.

## **2. Options and Derivatives**

Introduction to derivatives and options; forward and futures contracts; options; other derivatives; forward and future prices; stock index futures; interest rate futures; the use of futures for hedging; duration-based hedging strategies; option markets; call and put options; factors affecting option prices; put-call parity; option trading strategies: spreads; straddles; strips and straps; strangles; the principle of arbitrage; discrete processes and the binomial tree model; risk-neutral valuation.

## **3. Corporate Finance**

Patterns of corporate financing: common stock; debt; preferences; convertibles; Capital structure and the cost of capital; corporate debt and dividend policy; the Modigliani-Miller theorem.

### **Recommended Books and References:**

1. David G. Luenberger, *Investment Science*, Oxford University Press, USA, 1997.
2. Hull, John C., *Options, Futures and Other Derivatives*, Pearson Education, 6<sup>th</sup> edition, 2005.
3. Thomas E. Copeland, J. Fred Weston and Kuldeep Shastri, *Financial Theory and Corporate Policy*, Prentice Hall, 4<sup>th</sup> edition, 2003.
4. Richard A. Brealey and Stewart C. Myers, *Principles of Corporate Finance*, McGraw-Hill, 7<sup>th</sup> edition, 2002.
5. Stephen A. Ross, Randolph W. Westerfield and Bradford D. Jordan, *Fundamentals of Corporate Finance*. McGraw-Hill, 7<sup>th</sup> edition, 2005.
6. Burton G. Malkiel, *A Random Walk Down Wall Street*, W.W. Norton & Company, 2003.
7. William Sharpe, Gordon Alexander and Jeffery Bailey, *Investments*, Prentice Hall of India, 6<sup>th</sup> edition, 2003.

## **DISCIPLINE SPECIFIC ELECTIVE (xi)**

### **TOPICS IN MICROECONOMICS - II**

*Theory Credit: 6*

#### **1. Repeated Games.**

Finitely repeated games and backward induction; infinitely repeated games; history dependent strategies; one-step deviation property; the repeated prisoners' dilemma; idea of folk theorem.

#### **2. Simultaneous move games with incomplete information (Bayesian games).**

Strategies; Bayesian Nash equilibrium; auctions; other applications.

#### **3. Extensive form games with imperfect information.**

Strategies; beliefs and sequential equilibrium; applications.

#### **4. Information economics.**

Adverse selection; moral hazard; signalling games.



**Recommended Books and References:**

1. Martin J. Osborne, *An Introduction to Game Theory*, Oxford University Press, New Delhi, 2004.
2. Hugh Gravelle and Ray Rees, *Microeconomics*, Pearson Education, 2<sup>nd</sup> edition, 1992.

**DISCIPLINE SPECIFIC ELECTIVE (xii)  
ENVIRONMENTAL ECONOMICS**

*Theory Credit: 6*

**1. Introduction**

What is environmental economics; review of microeconomics and welfare economics.

**2. The Theory of Externalities**

Pareto optimality and market failure in the presence of externalities; property rights and the coase theorem.

**3. The Design and Implementation of Environmental Policy**

Overview; pigouvian taxes and effluent fees; tradable permits; choice between taxes and quotas under uncertainty; implementation of environmental policy.

**4. International Environmental Problems**

Trans-boundary environmental problems; economics of climate change; trade and environment.

**5. Measuring the Benefits of Environmental Improvements**

Non-Market values and measurement methods; risk assessment and perception.

**6. Sustainable Development**

Concepts; measurement.

**Recommended Books and References:**

1. Charles Kolstad, *Intermediate Environmental Economics*, Oxford University Press, 2<sup>nd</sup> edition, 2010.
2. Robert N. Stavins (ed.), *Economics of the Environment: Selected Readings*, W.W. Norton, 5<sup>th</sup> edition, 2005.
3. Roger Perman, Yue Ma, James McGilvray and Michael Common, *Natural Resource and Environmental Economics*, Pearson Education/Addison Wesley, 3<sup>rd</sup> edition, 2003.
4. Maureen L. Cropper and Wallace E. Oates, 1992, —Environmental Economics: A Survey,|| *Journal of Economic Literature*, Volume 30:675-740.

**DISCIPLINE SPECIFIC ELECTIVE (xiii)  
INTERNATIONAL ECONOMICS**

*Theory Credit: 6*

**1. Introduction**

What is international economics about? An overview of world trade.

## **2. Theories of International Trade**

The Ricardian, specific factors, and Heckscher-Ohlin models; new trade theories; the international location of production; firms in the global economy — outsourcing and multinational enterprises.

## **3. Trade Policy**

Instruments of trade policy; political economy of trade policy; controversies in trade policy.

## **4. International Macroeconomic Policy**

Fixed versus flexible exchange rates; international monetary systems; financial globalization and financial crises.

### ***Recommended Books and References:***

1. Paul Krugman, Maurice Obstfeld, and Marc Melitz, *International Economics: Theory and Policy*, Addison-Wesley (Pearson Education Indian Edition), 9<sup>th</sup> edition, 2012.
2. Dominick Salvatore, *International Economics: Trade and Finance*, John Wiley International Student Edition, 10<sup>th</sup> edition, 2011.

## **DISCIPLINE SPECIFIC ELECTIVE (xiv) DISSERTATION**

*Credit: 6*

*Revised*  
SYLLABUS FOR  
Bachelor of Arts (Honours)

**ENGLISH**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)



## COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Indian Classical Literature	ENC 1.11	6
	Core 2	European Classical Literature	ENC 1.21	6
II	Core 3	Indian Writing in English	ENC 2.11	6
	Core 4	British Poetry & Drama (14 <sup>th</sup> to 17 <sup>th</sup> Centuries)	ENC 2.21	6
III	Core 5	American Literature	ENC 3.11	6
	Core 6	Popular Literature	ENC 3.21	6
	Core 7	British Poetry & Drama (17 <sup>th</sup> & 18 <sup>th</sup> Centuries)	ENC 3.31	6
	Skill Enhancement Course 1	Creative Writing	ENS 3.11	2
IV	Core 8	British Literature (18 <sup>th</sup> Century)	ENC 4.11	6
	Core 9	British Romantic Literature	ENC 4.21	6
	Core 10	British Literature (19 <sup>th</sup> Century)	ENC 4.31	6
	Skill Enhancement Course 2	English Language Teaching	ENS 4.11	2
V	Core 11	Women's Writing	ENC 5.11	6
	Core 12	British Literature: The Early 20 <sup>th</sup> Century	ENC 5.21	6
	Discipline Specific Elective 1	Literary Criticism	END 5.11	6
	Discipline Specific Elective 2	Science Fiction & Detective Literature	END 5.21	6
VI	Core 13	Modern European Drama	ENC 6.11	6
	Core 14	Post Colonial Literatures	ENC 6.21	6
	Discipline Specific Elective 3	Literary Theory	END 6.11	6
	Discipline Specific Elective 4	Travel writing or Dissertation/project work	END 6.21	6

## SEMESTER - I

### CORE 1 (ENC 1.11)

#### INDIAN CLASSICAL LITERATURE

*Theory Credit: 6*

- UNIT I** Kalidasa *Abhijnana Shakuntalam*, tr. Chandra Rajan, in *Kalidasa: The Loom of Time* (New Delhi: Penguin, 1989).
- UNIT II** Vyasa 'The Dicing' and 'The Sequel to Dicing', 'The Book of the Assembly Hall'
- UNIT III** 'The Temptation of Karna', Book V 'The Book of Effort', in *The Mahabharata*: tr. and ed. J.A.B. van Buitenen (Chicago: Brill, 1975) pp. 106–69.
- UNIT IV** Sudraka *Mrcchakatika*, tr. M.M. Ramachandra Kale (N.Delhi: Motilal Banarasidass, 1962).
- UNIT V** Ilango Adigal 'The Book of Banci', in *Cilappatikaram: The Tale of an Anklet*, tr. R.Parthasarathy (Delhi: Penguin, 2004) book 3.

#### Suggested Topics and Background Prose Readings for Class Presentations Topics

- The Indian Epic Tradition: Themes and Recensions
- Classical Indian Drama: Theory and Practice
- Alankara and Rasa
- Dharma and the Heroic

#### Recommended Books and References:

1. Bharata, *Natyashastra*, tr. Manomohan Ghosh, vol. I, 2nd edn (Calcutta: Granthalaya, 1967) chap. 6: 'Sentiments', pp. 100–18.
2. Iravati Karve, 'Draupadi', in *Yuganta: The End of an Epoch* (Hyderabad: Disha, 1991) pp. 79–105
3. J.A.B. Van Buitenen, 'Dharma and Moksa', in Roy W. Perrett, ed., *Indian Philosophy, vol. V, Theory of Value: A Collection of Readings* (New York: Garland, 2000) pp. 33–40.
4. Vinay Dharwadkar, 'Orientalism and the Study of Indian Literature', in *Orientalism and the Postcolonial Predicament: Perspectives on South Asia*, ed. Carol A. Breckenridge and Peter van der Veer (New Delhi: OUP, 1994) pp. 158–95.

### CORE 2 (ENC 1.21)

#### EUROPEAN CLASSICAL LITERATURE

*Theory Credit: 6*

- UNIT I** Homer *The Illiad*, tr. E.V. Rieu (Harmondsworth: Penguin, 1985)
- UNIT II** Sophocles *Oedipus the King*, tr. Robert Fagles in *Sophocles: The Three Theban Plays* (Harmondsworth: Penguin, 1984).

**UNIT III** Plautus *Pot of Gold*, tr. E.F. Watling (Harmondsworth: Penguin, 1965).

**UNIT IV** Ovid Selections from *Metamorphoses* 'Bacchus', (Book III), 'Pyramus and Thisbe' (Book IV), 'Philomela' (Book VI), tr. Mary M. Innes (Harmondsworth: Penguin, 1975).

**UNIT V** Horace *Satires I: 4*, in *Horace: Satires and Epistles and Persius: Satires*, tr. Niall Rudd (Harmondsworth: Penguin, 2005).

**Suggested Topics and Background Prose Readings for Class Presentations Topics**

- The Epic
- Comedy and Tragedy in Classical Drama
- The Athenian City State
- Catharsis and Mimesis
- Satire
- Literary Cultures in Augustan Rome

**Recommended Books and References:**

1. Aristotle, *Poetics*, translated with an introduction and notes by Malcolm Heath, (London: Penguin, 1996) chaps. 6–17, 23, 24, and 26.
2. Plato, *The Republic*, Book X, tr. Desmond Lee (London: Penguin, 2007).
3. Horace, *Ars Poetica*, tr. H. Rushton Fairclough, *Horace: Satires, Epistles and Ars Poetica* (Cambridge Mass.: Harvard University Press, 2005) pp. 451–73.

## SEMESTER - II

### CORE 3 (ENC 2.11) INDIAN WRITING IN ENGLISH

Theory Credit: 6

**UNIT I** R.K. Narayan *The Guide*

**UNIT II** Anita Desai *Cry the Peacock*

**UNIT III** a. H.L.V. Derozio 'Freedom to the Slave' 'The Orphan Girl'  
b. Kamala Das 'Introduction,' 'My Grandmother's House'  
c. Nissim Ezekiel 'Enterprise' 'The Night of the Scorpion'

**UNIT IV** a. Mulk Raj Anand 'The Untouchable'  
b. Salman Rushdie 'The Free Radio'

**UNIT V** a. Rohinton Mistry 'Swimming Lesson'  
b. Shashi Deshpande 'The Intrusion'

#### **Suggested Topics and Background Prose Readings for Class Presentations Topics**

- Indian English
- Indian English Literature and its Readership
- Themes and Contexts of the Indian English Novel
- The Aesthetics of Indian English Poetry
- Modernism in Indian English Literature

#### **Recommended Books and References:**

1. Raja Rao, Foreword to *Kanthapura* (New Delhi: OUP, 1989) pp. v-vi.
2. Salman Rushdie, 'Commonwealth Literature does not exist', in *Imaginary Homelands* London: Granta Books, 1991) pp. 61-70.
3. Meenakshi Mukherjee, 'Divided by a Common Language', in *The Perishable Empire* (New Delhi: OUP, 2000) pp.187-203.
4. Bruce King, 'Introduction', in *Modern Indian Poetry in English* (New Delhi: OUP, 2<sup>nd</sup>edn, 2005) pp. 1-10.

### CORE 4 (ENC 2.21) BRITISH POETRY AND DRAMA: 14TH TO 17TH CENTURIES

Theory Credit: 6

**UNIT I** a. Geoffrey Chaucer *The Wife of Bath's Prologue*  
b. Edmund Spenser *Selections from Amoretti: Sonnet LXVII 'Like as a huntsman'* Sonnet LVII 'Sweet warrior...'

**UNIT II** John Donne 'The Sunne Rising' 'Batter My Heart'

**UNIT III** Christopher Marlowe *Doctor Faustus*



**UNIT IV** William Shakespeare *Macbeth*

**UNIT IV** History of English Literature: An Overview

**Suggested Topics and Background Prose Readings for Class Presentations Topics**

- Renaissance Humanism
- The Stage, Court and City
- Religious and Political Thought
- Ideas of Love and Marriage
- The Writer in Society

**Recommended Books and References:**

1. Pico Della Mirandola, excerpts from the *Oration on the Dignity of Man*, in *The Portable Renaissance Reader*, ed. James Bruce Ross and Mary Martin McLaughlin (New York: Penguin Books, 1953) pp. 476–9.
2. John Calvin, 'Predestination and Free Will', in *The Portable Renaissance Reader*, ed. James Bruce Ross and Mary Martin McLaughlin (New York: Penguin Books, 1953) pp. 704–11.
3. Baldassare Castiglione, 'Longing for Beauty' & 'Invocation of Love', in Bk 4 of *The Courtier*, 'Love & Beauty', tr. George Bull (Harmondsworth: Penguin, rpt.'83) pp. 324–8, 330–5.
4. Philip Sidney, *An Apology for Poetry*, ed. Forrest G. Robinson (Indianapolis: Bobbs-Merrill, 1970) pp. 13–18.

## SEMESTER - III

### CORE 5 (ENC 3.11) AMERICAN LITERATURE

*Theory Credit: 6*

**UNIT I** Tennessee Williams: *The Glass Menagerie*

**UNIT II** Toni Morrison *Beloved*

**UNIT III** Edgar Allan Poe 'The Purloined Letter'

**UNIT IV** F. Scott Fitzgerald 'The Great Gatsby'

**UNIT V** a. Walt Whitman 'O Captain, My Captain'  
b. Alexie Sherman 'Crow Testament'  
c. William Faulkner 'Dry September'

#### **Suggested Topics and Background Prose Readings for Class Presentations Topics**

- The American Dream
- Social Realism and the American Novel
- Folklore and the American Novel
- Black Women's Writings
- Questions of Form in American Poetry

#### **Recommended Books and References:**

1. Hector St John Crevecoeur, 'What is an American', (Letter III) in *Letters from an American Farmer* (Harmondsworth: Penguin, 1982) pp. 66–105.
2. Frederick Douglass, *A Narrative of the life of Frederick Douglass* (Harmondsworth: Penguin, 1982) chaps. 1–7, pp. 47–87.
3. Henry David Thoreau, 'Battle of the Ants' excerpt from 'Brute Neighbours', in *Walden* (Oxford: OUP, 1997) chap. 12.
4. Ralph Waldo Emerson, 'Self Reliance', in *The Selected Writings of Ralph Waldo Emerson*, ed. with a biographical introduction by Brooks Atkinson (New York: The Modern Library, 1964).
5. Toni Morrison, 'Romancing the Shadow', in *Playing in the Dark: Whiteness and Literary Imagination* (London: Picador, 1993) pp. 29–39.

### CORE 6 (ENC 3.21) POPULAR LITERATURE

*Theory Credit: 6*

**UNIT I** Lewis Carroll *Through the Looking Glass*

**UNIT II** Agatha Christie *The Murder of Roger Ackroyd*

**UNIT III** Ruskin Bond *The Room on the Roof*

**UNIT IV** DurgabaiVyam and Subhash Vyam*Bhimayana: Experiences of Untouchability/Autobiographical Notes on Ambedkar* (For the Visually Challenged students)

**UNIT V** George Orwell *Animal Farm*

**Suggested Topics and Background Prose Readings for Class Presentations Topics**

- Coming of Age
- The Canonical and the Popular
- Caste, Gender and Identity
- Ethics and Education in Children's Literature
- Sense and Nonsense
- The Graphic Novel

**Recommended Books and References:**

1. ChelvaKanaganayakam, 'Dancing in the Rarefied Air: Reading Contemporary Sri Lankan Literature' (*ARIEL*, Jan. 1998) rpt, Malashri Lal, Alamgir Hashmi, and Victor J. Ramraj, eds., *Post Independence Voices in South Asian Writings* (Delhi: Doaba Publications, 2001) pp. 51–65.
2. Sumathi Ramaswamy, 'Introduction', in *Beyond Appearances?: Visual Practices and Ideologies in Modern India* (Sage: Delhi, 2003) pp. xiii–xxix.
3. Leslie Fiedler, 'Towards a Definition of Popular Literature', in *Super Culture: American Popular Culture and Europe*, ed. C.W.E. Bigsby (Ohio: Bowling Green University Press, 1975) pp. 29–38.
4. Felicity Hughes, 'Children's Literature: Theory and Practice', *English Literary History*, vol. 45, 1978, pp. 542–61.

**CORE 7 (ENC 3.31)**

**BRITISH POETRY AND DRAMA: 17TH AND 18TH CENTURIES**

*Theory Credit: 6*

**UNIT I** John Milton *Paradise Lost: Book 1*(lines 1-282)

**UNIT II** John Milton *Paradise Lost: Book 1*(lines 283-798)

**UNIT III** Aphra Behn*The Rover*

**UNIT IV** Alexander Pope *The Rape of the Lock*

**UNIT V** John Webster *The Duchess of Malfi*

**Suggested Topics and Background Prose Readings for Class Presentations Topics**

- Religious and Secular Thought in the 17th Century
- The Stage, the State and the Market
- The Mock-epic and Satire
- Women in the 17th Century
- The Comedy of Manners

**Recommended Books and References:**

1. The Holy Bible, *Genesis*, chaps. 1–4, *The Gospel according to St. Luke*, chaps. 1–7 and 22–4.
2. Niccolo Machiavelli, *The Prince*, ed. and tr. Robert M. Adams (New York: Norton, 1992) chaps. 15, 16, 18, and 25.
3. Thomas Hobbes, selections: *The Leviathan*, pt. I (N. York: Norton, 2006) chaps. 8, 11, & 13.
4. John Dryden, 'A Discourse Concerning the Origin and Progress of Satire', in *The Norton Anthology of English Literature*, vol. 1, 9th edn, ed. Stephen Greenblatt (New York: Norton 2012) pp. 1767–8.

## SEMESTER - IV

### CORE 8 (ENC 4.11)

#### BRITISH LITERATURE: 18TH CENTURY

*Theory Credit: 6*

**UNIT I** William Congreve *The Way of the World*

**UNIT II** Jonathan Swift *Gulliver's Travels* (Books III and IV)

**UNIT III** Samuel Johnson 'London'

**UNIT IV** Thomas Gray 'Elegy Written in a Country Churchyard'

**UNIT V** Oliver Goldsmith: *The Vicar of Wakefield*.

#### **Suggested Topics and Background Prose Readings for Class Presentations Topics**

- The Enlightenment and Neoclassicism
- Restoration Comedy
- The Country and the City
- The Novel and the Periodical Press

#### **Recommended Books and References:**

1. Jeremy Collier, *A Short View of the Immorality and Profaneness of the English Stage* (London: Routledge, 1996).
2. Daniel Defoe, 'The Complete English Tradesman' (Letter XXII), 'The Great Law of Subordination Considered' (Letter IV), & 'The Complete English Gentleman', in *Literature and Social Order in Eighteenth-Century England*, ed. Stephen Copley (London: Croom Helm, 1984).
3. Samuel Johnson, 'Essay 156', in *The Rambler*, in *Selected Writings: Samuel Johnson*, ed. Peter Martin (Cambridge, Mass.: Harvard University Press, 2009) pp. 194–7; *Rasselas* Chapter 10; 'Pope's Intellectual Character: Pope and Dryden Compared', from *The Life of Pope*, in *The Norton Anthology of English Literature*, vol. 1, ed. Stephen Greenblatt, 8th edn (New York: Norton, 2006) pp. 2693–4, 2774–7.

### CORE 9 (ENC 4.21)

#### BRITISH ROMANTIC LITERATURE

*Theory Credit: 6*

**UNIT I** William Blake 'The Lamb', 'The Chimney Sweeper' (from *The Songs of Innocence* and *The Songs of Experience*) 'The Tyger' (*The Songs of Experience*) 'Introduction' to *The Songs of Innocence*

**UNIT II** William Wordsworth 'Tintern Abbey' 'Ode: Intimations of Immortality'

**UNIT III** Lord George Gordon Noel Byron 'Childe Harold': canto III, verses 36–45 (lines 316–405); canto IV, verses 178–86 (lines 1594–674)

- UNIT IV** a Percy Bysshe Shelley 'Ode to the West Wind'  
b. John Keats 'Ode to a Nightingale'

**UNIT V** Mary Shelley *Frankenstein*

**Suggested Topics and Background Prose Readings for Class Presentations Topics**

- Reason and Imagination
- Conceptions of Nature
- Literature and Revolution
- The Gothic
- The Romantic Lyric

**Recommended Books and References:**

1. William Wordsworth, 'Preface to Lyrical Ballads', in *Romantic Prose and Poetry*, ed. Harold Bloom and Lionel Trilling (New York: OUP, 1973) pp. 594–611.
2. John Keats, 'Letter to George and Thomas Keats, 21 December 1817', and 'Letter to Richard Woodhouse, 27 October, 1818', in *Romantic Prose and Poetry*, ed. Harold Bloom and Lionel Trilling (New York: OUP, 1973) pp. 766–68, 777–8.
3. Jean-Jacques Rousseau, 'Preface' to *Emile or Education*, tr. Allan Bloom (Harmondsworth: Penguin, 1991).
4. Samuel Taylor Coleridge, *Biographia Literaria*, ed. George Watson (London: Everyman, 1993) chap. XIII, pp. 161–66.

**CORE 10 (ENC 4.31)**

**BRITISH LITERATURE: 19TH CENTURY**

*Theory Credit: 6*

**UNIT I** Jane Austen *Pride and Prejudice*

**UNIT II** Emily Bronte *Wuthering Heights*

**UNIT III** Charles Dickens *Hard Times*

**UNIT IV** Alfred Tennyson 'The Lady of Shalott' 'Ulysses'

**UNIT V** a. Robert Browning 'My Last Duchess'  
b. Christina Rossetti 'The Goblin Market'

**Suggested Topics and Background Prose Readings for Class Presentations Topics**

- Utilitarianism
- The 19th Century Novel
- Marriage and Sexuality
- The Writer and Society
- Faith and Doubt
- The Dramatic Monologue

**Recommended Books and References:**

1. Karl Marx and Friedrich Engels, 'Mode of Production: The Basis of Social Life', 'The Social Nature of Consciousness', and 'Classes and Ideology', in *A Reader in Marxist Philosophy*, ed. Howard Selsam and Harry Martel (New York: International Publishers, 1963) pp. 186–8, 190–1, 199–201.
2. Charles Darwin, 'Natural Selection and Sexual Selection', in *The Descent of Man* in *The Norton Anthology of English Literature*, 8th edn, vol. 2, ed. Stephen Greenblatt (New York: Norton, 2006) pp. 1545–9.
3. John Stuart Mill, *The Subjection of Women* in *Norton Anthology of English Literature*, 8th edn, vol. 2, ed. Stephen Greenblatt (New York: Norton, 2006) chap. 1, pp. 1061–9.

## SEMESTER - V

### CORE 11 (ENC 5.11) WOMEN'S WRITING

*Theory Credit: 6*

- UNIT I** a. Emily Dickinson 'I cannot live with you' 'I'm wife; I've finished that'  
b. Sylvia Plath 'Daddy' 'Lady Lazarus'
- UNIT II** Christa Wolf Christopher Middleton: *The Quest for Christa T*
- UNIT III** a. Charlotte Perkins Gilman 'The Yellow Wallpaper'  
b. Katherine Mansfield 'Bliss'
- UNIT IV** Mary Wollstonecraft *A Vindication of the Rights of Woman* (New York: Norton, 1988)  
chap. 1, pp. 11–19; chap. 2, pp. 19–38.
- UNIT V** Ramabai Ranade 'A Testimony of our Inexhaustible Treasures', in *Pandita Ramabai Through Her Own Words: Selected Works*, tr. Meera Kosambi (New Delhi: OUP, 2000)  
pp. 295–324.

### **Suggested Topics and Background Prose Readings for Class Presentations Topics**

- The Confessional Mode in Women's Writing
- Sexual Politics
- Race, Caste and Gender
- Social Reform and Women's Rights

### **Recommended Books and References:**

1. Virginia Woolf, *A Room of One's Own* (New York: Harcourt, 1957) chaps. 1 and 6.
2. Simone de Beauvoir, 'Introduction', in *The Second Sex*, tr. Constance Borde and Shiela Malovany-Chevallier (London: Vintage, 2010) pp. 3–18.
3. Kumkum Sangari and Sudesh Vaid, eds., 'Introduction', in *Recasting Women: Essays in Colonial History* (New Delhi: Kali for Women, 1989) pp. 1–25.
4. Chandra Talapade Mohanty, 'Under Western Eyes: Feminist Scholarship and Colonial Discourses', in *Contemporary Postcolonial Theory: A Reader*, ed. Padmini Mongia (New York: Arnold, 1996) pp. 172–97.

### CORE 12 (ENC 5.21) BRITISH LITERATURE: THE EARLY 20TH CENTURY

*Theory Credit: 6*

- UNIT I** Joseph Conrad *Heart of Darkness*
- UNIT II** E.M Forster *Where Angels Fear to Tread*
- UNIT III** Virginia Woolf *Mrs Dalloway*



**UNIT IV** W.B. Yeats 'Leda and the Swan' 'The Second Coming' 'No Second Troy' 'Sailing to Byzantium'

**UNIT V** T.S. Eliot 'The Love Song of J. Alfred Prufrock' 'The Hollow Men'

**Suggested Topics and Background Prose Readings for Class Presentations Topics**

- Modernism, Post-modernism and non-European Cultures
- The Women's Movement in the Early 20th Century
- Psychoanalysis and the Stream of Consciousness
- The Uses of Myth
- The Avant Garde

**Recommended Books and References:**

1. Sigmund Freud, 'Theory of Dreams', 'Oedipus Complex', and 'The Structure of the Unconscious', in *The Modern Tradition*, ed. Richard Ellman et. al. (Oxford: OUP, 1965) pp. 571, 578–80, 559–63.
2. T.S. Eliot, 'Tradition and the Individual Talent', in *Norton Anthology of English Literature*, 8<sup>th</sup>edn, vol. 2, ed. Stephen Greenblatt (New York: Norton, 2006) pp. 2319–25.
3. Raymond Williams, 'Introduction', in *The English Novel from Dickens to Lawrence* (London: Hogarth Press, 1984) pp. 9–27.

## SEMESTER - VI

### CORE 13 (ENC 6.11)

#### MODERN EUROPEAN DRAMA

*Theory Credit: 6*

**UNIT I** Henrik Ibsen *A Public Enemy*

**UNIT II** Bertolt Brecht *The Good Woman of Szechuan*

**UNIT III** Samuel Beckett *Waiting for Godot*

**UNIT IV** Fritz Karinthy *Refund*

**UNIT V** Eugene Ionesco *Rhinoceros*

#### **Suggested Topics and Background Prose Readings for Class Presentations Topics**

- Politics, Social Change and the Stage
- Text and Performance
- European Drama: Realism and Beyond
- Tragedy and Heroism in Modern European Drama
- The Theatre of the Absurd

#### **Recommended Books and References:**

1. Constantin Stanislavski, *An Actor Prepares*, chap. 8, 'Faith and the Sense of Truth' tr. Elizabeth Reynolds Hapgood (Harmondsworth: Penguin, 1967) sections 1, 2, 7, 8,9, pp. 121–5, 137–46.
2. Bertolt Brecht, 'The Street Scene', 'Theatre for Pleasure or Theatre for Instruction', and 'Dramatic Theatre vs Epic Theatre', in *Brecht on Theatre: The Development of an Aesthetic*, ed. and tr. John Willet (London: Methuen, 1992) pp. 68–76, 121–8.
3. George Steiner, 'On Modern Tragedy', in *The Death of Tragedy* (London: Faber, 1995) pp. 303–24.

### CORE 14 (ENC 6.21)

#### POSTCOLONIAL LITERATURES

*Theory Credit: 6*

**UNIT I** Chinua Achebe *Things Fall Apart*

**UNIT II** Gabriel Garcia Marquez *Chronicle of a Death Foretold*

**UNIT III** a. Bessie Head 'The Collector of Treasures'  
b. Ama Ata Aidoo 'The Girl who can'

**UNIT IV** a. Pablo Neruda 'Tonight I can Write'  
b. Derek Walcott 'A Far Cry from Africa'  
c. David Malouf 'Revolving Days'  
d. Mamang Dai 'Small Towns and the River'

**UNIT V** Easterinekire ‘when the river sleeps’

**Suggested Topics and Background Prose Readings for Class Presentations Topics**

- De-colonization, Globalization and Literature
- Literature and Identity Politics
- Writing for the New World Audience
- Region, Race, and Gender
- Postcolonial Literatures and Questions of Form

**Recommended Books and References:**

1. Franz Fanon, ‘The Negro and Language’, in *Black Skin, White Masks*, tr. Charles Lam Markmann (London: Pluto Press, 2008) pp. 8–27.
2. Ngugi waThiong’o, ‘The Language of African Literature’, in *Decolonising the Mind* (London: James Curry, 1986) chap. 1, sections 4–6.
3. Gabriel Garcia Marquez, the Nobel Prize Acceptance Speech, in *Gabriel Garcia Marquez: New Readings*, ed. Bernard McGuirk and Richard Cardwell (Cambridge: Cambridge University Press, 1987).

## DISCIPLINE SPECIFIC ELECTIVE

### DISCIPLINE SPECIFIC ELECTIVE 1 (END 5.11) LITERARY CRITICISM

*Theory Credit: 6*

**UNIT I** William Wordsworth: *Preface to the Lyrical Ballads* (1802)

**UNIT II** P.B Shelly 'Defence of poetry'

**UNIT III** T.S. Eliot: "The Function of Criticism" 1920

**UNIT IV** I.A. Richards: *Principles of Literary Criticism* Chapters 1,2 and 34. London 1924 and *Practical Criticism*. London, 1929

**UNIT V** Cleanth Brooks: "The Language of Paradox" in *The Well-Wrought Urn: Studies in the Structure of Poetry* (1947)

#### **Suggested Topics and Background Prose Readings for Class Presentations Topics**

- Summarizing and Critiquing
- Point of View
- Reading and Interpreting
- Media Criticism
- Plot and Setting
- Citing from Critics' Interpretations

#### **Recommended Books and References:**

1. C.S. Lewis: Introduction in *An Experiment in Criticism*, CUP 1992
2. M.H. Abrams: *The Mirror and the Lamp*, Oxford University Press, 1971
3. Rene Wellek, Stephen G. Nicholas: *Concepts of Criticism*, Connecticut, Yale University 1963
4. Taylor and Francis Eds. *An Introduction to Literature, Criticism and Theory*, Routledge, 1996

### DISCIPLINE SPECIFIC ELECTIVE 2 (END 5.21) SCIENCE FICTION AND DETECTIVE LITERATURE

*Theory Credit: 6*

**UNIT I** Wilkie Collins *The Woman in White*

**UNIT II** Arthur Conan Doyle *The Sign of Four*

**UNIT III** Raymond Chandler *The Big Sleep*

**UNIT IV** H.R.F. Keating *Inspector Ghote Goes by Train*

**UNIT V** Isaac Asimov: a. "Nightfall" b. "The Last Question"

#### **Suggested Topics and Readings for Class Presentation Topics**

- Crime across the Media
- Constructions of Criminal Identity

- Cultural Stereotypes in Crime Fiction
- Crime Fiction and Cultural Nostalgia
- Crime Fiction and Ethics
- Crime and Censorship

**Recommended Books and References:**

1. J. Edmund Wilson, 'Who Cares Who Killed Roger Ackroyd?', *The New Yorker*, 20 June 1945.
2. George Orwell, *Raffles and Miss Blandish*, available at: <[www.georgeorwell.org/Raffles\\_and\\_Miss\\_Blandish/0.html](http://www.georgeorwell.org/Raffles_and_Miss_Blandish/0.html)>
3. W.H. Auden, *The Guilty Vicarage*, available at: <[harpers.org/archive/1948/05/the\\_guilty-vicarage/](http://harpers.org/archive/1948/05/the_guilty-vicarage/)>
4. Raymond Chandler, 'The Simple Art of Murder', *Atlantic Monthly*, Dec. 1944, available at: <http://www.en.utexas.edu/amlit/amlitprivate/scans/chandlerart.html>

**DISCIPLINE SPECIFIC ELECTIVE 3 (END 6.11)  
LITERARY THEORY**

*Theory Credit: 6*

**UNIT I Postmodernism**

- a. Roland Barthes "From Work to Text" in *Postmodern Literary Theory: An Anthology*. Niall, Lucy (ed), Wiley-Blackwell, 2000.
- b. Jean-Francois Lyotard: *The Postmodern Condition in Literary Theory: An Anthology*. Julie Rivkin & Michael Ryan (eds) Blackwell Publishing, 2004.

**UNIT II Marxism**

- a. Antonio Gramsci, 'The Formation of the Intellectuals' and 'Hegemony (Civil Society) and Separation of Powers', in *Selections from the Prison Notebooks*, ed. and tr. Quentin Hoare and Geoffrey Novell Smith (London: Lawrence and Wishart, 1971) pp. 5, 245–6.
- b. Louis Althusser, 'Ideology and Ideological State Apparatuses', in *Lenin and Philosophy and Other Essays* (New Delhi: Aakar Books, 2006) pp. 85–126.

**UNIT III Feminism**

- a. Elaine Showalter, 'Twenty Years on: A Literature of Their Own Revisited', in *A Literature of Their Own: British Women Novelists from Bronte to Lessing* (1977. Rpt. London: Virago, 2003) pp. xi–xxxiii.
- b. Luce Irigaray, 'When the Goods Get Together' (from *This Sex Which is Not One*), in *New French Feminisms*, ed. Elaine Marks and Isabelle de Courtivron (New York: Schocken Books, 1981) pp. 107–10.

**UNIT IV Poststructuralism**

- a. Jacques Derrida, 'Structure, Sign and Play in the Discourse of the Human Science', tr. Alan Bass, in *Modern Criticism and Theory: A Reader*, ed. David Lodge (London: Longman, 1988) pp. 108–23.
- b. Michel Foucault, 'Truth and Power', in *Power and Knowledge*, tr. Alessandro Fontana and Pasquale Pasquino (New York: Pantheon, 1977) pp. 109–33.

## **UNIT V Postcolonial Studies**

- a. Mahatma Gandhi, 'Passive Resistance' and 'Education', in *Hind Swaraj and Other Writings*, ed. Anthony J Parel (Delhi: CUP, 1997) pp. 88–106.
- b. Edward Said, 'The Scope of Orientalism' in *Orientalism* (Harmondsworth: Penguin, 1978) pp. 29–110.
- c. Aijaz Ahmad, "Indian Literature": Notes towards the Definition of a Category', in *In Theory: Classes, Nations, Literatures* (London: Verso, 1992) pp. 243–285.

### **Suggested Background Prose Readings and Topics for Class Presentations Topics**

- The East and the West
- Questions of Alterity
- Power, Language, and Representation
- The State and Culture

### **Recommended Books and References:**

1. Terry Eagleton, *Literary Theory: An Introduction* (Oxford: Blackwell, 2008).
2. Peter Barry, *Beginning Theory* (Manchester: Manchester University Press, 2002).
3. NDR Chandra (ed): *Contemporary Literary Criticism: Theory and Practice*, Vol. 1&2. (New Delhi, AuthorsPress, 2005)
4. Shormishtha Panja (ed) *Critical Theory: Textual Application*, (New Delhi: Worldview, 2002)
5. Ania Loomba: *Colonialism/Postcolonialism* (London: Routledge)

## **DISCIPLINE SPECIFIC ELECTIVE 4 (END 6.21)**

### **TRAVEL WRITING**

*Theory Credit: 6*

**UNIT I** Ibn Battuta: Khuswant Singh's *City*

**UNIT II** Mark Twain: *The Innocent Abroad* (Chapter VII , VIII and IX) (Wordsworth Classic)

**UNIT III** Ernesto Che Guevara: *The Motorcycle Diaries: A Journey around South America* (the Expert, Home land for victor, The city of viceroys), Harper Perennial

**UNIT IV** William Dalrymple: *City of Dijnn*(Prologue, Chapters I and II) Penguin Books

**UNIT V** Nahid Gandhi: *Alternative Realities: Love in the Lives of Muslim Women*, Chapter 'Love, War and Widow'

### **Suggested Topics and Background Prose Readings for Class Presentations Topics**

- Travel Writing and Ethnography
- Gender and Travel
- Globalization and Travel
- Travel and Religion
- Orientalism and Travel

**Recommended Books and References:**

1. Susan Bassnett, 'Travel Writing and Gender', in *Cambridge Companion to Travel Writing*, ed. Peter Hulme and Tim Young (Cambridge: CUP,2002) pp, 225-241
2. Tabish Khair, 'An Interview with William Dalrymple and Pankaj Mishra' in *Postcolonial Travel Writings: Critical Explorations*, ed. Justin D Edwards and Rune Graulund (New York: Palgrave Macmillan, 2011), 173-184
3. Casey Balton, 'Narrating Self and Other: A Historical View', in *Travel Writing: The Self and The Other* (Routledge, 2012), pp.1-29
4. Sachidananda Mohanty, 'Introduction: Beyond the Imperial Eyes' in *Travel Writing and Empire* (New Delhi: Katha, 2004) pp. ix –xx.
5. \*An optional dissertation/project work may be introduced in place of one DSE in the 6<sup>th</sup> Semester.

## SKILL ENHANCEMENT COURSE

### SKILL ENHANCEMENT COURSE 1 (ENS 3.11) CREATIVE WRITING

*Theory Credit: 2*

- UNIT I**     What is Creative Writing
- UNIT II**     The Art and Craft of Writing
- UNIT III**    Modes of creative Writing
- UNIT IV**    Writing for the Media
- UNIT V**     Preparing for Publication

#### **Recommended Books and References:**

1. *Creative writing: A Beginner's Manual* by Anjana Neira Dev and Others, Published by Pearson, Delhi, 2009.

### SKILL ENHANCEMENT COURSE 1 (ENS 4.11) ENGLISH LANGUAGE TEACHING

*Theory Credit: 2*

- UNIT I**     Knowing the Learner
- UNIT II**     Structures of English Language
- UNIT III**    Methods of Teaching English Language
- UNIT IV**    Methods of Teaching English Literature
- UNIT V**     Using Technology in Language Teaching

#### **Recommended Books and References:**

1. Penny Ur, *A Course in Language Teaching Teaching and Theory* (Cambridge: CUP, 1996)
2. Marianne Celce-Murcia, Donna M. Brinton, and Marguerite Ann Snow, *Teaching English as a Second or Foreign Language* (Delhi: Cengage Learning, 4<sup>th</sup>Edn, 2014).
3. Adrain Doff, *Teach English: A Training Course for Teachers* (Teachers' Workbook) (Cambridge: CUP, 1988)
4. *Business English* (New Delhi: Pearson, 2008)
5. R.K. Bansal & J.B. Harrison, *Spoken English: A Manual of Speech and Phonetics* (New Delhi: Orient Blackswan, 4<sup>th</sup>edn, 2013)
6. Mohammad Aslam, *Teaching of English* (New Delhi: CUP, 2<sup>nd</sup>edn, 2009)
7. Geetha Nagaraj, *ELT: Approaches, Methods, Techniques*. 1996, Hyderabad, Orient Longman
8. Ismail Thamarasseri, *ICT Enabled Education: Learner & Teacher Perspective*. 2013. New Delhi: APH Publishing Corporation.



*Revised*  
SYLLABUS FOR  
Bachelor of Arts/Science (Honours)

**GEOGRAPHY**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)



## COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Physical Geography (Theory)	GGC 1.11	4
		Thematic Cartography I (Practical)	GGC 1.12	2
	Core 2	Geomorphology (Theory)	GGC 1.21	4
		Cartographic Techniques I (Practical)	GGC 1.22	2
II	Core 3	Climatology (Theory)	GGC 2.11	4
		Graphical Representation of Weather Data (Practical)	GGC 2.12	2
	Core 4	Human Geography (Theory)	GGC 2.21	4
		General Cartography I (Practical)	GGC 2.22	2
III	Core 5	Economic Geography (Theory)	GGC 3.11	4
		Socio-Economic Survey (Practical)	GGC 3.12	2
	Core 6	Resource Geography (Theory)	GGC 3.21	4
		Map Projection I (Practical)	GGC 3.22	2
	Core 7	Hydrology and Oceanography (Theory)	GGC 3.31	4
		Map Projection II (Practical)	GGC 3.32	2
	Skill Enhancement Course 1	Remote Sensing (Practical) OR Advanced Spatial Statistical Techniques (Practical)	GGC 3.12(a) GGC 3.12(b)	2
	IV	Core 8	Environmental Geography and Disaster Management (Theory)	GGC 4.11
Environmental and Disaster Based Project Work (Practical)			GGC 4.12	2
Core 9		Settlement Geography (Theory)	GGC 4.21	4
		Survey (Practical)	GGC 4.22	2
Core 10		Geography of India (Theory)	GGC 4.31	4
		Cartographic Technique II (Practical)	GGC 4.32	2
Skill Enhancement Course 2		Geographical Information System (Practical) or Research Methods (Practical)	GGC 4.12(a) GGC 4.12(b)	2
V		Core 11	Regional Geography of Northeast India (Theory)	GGC 5.11
	Data Based on Northeast India (Practical)		GGC 5.12	2
	Core 12	Regional Planning and Development (Theory)	GGC 5.21	4
		Filed Work	GGC 5.22	2
	Discipline Specific Elective 1	Demography (Theory) OR Geography of Health and Wellbeing (Theory)	GGD 5.11(a) GGD 5.11(b)	4
		Cartographic Technique I (Practical)	GGD 5.12	2
	Discipline Specific Elective 2	Social Geography (Theory) OR Geography of Tourism (Theory)	GGD 5.21(a) GGD 5.21(b)	4
		Presentation (Practical)	GGD 5.22	2
	VI	Core 13	Advanced Geomorphology (Theory)	GGC 6.11
Cartographic Technique III (Practical)			GGC 6.12	2

	Core 14	Geography of Nagaland (Theory)	GGC 6.21	4
		Project: Field Study and Report (Practical)	GGC 6.22	2
	Discipline Specific Elective 3	Agriculture Geography (Theory) OR Urban Geography (Theory)	GGD 6.11(a) GGD 6.11(b)	4
		Graphical Representation of Data (Practical)	GGD 6.12	2
	Discipline Specific Elective 4	Political Geography (Theory)	GGD 6.21	4
		Cartographic Technique II (Practical)	GGD 6.22	2
		OR Dissertation	GGD 6.23	6

## SEMESTER – I

### CORE 1 (GGC 1.11) PHYSICAL GEOGRAPHY

Theory Credit: 4

Teaching Hours: 60

**Objective:** The objective of this paper is to understand the origin of the Earth and its various landforms. The inter-relation of various branches of geography with other branches of natural and social science.

- UNIT I** Physical geography (nature and scope); Branches of Physical Geography; Relation of geography with physical science (Geology, Meteorology, Hydrology) and social sciences (Economics, Political Science, Anthropology and History).
- UNIT II** Origin of Solar System and Earth (Tidal Hypothesis of Jeans and Jeffreys; Gaseous Theory by Kant; Nebular Hypothesis of Laplace and Big-Bang Theory).
- UNIT III** Forces affecting Earth's crust (endogenetic and exogenetic forces); Major landforms (Types and classification of Mountains, Plateau and Plains)
- UNIT IV** Origin and types of rocks; classification of igneous, sedimentary and metamorphic rocks
- UNIT V** Soils (classification, process of soil formation and soil types)

#### **Recommended Books and References:**

1. Bryant, H. Richard (2001): Physical Geography Made Simple, Rupa and Company, New Delhi.
2. Bunnett, R.B. (2003): Physical Geography in Diagrams, Fourth GCSE edition, Pearson Education (Singapore) Private Ltd.
3. Hugget, R.J. (2003): Fundamentals of Geomorphology, Routledge, London.
4. Monkhouse, F.J. (1979): Physical Geography, Methuen, London.
5. Negi, B.S. (2000): Physical Geography, Kedar Nath Ram Nath, Meerut.
6. Singh, S. (2003): Physical Geography, Prayag Pustak Bhawan, Allahabad. (2007): Physical Geography, Lakshmi Narain Agarwal, Agra.
7. Sharma, Y.K. (2007): Physical Geography, Lakshmi Narain Agarwal, Agra.
8. Strahler, A.N. and Strahler, A.m. (1992): Modern Physical Geography, John Wiley and Sons, New York.
9. Thornbury, W.D. (1960): Principles of Geomorphology, John Willey & Sons, New York.
10. Wooldrige, S.H and Morgan, R.S. (1959): The Physical Basis of Geography –An Outline of Geomorphology,

### CORE 1 (GGC 1.12) THEMATIC CARTOGRAPHY I

Practical Credit: 2

Teaching Hours: 30

- UNIT I** Concept of map and types of maps.
- UNIT II** Types of scale; preparation of scale-simple, comparative and diagonal.

**UNIT III** Enlargement and Reduction of map by graphical method; combination of maps of different scales.

**UNIT IV** Viva voce and Practical Notebook.

**Recommended Books and References:**

1. Binch, T.W. (1968): **Maps: Topographical and Statistical**, Clarendon Press, Oxford.
2. Khan, Md. Z.A. (1998): **Text Book of Practical Geography**, Concept Publishing, New Delhi.
3. Lownsberg, J.F. and Aldrich, F.T. (1979): **Introduction to Geographical Methods and Techniques**, Charles Marlin, Columbus.
4. Mishra, R.P. and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi.
5. Mohammad, N. (2008): **Practical Work in Geography**, Sunflower Publishers, New Delhi.
6. Sarkar, A.K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata.
7. Singh, L.R. (2006): **Fundamentals of Practical Geography**, Sharda Pustak Bhawan, Allahabad.
8. Singh, R.L. and Singh, Rana P.B. (1993): **Elements of Practical Geography**, Kalyani Publishers, New Delhi.

**CORE 2 (GGC 1.21)  
GEOMORPHOLOGY**

*Theory Credit: 4*

*Teaching Hours: 60*

**Objective:** *To acquaint the students with the growth and development in geomorphology, its place in physical geography and theories of formation of earth.*

**UNIT I** Geomorphology (Nature and scope); place of Geomorphology in Physical Geography

**UNIT II** Internal structure of Earth with special reference to seismological evidence

**UNIT III** Earth movements- Mountain building process; Theories regarding origin of mountains- continental drift theory, Isostasy and plate- tectonics

**UNIT IV** Volcano (definition, classification, landforms produced) and Earthquakes (definition, causes, landforms produced)

**UNIT V** Land forms- Works of river, wind, glacial, under- ground water.

**Recommended Books and References:**

1. Bryant, H. Richard (2001): **Physical Geography Made Simple**, Rupa and Company, New Delhi.
2. Hugget, R.J. (2003): **Fundamentals of Geomorphology**, Routledge, London.
3. Monkhouse, F.J. (1979): **Physical Geography**, Methuen, London.
4. Singh, S. (2003): **Physical Geography**, PrayagPustakBhawan, Allahabad.. (2007): **Physical Geography**, Lakshmi NarainAgarwal,Agra.
5. Sharma, Y.K. (2007): **Physical Geography**, Lakshmi NarainAgarwal, Agra.
6. Strahler, A.N. and Strahler, A.m. (1992): **Modern Physical Geography**, John Wiley and Sons, New York.

7. Thornbury, W.D. (1960): **Principles of Geomorphology**, John Willey&Sons, New York.
8. Wooldrige, S.H and Morgan, R.S. (1959): **The Physical Basis of Geography** –An Outline of Geomorphology, Longman Green & Co., London.

**CORE 2 (GGC 1.22)**  
**CARTOGRAPHIC TECHNIQUE I**

*Practical Credit: 2*

*Teaching Hours: 30*

- UNIT I** Interpretation of toposheet- a) Physiography b) Settlement c) Transport d) Land-use  
 e) Vegetation
- UNIT II** Representation by contour and their profile- Plateau, Cliff, Cirque, Ria coast, Fiord coast, River terrace
- UNIT III** Relief and Slope Analysis- Serial, Superimposed, Projected and Composite profiles
- UNIT IV** Viva voce and Practical Notebook.

**Recommended Books and References:**

1. Mishra, R.P. and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi.
2. Sarkar, A.K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata.
3. Singh, L.R. (2006): **Fundamentals of Practical Geography**, ShardaPustakBhawan, Allahabad.
4. Singh, R.L. and Singh, Rana P.B. (1993): **Elements of Practical Geography**, Kalyani Publishers, New Delhi.

## SEMESTER – II

### CORE 3 (GGC 2.11) CLIMATOLOGY

Theory Credit: 4

Contact Hours: 60

**Objective:** This paper encompasses very important branch of geography i.e. Climatology. It is to enable the students to understand the importance of various atmospheric factors in controlling the climate.

- UNIT I** Definition and significance of climatology; elements of weather and climate; Composition and structure of atmosphere.
- UNIT II** Insolation and heat balance (meaning and definition, distribution, factors affecting mechanism, solar radiation), Heat budget of the earth and the atmosphere.
- UNIT III** Temperature - Vertical and Horizontal distribution; Wind system - planetary, periodic and local winds, jet streams.
- UNIT IV** Air masses (meaning and characteristics); fronts (formation, classification and types); temperate and tropical cyclones.
- UNIT V** Major climatic types (Koppen's and Thornthwaite's classification of world climate); Global Climate change with special reference to role and response of man in climatic changes.

#### **Recommended Books and References:**

1. Chorley, R.J. (2001): Atmosphere, Weather and Climate. Methuen, London.
2. Crithfield, H.J. (2002): General Climatology. Prentice-Hall of India, New Delhi.
3. Finch, J.C. and Trewartha, G.T.: Elements of Weather and Climate. Prentice-Hall, London.
4. Lal, D.S. (1986): Climatology. Chaitanya Publications, Allahabad.
5. Oliver, J.E. and Hidore, J.J. (2003): Climatology: An Atmospheric Science, Pearson Education Private Ltd, Delhi.
6. Singh, S. (2005): Climatology. Prayag Pustak Bhawan, Allahabad.

### CORE 3 (GGC 2.12) GRAPHICAL REPRESENTATION OF WEATHER DATA

Practical Credit: 2

Teaching Hours: 30

- UNIT I** Handling and use of weather instruments (Max-Min Thermometer, Hygrometer, Barometer, Rain Gauge, and Anemometer).
- UNIT II** Interpretation of weather maps published by Indian Meteorological Department.
- UNIT III** Representation of weather data- Temperature, rainfall and humidity data by line and bar graph. Construction and significance of Hythergraph and Climograph.
- UNIT IV** Viva voce and Practical Note book.

#### **Recommended Books and References:**



1. Monkhouse, F.J. and Wilkinson, F.J. (1985): **Maps and Diagrams**, Methuen, London.
2. Raiz, E. (1962): **Principles of Cartography**, McGraw Hill, New York.
3. Sarkar, A.K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata.
4. Singh, L.R. (2006): **Fundamentals of Practical Geography**, ShardaPustakBhawan, Allahabad.
5. Singh, R.L. and Singh, Rana P.B. (1993): **Elements of Practical Geography**, Kalyani Publishers, New Delhi.

**CORE 4 (GGC 2.21)  
HUMAN GEOGRAPHY**

*Theory Credit: 4*

*Teaching Hours: 60*

**Objective:** *To acquaint the students with the nature of man- environment relationship and to make them understand the spatial distribution of different racial groups.*

**UNIT I** Meaning, nature and scope of Human Geography; development and branches of Human geography.

**UNIT II** Man-environment dynamic relationships; determinism and possibilism.

**UNIT III** Evolution of man; classification of races; characteristics of races and their broad distribution; Human adaptation to environment (Eskimos, Bushman, Gujjars).

**UNIT IV** Physical, economic and social factors influencing spatial distribution of world population; growth, distribution and density of population; Migration- types and consequences.

**UNIT V** Settlement-Geographical factors influencing human settlement; rural and urban settlement; Types and patterns of rural settlement; Urban settlement- morphology and functional classification.

**Recommended Books and References:**

1. Beyman, E.F. (1995): **Human Geography** – Culture, Connections and Landscape, Prentice Hall, New Jersey.
2. Hazra, Jayati et al., (1977): **Dimensions of Human Geography**, Rawat Publications, Jaipur.
3. Hopkins, I. (1982): **An Introduction to Human Geography**, Widenfield and Nicolson, London.
4. Hussain, M. (1994): **Human Geography**, Rawat Publications, Jaipur.
5. James, R. (2010): **The Cultural Landscape – An Introduction to Human Geography**, Prentice Hall of India, New Delhi.
6. Leong Goh Cheng (2003): **Physical and Human Geography**, Oxford University Press, New Delhi.
7. Norton, W. (1995): **Human Geography**, Oxford University Press, New York.
8. Singh, L.R. (2005): **Fundamentals of Human Geography**, Sharda Pustak Bhawan, Allahabad.
9. Stoddard, R.H., Wishart, D.J. and andBlouet, B.W.: **Human Geography**, Prentice-Hall, Englewood Cliffs, New Jersey.

**CORE 4 (GGC 2.22)**  
**GENERAL CARTOGRAPHY I**

*Practical Credit: 2*

*Teaching Hours: 30*

- UNIT I** The nature and scope of cartography, developments and trend, traditional versus modern cartography.
- UNIT II** Diagrammatic population data presentation by Line, bar and pie-diagram.
- UNIT III** Methods of constructing/ drawing maps -Representation of population data: Distribution, density and growth by dots, proportionate circles and spheres, Age-sex pyramid.
- UNIT IV** Viva voce and Practical Note book

***Recommended Books and References:***

1. Kanetker, T.P. and Kulkarni, S.V. (1967): **Surveying and Levelling**, (Vol I and II ), V.G. Prakashan, Poona
2. Mishra, R.P. and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi.
3. Sarkar, A. K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata
4. Singh, L.R. (2006): **Fundamentals of Practical Geography**, ShardaPustakBhawan, Allahabad.
5. Steers, J. A. (1965): **An Introduction to the Study of Map Projection**, University of London Press, London
6. Talukdar, S. (2008): **Introduction to Map Projection**, EBH Publishers, Guwahati.

## SEMESTER – III

### CORE 5 (GGC 3.11) ECONOMIC GEOGRAPHY

Theory Credit: 4

Teaching Hours: 60

**Objectives:** To acquaint the students with the dynamic aspect of economic geography, economic activities with various factors responsible for economic development.

- UNIT I** Meaning, Scope and Approaches to the study of economic geography; World economic system.
- UNIT II** Economic activities: Primary, Secondary, Tertiary and Quaternary.
- UNIT III** Agriculture: Physical and socio- economic factors influencing agriculture; types of agriculture; food crops and cash crops, distribution and production of rice, wheat, sugarcane and tea.
- UNIT IV** Factors influencing industrial location, distribution and production of iron and steel (USA and China) and Cotton Textiles (U.K. and India); Industrial location- theory of Weber.
- UNIT V** International trade- Mode of transport (waterways, roadways, railways and airways); Service Industries- Financial services, Tourism and Knowledge services-ITES & IT services.

#### **Recommended Books and References:**

1. Boesch, H. (1964): **Geography of World Economy**, D. Van Nosttrand Co., New York.
2. Bryson, J., Henry, N., Keeble, D. And Martin, R. (eds) (1999): **The Economic Geography Reader: Producing and Consuming Global Capitalism**, John Wiley and sons, Inc, New York.
3. Coe, N. (2007): **Economic Geography: A Contemporary Introduction**, Blackwell Publishers, Inc., Massachusetts.
4. Guha, J.S. and Chattoraj, P.R. (2002): **A new Approach to Economic Geography: A Study of Resources**, The World Press Private Limited, Kolkata.
5. Hannk, D.M. (1997): **Principles and Applications of Economic Geography: Economy, Policy, Environment**, John Wiley and Sons, Inc, New York.
6. Leong G.C. and Morgan, G. C.(1982): **Human and Economic Geography**, Oxford University Press, Singapore.
7. Miller, E. (1962): **Geography of Manufacturing Industries**, Prentice Hall, New York.
8. Pounds, N.J.G. (1970): **Introduction to Economic Geography**, John Murray, London.
9. Smith, D.M. (1971): **Industrial Location – An Economic Geographical Approach**, John Wiley, New York.
10. Roy, P. K. (2005): **Economic Geography, A Study of Resources**, New Central Book Agency (P) Ltd, Kolkata.

**CORE 5 (GGC 3.12)**  
**SOCIO-ECONOMIC SURVEY**

Practical Credit: 2

Teaching Hours: 30

**Field work and Research Methodology** (Socio-economic survey)

1. Field Work In Geographical Studies – Role, Value, Data and Ethics of Field-Work
2. Defining the Field and Identifying the Case Study – Rural / Urban / Physical / Human/ Environmental.
3. Field Techniques – Merits, Demerits and Selection of the Appropriate Technique; Observation (Participant / Non Participant), Questionnaires (Open/ Closed / Structured / Non-Structured); Interview with Special Focus on Focused Group Discussions; Space Survey (Transects and Quadrants, Constructing a Sketch)

-Each student will prepare an individual/ group report based on primary level and secondary data collected during field work

- The duration of the field work should not exceed 10 days

-Report should be about 15-20 pages excluding figures, tables, photographs, maps, references, and appendices

**CORE 6 (GGC 3.21)**  
**RESOURCE GEOGRAPHY**

Theory Credit: 4

Teaching Hours: 90

**Objective:** To understand the concept of resources, prevalent issues related to environment, geographical pattern of resource utilization and the concept of sustainable development.

**UNIT I** Concept of resources; Scope of resource geography; Types of resources.

**UNIT II** Human resources: Factors responsible for distribution of population, population pressure and resource utilization, human resource planning.

**UNIT III** Forest resources: Distribution, utilization and management.  
Water resources: utilization and management.

**UNIT IV** Energy resources: Conventional (Petroleum – distribution, production and utilization), Non-conventional (Solar energy – potential and utilization).

**UNIT V** Principles of conservation; Conservation of natural resources; Sustainable resource development and management.

**Recommended Books and References:**

1. Bryson, J., Henry, N., Keeble, D. and Martin, R. (eds.) (1999): **The Economic Geography Reader: Producing and Consuming Global Capitalism**, John Wiley and Sons, Inc, New York.
2. Coe, N. (2007): **Economic Geography: A Contemporary Introduction**, Blackwell Publishers, Inc., Massachusetts.
3. Guha, J.S. and Chattorji, P.R. (2002): **A New Approach to Economic Geography: A Study of Resources**, The World Press Private Limited, Kolkata.

4. Hanink, D.M. (1997): **Principles and Applications of Economic Geography: Economy, Policy, Environment**, John Wiley and Sons, Inc, New York.
5. Leong, G. C. and Morgan, G.C. (1982): **Human and Economic Geography**, Oxford University Press, Singapore.
6. Mackinnon, D. and Cumbers, A.(2007): **An Introduction to Economic Geography: Globalization, Uneven Development and Place**, Prentice Hall, New Jersey.
7. Parman, S.S. (2002): **Geography, Economics and Economic Geography**, ASD Publ., Pune.
8. Simmons, I.G. (1980): **The Ecology of Natural Resources**, Edward Arnold, London.
9. Simmons, I.G. (1991): **Earth, Air and Water: Resources and Environment in the 20<sup>th</sup> Century**, Edward Arnold, London.
10. Roy, P.K. (2005): **Economic Geography: A Study of Resources**, New Central Book Agency (P) Ltd, Kolkata.

**CORE 6 (GGC 3.22)**  
**MAP PROJECTION I**

*Practical Credit: 2*

*Teaching Hours: 30*

- UNIT I** Definition, classification, and uses of map projection.
- UNIT II** Map projection- Cylindrical (simple and equal area) with properties and uses
- UNIT III** Projections (Molleweid's and sinusoidal)
- UNIT IV** Viva voce and Practical note book

**Recommended Books and References:**

1. Kanetker, T.P. and Kulkarni, S.V. (1967): **Surveying and Levelling**, Vol I and II V.G. Prakashan, Poona
2. Monkhouse, F.J. and Wilkinson, F.J. (1985): **Maps and Diagrams**, Methuen, London.
3. Pugh, J.C. (1975): **Surveying for Field Scientists**, Methuen and Company Ltd., London.
4. Raiz, E. (1962): **Principles of Cartography**, McGraw Hill, New York.
5. Robinson, Arthur et al., (1978): **Elements of Cartography**, John Wiley and Sons, New York.
6. Sarkar, A.K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata.

**CORE 7 (GGC 3.31)**  
**HYDROLOGY AND OCEANOGRAPHY**

*Theory Credit: 4*

*Teaching Hours: 60*

**Objectives:** *This paper on physical geography is structured into components of hydrology and oceanography as these are closely interrelated.*

- UNIT I** Meaning and scope of Hydrology; Hydrological Cycle; Elements of Hydrological Cycle- Precipitation-intensity and duration, evaporation, infiltration, surface runoff.
- UNIT II** Drainage basin characteristics; Human impact on hydrological system; water balance of drainage basin.

- UNIT III** Groundwater: Occurrence, Depletion of Ground water-causes and consequences; water management.
- UNIT IV** Meaning and scope of Oceanography; Surface configuration of the ocean floor, movement of ocean water, temperature and salinity of ocean water.
- UNIT V** Coral reefs (Origin and Types): Darwin's theory of Subsidence; Murray's theory of non-subsidence; Marine deposits.

**Recommended Books and References:**

1. Chorley, R.J. (2001): **Atmosphere, Weather and Climate**, Methuen, London.
2. Crithfield, H.J. (2002): **General Climatology**, Prentice-Hall of India, New Delhi.
3. Finch, J.C. and Trewartha, G.T.: **Elements of Weather and Climate**, Prentice-Hall, London.
4. Lal, D.S. (1986): **Climatology**, Chaitanya Publications, Allahabad.
5. Melik, A. (2008): **Causes of Climate Change**, DVS Publ., New Delhi.
6. Negi, B.S. (2002): **Climatology and Oceanography**, Kedar Nath Ram Nath, Meerut.
7. Oliver, J.E. and Hidore, J.J. (2003): **Climatology: An Atmospheric Science**, Pearson Education Private Ltd, Delhi.
8. Singh, S. (2005): **Climatology**, Prayag Pustak Bhawan, Allahabad

**CORE 7 (GGC 3.32)**  
**MAP PROJECTION II**

*Practical Credit: 2*

*Teaching Hours: 30*

- UNIT I** Map projection: Polar Zenithal (Stereographic, Orthographic) with an outline maps drawn.
- UNIT II** Cylindrical map projection (Gall's and Mercator's) with outline maps drawn.
- UNIT III** Average slope map and block diagram (from same area).
- UNIT IV** Viva voce and Practical note book.

**Recommended Books and References:**

1. Talukdar, S. (2008): **Introduction to Map Projection**, EBH Publishers, Guwahati
2. Sarkar, A. K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata
3. Singh, L.R. (2006): **Fundamentals of Practical Geography**, Sharda Pustak Bhawan, Allahabad.
4. Steers, J. A. (1965): **An Introduction to the Study of Map Projection**, University of London Press, London
5. Mishra, R.P. and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi

## SEMESTER - IV

### CORE 8 (GGC 4.11)

#### ENVIRONMENTAL GEOGRAPHY AND DISASTER MANAGEMENT

Theory Credit: 4

Teaching Hours: 60

**Objective:** To identify and understand the emerging environmental issues at global and regional level, to create awareness and to acquaint the students with the knowledge of adaptation and management of the same.

- UNIT I** Definition, concept and scope of Environmental Geography; Approach to Environmental management.
- UNIT II** Emerging environmental problems: population growth, agriculture, deforestation, science and technology.
- UNIT III** Disaster – Meaning, Concept and Types (flood, forest fires, drought, landslides).
- UNIT IV** Earthquake zoning in India- Himalayan region and NE India; Tropical Cyclones (Typhoons, Hurricanes and Tornadoes)
- UNIT V** Response to Disasters – Community, Non-Government Organisations, National and International.

#### **Recommended Books and References:**

1. Cantledge, B.(ed). (1992): **Monitoring the Environment**, Oxford University Press. Oxford.
2. Frank W.L., (1986): **The Violent Earth**, Croom Helm, London.
3. Kapur, A., (2010): **Vulnerable India: A Geographical Study of Disasters**, Safe Publication, New Delhi.
4. Newson, M.(1992): **Land, Water and Development**, Routledge, London.
5. Saxena, H.M. (2003): **Environmental Geography**, Rawat Publications, Jaipur and New Delhi.
6. Singh, R.B. (ed.) (2006): **Natural Hazards and Disaster Management Vulnerability and Mitigation**, Rawat Publications, New Delhi.
7. Singh, S.(1991): **Environmental Geography**. Prayag Pustak Bhawan, Allahabad.
8. Strahler, A.N. & A.H. Strahler, 1976: **Geography and Man's Environment**, John Willey, New York.
9. UN and WMO, (2002): **Living with Risk: A Global Review of Disaster Reduction Initiatives, International Strategy for Disaster Reduction (ISDR)**, WMO and UN Publication.

### CORE 8 (GGC 4.12)

#### ENVIRONMENTAL AND DISASTER BASED PROJECT WORK

Practical Credit: 2

Teaching Hours: 30

Note: The Project report based on any one case study among following environmental issues or disasters and one disaster preparedness plan of respective college or locality.

1. Deforestation
2. Waste Management
3. Flood

4. Drought
5. Cyclone and Hailstorms
6. Earthquake
7. Landslide
8. Human induced disaster: Fire hazards, chemical, industrial accidents

**Recommended Books and References:**

1. Government of India (1997) Vulnerability atlas of India, New Delhi, Building Materials and Technology Promotion Council, Ministry of Urban Development, Govt. of India.
2. Kapur, A. (2010) Vulnerable India: A Geographical Study of Disasters. Sage Publication, New Delhi.
3. Modh, S. (2010) Managing Natural Disasters: Hydrological, Marine and Geological Disasters. Macmillan, Delhi.
4. Singh, R. B. (2005) Risk Assessment and Vulnerability analysis, IGNOU, New Delhi, Chapter 1,2 &3.
5. Singh, R.B. (ed) (2006) Natural Hazards and Disaster Management: Vulnerability and Mitigation, Rawat Publications, New Delhi.
6. Sinha, A. (2001) Disaster Management: Lessons drawn and Strategies For Future, New United Press, New Delhi.
7. Stoltman, J. P. et al (2004) International Perspectives on Natural Disasters Kluwer Academic Publications, Dordrecht.
8. Singh, Jagbir (2007) "Disaster Management future Challenges and Opportunities". I.K. International Pvt. Ltd., New Delhi (www.ikbooks.com).

**CORE 9 (GGC 4.21)**

**SETTLEMENT GEOGRAPHY**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Definition, nature, and scope of settlement geography; origin of settlements
- UNIT II** Rural Settlements: Types, patterns, functions, rural- urban continuum
- UNIT III** Urban settlement: origin and growth of urbanization, functional classification of town/cities
- UNIT IV** Salient features of human settlements in India, features and trend of urbanization.
- UNIT V** Social areas of the cities; classification of settlements- special reference to Northeast India

**Recommended Books and References:**

1. Hazra, Jayati et al., (1977): **Dimensions of Human Geography**, Rawat Publications, Jaipur.
2. Hopkins, I. (1982): **An Introduction to Human Geography**, Widenfield and Nicolson, London.
3. Hussain, M. (1994): **Human Geography**, Rawat Publications, Jaipur.
4. James, R. (2010): **The Cultural Landscape – An Introduction to Human Geography**, Prentice Hall of India, New Delhi.
5. Leong Goh Cheng (2003): **Physical and Human Geography**, Oxford University Press, New Delhi.
6. Norton, W. (1995): **Human Geography**, Oxford University Press, New York.



7. Singh, L.R. (2005): **Fundamentals of Human Geography**, Sharda Pustak Bhawan, Allahabad.
8. Stoddard, R.H., Wishart, D.J. and Blouet, B.W.: **Human Geography**, Prentice-Hall, Englewood Cliffs, New Jersey.
9. Knox P. L. and Pinch S., 2006: **Urban Social Geography: An Introduction**, Prentice Hall.
10. Ramachandran, R., 1992: **The Study of Urbanisation**, Oxford University Press, Delhi

### **CORE 9 (GGC 4.22)**

#### **SURVEY**

*Practical Credit: 2*

*Teaching Hours: 30*

**UNIT I** Importance of surveying in geography, instruments – handling and care of survey instruments.

**UNIT II** Survey- Chain and Tape survey (to plot an area within the college premises).

**UNIT III** Contouring by theodolite or dumpy level

**UNIT IV** Viva voce and Practical note book.

#### **Recommended Books and References:**

1. Talukdar, S. (2008): **Introduction to Map Projection**, EBH Publishers, Guwahati
2. Sarkar, A. K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata
3. Singh, L.R. (2006): **Fundamentals of Practical Geography**, Sharda Pustak Bhawan, Allahabad.
4. Steers, J. A. (1965): **An Introduction to the Study of Map Projection**, University of London Press, London
5. Mishra, R.P. and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi

### **CORE 10 (GGC 4.31)**

#### **GEOGRAPHY OF INDIA**

*Theory Credit: 4*

*Teaching Hours: 60*

**Objectives:** Aims and presenting a comprehensive, integrated and empirically based profile of India so as to sensitize the students with development issues, policies and programs designed to regional development.

**UNIT I** Locational significance; unity and diversity.; Physical environment-physiographic Characteristics (climate, soil and natural vegetation).

**UNIT II** Population characteristics: population growth distribution, density, structure and composition.

**UNIT III** Agriculture: agricultural development and Indian economy, modernization of Indian agriculture (Green Revolution), agro-climatic regions and special characteristics, Agricultural Trade (Wheat, Rice).

**UNIT IV** Transport: Roads and railways, air transport and water transport.

**UNIT V** Industry: Industrial development and Indian economy, distribution of major industries (cotton textile, petrochemicals and cement industries) and industrial policies.

**Recommended Books and References:**

1. Gautam, A. (2006): **Advanced Geography of India**, Sharda Pustak Bhawan, Allahabad.
2. Gopal Singh (1992): A Geography of India, Atma Ram & Sons, Lucknow.
3. Khullar, D.R. (2007): **A Comprehensive Geography**, Kalyani Publishers, New Delhi.
4. Kundee, A. (1992): **Urban Development Urban Research in India**, Khanna Pub.l, New Delhi.
5. Nag, P. and Gupta, S.S. (1992): **Geography of India**, Concept Publishing Company, New Delhi.
6. Premi, M.K. (2007): **Population of India**, NBT, New Delhi.
7. Singh, J. (2003): **India: A Comprehensive Systematic Geography**, Gyanodaya Prakashan, Gorakhpur.
8. Singh, R.L. (ed.) (1971): **India: A Regional Geography**, National Geographical Society of India, Varanasi.
9. Srinivasan, K. and Vlassoff, M. (2001): **Population and Development Nexus in India, Challenges for the new Millenium**, Tata Mc Graw Hill, New Delhi.
10. Tiwari, R.C. (2007): **Geography of India**, Prayag Pustak Bhawan, Allahabad.

**CORE 10 (GGC 4.32)**

**CARTOGRAPHIC TECHNIQUE II**

*Practical Credit: 2*

*Teaching Hours: 30*

**UNIT I** Thematic mapping of India showing population, climate and resources.

**UNIT II** Projection: Conical projection with one and two standard parallel

**UNIT III** Prismatic Compass survey (closed and open traverse).

**UNIT IV** Practical notebook and viva voce.

**Recommended Books and References:**

1. Talukdar, S. (2008): **Introduction to Map Projection**, EBH Publishers, Guwahati
2. Sarkar, A. K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata
3. Singh, L.R. (2006): **Fundamentals of Practical Geography**, Sharda Pustak Bhawan, Allahabad.
4. Steers, J. A. (1965): **An Introduction to the Study of Map Projection**, University of London Press, London
5. Mishra, R.P. and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi

## SEMESTER – V

### CORE 11 (GGC 5.11) REGIONAL GEOGRAPHY OF NORTHEAST INDIA

Theory Credit: 4

Teaching Hours: 60

**Objective:** To understand the geographical settings of North-East India and analyze the regions potentiality for sustainable development.

- UNIT I** Locational significance; Geology; Physiography; Climate.
- UNIT II** Soil-formation, types and distribution; natural vegetation-classification and forest resources.
- UNIT III** Agriculture and agricultural products; problems of agriculture.
- UNIT IV** Mineral and power resources; Industry-development (agro-based, forest-based & mineral-based industries)
- UNIT V** Population-growth, distribution and density; transport and communication.

#### **Recommended Books and References:**

1. Taher, M. and Ahmed, P. (Revised edition, 2014): **Geography of North East India**, Mani Manik Prakash, Guwahati
2. Bhattacharyya, N.N. (2005): **North East India: A systematic Geography**, Rajesh Pub. New Delhi.
3. Gopal Krishnan, R. : **Geography of North East India**
4. **Gopal Krishnan R. (1991): North-East India: Land, People and Economy, Vikash Publishing House, New Delhi.**
5. Sebu, Sonyhulo (2013): **Geography of Nagaland**, Spectrum Publications Guwahati, Delhi.
6. Singh, S. (1994): **Agricultural Development in India: A Regional Analysis**, Kaushal Publ., Shillong.

### CORE 11 (GGC 5.12) DATA BASED ON NORTH EAST INDIA

Practical Credit: 2

Teaching Hours: 30

- UNIT I** Cartographic representation of economic data of NE India in spatial and temporal context: Histogram, Pie graph, Age-Sex Pyramid
- UNIT II** Use of cartographic symbols and their uses: Iso-chronic cartograms, traffic flow diagrams and choropleth mapping
- UNIT III** Survey: Plane Table (Radiation and Intersection)
- UNIT IV** Viva voce and Practical note book

**Recommended Books and References:**

1. Kanetker, T.P. and Kulkarni, S.V. (1967): **Surveying and Levelling**, Vol I and II V.G. Prakashan, Poona
2. Monkhouse, F.J. and Wilkinson, F.J. (1985): **Maps and Diagrams**, Methuen, London.
3. Pugh, J.C. (1975): **Surveying for Field Scientists**, Methuen and Company Ltd., London.
4. Raiz, E. (1962): **Principles of Cartography**, McGraw Hill, New York.
5. Robinson, Arthur et al., (1978): **Elements of Cartography**, John Wiley and Sons, New York.
6. Sarkar, A.K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata.

**CORE 12 (GGC 5.21)**

**REGIONAL PLANNING AND DEVELOPMENT**

*Theory Credit: 4*

*Teaching Hours: 60*

**Objective:** *To acquaint the student with the basic concept of regional planning and development understand the paradigm shift of environmental issues and planning for sustainable development.*

**UNIT I** Geographical concept of regional planning, Application of regional concept in planning and development

**UNIT II** Regional Hierarchy (Micro, Meso and Macro region), types of regions and methods of delineation

**UNIT III** Integrated area planning, trends in regional development planning, regional disparities.

**UNIT IV** Concept of development, measurement of levels of regional development, Nature and scope of town/urban planning with special reference to India.

**UNIT V** Environmental issues in regional planning, planning for sustainable development

**Recommended Books and References:**

1. De Blij, H. J., Muller, P.O., Winkler Prine, A and Nijman, J. (2010): **The World Today: Concepts and Regions in Geography (5<sup>th</sup> Edition)**, John Wiley and Sons, U.S.A.
2. Alden J and R. Morgan (1974), **Regional Planning: A Comprehensive View**, Leonard Hill Books, Bath, U.K.
3. Dewar, D. et. al. (eds), (1986), **Regional Development and Settlement Policy**, Allen and Unwin, Boston
4. Friedmann, J. and William, A (1967), **Regional Development and Planning**, Rotterdam Univ. Press
5. Hilhorat, J.G.M., (1975): **Regional Planning**, Rotterdam Univ. Press.
6. Kuklinski, A. R. (ed) 1972: **Growth Poles and Growth Centres in Regional Planning**, Monton, The Hague
7. Misra, R. P., 1969: **Regional Planning, Concepts, Techniques, Policies**, University of Mysore.

**CORE 12 (GGC 5.22)**  
**FIELD WORK**

*Practical Credit: 2*

*Teaching Hours: 30*

The students are to prepare a project related to the theory paper. Students are to conduct an independent research (study) of a small areal unit (in nearby area).

***Recommended Books and References:***

1. Jones, P.A. (1968): **Field Work in Geography**, Longman, Green and Company Ltd., London.
2. Kumar, R. (2011): **Research Metodology (Third Edition)**, SAGE, New Delhi.
3. Lousenbury, J.F. and Aldrich, F.T. (1986): **Introduction to geographic Field Methods and Techniques**, Charles E. Merill Publ, Colombus.
4. Misra, H.N. and Singh, V.P. (2002): **Research Methodology in Geography**, Rawat, New Delhi.
5. Raina, R.M. (2011): **Research in Geography: Trends and Techniques**, Summit Enterprises, New Delhi.
6. Trivedi, R.N. and Shukla, D.P. (1996): **Research Methodology**, Radha Publ., New Delhi.

## SEMESTER - VI

### CORE 13 (GGC 6.11)

#### ADVANCED GEOMORPHOLOGY

Theory Credit: 4

Teaching Hours: 60

**Objective:** To acquaint the students with the growth and development in geomorphology, its place in physical geography and theories of formation of earth.

- UNIT I** Development of geomorphology: Geomorphological school in USA, Europe and India
- UNIT II** Fundamental concepts in geomorphology: Principal of uniformitarianism – James Hutton and Geomorphic process- W. D. Thornbury.
- UNIT III** Drainage system and pattern (Major drainage system-sequent, insequent, consequent, subsequent, obsequent, super-imposed; Major drainage pattern-trellised, dendritic, rectangular, radial, angular)
- UNIT IV** Concept of erosion; Normal Cycle of erosion – W. M. Davis, W. Penck; Dynamic Equilibrium theory by J. T. Hack
- UNIT V** Application of geomorphology to settlements, transport, land use, mining, and environmental hazards management.

#### **Recommended Books and References:**

1. Ahmed, E. (2004): **Geomorphology (reprint)**, Kalyani Publ., Ludhiana.
2. Bloom, A.L. (1992): **Geomorphology – A Systematic Analysis**, Prentice-Hall India, New Delhi.
3. Dayal, P. (1996): **A Text Book in Geomorphology**, shukla Book Depot, Patna.
4. Kale, V. And Gupta, A. (2001): **Elements of Geomorphology**, Oxford University Press, Delhi.
5. Kale, S. Vishwas and Gupta, Avijit (1996): **Introduction to Geomorphology**, Orient Longman, Calcutta.
6. Stoddard, D. R. (ed) (1996): **Process and Form in Geomorphology**, Routledge, London.
7. Thornbury, W. D.(1990): **Principles of Geomorphology**, Wiley Eastern Edition, New York.
8. Singh, S. (2004): **Geomorphology**, PrayagPustak Bhawan, Allahabad.
9. Skinner, B. J. And Poter, S.C. (1996): **The Dynamic Earth**, John Wileyand sons, New York.
10. Sparks, B.W. (1960): **Geomorphology**, Longman, London.

### CORE13 (GGC 6.12)

#### CARTOGRAPHIC TECHNIQUE III

Practical Credit: 2

Teaching Hours: 30

- UNIT I** Average slope determination (Wentworth's method), Drainage frequency and Drainage density
- UNIT II** Projections (Polyconic and Bonne's) with outline map
- UNIT III** Height determination using theodolite (Accessible and inaccessible object)

**UNIT IV** Viva voce and Practical note book.

**Recommended Books and References:**

1. Talukdar, S. (2008): **Introduction to Map Projection**, EBH Publishers, Guwahati
2. Sarkar, A. K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata
3. Singh, L.R. (2006): **Fundamentals of Practical Geography**, Sharda Pustak Bhawan, Allahabad.
4. Steers, J. A. (1965): **An Introduction to the Study of Map Projection**, University of London Press, London
5. Mishra, R.P. and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi.

**CORE 14 (GGC 6.21)  
GEOGRAPHY OF NAGALAND**

*Theory Credit: 4*

*Teaching Hours: 60*

**Objective:** *To understand the geographical settings of Nagaland and analyze the regions potentiality for sustainable development.*

- UNIT I** Location; Physical setting (geology, climate, drainage/river system)
- UNIT II** Population-demographic characteristics (growth, distribution, density, rural-urban Composition)
- UNIT III** Economy- Agri and allied; Industries (small scale and cottage industries; tourism and its potential); prospects and problems.
- UNIT IV** Resources-types, distribution, utilization and management (forests, mineral, hydro)
- UNIT V** Transport and communication: Transport-modes and their contribution to the economy; Communication-postal, telecommunication.

**Recommended Books and References:**

1. Gopal Krishnan, R.: Geography of North East India
2. Gopal Krishnan R. (1991): North-East India: Land, People and Economy, Vikash Publishing House, New Delhi.
3. Dr. SoyhunloSebu: Geography of Nagaland, Spectrum Publications, Guwahati, Assam. India.

**CORE 14 (GGC 2.62)**

**PROJECT: FIELD STUDY AND REPORT WRITING (BASED ON NAGALAND)**

*Practical Credit: 2*

*Teaching Hours: 30*

**Objectives:** *Geography being a field oriented subject it has been designed to let the students acquire firsthand knowledge of the surroundings on various aspects.*

**Field works:**

Meaning, types and objectives of fieldwork; field methods and techniques; importance of field work in geography, fieldwork based report writing.

**Field Study in local environment:**

Preparation of field report through fieldwork on any one of the following areas:

- A locality of the city/town
- A village near the city/ town

**Field Trip:** *to any nearby region for comparative study with the study area.*

**Report Writing**



## DISCIPLINE SPECIFIC ELECTIVE (DSE)

### DISCIPLINE SPECIFIC ELECTIVE 1 (GGD 5.11(a)) DEMOGRAPHY

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Definitions and scope of Population Geography; Historical development of Population Geography.
- UNIT II** Measures of population distribution and concentration, factors affecting population distribution – physical, social and cultural factors.
- UNIT III** World population distribution, density and growth, movement of population and the factors influencing migration – national, international, external, internal.
- UNIT IV** Population and resources: over population, under population, optimum population; Population problems/pressure in the developed and developing world.
- UNIT V** Population theories – Classical and Modern (Malthusian, Karl Marx and Demographic Transition).

#### **Recommended Books and References:**

1. Bhattacharya: Population Geography of India (1981).
2. Chandna, R.L: Introduction to Population Geography (1980).
3. Clarke: Population Geography and Developing Countries (1981).
4. Thompson W. S.: Population Problems.

### DISCIPLINE SPECIFIC ELECTIVE 1 (GGD 5.11(b)) GEOGRAPHY OF HEALTH AND WELLBEING

*Theory Credit:4*

*Teaching Hours: 60*

- UNIT I** Perspectives on Health: Definition; linkages with environment, development and health; driving forces in health and environmental trends - population dynamics, urbanization, poverty and inequality.
- UNIT II** Pressure on Environmental Quality and Health: Human activities and environmental pressure land use and agricultural development; industrialisation; **transport and energy**.
- UNIT III** Exposure and Health Risks: Air pollution; household wastes; water; housing; workplace.
- UNIT IV** Health and Disease Pattern in Environmental Context with special reference to India, Types of Diseases and their regional pattern (Communicable and Lifestyle related diseases).
- UNIT V** Climate Change and Human Health: Changes in climate system – heat and cold; Biological disease agents; food production and nutrition.

**Recommended Books and References:**

1. Akhtar Rais (Ed.), 1990: Environment and Health Themes in Medical Geography, Ashish Publishing House, New Delhi.
2. Avon Joan L. and Jonathan A Patzed.2001: Ecosystem Changes and Public Health,Baltimin, John Hopling Unit Press(ed).
3. Bradley,D.,1977: Water, Wastes and Health in Hot Climates, John Wiley Chichesten.
4. Christaler George and HristopolesDionissios, 1998: Spatio Temporal Environment Health Modelling, Boston Kluwer Academic Press.
5. Cliff, A.D. and Peter,H., 1988 : Atlas of Disease Distributions, Blackwell Publishers, Oxford.
6. Gatrell, A.,and Loytonen, 1998 : GIS and Health, Taylor and Francis Ltd, London.
7. Hardham T. and Tannav M.,(eds): Urban Health in Developing Countries; Progress, Projects, Earthgoan, London.
8. Murray C. and A. Lopez, 1996: The Global Burden of Disease, Harvard University Press.
9. Moeller Dade wed., 1993: Environmental Health, Cambridge, Harvard Univ. Press.
10. Phillips, D.and Verhasselt, Y., 1994: Health and Development, Routledge, London.
11. Tromp, S., 1980: Biometeorology: The Impact of Weather and Climate on Humans and their Environment, Heydon and Son.

**DISCIPLINE SPECIFIC ELECTIVE 1 (GGD 5.12)  
CARTOGRAPHIC TECHNIQUE I**

*Practical Credit:2*

*Teaching Hours:30*

Representation of statistical data using various techniques: Choropleth, Chorochromatic, Symbol or Choroschematic, Traffic flow, Block and block-pile diagram

**DISCIPLINE SPECIFIC ELECTIVE 2 (GGD 5.21(a))  
SOCIAL GEOGRAPHY**

*Theory Credit: 4*

*Teaching Hours:60*

**UNIT I** Social Geography: Concept, Origin, Nature and Scope.

**UNIT II** Peopling Process of India: Technology and Occupational Change; Migration.

**UNIT III** Social Categories: Caste, Religion and Race, and their Spatial distribution.

**UNIT IV** Geographies of Welfare and Well-being: Concept and Components – Healthcare, Housing and Education.

**UNIT V** Social Geographies of Inclusion and Exclusion, Slums, Gated Communities, Communal Conflicts and Crime.

**Recommended Books and References:**

1. Ahmed A., 1999: *Social Geography*, Rawat Publications.
2. Casino V. J. D., Jr., 2009) *Social Geography: A Critical Introduction*, Wiley Blackwell.
3. Cater J. and Jones T., 2000: *Social Geography: An Introduction to Contemporary Issues*, Hodder Arnold.

4. Holt L., 2011: *Geographies of Children, Youth and Families: An International Perspective*, Taylor & Francis.
5. Panelli R., 2004: *Social Geographies: From Difference to Action*, Sage.
6. Rachel P., Burke M., Fuller D., Gough J., Macfarlane R. and Mowl G., 2001: *Introducing Social Geographies*, Oxford University Press.
7. Smith D. M., 1977: *Human geography: A Welfare Approach*, Edward Arnold, London.
8. Smith D. M., 1994: *Geography and Social Justice*, Blackwell, Oxford.
9. Smith S. J., Pain R., Marston S. A., Jones J. P., 2009: *The SAGE Handbook of Social Geographies*, Sage Publications.
10. Sopher, David (1980): *An Exploration of India*, Cornell University Press, Ithasa

**DISCIPLINE SPECIFIC ELECTIVE 2 (GGD 5.21(b))  
GEOGRAPHY OF TOURISM**

*Theory Credit: 4*

*Teaching Hours:60*

- UNIT I** Scope and Nature: Concepts and Issues, Tourism, Recreation and Leisure Inter-Relations; Geographical Parameters of Tourism by Robinson.
- UNIT II** Growth and development of tourism; Types of Tourism: Nature Tourism, Cultural Tourism, Medical Tourism, Pilgrimage
- UNIT III** Recent Trends of Tourism: International and Regional; Domestic (India); Eco-Tourism, Sustainable Tourism, Meetings Incentives Conventions and Exhibitions (MICE)
- UNIT IV** Impact of Tourism: Economy, Environment, Society
- UNIT V** Tourism in India: Tourism Infrastructure; Case Studies of Himalaya, Desert and Coastal Areas; National Tourism Policy

***Recommended Books and References:***

1. Dhar, P.N. (2006) *International Tourism: Emerging Challenges and Future Prospects*. Kanishka, New Delhi.
2. Hall, M. and Stephen, P. (2006) *Geography of Tourism and Recreation – Environment, Place and Space*, Routledge, London.
3. Kamra, K. K. and Chand, M. (2007) *Basics of Tourism: Theory, Operation and Practise*, Kanishka Publishers, Pune.
4. Page, S. J. (2011) *Tourism Management: An Introduction*, Butterworth-Heinemann-USA. Chapter 2.
5. Raj, R. and Nigel, D. (2007) *Morpeth Religious Tourism and Pilgrimage Festivals Management: An International perspective* by, CABI, Cambridge, USA, [www.cabi.org](http://www.cabi.org).
6. *Tourism Recreation and Research Journal*, Center for Tourism Research and Development, Lucknow
7. Singh Jagbir (2014) “Eco-Tourism” Published by - I.K. International Pvt. Ltd. S-25, Green Park Extension, Uphaar Cinema Market, New Delhi, India ([www.ikbooks.com](http://www.ikbooks.com)).
8. Robinson, H. *Geography of tourism (Aspect Geographies)*; Published by MacDonal and Evans.

**DISCIPLINE SPECIFIC ELECTIVE 2 (GGD 5.22)  
PAPER PRESENTATION**

*Practical Credit: 2*

*Teaching Hours: 30*

**Note:** Students will be assigned topics based on the theory paper for presentation.

**DISCIPLINE SPECIFIC ELECTIVE 3 (GGD 6.11(a))  
AGRICULTURE GEOGRAPHY**

*Theory Credit: 4*

*Teaching Hours: 60*

**Objective:** The objective of this paper is to familiarize the students with importance of Agriculture Management keeping an emphasis on agriculture in Nagaland

**UNIT I** Agriculture geography: nature, scope, significance; Land use classification.

**UNIT II** Determinants of Agriculture: Physical, Economic, Social and Culture.

**UNIT III** Agricultural regions of the world (classification): Whittlesey's classification and Earl B Shaw's classification.

**UNIT IV** Indian agricultural regions: Agro-Climatic, Agro-ecological and crop combination Regions.

**UNIT V** Agricultural revolutions in India: Green, White, Blue, Pink

**Recommended Books and References:**

1. Anderson, E. (1970): **Geography of Agriculture**, W.M. C. Brown Co, Iowa
2. Bayliss Smith, T. P. (1987): **The Ecology of Agricultural Systems**, Cambridge University Press, London.
3. Gregor, H.P. (1990): **Geography of Agriculture**, Prentice – Hall, New York.
4. Grigg, D.B.(1974): **The Agricultural System of the World**, Cambridge University Press, London.
5. Shafi, M (2006): **Agricultural Geography**, Pearson Education, New Delhi.
6. Singh, S (1994): **Agricultural Development in India: A Regional Analysis**, Kaushal Publications, Shillong.
7. Singh, J. et al., (1984): **Agricultural Geography**, Tata Mc Graw hill, New Delhi.

**DISCIPLINE SPECIFIC ELECTIVE 3 (GGD 6.11(b))  
URBAN GEOGRAPHY**

*Theory Credit: 4*

*Teaching Hours :60*

**UNIT I** Urban geography: Introduction, nature and scope

**UNIT II** Patterns of Urbanisation in developed and developing countries

- UNIT III** Functional classification of cities: Quantitative and Qualitative Methods
- UNIT IV** Urban Issues: problems of housing, slums, civic amenities (water and transport)
- UNIT V** Case studies of Delhi, Mumbai, Kolkata, Chennai and Chandigarh with reference to Land use and Urban Issues

**Recommended Books and References:**

1. Fyfe N. R. and Kenny J. T., 2005: *The Urban Geography Reader*, Routledge.
2. Graham S. and Marvin S., 2001: *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition*, Routledge.
3. Hall T., 2006: *Urban Geography*, Taylor and Francis.
4. Kaplan D. H., Wheeler J. O. and Holloway S. R., 2008: *Urban Geography*, John Wiley.
5. Knox P. L. and McCarthy L., 2005: *Urbanization: An Introduction to Urban Geography*, Pearson Prentice Hall New York.
6. Knox P. L. and Pinch S., 2006: *Urban Social Geography: An Introduction*, Prentice-Hall.
7. Pacione M., 2009: *Urban Geography: A Global Perspective*, Taylor and Francis.
8. Sassen S., 2001: *The Global City: New York, London and Tokyo*, Princeton University Press.
9. Ramachandran R (1989): *Urbanisation and Urban Systems of India*, Oxford University Press, New Delhi
10. Ramachandran, R., 1992: *The Study of Urbanisation*, Oxford University Press, Delhi
11. Singh, R.B. (Eds.) (2001) *Urban Sustainability in the Context of Global Change*, Science Pub., Inc., Enfield (NH), USA and Oxford & IBH Pub., New Delhi.
12. Singh, R.B. (Ed.) (2015) *Urban development, challenges, risks and resilience in Asian megacities. Advances in Geographical and Environmental Studies*, Springer

**DISCIPLINE SPECIFIC ELECTIVE 3 (GGD 6.12)  
GRAPHICAL REPRESENTATION OF DATA**

*Practical Credit: 2*

*Teaching Hours: 30*

- UNIT I** Graphical representation using block-pile diagram.
- UNIT II** Representation of data: Cumulative graph, Ergograph.
- UNIT III** Distribution of urban population using simple and multiple dot.
- UNIT IV** Viva voce and Practical Note book

**Recommended Books and References:**

1. Mishra, R.P. and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi.
2. Sarkar, A. K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata
3. Singh, R. L.. (2006): **Fundamentals of Practical Geography**, Sharda Pustak Bhawan, Allahabad.

**DISCIPLINE SPECIFIC ELECTIVE 4 (GGD 6.21(a))  
POLITICAL GEOGRAPHY**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Introduction: Concepts, Nature and Scope.
- UNIT II** State, Nation and Nation State – Concept of Nation and State, Attributes of State – Frontiers, Boundaries, Shape, Size, Territory and Sovereignty, Concept of Nation State; Geopolitics; Theories (Heartland and Rimland)
- UNIT III** Electoral Geography – Geography of Voting, Geographic Influences on Voting pattern, Geography of Representation, Gerrymandering.
- UNIT IV** Political Geography of Resource Conflicts – Water Sharing Disputes, Disputes and Conflicts Related to Forest Rights and Minerals.
- UNIT V** Politics of Displacement: Issues of relief, compensation and rehabilitation: with reference to Dams and Special Economic Zones

**Recommended Books and References:**

1. Agnew J., 2002: *Making Political Geography*, Arnold.
2. Agnew J., Mitchell K. and Toal G., 2003: *A Companion to Political Geography*, Blackwell.
3. Cox K. R., Low M. and Robinson J., 2008: *The Sage Handbook of Political Geography*, Sage Publications.
4. Cox K., 2002: *Political Geography: Territory, State and Society*, Wiley-Blackwell
5. Gallaher C., et al, 2009: *Key Concepts in Political Geography*, Sage Publications.
6. Glassner M., 1993: *Political Geography*, Wiley.
7. Jones M., 2004: *An Introduction to Political Geography: Space, Place and Politics*, Routledge. Mathur H M and M MCernea (eds.) Development, Displacement and Resettlement – Focus on Asian Experience, Vikas, Delhi
8. Painter J. and Jeffrey A., 2009: *Political Geography*, Sage Publications.
9. Taylor P. and Flint C., 2000: *Political Geography*, Pearson Education.
10. Verma M K (2004): Development, Displacement and Resettlement, Rawat Publications, Delhi
11. Hodder Dick, Sarah J Llyod and Keith S McLachlan (1998), *Land Locked States of Africa and Asia* (vo.2), Frank Cass

**DISCIPLINE SPECIFIC ELECTIVE 4 (GGD 6.22(a))  
CARTOGRAPHIC TECHNIQUE II**

*Practical Credit: 2*

*Teaching Hours: 30*

History of maps. Types of maps: Cadastral maps, Topographical maps, Walls maps, Chorographical or Atlas maps. Importance and uses of maps. Conventional signs and symbols. Map drawing equipments. Map drawings: boundaries (international, national, state, district, etc).

**Recommended Books and References:**

1. Singh, R. L. and Singh, Rana: Elements of Practical Geography (Revised edition), Kalyan Publishers.
2. Monkhouse, F.J. and Wilkinson, F.J. (1985): **Maps and Diagrams**, Methuen, London.

3. Singh, L.R. (2006): **Fundamentals of Practical Geography**, Sharda Pustak Bhawan, Allahabad.

**DISCIPLINE SPECIFIC ELECTIVE 4 (GGD 6.21(b))  
DISSERTATION**

*Credit: 6*

*Teaching Hours: 90*

This dissertation/project will be in lieu of a discipline specific elective paper. The students will be asked to select topics based on their interest. The topics will be of the specific course they are undertaking i.e. geography. The students will be assisted by their respective teacher in charge and at the end of the semester, the students will have to present a seminar of their projects at the end of the semester. They will also have to submit a hard copy of their project.

The paper will be assessed on the following points:

**Project report**

**Seminar/presentation**

**Viva-voce**

## SKILL ENHANCEMENT COURSE

### SKILL ENHANCEMENT COURSE 1 (GGS 3.12(a)) REMOTE SENSING (PRACTICAL)

Practical Credit: 2

Teaching Hours: 30

1. Remote Sensing: Definition and types; Processes and elements of remote sensing; platforms and sensors.
2. Photogrammetry: Aerial Photography (Principles, Types and Geometry of Aerial Photograph)
3. Image Processing and Interpretation (Digital and Manual): Pre-processing (Radiometric and Geometric Correction); Enhancement (Filtering); Classification (Supervised and Un-supervised)
4. Application of Remote Sensing: Land Use and Land Cover

#### **Recommended Books and References:**

1. Bhatta, B. (2008) Remote Sensing and GIS, Oxford University Press, New Delhi.
2. Campbell J. B., 2007: *Introduction to Remote Sensing*, Guildford Press
3. Chauniyal, D. (2010) Sudur Samvedana Avam Bhaugolik Suchna Pranali, Sharda Pustak Bhawan, Allahabad.
4. Jensen, J. R. (2005) *Introductory Digital Image Processing: A Remote Sensing Perspective*, Pearson Prentice-Hall.
5. Joseph, G. 2005: *Fundamentals of Remote Sensing*, United Press India.
6. Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: *Remote Sensing and Image Interpretation*, Wiley. (Wiley Student Edition).
7. Li, Z., Chen, J. and Batsavias, E. (2008) *Advances in Photogrammetry, Remote Sensing and Spatial Information Sciences* CRC Press, Taylor and Francis, London
8. Mukherjee, S. (2004) *Textbook of Environmental Remote Sensing*, Macmillan, Delhi.
9. Nag P. and Kudra, M., 1998: *Digital Remote Sensing*, Concept, New Delhi.
10. Singh R. B. and Murai S., 1998: *Space-informatics for Sustainable Development*, Oxford and IBH Pub.

### SKILL ENHANCEMENT COURSE 1 (GGS 3.12(b)) ADVANCED SPATIAL STATISTICAL TECHNIQUES

Practical Credit: 2

Teaching Hours: 30

1. Statistics and Statistical Data: Spatial and non-spatial.
2. Sampling: Sampling plans for spatial and non-spatial data, sampling distributions.
3. Correlation: Rank order correlation and product moment correlation.
4. Regression Analysis: linear regression, residuals from regression, and simple curvilinear regression.
5. Time Series Analysis: Time Series processes; Smoothing time series; Time series components.

*Note: Any Statistical Software Package (SPSS, MS Excel, R, etc.) may be used for practice.*

#### **Recommended Books and References:**

1. Bart James E and Gerld M. Barber, 1996: *Elementary Statistics for Geographers*, The Guieford Press, London.



2. Eldon, D., 1983: Statistics in Geography: A Practical Approach, Blackwell, London.
3. Cressie, N.A.C., 1991: Statistics for Spatial Analysis, Wiley, New York.
4. Gregory, S., 1978: Statistical Methods and the Geographer (4th Edition), Longman, London.
5. Haining, R.P., 1990: Spatial Data Analysis in the Social and Environmental Science, Cambridge University Press, Cambridge.
6. Mc Grew, Jr. and Cahrls, B. M., 1993: An Introduction to Statistical Problem Solving in Geography, W.C. Brocan Publishers, New Jersey.
7. Mathews, J.A., 1987: Quantitative and Statistical Approaches to Geography: A Practical Manual Pergamon, Oxford.
8. S.K., 1998: Statistics for Geoscientists: Techniques and Applications, Concept Publishing Company, New Delhi.
9. Wei, W.S., 1990: Time Series Analysis: Variate and Multivariate Methods, Addison Wesley Publishing.
10. Yeates, Mauris, 1974: An Introduction to Quantitative Analysis in Human Geography, Mc Grawhill, New York.

**SKILL ENHANCEMENT COURSE 2 (GGS 4.12(a))  
GEOGRAPHICAL INFORMATION SYSTEM**

*Practical Credit: 2*

*Teaching Hours: 60*

1. Geographical Information System (GIS): Definition and development, Standard GIS softwares.
2. Components of GIS; GIS Data Structures: Types (spatial and non-spatial).
3. Global Positioning System (GPS) – Principles and Uses.
4. Interpretation and Application of GIS: Land Use Mapping; Basic Spatial data Analysis.

**Practical Record:** *A project file consisting of 5 exercises on using any GIS Software on abovementioned themes.*

**Recommended Books and References:**

1. Bhatta, B. (2010) Analysis of Urban Growth and Sprawl from Remote Sensing, Springer, Berlin Heidelberg.41
2. Burrough, P.A., and McDonnell, R.A. (2000) Principles of Geographical Information System- Spatial
3. Information System and Geo-statistics. Oxford University Press
4. Chauniyal, D.D. (2010) SudurSamvedanevamBhogolikSuchanaPranali, Sharda Pustak Bhawan, Allahabad
5. Heywoods, I., Cornelius, S and Carver, S. (2006) An Introduction to Geographical Infromation system. Prentice Hall.
6. Jha, M.M. and Singh, R.B. (2008) Land Use: Reflection on Spatial Informatics Agriculture and Development, New Delhi: Concept.
7. Nag, P. (2008) Introduction to GIS, Concept India, New Delhi.
8. Sarkar, A. (2015) Practical geography: A systematic approach. Orient Black Swan Private Ltd., New Delhi
9. Singh, R.B. and Murai, S. (1998) Space Informatics for Sustainable Development, Oxford and IBH, New Delhi.

**SKILL ENHANCEMENT COURSE 2 (GGS 4.12(b))**  
**RESEARCH METHODS**

*Practical Credit: 2*

*Teaching Hours: 30*

1. Geographic Enquiry: Definition and Ethics; Framing Research Questions, Objectives and Hypothesis; Literature Review; Preparing Sample Questionnaire
2. Data Collection: Type and Sources of Data; Methods of Collection; Input and Editing
3. Data Analysis: Qualitative Data Analysis; Quantitative Data Analysis; Data Representation Techniques
4. Structure of a Research Report: Preliminaries; Text; References, Bibliography and Citations; Abstract
5. Preparation of Research Report

***Recommended Books and References:***

1. Creswell J., 1994: Research Design: Qualitative and Quantitative Approaches Sage Publications.
2. Dikshit, R. D. 2003. The Art and Science of Geography: Integrated Readings. Prentice-Hall of India, New Delhi.
3. Evans M., 1988: "Participant Observation: The Researcher as Research Tool" in Qualitative Methods in Human Geography, eds. J. Eyles and D. Smith, Polity.
4. Misra, R.P. (2002) Research Methodology, Concept Publications, New Delhi.
5. Mukherjee, Neela 1993. Participatory Rural Appraisal: Methodology and Application. Concept Publs. Co., New Delhi.
6. Mukherjee, Neela 2002. Participatory Learning and Action: with 100 Field Methods. Concept Publs. Co., New Delhi
7. Robinson A., 1998: "Thinking Straight and Writing That Way", in Writing Empirical Research Reports: A Basic Guide for Students of the Social and Behavioural Sciences, eds. by F. Pryczak and R. Bruce Pryczak, Publishing: Los Angeles.
8. Special Issue on "Doing Fieldwork" The Geographical Review 91:1-2 (2001).
9. Stoddard R. H., 1982: Field Techniques and Research Methods in Geography, Kendall/Hunt.
10. Wolcott, H. 1995. The Art of Fieldwork. Alta Mira Press, Walnut Creek, CA.
11. Yadav, H. (2013) ShodhPravidhi Evam MatratamakBhugol, Raja Publications, Delhi.

*Revised*  
SYLLABUS FOR  
Bachelor of Science (Honours)

**GEOLOGY**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)



### COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Earth System Science (Theory)	GLC 1.11	4
		Earth System Science (Practical)	GLC 1.12	2
	Core 2	Mineral Science (Theory)	GLC 1.21	4
		Mineral Science (Practical)	GLC 1.22	2
II	Core 3	Elements of Geochemistry (Theory)	GLC 2.11	4
		Elements of Geochemistry (Practical)	GLC 2.12	2
	Core 4	Structural Geology (Theory)	GLC 2.21	4
		Structural Geology (Practical)	GLC 2.22	2
III	Core 5	Igneous Petrology (Theory)	GLC 3.11	4
		Igneous Petrology (Practical)	GLC 3.12	2
	Core 6	Sedimentary Petrology (Theory)	GLC 3.21	4
		Sedimentary Petrology (Practical)	GLC 3.22	2
	Core 7	Palaeontology (Theory)	GLC 3.31	4
		Palaeontology (Practical)	GLC 3.32	2
	Skill Enhancement Course 1	Field Work I- Basic Field Training	GLS 3.12	2
	IV	Core 8	Metamorphic Petrology (Theory)	GLC 4.11
Metamorphic Petrology (Practical)			GLC 4.12	2
Core 9		Stratigraphic Principles and Indian Stratigraphy (Theory)	GLC 4.21	4
		Stratigraphic Principles and Indian Stratigraphy (Practical)	GLC 4.22	2
Core 10		Hydrogeology (Theory)	GLC 4.31	4
		Hydrogeology (Practical)	GLC 4.32	2
Skill Enhancement Course 2		Field Work II- (i) Precambrian Geology OR (ii) Tertiary Geology OR (iii) Economic Geology	GLS 4.12(a)  GLS 4.12(b)  GLS 4.12(c)	2
V		Core 11	Economic Geology (Theory)	GLC 5.11
	Economic Geology (Practical)		GLC 5.12	2
	Core 12	Geomorphology (Theory)	GLC 5.21	4
		Geomorphology (Practical)	GLC 5.22	2
	Discipline Specific Elective 1	Exploration Geology (Theory) OR Evolution of Life through Time (Theory)	GLD 5.11(a)	4
			GLD 5.11(b)	
		Exploration Geology (Practical) OR Evolution of Life through Time (Practical)	GLD 5.12(a)	2
			GLD 5.12(b)	
	Discipline Specific Elective 2	Geology of Nagaland (Theory) OR Introduction to Geophysics (Theory)	GLD 5.21(a)	4
			GLD 5.21(b)	
Geology of Nagaland (Practical) OR Introduction to Geophysics (Practical)		GLD 5.22(a)	2	
		GLD 5.22(b)		

VI	Core 13	Engineering Geology (Theory)	GLC 6.11	4
		Engineering Geology (Practical)	GLC 6.12	2
	Core 14	Remote Sensing and GIS (Theory)	GLC 6.21	4
		Remote Sensing and GIS (Practical)	GLC 6.22	2
	Discipline Specific Elective 3	Environmental Geology (Theory) OR Urban Geology (Theory)	GLD 6.11(a) GLD 6.11(b)	4
		Environmental Geology (Practical) OR Urban Geology (Practical)	GLD 6.12(a) GLD 6.12(b)	2
		Fuel Geology (Theory) OR Earth and Climate (Theory)	GLD 6.21(a) GLD 6.21(b)	4
		Fuel Geology (Practical) OR Earth and Climate (Practical)	GLD 6.22(a) GLD 6.22(b)	2

## SEMESTER - I

### CORE 1 (GLC 1.11) EARTH SYSTEM SCIENCES

*Theory Credit: 4*

- UNIT I** Introduction to various branches of Geology. General characteristics and origin of the Universe. The terrestrial and jovian planets. Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age. Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere. Convection in Earth's core and production of its magnetic field
- UNIT II** Concept of plate tectonics, sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts.
- UNIT III** Oceanic current system and effect of Coriolis force, Concepts of eustasy, Land-air-sea interaction. Wave erosion and beach processes. Atmospheric circulation, weather and climatic changes. Earth's heat budget. Soils- processes of formation.
- UNIT IV** Nature of stratigraphic records. Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods and their application in geological studies. History of development in the concepts of uniformitarianism, catastrophism and neptunism. Laws of superposition and faunal succession. Introduction to geomorphology of Indian subcontinent.
- UNIT V** Distribution of elements in solar system and in Earth. Chemical differentiation and composition of the Earth. General concepts about geochemical cycles and mass balance. Geochemical behavior of major elements. Mass conservation of elements and isotopic fractionation.

### CORE 1 (GLC 1.12) EARTH SYSTEM SCIENCES

*Practical Credit: 2*

1. Study of major geomorphic features and their relationships with outcrops through physiographic models.
2. Study of soil profile of any specific area
3. Study of distribution of major lithostratigraphic units on the map of India
4. Study of major ocean currents of the World
5. Study of seismic profile of a specific area and its interpretation

#### **Recommended Books and References:**

1. Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor & Francis.

- Emiliani, C. (1992). *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.
- Gross, M. G. (1977). *Oceanography: A view of the earth*.

**CORE 2 (GLC 1.21)**  
**MINERAL SCIENCE**

*Theory Credit: 4*

- UNIT I** Elementary ideas about crystal morphology in relation to internal structures. Crystal parameters and indices. Crystal symmetry and common crystal forms- dome, prism, pyramid and pinacoid
- UNIT II** Study of normal classes of the Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic and Triclinic systems. Classification of 32 point groups.
- UNIT III** Minerals - definition and classification and physical properties. Isomorphism, polymorphism and pseudomorphism. Silicate structures, Cubic Close Packing and Hexagonal Close Packing structures.
- UNIT IV** Study of common rock-forming minerals – Silica, Feldspar, Pyroxene, Amphibole, Mica, Alumino silicate and Garnet Family
- UNIT V** Introduction to the petrological microscope.  
 Nature of light: Isotropic and anisotropic substances, Ordinary and polarised light, Refractive index, Birefringence, Pleochroism, Twinkling, Interference colour, Extinction and Twinning

**CORE 3 (GLC 1.22)**  
**MINERAL SCIENCE**

*Practical Credit: 2*

- Observation and documentation on symmetry of crystals
- Study of physical properties of minerals in hand specimen
- Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite
- Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rose quartz, Smoky quartz, Rock crystal. Native Metals/non-metals, Sulfides, Oxides- Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite Hydroxides, Halides, Carbonates, Sulfates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.
- Study of some key silicate minerals under optical microscope and their characteristic properties

**Recommended Books and References:**

- Klein, C., Dutrow, B., Dwight, J., & Klein, The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.



2. Kerr, P. F. (1959). *Optical Mineralogy*. McGraw-Hill.
3. Verma, P. K. (2010). *Optical Mineralogy (Four Colour)*. Ane Books Pvt Ltd.
4. Deer, W. A., Howie, R. A., & Zussman, J. (1992). *An introduction to the rock-forming minerals* (Vol. 696). London: Longman.

## SEMESTER - II

### CORE 3 (GLC 2.11) ELEMENTS OF GEOCHEMISTRY

*Theory Credit: 4*

- UNIT I** Introduction to properties of elements: The periodic table Chemical bonding, states of matter and concept of major, minor and trace elements.  
Geochemical classification of elements.
- UNIT II** Composition of different Earth reservoirs and the nuclides and radioactivity conservation of mass, isotopic and elemental fractionation. Concept of radiogenic isotopes in geochronology and isotopic tracers
- UNIT III** Advection and diffusion. Chromatography Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations Elements of marine chemistry. Mineral reactions- diagenesis and hydrothermal reactions.
- UNIT IV** The solid Earth – geochemical variability of magma and its products.  
The Earth in the solar system. Composition of the bulk silicate Earth. Meteorites
- UNIT V** Geochemical behaviour of selected elements like Si, Al, Fe K, Na and Mg

### CORE 3 (GLC 2.12) ELEMENTS OF GEOCHEMISTRY

*Practical Credit: 2*

1. Types of geochemical data analysis and interpretation; of common geochemical plots.
2. Geochemical analysis of geological materials.
3. Geochemical variation diagrams and its interpretations.

#### **Recommended Books and References:**

1. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
1. Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
2. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
3. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
4. Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles and Applications, Wiley India Pvt. Ltd

**CORE 4 (GLC 2.21)**  
**STRUCTURAL GEOLOGY**

*Theory Credit: 4*

- UNIT I** Effects of topography on structural features, topographic and structural maps, important representative factors of the map
- UNIT II** Concept of rock deformation: Stress and Strain in rocks and their geological significance, Planar and linear structures; dip and strike; Outcrop patterns of different structures.
- UNIT III** **Folds:** Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding
- UNIT IV** Description and origin of foliations: axial plane cleavage and its tectonic significance. Description and origin of lineation and relationship with the major structures
- UNIT V** Geometric and genetic classification of Joints and faults. Effects of faulting on the outcrops, Criteria for recognition of faults.

**CORE 4 (GLC 2.22)**  
**STRUCTURAL GEOLOGY**

*Practical Credit: 2*

1. Basic idea of topographic contours, Topographic sheets of various scales.
2. Introduction to Geological maps: Lithological and Structural maps
3. Structural contouring and 3-point problems of dip and strike
4. Drawing profile sections and interpretation of geological maps of different complexities
5. Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.)

***Recommended Books and References:***

1. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
2. Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.
3. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
4. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
5. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
6. Lahee F. H. (1962) Field Geology. McGraw Hill

## SEMESTER - III

### CORE 5 (GLC 3.11) IGNEOUS PETROLOGY

*Theory Credit: 4*

- UNIT I** Introduction to Igneous petrology: Heat flow, geothermal gradients through time, origin and nature of magma, magmatic differentiation and assimilation.
- UNIT II** Classification of igneous rocks: mineralogical and chemical classification, Textures and structures of igneous rocks, Mode of occurrence of Igneous rocks.
- UNIT III** Phase diagrams and petrogenesis. Binary and Ternary Phase diagrams in understanding crystal-melt equilibrium in basaltic and granitic magmas. Magma generation in crust and mantle, their emplacement and evolution.
- UNIT IV** Magmatism in different tectonic settings. Magmatism in the oceanic domains (MORB, OIB). Magmatism along the plate margins (Island arcs/continental arcs)
- UNIT V** Petrogenesis of Felsic and Mafic igneous rocks: Granitoides, Basalt, Gabbros, Alkaline rocks, kimberlites & lamproites and Komatiites.

### CORE 5 (GLC 3.12) IGNEOUS PETROLOGY

*Practical Credit: 2*

Study of important igneous rocks in hand specimens and thin sections- granite, granodiorite, diorite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite, dacite,

#### **Recommended Books and References:**

1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
3. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
4. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
5. McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
6. Myron G. Best (2001). Igneous and Metamorphic Petrology,
7. K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
8. Bose M.K. (1997). Igneous Petrology.
9. G W Tyrrell. (1926). Principles of Petrology. Springer

**CORE 6 (GLC 3.21)**  
**SEDIMENTARY PETROLOGY**

*Theory Credit: 4*

- UNIT I** Origin of sediments: Physical and chemical weathering, soils and paleosols.
- UNIT II** Classification of sedimentary rocks. Textures in sedimentary rock: Grain size scale, particle size distribution, particle shape and fabric.
- UNIT III** Laminar and turbulent flow, transportation and deposition. Palaeocurrent analysis: Palaeocurrents for different sedimentary environments. Sedimentary structures: Ripple marks, cross beds, mudcracks, graded bedding, flute marks, loadcast, tracks, trails and related structures.
- UNIT IV** Siliciclastic rocks: Conglomerates, sandstones, mudrocks. Carbonate rocks: limestone and its classification, dolomite and dolomitisation
- UNIT V** Diagenesis: Concepts and stages of diagenesis. Compaction, cementation and authigenesis/ neomorphism.

**CORE 7 (GLC 3.22)**  
**SEDIMENTARY PETROLOGY**

*Practical Credit: 2*

Exercises on sedimentary structures. Particle size distribution and statistical treatment  
Paleocurrent analysis Petrography of clastic and non-clastic rocks through hand specimens and thin sections

***Recommended Books and References:***

1. Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan.
2. Tucker, M. E. (2006) Sedimentary Petrology, Blackwell Publishing.
1. 3. Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin- Hyman, London.
3. Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell

**CORE 7 (GLC 3.31)**  
**PALAEONTOLOGY**

*Theory Credit: 4*

- UNIT I** Fossilization and fossil record: Fossilization processes and modes of preservation, Introduction to Paleobotany, Gondwana Flora and Ichnology.
- UNIT II** Species concept with special reference to paleontology, Taxonomic hierarchy. Theory of organic evolution interpreted from fossil record.

**UNIT III** Brief introduction to important invertebrate groups (Bivalvia, Gastropoda, Brachiopoda and Echinoidea) and their biostratigraphic significance. Significance of ammonites in Mesozoic biostratigraphy.

**UNIT IV** Mesozoic reptiles with special reference to origin, diversity and extinction of dinosaurs. Evolution of horse and intercontinental migrations. Human Evolution.

**UNIT V** Application of Fossils in stratigraphy: Biozones, index fossils and correlation. Fossils and palaeoenvironmental analysis. Application of palaeontology in palaeoecology.

### **CORE 7 (GLC 3.32)**

#### **PALAEONTOLOGY**

*Practical Credit: 2*

1. Study of fossils showing various modes of preservation
2. Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils

#### ***Recommended Books and References:***

1. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
2. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.
3. Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
4. Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
5. Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing

## SEMESTER - IV

### CORE 8 (GLC 4.11) METAMORPHIC PETROLOGY

*Theory Credit: 4*

- UNIT I** Metamorphism: Definition of metamorphism. Factors controlling metamorphism. Types of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism.
- UNIT II** Metamorphic facies and grades: Index minerals, Concept of metamorphic facies and grade, Chemographic projections, Mineralogical phase rule, Structure and textures of metamorphic rocks.
- UNIT III** Metamorphism and Tectonism: Relationship between metamorphism and deformation, Prograde and retrograde metamorphism.
- UNIT IV** Brief idea of anatexis and origin of migmatites. Metasomatism and role of fluids in metamorphism.
- UNIT V** Metamorphic rock associations- schists, gneisses, khondalites, charnockites, eclogites, quartzite and marble.

### CORE 8 (GLC 4.12) METAMORPHIC PETROLOGY

*Practical Credit: 2*

Megascopic and microscopic study (textural and mineralogical) of the following metamorphic rocks:

Low grade metamorphic rocks: serpentinites, albite-epidote-chlorite quartz schist, slate, talc-tremolite calcite-quartz schist.

Medium to high grade metamorphic rocks: Gneisses, amphibolite, hornfels, garnetiferous schists, sillimanite-kyanite-bearing rocks, Granulites, eclogite, diopside-forsterite marble.

Laboratory exercises in graphic plots for petrochemistry and interpretation of assemblages.

#### **Recommended Books and References:**

1. Philpotts, A., & Ague, J. (2009). *Principles of igneous and metamorphic petrology*. Cambridge University Press.
2. Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.
3. Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*. Routledge.
4. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
5. Yardley, B. W., & Yardley, B. W. D. (1989). *An introduction to metamorphic petrology*. Longman Earth Science Series.

## **CORE 9 (GLC 4.21)**

### **STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHIC**

*Theory Credit: 4*

- UNIT I** Concepts of litho-, bio- and chrono-stratigraphy. Dynamic stratigraphy: chemostratigraphy, seismic stratigraphy, sequence stratigraphy. Magnetostratigraphy.
- UNIT II** International Stratigraphic Code – development of a standardized stratigraphic nomenclature. Concepts of Stratotypes. Global Stratotype Section and Point (GSSP). Concept of paleogeographic reconstruction.
- UNIT III** Brief introduction to tectonic subdivisions of India. Introduction to Indian Shield. Introduction to Proterozoic basins of India: Geology of Vindhyan and Cudappah basins.
- UNIT IV** Paleozoic succession of Kashmir and its correlatives from Spiti and Zaskar Stratigraphy  
Mesozoic stratigraphy of India: Triassic successions of Spiti, Jurassic of Kutch, Cretaceous of Trichinopoly. Cenozoic stratigraphy of Assam.
- UNIT V** Important Stratigraphic boundaries in India: Precambrian-Cambrian boundary, Permian-Triassic boundary and Cretaceous-Tertiary boundary. Volcanic provinces of India: Deccan, Rajmahal and Sylhet Trap.

## **CORE 9 (GLC 4.22)**

### **STRATIGRAPHIC PRINCIPLES AND INDIAN STRATIGRAPHIC**

*Practical Credit: 2*

1. Study of geological map of India and identification of major stratigraphic units.
2. Study of rocks in hand specimens from known Indian stratigraphic horizons
3. Drawing various paleogeographic maps of Precambrian time
4. Study of different Proterozoic supercontinent reconstructions.

#### ***Recommended Books and References:***

1. Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi
2. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
3. Ramakrishnan, M. & Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.
4. Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd.



**CORE 10 (GLC 4.31)  
HYDROGEOLOGY**

*Theory Credit: 4*

- UNIT I** Scope of hydrogeology. Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration and subsurface movement of water. Rock properties affecting groundwater, Vertical distribution of subsurface water. Types of aquifer, aquifer parameters.
- UNIT II** Darcy's law and its validity, Intrinsic permeability and hydraulic conductivity, Laminar and turbulent groundwater flow.
- UNIT III** Basic concepts of well hydraulics and groundwater exploration. Surface-based groundwater exploration methods. Introduction to subsurface borehole logging methods.
- UNIT IV** Physical and chemical properties of water and water quality. Introduction to methods of interpreting groundwater quality data using standard graphical plots, Sea water intrusion in coastal aquifers.
- UNIT V** Surface and subsurface water interaction. Groundwater level fluctuations. Basic concepts of water balance studies, issues related to groundwater resources development and management. Rainwater harvesting.

**CORE 10 (GLC 4.32)  
ON HYDROGEOLOGY**

*Practical Credit: 2*

Preparation and interpretation of water level contour maps and depth to water level maps

Study, preparation and analysis of hydrographs for differing groundwater conditions

Water potential zones of India (map study).

Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams)

Simple numerical problems related to: determination of permeability in field and laboratory, Groundwater flow, Well hydraulics etc.

***Recommended Books and References:***

1. Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
2. Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
3. Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw- Hill Pub. Co. Ltd.

## SEMESTER - V

### CORE 11 (GLC 5.11) ECONOMIC GEOLOGY

*Theory Credit: 4*

- UNIT I** Ores, gangue minerals, tenor. Metallic and non-metallic minerals. Resources and reserves. Metallogenetic provinces and Epochs. Textures and structures of ores.
- UNIT II** Processes of formation of ore deposits: Magmatic, hydrothermal, metamorphic, sedimentation, residual and mechanical concentration and oxidation and supergene enrichment.
- UNIT III** Chemical composition, occurrence, origin, uses and distribution of the following economic mineral deposits in India: iron, manganese, chromium, copper, aluminium and gold.
- UNIT IV** Chemical composition, occurrence, origin, uses and distribution of the following industrial mineral deposits in India: magnesite, graphite, mica, asbestos, sillimanite and kyanite.
- UNIT V** Brief account on the following economic deposits in the North East India: coal, petroleum, limestone and uranium. Introduction to gemstones.

### CORE 11 (GLC 5.12) ECONOMIC GEOLOGY

*Practical Credit: 2*

Megascope identification

Study of microscopic properties of ore forming minerals (Oxides and sulphides).

**Preparation of maps:** Distribution of important ores and other economic minerals in India.

#### **Recommended Books and References:**

1. Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.
2. Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
3. Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
4. Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
5. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
6. Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
7. Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.

**CORE 12 (GLC 5.21)  
GEOMORPHOLOGY**

*Theory Credit: 4*

- UNIT I** Introduction to Geomorphology, Endogenic - Diastropism and Exogenic processes- Degradational, Aggradational, Extraterrestrial, Anthropogenic processes.
- UNIT II** Topography, Hypsometry, Large Scale Topography - Ocean basins, Plate tectonics overview, Large scale mountain ranges (with emphasis on Himalaya).
- UNIT III** Weathering and associated landforms. Glacial and Periglacial processes and landforms. Fluvial processes and landforms, Aeolian Processes and landforms. Landforms associated with igneous activity.
- UNIT IV** Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, Long-term landscape development
- UNIT V** Overview of Indian Geomorphology: Northern mountains, the Great Plains, Central Highlands, Peninsular Plateau, Coastal Plains and the Islands. Hill slopes.

**CORE 12 (GLC 5.22)  
GEOMORPHOLOGY**

*Practical Credit: 2*

Reading topographic maps, Concept of scale Preparation of a topographic profile, Preparation of longitudinal profile of a river; Preparing Hack Profile; Calculating Stream length gradient index, Morphometry of a drainage basin, Calculating different morphometric parameters, Preparation of geomorphic map, Interpretation of geomorphic processes from the geomorphology of the area

***Recommended Books and References:***

1. Robert S. Anderson and Suzanne P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.
2. M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.
3. Thornburry

## SEMESTER - VI

### CORE 13 (GLC 6.11) ENGINEERING GEOLOGY

*Theory Credit: 4*

- UNIT I** Role of Geology in Engineering. Site investigation and characterization (relief, lithology, structures, ground water conditions)
- UNIT II** Foundation treatment: Grouting, Rock Bolting and other support mechanisms.  
Rock aggregates: significance as construction material.
- UNIT III** Concept, Mechanism and Significance of: Rock Structure Rating (RSR), Rock Mass Rating (RMR) and Tunneling Quality Index (TQI).
- UNIT IV** Geological considerations in the constructions of Dams and Tunnels. Tunnelling methods.
- UNIT V** Geological considerations in the constructions of Highways and Bridges. Landslides: causes and corrective/preventive measures.

### CORE 13 (GLC 6.12) ENGINEERING GEOLOGY

*Practical Credit: 2*

1. Computation of reservoir area, catchment area, reservoir capacity and reservoir life.
2. Merits, demerits & remedial measures based upon geological cross sections of project sites.
3. Computation of Index properties of rocks.
4. Computation of RQD, RSR, RMR and 'Q'

#### **Recommended Books and References:**

1. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.
3. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
4. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
5. Bell: F.G-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
6. Bell, .F.G, 2007. *Engineering Geology*, Butterworth-Heineman

**CORE 14 (GLC 6.21)**  
**REMOTE SENSING AND GIS**

*Theory Credit: 4*

- UNIT I** Photogeology: Types and acquisition of aerial photographs. Scale and resolution. Principles of stereoscopy, relief displacement, vertical exaggeration and distortion. Elements of air photo interpretation. Identification of sedimentary, igneous and metamorphic rocks.
- UNIT II** Concepts in Remote Sensing. Sensors and scanners. Satellites and their characteristics.
- UNIT III** Digital image processing, Image Errors, Rectification and Restoration, Image Enhancement, Filtering, Image Rationing, Image classification.
- UNIT IV** GIS, Datum, Coordinate systems and Projection systems. Spatial data models and data editing. Introduction to DEM analysis.
- UNIT V** GPS, Concepts of GPS. Integrating GPS data with GIS, Applications in earth system sciences.

**CORE 14 (GLC 6.22)**  
**REMOTE SENSING AND GIS**

*Practical Credit: 2*

1. Aerial Photo interpretation, identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms
2. Introduction to DIP and GIS softwares. Digital Image Processing exercises including analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signatures Creating a FCC from raw data, Registration of satellite data with a toposheet of the area
3. Enhancing the satellite images; Generating NDVI images and other image ratio and its interpretation
4. Classification of images.DEM analysis: generating slope map, aspect map and drainage network map and its applications

**Recommended Books and References:**

1. Demers, M.N., 1997. *Fundamentals of Geographic Information System*, John Wiley & sons. Inc.
2. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. *GPS: Theory & Practice*, Springer Wien New York.
3. Jensen, J.R., 1996. *Introductory Digital Image Processing: A Remote Sensing Perspective*, Springer- Verlag.
4. Lillesand, T. M. & Kiefer, R.W., 2007. *Remote Sensing and Image Interpretation*, Wiley.
5. Richards, J.A. and Jia, X., 1999. *Remote Sensing Digital Image Analysis*, Springer-Verlag.

## **DISCIPLINE SPECIFIC ELECTIVE**

### **DISCIPLINE SPECIFIC ELECTIVE 1 (GLD 5.11(a)) EXPLORATION GEOLOGY**

*Theory Credit: 4*

- UNIT I** Resource reserve definitions. Prospecting and exploration-conceptualization, methodology and stages
- UNIT II** Prospecting and Exploration, Principles of mineral exploration. Sampling, Geochemical exploration, Remote sensing, Geophysical prospecting, Radioactive methods. Ore grade, Assessment of grade.
- UNIT III** Core and non-core drilling, Planning of bore holes and location of boreholes on ground Core-logging
- UNIT IV** Reserve estimations and Errors, Principles of reserve estimation, density and bulk density, Factors affecting reliability of reserve estimation, Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks)
- UNIT V** Principles of Mineral economics: strategic, critical and essential minerals. National and domestic mineral policies. Mineral concession rules. Marine mineral resources. Laws of

### **DISCIPLINE SPECIFIC ELECTIVE 1 (GLD 5.12(a)) EXPLORATION GEOLOGY**

*Practical Credit: 2*

1. Identification of anomaly
2. Concept of weighted average in anomaly detection
3. Geological cross-section
4. Models of reserve estimation

#### ***Recommended Books and References:***

1. Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
2. Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.
3. Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.

### **DISCIPLINE SPECIFIC ELECTIVE 1 (GLD 5.11(b)) EVOLUTION OF LIFE THROUGH TIME**

*Theory Credit: 4*

- UNIT I** Fossils and chemical remains of ancient life. Geological Time Scale with emphasis on major bio-events. Fossilization processes and modes of fossil preservation.

- UNIT II** Biosphere as a system, processes and products. Biogeochemical cycles. Microbes-mineral interactions, microbial mats.
- UNIT III** Archean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life. Precambrian microfossils – The garden of Ediacara.
- UNIT IV** The Cambrian Explosion. Origin of vertebrates and radiation of fishes. Origin of tetrapods - Life out of water. Early land plants and impact of land vegetation.
- UNIT V** Life after the largest (P/T) mass extinction, life in the Jurassic seas. Origin of mammals. Rise and fall of dinosaurs. Origin of birds; and spread of flowering plants.

**DISCIPLINE SPECIFIC ELECTIVE 1 (GLD 5.12(b))  
EVOLUTION OF LIFE THROUGH TIME**

*Practical Credit: 2*

1. Study of modes of fossil preservation
2. Study of fossils from different stratigraphic levels
3. Exercises related to major evolutionary trends in important groups of animals and plants

***Recommended Books and References:***

1. Stanley, S.M., 2008 Earth System History
2. Jonathan I. Lumine W.H. Freeman Earth-Evolution of a Habitable World, Cambridge University Press.
3. Canfield, D.E. & Konhauser, K.O., 2012 Fundamentals of Geobiology Blackwell
4. Cowen, R., 2000 History of Life, Blackwell

**DISCIPLINE SPECIFIC ELECTIVE 2 (GLD 5.21(a))  
GEOLOGY OF NAGALAND**

*Theory Credit: 4*

- UNIT I** Introduction to Geology of Nagaland: physiography, stratigraphy, fossil content and tectonic setting.
- UNIT II** Schuppen belt: stratigraphy, structure and petrology of the litho-units. Geological characteristics of thrusts with special reference to the Naga and Disang thrusts.
- UNIT III** Inner fold belt: stratigraphy, structure and petrology of the various litho-units.
- UNIT IV** Ophiolite belt: major litho-units, structure, tectonic setting and evolution of Naga Ophiolite Belt.
- UNIT V** Mineral resources of Nagaland with special reference to coal, petroleum, limestone, metaliferrous deposits (chromium, nickel and cobalt) and dimensional stones (marble and serpentinite).

**DISCIPLINE SPECIFIC ELECTIVE 2 (GLD 5.22(a))  
GEOLOGY OF NAGALAND**

*Practical Credit: 2*

Megascopic studies of Disang shale, Barail sandstone, Surma sandstone and shale, Tipam sandstone, Girujan clay, Dihing pebbles and boulders, vesicular basalt, spilite, gabbro, pyroxenite, peridotite, serpentinite, dolerite, plagiogranite, norite, lherzolite, harzburgite, wherlite, blue schist, phyllite, marble, limestone and conglomerate. Study of the following minerals: asbestos, coal, chert, cobalt, covellite, chromite, chalcopyrite, bornite, magnetite, haematite, brucite, nickel, magnesite, jasper, pyrite, steatite, talc and jadeite. Study of available fossils of Nagaland.

**Recommended Books and References:**

1. Geology of India and Burma – M.S. Krishnan, 1982. CBS Publishers & Distributors.
2. Fundamentals of Historical Geology and Stratigraphy of India – Ravindra Kumar.
3. Geology of India – D.N. Wadia. Tata McGraw Hill Publishing.
4. Phanerozoic Ophiolites of India – P.C. Ghose. Sumna Publishers & Distributors, Patna.
5. Geology of Nagaland Ophiolite – Geological Survey of India Memoirs, v. 119.

**DISCIPLINE SPECIFIC ELECTIVE 2 (GLD 5.21(b))  
INTRODUCTION TO GEOPHYSICS**

*Theory Credit: 4*

- UNIT I** Interrelationship between geology and geophysics, Role of geological and geophysical data in explaining geodynamical features of the earth.
- UNIT II** Different types of geophysical methods - gravity, magnetic, electrical and seismic; their principles and applications. Concepts and Usage of corrections in geophysical data.
- UNIT III** Different types of surveys, grid and route surveys, profiling and sounding techniques. Scales of survey, Presentation of geophysical data.
- UNIT IV** Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics.
- UNIT V** Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly, and depth of exploration

**DISCIPLINE SPECIFIC ELECTIVE 2 (GLD 5.22(b))  
INTRODUCTION TO GEOPHYSICS**

*Practical Credit: 2*

1. Anomaly and background- Graphical method
2. Study and interpretation of seismic reflector geometry
3. Problems on gravity anomaly



**Recommended Books and References:**

1. Outlines of Geophysical Prospecting - A manual for geologists by Ramachandra Rao, M.B., Prasaranga, University of Mysore, Mysore, 1975.
2. Exploration Geophysics - An Outline by Bhimasarikaram V.L.S., Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.
3. Dobrin, M.B. (1984) An introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.
4. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied geophysics* (Vol. 1). Cambridge university press.
5. Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.

**DISCIPLINE SPECIFIC ELECTIVE 3 (GLD 6.11(a))****ENVIRONMENTAL GEOLOGY**

*Theory Credit: 4*

- UNIT I** Introduction to environmental geology; cultural and environmental awareness, geology a basic environment awareness, geology as a basic environmental Science. Earth as a system, Sustainability and limitation of resources.
- UNIT II** Environmental pollution: causes, impacts, remediation/mitigation measures of air and water pollution. Vehicular pollution.
- UNIT III** Geological hazards: Primary and secondary hazards, Seismic engineering, early warning systems, Planning and education. Stabilizing hill slopes and controlling landslides, Vulnerability zone, types and mitigation measures.
- UNIT IV** Anthropogenic hazard: causes, impact and preventive measures on deforestation. Soil sickness, soil loss equation, conservation method.
- UNIT V** Geo- environmental Problems of NE India: Geological and topographic characteristics, climate, drainage, groundwater, soil, land use, land capability, forest cover and their mitigation.

**DISCIPLINE SPECIFIC ELECTIVE 3 (GLD 6.12(a))****ENVIRONMENTAL GEOLOGY**

*Practical Credit: 2*

Case studies on population growth, deforestation, water and air pollution, earthquake zones of the world, landslide zonation maps and geo environmental problems of North east India.

**Recommended Books and References:**

1. Environmental Geology - E.A. Keller.
2. Environmental Problems and Solutions - D.K. Asthana.
3. Environmental Science and Engineering – R. Sivakumar.
4. Ecology and Environment - P.D. Sharma.

**DISCIPLINE SPECIFIC ELECTIVE 3 (GLD 6.11(b))  
URBAN GEOLOGY**

*Theory Credit: 4*

- UNIT I** Geology in Urban Constructions. Geotechnical feature and mapping for subsurface in Metropolitan areas. Building materials, Excavation and cutting in urban areas.
- UNIT II** Soil studies, Chemistry and geochemistry of soil in relation to ground water and fertilizer. Effect of pollutants on vegetable contamination.
- UNIT III** Geotechnical site characterization, Geotechnical and land use mapping, Decision making in urban land use, Geological problems in construction of underground structures in urban areas.
- UNIT IV** Water lagging in built-up areas, Source of water, Standards for various uses of water Sources of contamination. Waste waters: Sources and its disinfection and treatment.
- UNIT V** Geotechnical characterization for waste sites, Domestic waste, Industrial waste, Need for special purpose mapping for selection of waste disposal sites.

**DISCIPLINE SPECIFIC ELECTIVE 3 (GLD 6.12(b))  
URBAN GEOLOGY**

*Practical Credit: 2*

1. Map Reading
2. Ground water flow direction estimation
3. Case studies of Urban flood; Flood hydrographs
4. Case studies of urban planning

***Recommended Books and References:***

1. Huggenberger, P. and Eptin, J. 2011 Urban Geology: Process-Oriented Concepts for Adaptive and Integrated Resource Management. Springer
2. Lollino, G. et al. (Ed.), Engineering Geology for Society and Territory. Springer

**DISCIPLINE SPECIFIC ELECTIVE 4 (GLD 6.21(a))  
FUEL GEOLOGY**

*Theory Credit: 4*

- UNIT I** Definition and origin of Coal. Basic classification of coal. Introduction to lithotypes, micro lithotypes and macerals in coal, Proximate and Ultimate analysis.
- UNIT II** Coal Bed Methane (CBM), Underground coal gasification and Coal liquefaction.
- UNIT III** Chemical composition and physical properties of crude oil, Origin and migration of crude oil.

- UNIT IV** Reservoir rocks - clastic and chemical., hydrocarbon traps - structural, stratigraphic and combination, Cap rocks - definition and general properties.
- UNIT V** Gas Hydrates. Radioactive minerals: Occurrence and origin of Uranium and Thorium bearing minerals, reserves in India. Nuclear waste disposal.

**DISCIPLINE SPECIFIC ELECTIVE 4 (GLD 6.22(a))  
FUEL GEOLOGY**

*Practical Credit: 2*

1. Study of hand specimens of coal
2. Reserve estimation of coal
3. Section correlation and identification of hydrocarbon prospect
4. Panel and Fence diagrams

***Recommended Books and References:***

1. Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.
2. Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
3. Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
4. Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.

**DISCIPLINE SPECIFIC ELECTIVE 4 (GLD 6.21(b))  
EARTH AND CLIMATE**

*Theory Credit: 4*

- UNIT I** Components of the climate system. Climate forcing, Climate controlling factors. Climate system response, response rates and interactions within the climate system.
- UNIT II** Incoming solar radiation, receipt and storage of heat. Heat transformation. Earth's heat budget. Interactions amongst various sources of earth's heat.
- UNIT III** Layering of atmosphere and atmospheric Circulation. Atmosphere and ocean interaction and its effect on climate. Heat transfer in ocean. Global oceanic conveyor belt and its control on earth's climate.
- UNIT IV** Climate Change: natural vs. anthropogenic effects. Humans and climate change. Brief introduction to archives of climate change.
- UNIT V** Milankovitch cycles and variability in the climate. Glacial-interglacial stages. Pleistocene Glacial-Interglacial cycles. Marine isotope stages.
- UNIT VI** Mechanism of monsoon. Monsoonal variation through time. Factors associated with monsoonal intensity. Effects of monsoon.

**DISCIPLINE SPECIFIC ELECTIVE 4 (GLD 6.22(b))  
EARTH AND CLIMATE**

*Practical Credit: 2*

1. Study of distribution of major climatic regimes of India on map
2. Distribution of major wind patterns on World map
3. Preparation of paleogeographic maps (distribution of land and sea) of India during specific geological time intervals
4. Numerical exercises on interpretation of proxy records for paleoclimate

***Recommended Books and References:***

1. Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
2. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlett
3. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher
4. Aguado, E., and Burt, J., 2009. Understanding weather

## **SKILL ENHANCEMENT COURSE**

### **SKILL ENHANCEMENT COURSE 1 (GLS 3.12)**

#### **FIELD WORK-I: BASIC FIELD TRAINING**

*Practical Credit: 2*

- UNIT I** Orientation of Topographic sheet in field, marking location in toposheet, Bearing (Front and back). Concepts of map reading, Distance, height and pace approximation
- UNIT II** Identification of rock types in field; structures and texture of rocks, Use of hand lense.
- UNIT III** Basic field measurement techniques: Bedding dip and strike, Litholog measurement
- UNIT IV** Reading contours and topography

### **SKILL ENHANCEMENT COURSE 2 (GLS 4.12(a))**

#### **FIELD WORK-II: PRECAMBRIAN GEOLOGY FIELD**

*Practical Credit: 2*

1. Field transect in any Precambrian terrain
2. Study of craton ensemble including basic intrusive suites
3. Precambrian sedimentary basin
4. Basement-Cover relation in: a. fold belts, b. sedimentary successions

### **SKILL ENHANCEMENT COURSE 2 (GLS 4.12(b))**

#### **FIELD WORK-II: TERTIARY GEOLOGY FIELD**

*Practical Credit: 2*

Field training along Tertiary terrain. Documentation of stratigraphic details in the field. Collection of sedimentological, stratigraphic and structural details.

### **SKILL ENHANCEMENT COURSE 2 (GLS 4.12(c))**

#### **FIELD WORK-II: ECONOMIC GEOLOGY FIELD**

*Practical Credit: 2*

#### **Module I**

- UNIT I** Visit to any mineral deposit
- UNIT II** Mode occurrence of ore, Ore mineralogy
- UNIT III** Ore formation process
- UNIT IV** Basic techniques of surveying, concept of outcrop mapping

**Module 2**

**UNIT I** Visit to underground or open cast mine

**UNIT II** Practical experience of mining methods

**UNIT III** Underground mapping/ Bench mapping

*Revised*  
SYLLABUS FOR  
Bachelor of Science (Honours)

**MATHEMATICS**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)





### COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT	
I	Core 1	Calculus (Theory)	MAC 1.11	4	
		Calculus (Practical)	MAC 1.12	2	
	Core 2	Algebra (Theory)	MAC 1.21	5	
		Algebra (Tutorial)		1	
II	Core 3	Real Analysis (Theory)	MAC 2.11	5	
		Real Analysis (Tutorial)		1	
	Core 4	Differential Equations (Theory)	MAC 2.21	4	
		Differential Equations (Practical)	MAC 2.22	2	
III	Core 5	Theory of Real Functions (Theory)	MAC 3.11	5	
		Theory of Real Functions (Tutorial)		1	
	Core 6	Group Theory I (Theory)	MAC 3.21	5	
		Group Theory I (Tutorial)		1	
	Core 7	PDE and Systems of ODE (Theory)	MAC 3.31	4	
		PDE and Systems of ODE (Practical)	MAC 3.32	2	
	Skill Enhancement Course 1	Logic and Sets (Theory) OR Computer Graphics (Theory)	MAS 3.11(a)  MAS 3.11(b)	2	
	IV	Core 8	Numerical Methods (Theory)	MAC 4.11	4
Numerical Methods (Practical)			MAC 4.12	2	
Core 9		Riemann Integration and Series of Functions (Theory)	MAC 4.21	5	
		Riemann Integration and Series of Functions (Tutorial)		1	
Core 10		Ring Theory and Linear Algebra I (Theory)	MAC 4.31	5	
		Ring Theory and Linear Algebra I (Tutorial)		1	
Skill Enhancement Course 2		Graph Theory OR Operating System - Linux	MAS 4.11(a)  MAS 4.11(b)	2	
V		Core 11	Multivariate Calculus (Theory)	MAC 5.11	5
	Multivariate Calculus (Tutorial)			1	
	Core 12	Group Theory II (Theory)	MAC 5.21	5	
		Group Theory II (Tutorial)		1	
	Discipline Specific Elective 1	Portfolio Optimization (Theory) OR Number Theory (Theory) OR Analytical Geometry (Theory)	MAD 5.11(a)  MAD 5.11(b)  MAD 5.11(c)	5	
		Portfolio Optimization (Tutorial) OR Number Theory (Tutorial) OR Analytical Geometry (Tutorial)		1	
		Discipline Specific Elective 2	Industrial Mathematics (Theory) OR Boolean Algebra and Automata Theory (Theory) OR	MAD 5.21(a)  MAD 5.21(b)  MAD 5.21(c)	5

		Probability and Statistics (Theory)		
		Industrial Mathematics (Tutorial) OR Boolean Algebra and Automata Theory (Tutorial) OR Probability and Statistics (Tutorial)		1
<b>VI</b>	Core 13	Metric Spaces and Complex Analysis (Theory)	MAC 6.11	5
		Metric Spaces and Complex Analysis (Tutorial)		1
	Core 14	Ring Theory and Linear Algebra II (Theory)	MAC 6.21	5
		Ring Theory and Linear Algebra II (Tutorial)		1
	Discipline Specific Elective 3	Theory of Equations (Theory) OR Bio-Mathematics (Theory) OR Linear Programming (Theory)	MAD 6.11(a) MAD 6.11(b) MAD 6.11(c)	5
		Theory of Equations (Tutorial) OR Bio-Mathematics (Tutorial) OR Linear Programming (Tutorial)		1
	Discipline Specific Elective 4	Mathematical Modelling (Theory) OR Mechanics (Theory) OR Differential Geometry (Theory)	MAD 6.21(a) MAD 6.21(b) MAD 6.21(c)	4 5 5
		Mathematical Modelling (Practical) OR Mechanics (Tutorial) OR Differential Geometry (Tutorial)	MAD 6.22(a)	2 1 1

## SEMESTER - I

### CORE 1 (MAC 1.11) CALCULUS

*Theory Credit: 4*

- UNIT I** Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type  $e^{ax+bx}$ ,  $e^{ax+b}\cos x$ ,  $(ax+b)^n\sin x$ ,  $(ax+b)^n\cos x$ , concavity and inflection points, asymptotes.
- UNIT II** Curve tracing in Cartesian coordinates, introduction to polar coordinates and curve tracing in polar coordinates of standard curves (cycloid, cardioid, other simple curves), L'Hospital's rule, applications in business, economics and life sciences.
- UNIT III** Reduction formulae, derivations and illustrations of reduction formulae of the type  $\int \sin^n x dx$ ,  $\int \cos^n x dx$ ,  $\int \tan^n x dx$ ,  $\int \sec^n x dx$ ,  $\int x^m(\log x)^n dx$ ,  $\int \sin^m x \cos^n x dx$ , Volumes by slicing disks and washers methods, volumes by cylindrical shells, volumes by parametric equations, Parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution.
- UNIT IV** Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics.
- UNIT V** Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modeling ballistics and planetary motion, Kepler's second law.

### CORE 1 (MAC 1.12) CALCULUS

*Practical Credit: 2*

#### **List of Practicals (using any software)**

- (i) Plotting of graphs of function  $e^{ax+b}$ ,  $\log(ax+b)$ ,  $1/(ax+b)$ ,  $\sin(ax+b)$ ,  $\cos(ax+b)$ ,  $|ax+b|$  and to illustrate the effect of a and b on the graph.
- (ii) Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
- (iii) Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).
- (iv) Obtaining surface of revolution of curves.
- (v) Tracing of conics in cartesian coordinates/ polar coordinates.
- (vi) Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using cartesian coordinates.
- (vii) Matrix operation (addition, multiplication, inverse, transpose).

#### **Recommended Books and References:**

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.

2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, *Calculus*, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, *Introduction to Calculus and Analysis (Volumes I & II)*, Springer-Verlag, New York, Inc., 1989.

## **CORE 2 (MAC 1.21)**

### **ALGEBRA**

*Theory Credit: 5*

*Tutorial Credit: 1*

**UNIT I** Polar representation of complex numbers,  $n^{\text{th}}$  roots of unity, De Moivre's theorem for rational indices and its applications.

**UNIT II** Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

**UNIT III** Systems of linear equations, row reduction and echelon forms, the matrix equation  $Ax=b$ , solution sets of linear systems, applications of linear systems.

**UNIT IV** Introduction to vector space, vector equations, linear independence of vectors, Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices.

**UNIT V** Dimension of a vector space, subspaces of  $\mathbb{R}^n$ , dimension of subspaces of  $\mathbb{R}^n$  and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.

### **Recommended Books and References:**

1. Titu Andreescu and Dorin Andrica, *Complex Numbers from A to Z*, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, *Linear Algebra and its Applications*, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

## SEMESTER - II

### CORE 3 (MAC 2.11) REAL ANALYSIS

Theory Credit: 5

Tutorial Credit: 1

- UNIT I** Review of Algebraic and Order Properties of  $R$ ,  $\delta$ -neighborhood of a point in  $R$ , Idea of countable sets, uncountable sets and uncountability of  $R$ . Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima,
- UNIT II** The Completeness Property of  $R$ , The Archimedean Property, Density of Rational (and Irrational) numbers in  $R$ , Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for bounded sets.
- UNIT III** Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem.
- UNIT IV** Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion.
- UNIT V** Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's  $n^{\text{th}}$  root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.

#### **Recommended Books and References:**

1. R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, *An Introduction to Analysis*, 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, *Elementary Real Analysis*, Prentice Hall, 2001.
4. S.K. Berberian, *A First Course in Real Analysis*, Springer Verlag, New York, 1994.

**CORE 4 (MAC 2.21)**  
**DIFFERENTIAL EQUATIONS**

*Theory Credit: 4*

- UNIT I** Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.
- UNIT II** Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting.
- UNIT III** General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications.
- UNIT IV** Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.
- UNIT V** Equilibrium points, Interpretation of the phase plane, predatory-prey model and its analysis, epidemic model of influenza and its analysis, battle model and its analysis.

**CORE 4 (MAC 2.22)**  
**DIFFERENTIAL EQUATIONS**

*Practical Credit: 2*

**List of Practical (using any software)**

1. Plotting of second order solution family of differential equation.
2. Plotting of third order solution family of differential equation.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. Lake pollution model (with constant/seasonal flow and pollution concentration).
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).
8. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
9. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
10. Battle model (basic battle model, jungle warfare, long range weapons).
11. Plotting of recursive sequences.
12. Study the convergence of sequences through plotting.
13. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
14. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
15. Cauchy's root test by plotting  $n^{\text{th}}$  roots.
16. Ratio test by plotting the ratio of  $n^{\text{th}}$  and  $(n+1)^{\text{th}}$  term.

**Recommended Books and References:**

1. Belinda Barnes and Glenn R. Fulford, *Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab*, 2nd Ed., Taylor and Francis group, London and New York, 2009.
2. C.H. Edwards and D.E. Penny, *Differential Equations and Boundary Value problems Computing and Modeling*, Pearson Education India, 2005.
3. S.L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, India, 2004.
4. Martha L Abell, James P Braselton, *Differential Equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press, 2004.

## SEMESTER - III

### CORE 5 (MAC 3.11)

#### THEORY OF REAL FUNCTIONS

Theory Credit: 5

Tutorial Credit: 1

- UNIT I** Limits of functions ( $\varepsilon$ - $\delta$  approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity.
- UNIT II** Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.
- UNIT III** Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle's theorem, Mean value theorem. Cauchy's mean value theorem.
- UNIT IV** L'Hospital's rule. Intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials. Taylor's theorem to inequalities.
- UNIT V** Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions,  $\ln(1+x)$ ,  $\frac{1}{ax+b}$ , and  $(1+x)^n$ .

#### **Recommended Books and References:**

1. R. Bartle and D.R. Sherbert, *Introduction to Real Analysis*, John Wiley and Sons, 2003.
2. S.R. Ghorpade and B.V. Limaye, *A Course in Calculus and Real Analysis*, Springer, 2006.
3. K.A. Ross, *Elementary Analysis: The Theory of Calculus*, Springer, 2004.
4. A. Mattuck, *Introduction to Analysis*, Prentice Hall, 1999.

### CORE 6 (MAC 3.21)

#### GROUP THEORY I

Theory Credit: 5

Tutorial Credit: 1

- UNIT I** Definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), Symmetries of a square, Dihedral groups, elementary properties of groups.
- UNIT II** Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. Properties of cyclic groups, classification of subgroups of cyclic groups.



- UNIT III** Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.
- UNIT IV** External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.
- UNIT V** Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.

**Recommended Books and References:**

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi, 1999.
4. Joseph J. Rotman, *An Introduction to the Theory of Groups*, 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, *Topics in Algebra*, Wiley Eastern Limited, India, 1975.

**CORE 7 (MAC 3.31)  
PDE AND SYSTEMS OF ODE**

*Theory Credit: 4*

- UNIT I** Partial Differential Equations – Basic concepts and Definitions, Mathematical Problems. First-Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Canonical Forms of First-order Linear Equations.
- UNIT II** Method of Separation of Variables for solving first order partial differential equations. Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order Linear Equations to canonical forms.
- UNIT III** The Cauchy problem, the Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string. Initial Boundary Value Problems, Semi-Infinite String with a fixed end, Semi-Infinite String with a Free end,
- UNIT IV** Equations with non-homogeneous boundary conditions, Non-Homogeneous Wave Equation. Method of separation of variables, Solving the Vibrating String Problem, Solving the Heat Conduction problem.
- UNIT V** Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions, The method of successive approximations, the Euler method, the modified Euler method, The Runge-Kutta method.

**CORE 7 (MAC 3.32)**  
**PDE AND SYSTEMS OF ODE**

Practical Credit: 2

**List of Practicals (using any software)**

- (i) Solution of Cauchy problem for first order PDE.
- (ii) Finding the characteristics for the first order PDE.
- (iii) Plot the integral surfaces of a given first order PDE with initial data.
- (iv) Solution of wave equation  $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$  for the following associated conditions
  - (a)  $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), x \in R, t > 0$
  - (b)  $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), u(0, t) = 0, x \in (0, \infty), t > 0$
  - (c)  $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), u_x(0, t) = 0, x \in (0, \infty), t > 0$
  - (d)  $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), u(0, t) = 0, u(1, 0) = 0, x \in (0, \infty), t > 0$
- (v)  $\frac{\partial u}{\partial t} - k^2 \frac{\partial^2 u}{\partial x^2} = 0$  for the following associated conditions
  - (a)  $u(x, 0) = \phi(x), u(0, t) = a, u(l, t) = b, 0 < x < l, t > 0$
  - (b)  $u(x, 0) = \phi(x), x \in R, 0 < t < T$
  - (c)  $u(x, 0) = \phi(x), u(0, t) = a, x \in (0, \infty), t \geq 0$

**Recommended Books and References:**

1. TynMyint-U and Lokenath Debnath, *Linear Partial Differential Equations for Scientists and Engineers*, 4th edition, Springer, Indian reprint, 2006.
2. S.L. Ross, *Differential equations*, 3rd Ed., John Wiley and Sons, India, 2004.
3. Martha L Abell, James P Braselton, *Differential equations with MATHEMATICA*, 3<sup>rd</sup> Ed., Elsevier Academic Press, 2004.

## SEMESTER - IV

### CORE 8 (MAC 4.11) NUMERICAL METHODS

*Theory Credit: 4*

*Use of Scientific Calculator is allowed.*

- UNIT I** Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation.
- UNIT II** Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.
- UNIT III** System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.
- UNIT IV** Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.
- UNIT V** Numerical Integration: Trapezoidal rule, Simpson's 1/3<sup>rd</sup> rule, Simpson's 3/8<sup>th</sup> rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule. Ordinary Differential Equations: Euler's method. Runge-Kutta methods of orders two and four.

### CORE 8 (MAC 4.12) NUMERICAL METHODS

*Practical Credits: 2*

#### **List of Practicals (using any software)**

- (i) Calculate the sum  $1 + \frac{1}{2} + \frac{1}{3} + \dots + \frac{1}{N}$
- (ii) To find the absolute value of an integer.
- (iii) Enter 100 integers into an array and sort them in an ascending order.
- (iv) Bisection Method.
- (v) Newton Raphson Method.
- (vi) Secant Method.
- (vii) RegulaFalsi Method.
- (viii) LU decomposition Method.
- (ix) Gauss-Jacobi Method.
- (x) SOR Method or Gauss-Siedel Method.
- (xi) Lagrange Interpolation or Newton Interpolation.
- (xii) Simpson's rule.

**Note:** For any of the CAS (Computer aided software) Data types-simple data types, floating datatypes, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

**Recommended Books and References:**

1. Brian Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, *Numerical Methods for Scientific and Engineering Computation*, 6th Ed., New age International Publisher, India, 2007.
3. C.F. Gerald and P.O. Wheatley, *Applied Numerical Analysis*, Pearson Education, India, 2008.
4. Uri M. Ascher and Chen Greif, *A First Course in Numerical Methods*, 7th Ed., PHI Learning Private Limited, 2013.
5. John H. Mathews and Kurtis D. Fink, *Numerical Methods using Matlab*, 4th Ed., PHI Learning Private Limited, 2012.

**CORE 9 (MAC 4.21)****RIEMANN INTEGRATION AND SERIES OF FUNCTIONS**

Theory Credit: 5

Tutorial Credit: 1

**UNIT I** Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions.

**UNIT II** Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorems of Calculus.

**UNIT III** Improper integrals; Convergence of Beta and Gamma functions.

**UNIT IV** Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

**UNIT V** Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem.

**Recommended Books and References:**

1. K.A. Ross, *Elementary Analysis, The Theory of Calculus*, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
2. R.G. Bartle D.R. Sherbert, *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
3. Charles G. Denlinger, *Elements of Real Analysis*, Jones & Bartlett (Student Edition), 2011.

**CORE 10 (MAC 4.31)****RING THEORY AND LINEAR ALGEBRA I**

Theory Credit: 5

Tutorial Credit: 1

- UNIT I** Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring.
- UNIT II** Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.
- UNIT III** Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients.
- UNIT IV** Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.
- UNIT V** Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

**Recommended Books and References:**

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra*, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
4. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi, 1999.
5. S. Lang, *Introduction to Linear Algebra*, 2nd Ed., Springer, 2005.
6. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.
7. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India, 1999.
8. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra*, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. D.A.R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

## SEMESTER – V

### CORE 11 (MAC 5.11) MULTIVARIATE CALCULUS

Theory Credit: 5

Tutorial Credit: 1

*Use of Scientific calculator is allowed.*

- UNIT I** Functions of several variables, limit and continuity of functions of two variables Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters.
- UNIT II** Directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl
- UNIT III** Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates.
- UNIT IV** Change of variables in double integrals and triple integrals. Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path.
- UNIT V** Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.

#### **Recommended Books and References:**

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
3. E. Marsden, A.J. Tromba and A. Weinstein, *Basic Multivariable Calculus*, Springer (SIE), Indian reprint, 2005.
4. James Stewart, *Multivariable Calculus, Concepts and Contexts*, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

### CORE 12 (MAC 5.21) GROUP THEORY II

Theory Credit: 5

Tutorial Credit: 1

- UNIT I** Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.

- UNIT II** Properties of external direct products, the group of units modulo  $n$  as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups.
- UNIT III** Group actions, stabilizers and kernels, permutation representation associated with a given group action, Applications of group actions: Generalized Cayley's theorem, Index theorem.
- UNIT IV** Groups acting on themselves by conjugation, class equation and consequences, conjugacy in  $S_n$ ,  $p$ -groups.
- UNIT V** Sylow's theorems and consequences, Cauchy's theorem, Simplicity of  $A_n$  for  $n \geq 5$ , non-simplicity tests.

**Recommended Books and References:**

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, 1999.
4. David S. Dummit and Richard M. Foote, *Abstract Algebra*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
5. J.R. Durbin, *Modern Algebra*, John Wiley & Sons, New York Inc., 2000.
6. D. A. R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

## SEMESTER - VI

### CORE 13 (MAC 6.11)

#### METRIC SPACES AND COMPLEX ANALYSIS

Theory Credit: 5

Tutorial Credit: 1

- UNIT I** Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's theorem. Subspaces, dense sets, separable spaces.
- UNIT II** Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, Banach Fixed point Theorem. Connectedness, connected subsets of  $\mathbb{R}$ .
- UNIT III** Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.
- UNIT IV** Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy-Goursat theorem, Cauchy integral formula.
- UNIT V** Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series.

#### **Recommended Books and References:**

1. Satish Shirali and Harikishan L. Vasudeva, *Metric Spaces*, Springer Verlag, London, 2006.
2. S. Kumaresan, *Topology of Metric Spaces*, 2nd Ed., Narosa Publishing House, 2011.
3. G.F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 2004.
4. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications*, 8th Ed., McGraw – Hill International Edition, 2009.
5. Joseph Bak and Donald J. Newman, *Complex Analysis*, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.

### CORE 14 (MAC 6.21)

#### RING THEORY AND LINEAR ALGEBRA II

Theory Credit: 5

Tutorial Credit: 1

- UNIT I** Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion.



- UNIT II** Unique factorization in  $Z[x]$ . Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains.
- UNIT III** Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators, Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem. The minimal polynomial for a linear operator.
- UNIT IV** Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator.
- UNIT V** Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem.

**Recommended Books and References:**

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, 1999.
4. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra*, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
5. S. Lang, *Introduction to Linear Algebra*, 2nd Ed., Springer, 2005.
6. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.
5. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India, 1999.
6. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra*, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
7. S.H. Friedberg, A.L. Insel and L.E. Spence, *Linear Algebra*, Prentice Hall of India Pvt. Ltd., 2004.

## DISCIPLINE SPECIFIC ELECTIVE

### DISCIPLINE SPECIFIC ELECTIVE 1 (MAD 5.11(a)) PORTFOLIO OPTIMIZATION

Theory Credit: 5

Tutorial Credit: 1

- UNIT I** Financial markets. Investment objectives. Measures of return and risk. Types of risks. Risk free assets.
- UNIT II** Mutual funds. Portfolio of assets. Expected risk and return of portfolio. Diversification.
- UNIT III** Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier.
- UNIT IV** Portfolios with short sales. Capital market theory.
- UNIT V** Capital assets pricing model- the capital market line, beta of an asset, beta of a portfolio, security market line. Index tracking optimization models. Portfolio performance evaluation measures.

#### **Recommended Books and References:**

1. F. K. Reilly, Keith C. Brown, *Investment Analysis and Portfolio Management*, 10th Ed., South-Western Publishers, 2011.
2. H.M. Markowitz, *Mean-Variance Analysis in Portfolio Choice and Capital Markets*, Blackwell, New York, 1987.
3. M.J. Best, *Portfolio Optimization*, Chapman and Hall, CRC Press, 2010.
4. D.G. Luenberger, *Investment Science*, 2nd Ed., Oxford University Press, 2013.

### DISCIPLINE SPECIFIC ELECTIVE 1(MAD 5.11(b)) NUMBER THEORY

Theory Credit: 5

Tutorial Credit: 1

- UNIT I** Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.
- UNIT II** Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula
- UNIT III** The greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

- UNIT IV** Order of an integer modulo  $n$ , primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli.
- UNIT V** Public key encryption, RSA encryption and decryption, the equation  $x^2 + y^2 = z^2$ , Fermat's Last theorem.

**Recommended Books and References:**

1. David M. Burton, *Elementary Number Theory*, 6th Ed., Tata McGraw-Hill, Indian reprint, 2007.
2. Neville Robinns, *Beginning Number Theory*, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007.

**DISCIPLINE SPECIFIC ELECTIVE 1(MAD 5.11(c))  
ANALYTICAL GEOMETRY**

*Theory Credit: 5*

*Tutorial Credit: 1*

- UNIT I** Techniques for sketching parabola, ellipse and hyperbola.
- UNIT II** Reflection properties of parabola, ellipse and hyperbola.
- UNIT III** Classification of quadratic equations representing lines, parabola, ellipse and hyperbola.
- UNIT IV** Spheres, Cylindrical surfaces.
- UNIT V** Illustrations of graphing standard quadric surfaces like cone, ellipsoid.

**Recommended Books and References:**

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) Pvt. Ltd. 2002.
3. S.L. Loney, *The Elements of Coordinate Geometry*, McMillan and Company, London.
4. R.J.T. Bell, *Elementary Treatise on Coordinate Geometry of Three Dimensions*, McMillan India Ltd., 1994.

**DISCIPLINE SPECIFIC ELECTIVE 2(MAD 5.21(a))  
INDUSTRIAL MATHEMATICS**

*Theory Credit: 5*

*Tutorial Credit: 1*

- UNIT I** Medical Imaging and Inverse Problems. The content is based on Mathematics of X-ray and CT scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices.

- UNIT II** Introduction to Inverse problems: Why should we teach Inverse Problems? Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations. Geological anomalies in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography.
- UNIT III** X-ray: Introduction, X-ray behavior and Beers Law (The fundamental question of image construction) Lines in the plane.
- UNIT IV** Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms).
- UNIT V** Back Projection: Definition, properties and examples.  
CT Scan: Revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan.

**Recommended Books and References:**

1. Timothy G. Feeman, *The Mathematics of Medical Imaging, A Beginners Guide*, Springer Undergraduate Text in Mathematics and Technology, Springer, 2010.
2. C.W. Groetsch, *Inverse Problems, Activities for Undergraduates*, The Mathematical Association of America, 1999.
3. Andreas Kirsch, *An Introduction to the Mathematical Theory of Inverse Problems*, 2nd Ed., Springer, 2011.

**DISCIPLINE SPECIFIC ELECTIVE 2 (MAD 5.21(b))  
BOOLEAN ALGEBRA AND AUTOMATA THEORY**

*Theory Credit: 5*

*Tutorial Credit: 1*

- UNIT I** Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms.
- UNIT II** Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.
- UNIT III** Introduction: Alphabets, strings, and languages. Finite Automata and Regular Languages: deterministic and non-deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages.
- UNIT IV** Context Free Grammars and Pushdown Automata: Context free grammars (CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non-deterministic PDA, properties of context free languages; normal forms, pumping lemma, closure properties, decision properties.

**UNIT V** Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence.  
 Undecidability: Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem, Post Correspondence Problem, and undecidability problems About CFGs.

**Recommended Books and References:**

1. B A. Davey and H. A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 1990.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*, (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Günter Pilz, *Applied Abstract Algebra*, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
4. J. E. Hopcroft, R. Motwani and J. D. Ullman, *Introduction to Automata Theory, Languages, and Computation*, 2nd Ed., Addison-Wesley, 2001.
5. H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, *Elements of the Theory of Computation*, 2nd Ed., Prentice-Hall, NJ, 1997.
6. J.A. Anderson, *Automata Theory with Modern Applications*, Cambridge University Press, 2006.

**DISCIPLINE SPECIFIC ELECTIVE 2(MAD 5.21(c))  
 PROBABILITY AND STATISTICS**

*Theory Credit: 5*  
*Tutorial Credit: 1*

**UNIT I** Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function.

**UNIT II** Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential. Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions.

**UNIT III** Expectation of function of two random variables, conditional expectations, independent random variables. Bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.

**UNIT IV** Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance,

**UNIT V** Markov Chains, Chapman-Kolmogorov equations, classification of states.

**Recommended Books and References:**

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics*, Pearson Education, Asia, 2007.

2. Irwin Miller and Marylees Miller, John E. Freund, *Mathematical Statistics with Applications*, 7th Ed., Pearson Education, Asia, 2006.
3. Sheldon Ross, *Introduction to Probability Models*, 9th Ed., Academic Press, Indian Reprint, 2007.
4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, *Introduction to the Theory of Statistics*, 3rd Ed., Tata McGraw- Hill, Reprint 2007

**DISCIPLINE SPECIFIC ELECTIVE 3(MAD 6.11(a))  
THEORY OF EQUATIONS**

*Theory Credit: 5*

*Tutorial Credit: 1*

- UNIT I** General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials, General properties of equations, Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.
- UNIT II** Symmetric functions, Applications of symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations.
- UNIT III** Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.
- UNIT IV** Symmetric functions of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.
- UNIT V** Separation of the roots of equations, Strums theorem, Applications of Strum's theorem, Conditions for reality of the roots of an equation and biquadratic. Solution of numerical equations.

***Recommended Books and References:***

1. W.S. Burnside and A.W. Panton, *The Theory of Equations*, Dublin University Press, 1954.
2. C. C. MacDuffee, *Theory of Equations*, John Wiley & Sons Inc., 1954.

**DISCIPLINE SPECIFIC ELECTIVE 3(MAD 6.11(b))  
BIO-MATHEMATICS**

*Theory Credit: 5*

*Tutorial Credit: 1*

- UNIT I** Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat.
- UNIT II** Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation.

- UNIT III** Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario.
- UNIT IV** Spatial Models: One species model with diffusion, Two species model with diffusion, Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Travelling wave solutions, Spread of genes in a population.
- UNIT V** Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model), Numerical solution of the models and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

**Recommended Books and References:**

1. L.E. Keshet, *Mathematical Models in Biology*, SIAM, 1988.
2. J. D. Murray, *Mathematical Biology*, Springer, 1993.
3. Y.C. Fung, *Biomechanics*, Springer-Verlag, 1990.
4. F. Brauer, P.V.D. Driessche and J. Wu, *Mathematical Epidemiology*, Springer, 2008.
5. M. Kot, *Elements of Mathematical Ecology*, Cambridge University Press, 2001.

**DISCIPLINE SPECIFIC ELECTIVE 3(MAD 6.11(c))  
LINEAR PROGRAMMING**

*Theory Credit: 5*

*Tutorial Credit: 1*

- UNIT I** Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison.
- UNIT II** Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.
- UNIT III** Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution.
- UNIT IV** Algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.
- UNIT V** Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.

**Recommended Books and References:**

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and NetworkFlows*, 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research*, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.
4. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.

**DISCIPLINE SPECIFIC ELECTIVE 4(MAD 6.21(a))  
MATHEMATICAL MODELING**

*Theory Credit: 4*

- UNIT I** Power series solution of a differential equation about an ordinary point, solution about a regular singular point.
- UNIT II** Bessel's equation and Legendre's equation, Laplace transform and inverse transform, application to initial value problem up to second order.
- UNIT III** Monte Carlo Simulation Modeling: simulating deterministic behavior (area under a curve, volume under a surface).
- UNIT IV** Generating Random Numbers: middle square method, linear congruence, Queuing Models: harbor system, morning rush hour.
- UNIT V** Overview of optimization modeling, Linear Programming Model: geometric solution algebraic solution, simplex method, sensitivity analysis

**DISCIPLINE SPECIFIC ELECTIVE 4(MAD 6.22(a))  
MATHEMATICAL MODELING**

*Practical Credit: 2*

**List of Practicals (using any software)**

- (i) Plotting of Legendre polynomial for  $n = 1$  to 5 in the interval  $[0,1]$ . Verifying graphically that all the roots of  $P_n(x)$  lie in the interval  $[0,1]$ .
- (ii) Automatic computation of coefficients in the series solution near ordinary points.
- (iii) Plotting of the Bessel's function of first kind of order 0 to 3.
- (iv) Automating the Frobenius Series Method.
- (v) Random number generation and then use it for one of the following (a) Simulate area under a curve (b) Simulate volume under a surface.
- (vi) Programming of either one of the queuing model (a) Single server queue (e.g. Harbor system) (b) Multiple server queue (e.g. Rush hour).
- (vii) Programming of the Simplex method for 2/3 variables.

**Recommended Books and References:**

1. TynMyint-U and Lokenath Debnath, *Linear Partial Differential Equation for Scientists*



and Engineers, Springer, Indian reprint, 2006.

2. Frank R. Giordano, Maurice D. Weir and William P. Fox, *A First Course in Mathematical Modeling*, Thomson Learning, London and New York, 2003.

#### **DISCIPLINE SPECIFIC ELECTIVE 4(MAD 6.21(b)) MECHANICS**

*Theory Credit: 5*

*Tutorial Credit: 1*

- UNIT I** Moment of a force about a point and an axis, couple and couple moment, Moment of a couple about a line, resultant of a force system, distributed force system, free body diagram, free body involving interior sections, general equations of equilibrium, two point equivalent loading, problems arising from structures, static indeterminacy.
- UNIT II** Laws of Coulomb friction, application to simple and complex surface contact friction problems, transmission of power through belts, screw jack, wedge, first moment of an area and the centroid, other centers.
- UNIT III** Theorem of Pappus-Guldinus, second moments and the product of area of a plane area, transfer theorems, relation between second moments and products of area, polar moment of area, principal axes.
- UNIT IV** Conservative force field, conservation for mechanical energy, work energy equation, kinetic energy and work kinetic energy expression based on center of mass, moment of momentum equation for a single particle and a system of particles, translation and rotation of rigid bodies.
- UNIT V** Chasles' theorem, general relationship between time derivatives of a vector for different references, relationship between velocities of a particle for different references, acceleration of particle for different references.

#### **Recommended Books and References:**

1. I.H. Shames and G. Krishna Mohan Rao, *Engineering Mechanics: Statics and Dynamics*, (4th Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
2. R.C. Hibbeler and Ashok Gupta, *Engineering Mechanics: Statics and Dynamics*, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.

#### **DISCIPLINE SPECIFIC ELECTIVE 4(MAD 5.21(c)) DIFFERENTIAL GEOMETRY**

*Theory Credit: 5*

*Tutorial Credit: 1*

- UNIT I** Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.

- UNIT II** Theory of Surfaces: Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula, Conjugate and Asymptotic lines.  
Developables: Developable associated with space curves and curves on surfaces, Minimal surfaces.
- UNIT III** Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem. Surfaces of constant curvature. Conformal mapping. Geodesic mapping. Tissot's theorem.
- UNIT IV** Tensors: Summation convention and indicial notation, Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different type, Algebra of tensors and contraction.
- UNIT V** Metric tensor and 3-index Christoffel symbols, Parallel propagation of vectors, Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components.

***Recommended Books and References:***

2. T.J. Willmore, *An Introduction to Differential Geometry*, Dover Publications, 2012.
3. B. O'Neill, *Elementary Differential Geometry*, 2nd Ed., Academic Press, 2006.
4. C.E. Weatherburn, *Differential Geometry of Three Dimensions*, Cambridge University Press 2003.
5. D.J. Struik, *Lectures on Classical Differential Geometry*, Dover Publications, 1988.
6. S. Lang, *Fundamentals of Differential Geometry*, Springer, 1999.
7. B. Spain, *Tensor Calculus: A Concise Course*, Dover Publications, 2003.

## SKILL ENHANCEMENT COURSE

### SKILL ENHANCEMENT COURSE 1 (MAS 3.11(a)) LOGIC AND SETS

*Theory Credit: 2*

- UNIT I** Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.
- UNIT II** Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.
- UNIT III** Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations.
- UNIT IV** Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections.
- UNIT V** Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-ary relations.

#### **Recommended Books and References:**

1. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics*, Pearson Education, 1998.
2. P.R. Halmos, *Naive Set Theory*, Springer, 1974.
3. E. Kamke, *Theory of Sets*, Dover Publishers, 1950.

### SKILL ENHANCEMENT COURSE 1 (MAS 3.11(b)) COMPUTER GRAPHICS

*Theory Credit: 2*

- UNIT I** Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators.
- UNIT II** Colour display techniques, interactive input/output devices.
- UNIT III** Points, lines and curves: Scan conversion, line-drawing algorithms.
- UNIT IV** Circle and ellipse generation, conic-section generation, polygon filling anti aliasing.
- UNIT V** Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms.

**Recommended Books and References:**

1. D. Hearn and M.P. Baker, *Computer Graphics*, 2nd Ed., Prentice–Hall of India, 2004.
2. J.D. Foley, A van Dam, S.K. Feiner and J.F. Hughes, *Computer Graphics: Principals and Practices*, 2nd Ed., Addison-Wesley, MA, 1990.
3. D.F. Rogers, *Procedural Elements in Computer Graphics*, 2nd Ed., McGraw Hill Book Company, 2001.
4. D.F. Rogers and A.J. Admas, *Mathematical Elements in Computer Graphics*, 2nd Ed., McGraw Hill Book Company, 1990.

**SKILL ENHANCEMENT COURSE 2 (MAS 4.11(a))  
GRAPH THEORY**

*Theory Credit: 2*

**UNIT I** Definition, examples and basic properties of graphs, pseudo graphs, complete graphs.

**UNIT II** Bi-partite graphs, weighted graph, adjacency and incidence matrices,

**UNIT III** Isomorphism of graphs paths and circuits, Eulerian circuits.

**UNIT IV** Hamiltonian cycles, Travelling salesman’s problem.

**UNIT V** Shortest path, Dijkstra’s algorithm, Floyd-Warshall algorithm.

**Recommended Books and References:**

1. B.A. Davey and H.A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 1990.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Gunter Pilz, *Applied Abstract Algebra*, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

**SKILL ENHANCEMENT COURSE 2 (MAS 4.11(b))  
OPERATING SYSTEM: LINUX**

*Theory Credit: 2*

**UNIT I** Linux – The Operating System: Linux history, Linux features, Linux distributions, Linux’s relationship to Unix.

**UNIT II** Overview of Linux architecture, Installation, Start up scripts, system processes (an overview), Linux Security, The Ext2 and Ext3 File systems: General Characteristics of, The Ext3 File system, file permissions.

**UNIT III** User Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools.

**UNIT IV** Resource Management in Linux: file and directory management, system calls for files  
Process Management, Signals.

**UNIT V** IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes,  
Memory Management, library and system calls for memory.

**Recommended Books and References:**

1. Arnold Robbins, *Linux Programming by Examples The Fundamentals*, 2nd Ed., Pearson Education, 2008.
2. Cox K, *Red Hat Linux Administrator's Guide*, PHI, 2009.
3. R. Stevens, *UNIX Network Programming*, 3rd Ed., PHI, 2008.
4. Sumitabha Das, *Unix Concepts and Applications*, 4th Ed., TMH, 2009.
5. Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, *Linux in a Nutshell*, 6th Ed., O'Reilly Media, 2009.
6. Neil Matthew, Richard Stones, Alan Cox, *Beginning Linux Programming*, 3rd Ed., 2004.



*Revised*  
SYLLABUS FOR  
Bachelor of Science (Honours)

**PHYSICS**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)





## COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT	
I	Core 1	Mathematical Physics (Theory)	PHC 1.11	4	
		Mathematical Physics (Practical)	PHC 1.12	2	
	Core 2	Mechanics (Theory)	PHC 1.21	4	
		Mechanics (Practical)	PHC 1.22	2	
II	Core 3	Electricity and Magnetism (Theory)	PHC 2.11	4	
		Electricity and Magnetism (Practical)	PHC 2.12	2	
	Core 4	Waves and Optics (Theory)	PHC 2.21	4	
		Waves and Optics (Practical)	PHC 2.22	2	
III	Core 5	Mathematical Physics II (Theory)	PHC 3.11	4	
		Mathematical Physics II (Practical)	PHC 3.12	2	
	Core 6	Thermal Physics (Theory)	PHC 3.21	4	
		Thermal Physics (Practical)	PHC 3.22	2	
	Core 7	Digital Systems and Applications (Theory)	PHC 3.31	4	
		Digital Systems and Applications (Practical)	PHC 3.32	2	
Skill Enhancement Course 1	Basic Instrumentation Skills (Practical) OR Physics Workshop Skill (Practical)	PHS 3.12(a) PHS 3.12(b)	2		
IV	Core 8	Mathematical Physics III (Theory)	PHC 4.11	4	
		Mathematical Physics III (Practical)	PHC 4.12	2	
	Core 9	Elements of Modern Physics (Theory)	PHC 4.21	4	
		Elements of Modern Physics (Practical)	PHC 4.22	2	
	Core 10	Analog Systems and Applications (Theory)	PHC 4.31	4	
		Analog Systems and Applications (Practical)	PHC 4.32	2	
Skill Enhancement Course 2	Computational Physics (Practical) OR Radiation Safety (Practical)	PHS 4.12(a) PHS 4.12(b)	2		
V	Core 11	Quantum Mechanics and Applications (Theory)	PHC 5.11	4	
		Quantum Mechanics and Applications (Practical)	PHC 5.12	2	
	Core 12	Solid State Physics (Theory)	PHC 5.21	4	
		Solid State Physics (Practical)	PHC 5.22	2	
	Discipline Specific Elective 1	Advance Mathematical Physics-I (Theory) OR Classical Dynamics	PHD 5.11(a) PHD 5.11(b)	4 6	
		Advance Mathematical Physics-I(Practical)	PHD 5.12(b)	2	
		Discipline Specific Elective 2	Nuclear and Particle Physics(Theory) OR Nano Material and Applications(Theory)	PHD 5.21(a) PHD 5.21(b)	5 4
	Nuclear and Particle Physics (Tutorial) OR Nano Material and Applications (Practical)			1 2	
	Core 13		Electromagnetic Theory (Theory)	PHC 6.11	4
			Electromagnetic Theory (Practical)	PHC 6.12	2
VI	Core 14	Statistical Mechanics (Theory)	PHC 6.21	4	
		Statistical Mechanics (Practical)	PHC 6.22	2	
	Discipline Specific Elective 3	Advance Mathematical Physics-II (Theory) OR Digital Signal Processing (Theory)	PHD 6.11(a) PHD 6.11(b)	5 4	
		Advance Mathematical Physics-II (Tutorial)		1	

		OR Digital Signal Processing (Practical)	PHD 6.12(b)	2
	Discipline Specific Elective 4	Astronomy and Astrophysics (Theory)	PHD 6.21(a)	5
		OR Atmospheric Physics (Theory)	PHD 6.21(b)	4
		OR Physics of Earth (Theory)	PHD 6.21(c)	5
		Astronomy and Astrophysics (Tutorial)		1
		OR Atmospheric Physics (Practical)	PHD 6.22(b)	2
		OR Physics of Earth (Tutorial)		1

## SEMESTER - I

### CORE 1 (PHC 1.11) MATHEMATICAL PHYSICS-I

Theory Credit: 4

Teaching Hours: 60

The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

- UNIT I    Calculus:** Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).  
First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. (12 Hours)
- UNIT II    Vector Calculus:** Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.  
**Vector Differentiation:** Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. (12 Hours)
- UNIT III    Vector Integration:** Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). (12 Hours)
- UNIT IV    Orthogonal Curvilinear Coordinates:** Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.
- UNIT V    Introduction to probability:** Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing.  
**Dirac Delta function and its properties:** Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

#### **Recommended Books and Recommended Books and References:**

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7<sup>th</sup>Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.

5. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Mathematical Physics, Goswami, 1<sup>st</sup> edition, Cengage Learning
8. Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F. Riley & M.P. Hobson, 2011, Cambridge Univ. Press

**CORE 1 (PHC 1.12)**  
**MATHEMATICAL PHYSICS-I**

Practical Credit: 2

Teaching Hours: 60

**LAB:**

*The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.*

- *Highlights the use of computational methods to solve physical problems*
- *The course will consist of lectures (both theory and practical) in the Lab*
- *Evaluation done not on the programming but on the basis of formulating the problem*
- *Aim at teaching students to construct the computational problem to be solved*
- *Students can use any one operating system Linux or Microsoft Windows*

<b>Topics</b>	<b>Description with Applications</b>
Introduction and Overview	Computer architecture and organization, memory and input/output devices.
Basics of Scientific Computing	Binary and Decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow – emphasize the importance of making equations in terms of dimensionless variables. Iterative methods.
Review of C and C++ Programming fundamentals	Introduction of programming, constants, variables and data types, operators and expressions, I/O statements, scanf and printf, c in and c out, Manipulations for data formatting, Control statements, (decision making and looping statements)(If statement, If else statement, Nested if Structure, Else if statement, Ternary operator, Go to statement, Switch statement. Unconditional and Conditional looping. While loop, Do – while loop, FOR loop, Break and continue statements, Nested Loops) Arrays(1D and 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects.
Programs:	Sum and average of a list of numbers, largest of a given list of numbers, and its location in the list, sorting of numbers, in ascending, descending order, Binary search.
Random Number Generation	Area of circle, area of square, volume of sphere, value of $\pi$ .

Solution of Algebraic and Transcendental equations, by bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equations, solving $\alpha = \tan \alpha$ , $I = I_0 \left( \frac{\sin \alpha}{\alpha} \right)$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation.	Evaluation of trigonometric functions, eg. $\sin \theta$ , $\cos \theta$ , $\tan \theta$ etc.
Numerical differentiation, (Forward and Backward difference formula) and Integration, (Trapezoidal and Simpson rules) Monte Carlo method.	Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of the B – H Hysteresis loop
Solution of Ordinary Differential Equations (ODE) First order differential equation Euler, modified Euler, and Runge Kutta(RK) 2 <sup>nd</sup> and 4 <sup>th</sup> order methods.	<p>First order differential equation</p> <p>(i) Radioactive decay</p> <p>(ii) Current in RC, LC circuits (DC)</p> <p>(iii) Newton's law of Cooling</p> <p>(iv) Classical equations of motion</p> <p>Attempt following using RK 4<sup>th</sup> order methods:</p> $\frac{dx}{dt} = y + x - \frac{x^3}{3}; \quad \frac{dy}{dx} = -x$ <p>for <math>x(0) = 0</math>, <math>y(0) = -1, -2, -3, -4</math></p> <p>Plot <math>x</math> vs <math>y</math> for each of the four conditions, on the same screen for <math>0 \leq t \leq 15</math>.</p> $\frac{d^2\theta}{dt^2} = -\sin \theta.$ <p>When pendulum is released from rest, at angular displacement <math>\alpha</math>, <math>\theta(0) = \alpha</math>, <math>\dot{\theta}(0) = 0</math>. Solve the equation for <math>\alpha = 0.1, 0.5, 1.0</math> and plot <math>\theta</math> as function of time in the range <math>0 \leq t \leq 8\pi</math>. Also plot the analytic solution valid for <math>\sin \theta = \theta</math></p>

**Recommended Books and Recommended Books and References:**

1. Introduction to Numerical Analysis, S.S. Sastry, 5<sup>th</sup>Edn., 2012, PHI Learning Pvt. Ltd.
2. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
3. Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al, 3<sup>rd</sup>Edn., 2007, Cambridge University Press.
4. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
5. Elementary Numerical Analysis, K.E. Atkinson, 3<sup>rd</sup>Edn., 2007, Wiley India Edition.
6. Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
7. An Introduction to computational Physics, T. Pang, 2<sup>nd</sup>Edn., 2006, Cambridge Univ. Press
8. Computational Physics, Darren Walker, 1<sup>st</sup>Edn., 2015, Scientific International Pvt. Ltd.

**CORE 2 (PHC 1.21)**  
**MECHANICS**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I**    **Fundamentals of Dynamics:** Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.  
**Work and Energy:** Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.  
**Collisions:** Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames. *(12 Hours)*
- UNIT II**    **Rotational Dynamics:** Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. *(12 Hours)*
- UNIT III**    **Elasticity:** Relation between Elastic constants. Twisting torque on a Cylinder or Wire.  
**Fluid Motion:** Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube. *(12 Hours)*  
**Oscillations:** SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. *(12 Hours)*
- UNIT IV**    **Non-Inertial Systems:** Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.  
**Gravitation and Central Force Motion:** Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere.  
Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).  
**Non-Inertial Systems:** Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. *(12 Hours)*
- UNIT V**    **Special Theory of Relativity:** Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of

mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. (12 Hours)

**Recommended Books and Recommended Books and References:**

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
5. Feynman Lectures, Vol. I, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
8. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
9. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
10. Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
11. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

**CORE 2 (PHC 1.22)  
MECHANICS LAB**

*Practical Credit: 2*

*Teaching Hours: 60*

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b)  $g$  and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine  $g$  and velocity for a freely falling body using Digital Timing Technique
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
10. To determine the elastic Constants of a wire by Searle's method.
11. To determine the value of  $g$  using Bar Pendulum.
12. To determine the value of  $g$  using Kater's Pendulum.

**Recommended Books and Recommended Books and References:**

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11<sup>th</sup>Edn, 2011, Kitab Mahal
4. Engineering Practical Physics, S.Panigrahi& B.Mallick,2015, Cengage Learning India Pvt. Ltd.
5. Practical Physics, G.L. Squires, 2015, 4<sup>th</sup> Edition, Cambridge University Press.

## SEMESTER - II

### CORE 3 (PHC 2.11)

### ELECTRICITY AND MAGNETISM

Theory Credit: 4

Teaching Hours: 60

- UNIT I Electric Field and Electric Potential:** Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.  
Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.  
Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. (12 Hours)
- UNIT II** Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.  
**Dielectric Properties of Matter:** Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics. (12 Hours)
- UNIT III Magnetic Field:** Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.  
**Magnetic Properties of Matter:** Magnetization vector (**M**). Magnetic Intensity(**H**). Magnetic Susceptibility and permeability. Relation between **B**, **H**, **M**. Ferromagnetism. B-H curve and hysteresis. (12 Hours)
- UNIT IV Electromagnetic Induction:** Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.  
**Electrical Circuits:** DC Transients: Current growth and decay in LR, CR, LCR circuits with an direct current input  
AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) quality Factor, and (4) Band Width. Parallel LCR Circuit. (12 Hours)
- UNIT V Network theorems:** Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.  
**Ballistic Galvanometer:** Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR. (12 Hours)



**Recommended Books and Recommended Books and References:**

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
5. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
6. Electricity and Magnetism, J.H.Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

**CORE 3 (PHC 2.12)**

**ELECTRICITY AND MAGNETISM LAB**

*Practical Credit: 2*

*Teaching Hours: 60*

Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To compare capacitances using De'Sauty's bridge.
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self inductance of a coil by Anderson's bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
11. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
12. Determine a high resistance by leakage method using Ballistic Galvanometer.
13. To determine self-inductance of a coil by Rayleigh's method.
14. To determine the mutual inductance of two coils by Absolute method.

**Recommended Books and Recommended Books and References:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11<sup>th</sup> Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
4. Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
5. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

**CORE 4 (PHC 2.21)**  
**WAVES AND OPTICS**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** **Superposition of Collinear Harmonic oscillations:** Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.  
**Superposition of two perpendicular Harmonic Oscillations:** Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses. (12 Hours)
- UNIT II** **Wave Motion:** Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.  
**Velocity of Waves:** Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. (12 Hours)
- UNIT III** **Superposition of Two Harmonic Waves:** Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. (12 Hours)
- UNIT VI** **Wave Optics:** Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.  
**Interference:** Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.  
**Interferometer:** Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer. (12 Hours)
- UNIT V** **Diffraction:** Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only)  
**Fraunhofer diffraction:** Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.  
**Fresnel Diffraction:** Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.  
**Holography:** Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. (12 Hours)

**Recommended Books and Recommended Books and References:**

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. Principles of Optics, Max Born and Emil Wolf, 7<sup>th</sup>Edn., 1999, Pergamon Press.
4. Optics, AjoyGhatak, 2008, Tata McGraw Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

**CORE 4 (PHC 2.22)**

**WAVES AND OPTICSLAB**

*Practical Credit: 2*

*Teaching Hours: 60*

To determine the frequency of an electric tuning fork by Melde's experiment and verify  $\lambda^2 \propto T$  law.

To investigate the motion of coupled oscillators.

To study Lissajous Figures.

Familiarization with: Schuster's focusing; determination of angle of prism.

To determine refractive index of the Material of a prism using sodium source.

To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.

To determine the wavelength of sodium source using Michelson's interferometer.

To determine wavelength of sodium light using Fresnel Biprism.

To determine wavelength of sodium light using Newton's Rings.

To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.

To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.

To determine dispersive power and resolving power of a plane diffraction grating.

**Recommended Books and Recommended Books and References:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11<sup>th</sup> Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

## SEMESTER - III

### CORE 5 (PHC 3.11) MATHEMATICAL PHYSICS-II

Theory Credit: 4

Teaching Hours: 60

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

**UNIT I Fourier Series:** Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity. (12 Hours)

**UNIT II Frobenius Method and Special Functions:** Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions ( $J_0(x)$  and  $J_1(x)$ ) and Orthogonality. (12 Hours)

**UNIT III Some Special Integrals:** Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). (12 Hours)

**UNIT IV Theory of Errors:** Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line. (12 Hours)

**UNIT V Partial Differential Equations:** Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation. (12 Hours)

#### **Recommended Books and Recommended Books and References:**

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
6. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
7. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

**CORE 5 (PHC 3.12)**  
**MATHEMATICAL PHYSICS-II LAB**

Practical Credit: 2

Teaching Hours: 60

The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem

$x^2 \frac{d^2 y}{dx^2} - 4x(1+x) \frac{dy}{dx} + 2(1+x)y = x^3$  with binary conditions  
 $x=1, y = \frac{1}{2}e^2, \frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5$  for  $1 \leq x \leq 3$ . Plot  $y$  and  $\frac{dy}{dx}$  against  $x$  in the given range on the same graph.

**Recommended Books and Recommended Books and References:**

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3<sup>rd</sup> ed., 2006, Cambridge University Press
2. Complex Variables, A.S. Fokas & M.J. Ablowitz, 8<sup>th</sup> Ed., 2011, Cambridge Univ. Press
3. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett
4. Computational Physics, D.Walker, 1<sup>st</sup>Edn., 2015, Scientific International Pvt. Ltd.
5. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3<sup>rd</sup>Edn., Cambridge University Press
6. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
7. Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
8. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
9. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
10. [www.scilab.in/textbook\\_companion/generate\\_book/291](http://www.scilab.in/textbook_companion/generate_book/291)

**CORE 6 (PHC 3.21)**  
**THERMAL PHYSICS**

Theory Credit: 4

Teaching Hours: 60

(Include related problems for each topic)

**UNIT I Kinetic Theory of Gases**

**Distribution of Velocities:** Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.

**Molecular Collisions:** Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. (12 Hours)

**UNIT II Real Gases:** Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO<sub>2</sub> Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding

States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling. (12 Hours)

### UNIT III Introduction to Thermodynamics

**Zeroth and First Law of Thermodynamics:** Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. (12 Hours)

**Second Law of Thermodynamics:** Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2<sup>nd</sup> Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. (12 Hours)

**UNIT IV Entropy:** Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature-Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. (12 Hours)

**Thermodynamic Potentials:** Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications.

**UNIT V** Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius-Clapeyron Equation and Ehrenfest equations

**Maxwell's Thermodynamic Relations:** Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius-Clapeyron equation, (2) Values of  $C_p - C_v$ , (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. (12 Hours)

### Recommended Books and Recommended Books and References:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2<sup>nd</sup> Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2<sup>nd</sup> Ed., 2012, Oxford University Press
7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

**CORE 6 (PHC 3.22)**  
**THERMAL PHYSICSLAB**

*Practical Credit: 2*

*Teaching Hours: 60*

4. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
5. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
6. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
7. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
8. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
9. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
10. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

**Recommended Books and Recommended Books and References:**

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11<sup>th</sup> Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

**CORE 7 (PHC 3.31)**  
**DIGITAL SYSTEMS AND APPLICATIONS**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Introduction to CRO:** Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

**Integrated Circuits** (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital ICs.

**Digital Circuits:** Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. (12 Hours)

**UNIT II Boolean algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

**Data processing circuits:** Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

**Arithmetic Circuits:** Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. (12 Hours)

**UNIT III Sequential Circuits:** SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

**Timers:** IC 555: block diagram and applications: Astablemultivibrator and Monostable multivibrator.

**Shift registers:** Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). (12 Hours)

**UNIT IV Counters (4 bits):** Ring Counter. Asynchronous counters, Decade Counter. SynchronousCounter.

**Computer Organization:** Input/Output Devices. Data storage (idea of RAM and ROM).Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map. (12 Hours)

**UNIT V Intel 8085 Microprocessor Architecture:** Main features of 8085. Block diagram.Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI.

**Introduction to Assembly Language:** 1 byte, 2 byte & 3 byte instructions. (12 Hours)

#### **Recommended Books and Recommended Books and References:**

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7<sup>th</sup> Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2<sup>nd</sup>Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics G K Kharate ,2010, Oxford University Press
5. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
6. Logic circuit design, Shimon P. Vingron, 2012, Springer.
7. Digital Electronics, SubrataGhoshal, 2012, Cengage Learning.
8. Digital Electronics, S.K. Mandal, 2010, 1<sup>st</sup> edition, McGraw Hill
9. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

#### **CORE 7 (PHC 3.32)**

#### **DIGITAL SYSTEMS AND APPLICATIONSLAB**

*Practical Credit: 2*

*Teaching Hours: 60*

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.



7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astablemultivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.
16. Write the following programs using 8085 Microprocessor
  - a) Addition and subtraction of numbers using direct addressing mode
  - b) Addition and subtraction of numbers using indirect addressing mode
  - c) Multiplication by repeated addition.
  - d) Division by repeated subtraction.
  - e) Handling of 16-bit Numbers.
  - f) Use of CALL and RETURN Instruction.
  - g) Block data handling.
  - h) Other programs (e.g. Parity Check, using interrupts, etc.).

***Recommended Books and Recommended Books and References:***

1. Modern Digital Electronics, R.P. Jain, 4<sup>th</sup> Edition, 2010, Tata McGraw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
3. Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
4. Microprocessor 8085:Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.

## SEMESTER - IV

### CORE 8 (PHC 4.11) MATHEMATICAL PHYSICS-III

Theory Credit: 4

Teaching Hours: 60

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

**UNIT I Complex Analysis:** Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. (12 Hours)

**UNIT II** Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals. (12 Hours)

**UNIT III Integrals Transforms:** Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. (12 Hours)

**UNIT IV** Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1<sup>st</sup> and 2<sup>nd</sup> order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. (12 Hours)

**UNIT V** Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. Application of Laplace Transforms to 2<sup>nd</sup> order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1<sup>st</sup> order. Solution of heat flow along infinite bar using Laplace transform. (12 Hours)

#### **Recommended Books and Recommended Books and References:**

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3<sup>rd</sup> ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
3. Complex Variables, A.S. Fokas & M.J. Ablowitz, 8<sup>th</sup> Ed., 2011, Cambridge Univ. Press
4. Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
5. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7<sup>th</sup> Ed. 2003, Tata McGraw-Hill
6. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

**CORE 8 (PHC 4.12)**  
**MATHEMATICAL PHYSICS-III LAB**

Practical Credit: 2

Teaching Hours: 60

**Scilab (or equivalent) based simulations experiments based on Mathematical Physics problems like**

1. Solve:  
 $dy/dx = e^{-x}$  with  $y = 0$  and  $x = 0$   
 $dy/dx + e^{-x}y = x^2$   
 $d^2y/dy^2 + 2dy/dt = -y$   
 $d^2y/dt^2 + e^{-1}dy/dt = -y$
2. Dirac Delta function:  
Evaluate  $\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{-\frac{(x-2)^2}{2\sigma^2}} (x+3)dx$  for  $\sigma = 1, 0.1, 0.01$  and show it tends to 5
3. Fourier Series:
4. Program to sum  $\sum_{n=1}^{\infty} (0.2)^n$  and evaluate the Fourier coefficients of a given periodic function (square wave)
5. Frobenius' method and special functions:  
 $\int_{-1}^{+1} P_n(\mu)P_m(\mu)d\mu = \delta_{n,m}$  Plot  $P_n(x), j_v(x)$  Show recursion relation.
6. Calculation of error for each data point of observations recorded in experiments done in previous semesters (Choose any two)
7. Calculation of least square fitting manually, without giving weightage to error, confirmation of least square fitting of data through computer program
8. Evaluation of trigonometric functions eg.  $\sin \theta$ , . Given Bessel's function at N points, find its value at an intermediate point. Complex analysis: Integrate  $1/(x^2 + 2)$  numerically and check with computer integration.
9. Compute the  $n^{\text{th}}$  roots of unity for  $n = 2, 3, \text{ and } 4$ .
10. Find the two square roots of  $-5 + 12j$
11. Integral transform FFT of  $e^{-x^2}$
12. Solve Kirchoff's Current Law for any node of an arbitrary circuit using Laplace's transform.
13. Perform circuit analysis of a general LCR circuit using Laplace's transform.

**Recommended Books and Recommended Books and References:**

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3<sup>rd</sup> ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
3. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
4. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
5. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand& Company
6. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing

**CORE 9 (PHC 4.21)**  
**ELEMENTS OF MODERN PHYSICS**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions. Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction. *(12 Hours)*
- UNIT II** Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. *(12 Hours)*
- UNIT III** One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier. Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers. *(12 Hours)*
- UNIT IV** Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. *(12 Hours)*
- UNIT V** Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).  
**Lasers:** Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing. *(12 Hours)*

**Recommended Books and Recommended Books and References:**

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill

6. Quantum Mechanics: Theory & Applications, A.K.Ghatak&S.Lokanathan, 2004, Macmillan
7. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
8. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2<sup>nd</sup>Edn, Tata McGraw-Hill Publishing Co. Ltd.
9. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
10. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3<sup>rd</sup>Edn., Institute of Physics Pub.
11. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

### **CORE 9 (PHC 4.22)**

#### **ELEMENTS OF MODERN PHYSICSLAB**

*Practical Credit: 2*

*Teaching Hours: 60*

1. Measurement of Planck's constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of  $e/m$  by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

#### **Recommended Books and Recommended Books and References:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11<sup>th</sup>Edn, 2011,Kitab Mahal

### **CORE 10 (PHC 4.31)**

#### **ANALOG SYSTEMS AND APPLICATIONS**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Semiconductor Diodes:** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode. (12 Hours)

- UNIT II Two-terminal Devices and their Applications:** (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.  
**Bipolar Junction transistors:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains  $\alpha$  and  $\beta$  Relations between  $\alpha$  and  $\beta$ . Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. (12 Hours)
- UNIT III Amplifiers:** Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.  
**Coupled Amplifier:** Two stage RC-coupled amplifier and its frequency response.(12 Hours)
- UNIT IV Feedback in Amplifiers:** Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.  
**Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phaseshift oscillator, determination of Frequency. Hartley & Colpitts oscillators. (12 Hours)
- UNIT V Operational Amplifiers (Black Box approach):** Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.  
**Applications of Op-Amps:** (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.  
**Conversion:** Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation) (12 Hours)

**Recommended Books and Recommended Books and References:**

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B.G. Streetman & S.K. Banerjee, 6<sup>th</sup> Edn., 2009, PHI Learning
4. Electronic Devices & circuits, S. Salivahanan & N.S. Kumar, 3<sup>rd</sup> Ed., 2012, Tata Mc-Graw Hill
5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4<sup>th</sup> edition, 2000, Prentice Hall
6. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6<sup>th</sup> Edn., Oxford University Press.
7. Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk, 2008, Springer
8. Semiconductor Devices: Physics and Technology, S.M. Sze, 2<sup>nd</sup> Ed., 2002, Wiley India
9. Microelectronic Circuits, M.H. Rashid, 2<sup>nd</sup> Edition, Cengage Learning
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

**CORE 10 (PHC 4.32)**  
**ANALOG SYSTEMS AND APPLICATIONSLAB**

*Practical Credit: 2*

*Teaching Hours: 60*

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitt's oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
14. To design inverting amplifier using Op-amp (741,351) and study its frequency response
15. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
16. To study the zero-crossing detector and comparator
17. To add two dc voltages using Op-amp in inverting and non-inverting mode
18. To design a precision Differential amplifier of given I/O specification using Op-amp.
19. To investigate the use of an op-amp as an Integrator.
20. To investigate the use of an op-amp as a Differentiator.
21. To design a circuit to simulate the solution of a 1<sup>st</sup>/2<sup>nd</sup> order differential equation.

***Recommended Books and Recommended Books and References:***

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
2. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4<sup>th</sup> edition, 2000, Prentice Hall.
3. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
4. Electronic Devices & circuit Theory, R.L. Boylestad& L.D. Nashelsky, 2009, Pearson

## SEMESTER - V

### CORE 11 (PHC 5.11) QUANTUM MECHANICS

Theory Credit: 4

Teaching Hours: 60

**UNIT I Linear spaces:** Vector spaces and subspaces, Linear dependence and independence, Basis and dimensions, Linear operators, Inverses, Inverse and rank of an operator, Matrix representation, Similarity transformations, Eigenvalues and eigenvectors, Norm and inner product, Cauchy- Schwarz inequality, Orthogonality, introduction only to Gramm-Schmidt Orthogonalization procedure, Self adjoint and Unitary transformations, Eigenvalues and eigenvectors of Hermitian & Unitary transformation, diagonalization. (12 Hours)

**UNIT II Operators:** Introduction to Hilbert space, Dirac's Bra and Ket notations, quantum mechanical operators and observables, different types of operators- linear operator, Hermitian operator, parity operator projection operator, Identity operator, Reflection operator and Unitary operator, matrix representation of operator, change of basis, commutation relations for orbital angular momentum, eigen function of angular momentum operators matrix representation of angular momentum operators. (12 hours)

**UNIT III Introduction to Quantum Mechanics:** Black body radiation, Plank hypothesis, Specific heat of solids, Photoelectric effect, Compton effect, classical atomic structure models, Bohr's theory of Hydrogen spectrum, Heisenberg's uncertainty relation, wave-particle duality, inadequacy of classical physics, the formulation of Quantum mechanics. (12 Hours)

**UNIT IV Schrödinger wave equation:** Development of wave equation- Schrödinger time-independent and dependent wave equation, Ehrenfest theorem, postulates of quantum mechanics, solution of time dependent Schrödinger equation, properties of wave function interpretation of wave function, Probability and probability current densities in three dimensions condition for physical acceptability of wave function, Normalization. (12 Hours)

**UNIT V One dimensional problems:** Particle in one dimension: boundary conditions at the surface of infinite potentials, infinite potential well, finite potential well, linear harmonic oscillator. (12 Hours)

### CORE 11 (PHC 5.12) QUANTUM MECHANICS AND APPLICATIONS LAB

Practical Credit: 2

Teaching Hours: 60

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}(V(r) - E) \text{ where } V(r) = -\frac{e^2}{r}$$

Where, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom



is  $\approx -13.6$  eV. Take  $e = 3.795$  (eVÅ)<sup>1/2</sup>,  $\hbar c = 1973$  (eV Å) and  $m = 0.511 \times 10^6$  eV/c<sup>2</sup>.

2. Solve the s wave radial Schroedinger equation for an atom:

$$\frac{d^2 y}{dr^2} = A(r)u(r) \text{ where } A(r) = \frac{2m}{\hbar^2} [V(r) - E]$$

Where  $m$  is the reduced mass of the hydrogen atom.,for the screened coulomb potential,

$$V(r) = -\frac{e^2}{r} e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take  $e = 3.795$  (eVÅ)<sup>1/2</sup>,  $m = 0.511 \times 10^6$  eV/c<sup>2</sup>, and  $a = 3$  Å,  $5$  Å,  $7$  Å. In these  $\hbar c = 1973$  units (eVÅ). The ground state energy is expected to be above  $-12$  eV in all three cases.

1. Solve the S wave radial Schroedinger equation for a particle of mass  $m$

$$\frac{d^2 y}{dr^2} = A(r)u(r) \text{ where } A(r) = \frac{2m}{\hbar^2} [V(r) - E] \text{ for anharmonic oscillator potential } V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy in MeV, of a particle of accuracy of three significant digits. Also plot the corresponding wave function. Choose  $m = 940$  MeV/c<sup>2</sup>,  $k = 100$  MeV /fm<sup>-2</sup>,  $b = 0, 10, 30$  MeVfm<sup>-3</sup>. In these units,  $\hbar c = 197.3$  MeVfm. The ground state energy is expected to lie between 90 and 110 MeV in all three cases

2. Solve the s-wave radial Schrodinger equation for the vibrations of

$$\frac{d^2 y}{dr^2} = A(r)u(r) \text{ where } A(r) = \frac{2\mu}{\hbar^2} [V(r) - E] \text{ where } \mu \text{ is the reduced mass of the two atom system}$$

for the Morse potential,  $V(r) = D(e^{-2\alpha r'} - e^{-\alpha r'})$ ,  $r' = \frac{r - r_0}{r_0}$ . Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take  $m = 940 \times 10^6$  eV / C<sup>2</sup>,  $D = 0.755501$  eV,  $\alpha = 1.44$ ,  $r_0 = 0.131349$  Å<sup>0</sup>

### Laboratory based experiments:

1. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
2. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
3. To show the tunneling effect in tunnel diode using I-V characteristics.
4. Quantum efficiency of CCDs

### Recommended Books and Recommended Books and References:

1. Schaum's outline of Programming with C++. J.Hubbard, 2 0 0 0 , McGraw-Hill Publication
2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al., 3<sup>rd</sup> Edn., 2007, Cambridge University Press.
3. An introduction to computational Physics, T.Pang, 2<sup>nd</sup> Edn., 2006, Cambridge Univ. Press
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer.
5. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
6. Scilab Image Processing: L.M.Surhone. 2010 Betascript Publishing ISBN:978-6133459274

**CORE 12 (PHC 5.21)**  
**SOLID STATE PHYSICS**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Crystal Structure:** Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. (12 Hours)

**UNIT II Elementary Lattice Dynamics:** Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids.  $T^3$  law (12 Hours)

**UNIT III Magnetic Properties of Matter:** Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia- and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.  
**Superconductivity:** Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation). (12 Hours)

**UNIT IV Dielectric Properties of Materials:** Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius-Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeier relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes. (12 Hours)

**UNIT V Ferroelectric Properties of Materials:** Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.  
**Elementary band theory:** Kronig-Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient. (12 Hours)

**Recommended Books and Recommended Books and References:**

1. Introduction to Solid State Physics, Charles Kittel, 8<sup>th</sup> Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 4<sup>th</sup> Edition, 2015, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
6. Solid State Physics, Rita John, 2014, McGraw Hill
7. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
8. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

**CORE 12 (PHC 5.22)**  
**SOLID STATE PHYSICSLAB**

*Practical Credit: 2*

*Teaching Hours: 60*

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150°C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

***Recommended Books and Recommended Books and References:***

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11<sup>th</sup> Ed., 2011, Kitab Mahal
4. Elements of Solid State Physics, J.P. Srivastava, 2<sup>nd</sup> Ed., 2006, Prentice-Hall of India.

## SEMESTER - VI

### CORE 13 (PHC 4.11)

### ELECTROMAGNETIC THEORY

Theory Credit: 4

Teaching Hours: 60

**UNIT I Maxwell Equations:** Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. (12 Hours)

**UNIT II EM Wave Propagation in Unbounded Media:** Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. (12 Hours)

**UNIT III EM Wave in Bounded Media:** Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence) (12 Hours)

**UNIT IV Polarization of Electromagnetic Waves:** Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light (12 Hours)

**UNIT V Rotatory Polarization:** Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.  
**Wave Guides:** Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.  
**Optical Fibres:** Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only). (12 Hours)

#### Recommended Books and Recommended Books and References:

1. Introduction to Electrodynamics, D.J. Griffiths, 3<sup>rd</sup> Ed., 1998, Benjamin Cummings.
2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning

6. Engineering Electromagnetic, William H. Hayt, 8<sup>th</sup> Edition, 2012, McGraw Hill.
7. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
8. Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
9. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
10. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

**CORE 13 (PHC 4.12)**  
**ELECTROMAGNETIC THEORYLAB**

*Practical Credit: 2*

*Teaching Hours: 60*

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan's law of radiation and to determine Stefan's constant.
12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

**Recommended Books and Recommended Books and References:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11<sup>th</sup> Ed., 2011, Kitab Mahal
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

**CORE 14 (PHC 4.21)**  
**STATISTICAL MECHANICS**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I    Classical Statistics:** Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its

Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. (12 Hours)

**UNIT II Classical Theory of Radiation:** Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. (12 Hours)

**UNIT III Quantum Theory of Radiation:** Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. (12 Hours)

**UNIT IV Bose-Einstein Statistics:** B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), (12 Hours)

**UNIT V** Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.  
**Fermi-Dirac Statistics:** Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. (12 Hours)

**Recommended Books and Recommended Books and References:**

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2<sup>nd</sup> Ed., 1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

**CORE 14 (PHC 4.22)**

**STATISTICAL MECHANICSLAB**

Practical Credit: 2

Teaching Hours: 60

Use C/C++/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
  - a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
  - b) Study of transient behavior of the system (approach to equilibrium)
  - c) Relationship of large N and the arrow of time

- d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
  - e) Computation and study of mean molecular speed and its dependence on particle mass
  - f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed
2. Computation of the partition function  $Z(\square)$  for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles  $N$  under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
    - a) Study of how  $Z(\square)$ , average energy  $\langle E \rangle$ , energy fluctuation  $\square E$ , specific heat at constant volume  $C_v$ , depend upon the temperature, total number of particles  $N$  and the spectrum of single particle states.
    - c) Ratios of occupation numbers of various states for the systems considered above
    - d) Computation of physical quantities at large and small temperature  $T$  and comparison of various statistics at large and small temperature  $T$ .
  3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.
  4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.
  5. Plot the following functions with energy at different temperatures
    - a) Maxwell-Boltzmann distribution
    - b) Fermi-Dirac distribution
    - c) Bose-Einstein distribution

**Recommended Books and Recommended Books and References:**

- Elementary Numerical Analysis, K.E. Atkinson, 3<sup>rd</sup> Edn. 2007, Wiley India Edition
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2<sup>nd</sup> Ed., 1996, Oxford University Press.
- Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
- Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
- Scilab Image Processing: L.M. Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

## DISCIPLINE SPECIFIC ELECTIVES

### DISCIPLINE SPECIFIC ELECTIVES 1 (PHD 5.11(a)) ADVANCED MATHEMATICAL PHYSICS-I

Theory Credit: 4

Teaching Hours: 60

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

**UNIT I Linear Vector Spaces:** Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices. (12 Hours)

**UNIT II Matrices:** Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product. Eigen-values and Eigenvectors. Cayley-Hamilton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix. (12 Hours)

**UNIT III Cartesian Tensors:** Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Anti-symmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry:

**UNIT IV** Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law. (12 Hours)

**UNIT V General Tensors:** Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor. (12 Hours)

#### **Recommended Books and References:**

1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
3. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge



University Press

4. Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
5. Linear Algebra, W. Cheney, E.W. Cheney & D.R. Kincaid, 2012, Jones & Bartlett Learning
6. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
7. Mathematical Methods for Physicists & Engineers, K.F. Riley, M.P. Hobson, S.J. Bence, 3<sup>rd</sup> Ed., 2006, Cambridge University Press

### **DISCIPLINE SPECIFIC ELECTIVES 1 (PHD 5.12(a)) ADVANCED MATHEMATICAL PHYSICS-I**

*Practical Credit: 2*

*Scilab/ C++ based simulations experiments based on Mathematical Physics problems like*

1. Linear algebra:

- Multiplication of two 3 x 3 matrices.
- Eigenvalue and eigenvectors of

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 3 & 3 & 4 \end{pmatrix}; \begin{pmatrix} 1 & -i & 3-4i \\ +i & 2 & 4 \\ 3-4i & 4 & 3 \end{pmatrix}; \begin{pmatrix} 2 & -i & 2i \\ +i & 4 & 3 \\ -2i & 3 & 5 \end{pmatrix}$$

2. Orthogonal polynomials as eigen functions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization.
4. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of Hermitian differential operator.
5. Lagrangian formulation in Classical Mechanics with constraints.
6. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
7. Estimation of ground state energy and wave function of a quantum system.

#### **Recommended Books and References:**

1. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
2. Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
3. Scilab Image Processing: L.M. Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

### **DISCIPLINE SPECIFIC ELECTIVES 1 (PHD 5.11(b)) CLASSICAL DYNAMICS**

*Theory Credit: 5*

*Teaching Hours: 75*

*Tutorials: 1*

*The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.*

**UNIT I Classical Mechanics of Point Particles:** Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed

electric and magnetic fields. Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators

**UNIT II** Canonical momenta & Hamiltonian. Hamilton's equations of motion. Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy.

**UNIT III** **Small Amplitude Oscillations:** Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N - 1) - identical springs.

**UNIT IV** **Special Theory of Relativity:** Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time -dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation.

**UNIT V** Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

**Fluid Dynamics:** Density  $\rho$  and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.

#### **Recommended Books and References:**

1. Classical Mechanics, H. Goldstein, C.P. Poole, J.L. Safko, 3<sup>rd</sup>Edn. 2002, Pearson Education.
2. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
3. Classical Electrodynamics, J.D. Jackson, 3<sup>rd</sup> Edn., 1998, Wiley.
4. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4<sup>th</sup>Edn., 2003, Elsevier.
5. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
6. Classical Mechanics, P.S. Joag, N.C. Rana, 1<sup>st</sup> Edn., McGraw Hall.
7. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
8. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
9. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

#### **DISCIPLINE SPECIFIC ELECTIVES 2 (PHD 5.21(a)) NUCLEAR AND PARTICLE PHYSICS**

*Theory Credit: 5*  
*Tutorials: 1*

*Teaching Hours: 75*

**UNIT I** **General Properties of Nuclei:** Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding

energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excited states.

**UNIT II Nuclear Models:** Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

**UNIT III Radioactivity decay:** (a) Alpha decay: basics of  $\alpha$ -decay processes, theory of  $\alpha$ -emission, Gamow factor, Geiger Nuttall law,  $\alpha$ -decay spectroscopy. (b)  $\beta$ -decay: energy kinematics for  $\beta$ -decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.  
**Nuclear Reactions:** Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

**UNIT IV Interaction of Nuclear Radiation with matter:** Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

**Detector for Nuclear Radiations:** Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

**UNIT V Particle Accelerators:** Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

**Particle physics:** Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.

#### **Recommended Books and References:**

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
4. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
5. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
6. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
7. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).
8. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
9. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
10. Theoretical Nuclear Physics, J.M. Blatt & V.F. Weisskopf (Dover Pub. Inc., 1991)

**DISCIPLINE SPECIFIC ELECTIVES 2 (PHD 5.21(b))**  
**NANO MATERIALS AND APPLICATIONS**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Nanoscale Systems:** Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. *(12 Hours)*

**UNIT II Synthesis of Nanostructure Materials:** Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.  
**Characterization:** X-Ray Diffraction. Optical Microscopy. Electron Scanning Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. *(12 Hours)*

**UNIT III Optical Properties:** Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of hetero structures and nanostructures. *(12 Hours)*

**UNIT IV Electron Transport:** Carrier transport in nano structures. Coulomb blockade effect, thermionic emission, tunneling and hopping conductivity. Defects and impurities: Deep level and surface defects. *(12 Hours)*

**UNIT V Applications:** Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). *(12 Hours)*

**Recommended Books and References:**

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
5. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
6. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
7. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

**DISCIPLINE SPECIFIC ELECTIVES 2 (PHD 5.22(b))**  
**NANO MATERIALS AND APPLICATIONS**

*Practical Credit: 2*

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

**Recommended Books and References:**

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
3. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

**DISCIPLINE SPECIFIC ELECTIVES 3 (PHD 6.11(a))**  
**ADVANCED MATHEMATICAL PHYSICS –II**

*Theory Credit: 5*

*Teaching Hours: 75*

*Tutorials: 1*

**UNIT I     Calculus of Variations:** Variable Calculus: Variational Principle, Euler's Equation and its Application to Simple Problems. Geodesics. Concept of Lagrangian. Generalized coordinates. Definition of canonical moment, Euler-Lagrange's Equations of Motion and its Applications to Simple Problems (e.g., Simple Pendulum and One dimensional harmonic oscillator).

**UNIT II**     Definition of Canonical Momenta. Canonical Pair of Variables. Definition of Generalized Force: Definition of Hamiltonian (Legendre Transformation). Hamilton's Principle. Poisson Brackets and their properties. Lagrange Brackets and their properties.

**UNIT III     Group Theory:** Review of sets, Mapping and Binary Operations, Relation, Types of Relations. Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group,

Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel. Some special groups with operators. Matrix Representations: Reducible and Irreducible.

**UNIT III Advanced Probability Theory:** Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Expectation and Variance.

**UNIT V** Special Probability distributions: The binomial distribution, The poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares.

**Recommended Books and References:**

1. Mathematical Methods for Physicists: Weber and Arfken, 2005, Academic Press.
2. Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.
3. Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.
4. Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover
5. Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong, 2012, Oxford University Press
6. Introduction to Mathematical Probability, J. V. Uspensky, 1937, Mc Graw-Hill.

**DISCIPLINE SPECIFIC ELECTIVES 3 (PHD 6.11(b))**

**DIGITAL SIGNAL PROCESSING**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Discrete-Time Signals and Systems:** Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response. (12 Hours)

**UNIT II Discrete-Time Fourier Transform:** Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. **The z-Transform:** Bilateral (Two-Sided) z-Transform, Inverse z-Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of-Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the z-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations. (12 Hours)

**UNIT III Filter Concepts:** Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters.

**Discrete Fourier Transform:** Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation,

Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing. (12 Hours)

**UNIT IV Fast Fourier Transform:** Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor ( $W_N$ ), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms.

**Realization of Digital Filters:** Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I. (12 Hours)

**UNIT V Finite Impulse Response Digital Filter:** Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators.

**Infinite Impulse Response Digital Filter:** Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method. (12 Hours)

**Recommended Books and References:**

1. Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
2. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
3. Modern Digital and Analog Communication Systems, B.P. Lathi, 1998, 3<sup>rd</sup>Edn. Oxford University Press.
4. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
5. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
6. Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and
7. D.G. Manolakis, 2007, 4<sup>th</sup> Edn., Prentice Hall.

**DISCIPLINE SPECIFIC ELECTIVES 3 (PHD 6.12(b))  
DIGITAL SIGNAL PROCESSING LAB**

*Practical Credit: 2*

*Scilab based simulation based experiments:*

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence  $\delta(n)$ , unit step sequence  $u(n)$ , ramp sequence  $r(n)$  (d) real valued exponential sequence  $x(n) = (0.8)^n u(n)$  for  $0 \leq n \leq 50$
2. Write a sequence to compute the convolution sum of a dectangle signal (or gate function)with itself for  $N=5$

$$x(n) = \text{rect}\left(\frac{n}{2N}\right) = \Pi\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \leq n \leq N \\ 0 & \text{elsewhere} \end{cases}$$

3. An LTI system is specified by the difference equation  $y(n) = 0.8y(n-1) + x(n)$ . Determine:
  - (a) Determine  $H(e^{j\omega})$
  - (b) Calculate the plot of the steady state response  $y_{ss}(n)$  to  $x(n) = \cos(0.5\pi n)u(n)$
4. Given the casual system  $y(n) = 0.9y(n-1) + x(n)$ 
  - (a) Find  $H(z)$  and sketch the pole zero plot
  - (b) Plot the frequency response  $|H(e^{j\omega})|$  and  $\angle H(e^{j\omega})$
5. Design a digital filter to eliminate the lower frequency sinusoid of  $x(t) = \sin 7t + \sin 200t$ . The sampling frequency is  $f_s = 500\text{Hz}$ . Plot its pole zero diagram, magnitude response, input and output of the filter.
6. Let  $x(n)$  be a four point sequence.  $x(n) = \begin{cases} 1, & 0 \leq n \leq 3 \\ 0, & \text{Otherwise} \end{cases}$ 

Compute the DTFT  $X(e^{j\omega})$  and plot its magnitude.

  - (a) Compute and plot the four point DFT of  $x(n)$
  - (b) Compute and plot the 8 point DFT of  $x(n)$  (by appending four zeros)
  - (c) Compute and plot the 16 point DFT of  $x(n)$  (by appending 12 zeros)
7. Let  $x(n)$  and  $h(n)$  be the two four point sequences.  $x(n) = \begin{cases} 1, 2, 2, 1 \\ \end{cases}$  and  $h(n) = \begin{cases} 1, -1, -1, 1 \\ \end{cases}$  write a program to compute their linear convolution using circular convolution.
8. Using rectangular window, design a FIR low pass filter with a pass band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.
9. Design a FIR filter to meet the following specifications:
 

Pass band edge  $F_p = 2\text{KHz}$

Stopband edge  $F_s = 5\text{KHz}$

Passband attenuation  $A_p = 4.2\text{dB}$

Stopband attenuation  $A_s = 42\text{dB}$

Sampling frequency  $F_s = 20\text{KHz}$
10. The frequency response of a linear phase digital differentiator is given by  $H_d(e^{j\omega}) = j\omega e^{-j\omega\tau} \quad |\omega| \leq \pi$ 

Using a humming window, of length  $M=21$ , design a digital FIR differentiator. Plot the amplitude response.

**Recommended Books and References:**

1. Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India.
2. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3<sup>rd</sup>Edn., Cambridge University Press
3. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
4. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
5. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
6. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
7. Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444



8. Scilab Image Processing: L.M. Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

**DISCIPLINE SPECIFIC ELECTIVES 4 (PHD 6.21(a))  
ASTRONOMY AND ASTROPHYSICS**

Theory Credit: 5

Teaching Hours: 60

Tutorials: 1

**UNIT I Astronomical Scales:** Astronomical distance, mass and time, radiant flux and luminosity, Brightness, magnitude system, apparent and absolute magnitude scale, distance modulus. Measurement of Astronomical distances, determination of distance by Parallax method, gravitational potential energy of a star, internal temperature of a star, internal pressure of a star. Stellar spectra, stellar spectral classification, Hertzsprung-Russell diagram.

**UNIT II Basic Concepts of positional astronomy:** Basics of spherical trigonometry, the celestial sphere, circles on celestial sphere, cardinal points, spherical triangle, season, different motions of earth- spin, revolution, obliquity, tilt, eccentricity. Equinoctial points, solstices, constellations Geographic coordinate systems, Astronomical coordinate systems- equatorial, ecliptic and galactic. Diurnal motion of stars, circumpolar star. Measurement of time, sidereal time, apparent solar time mean solar time, equation of motion calendar.

**UNIT III Astronomical techniques:** Basic optical definitions for astronomy (magnification, light gather power, resolving power, diffraction limit, atmospheric windows), optical telescopes (Types of reflecting telescopes, telescope mounting, space telescopes, detectors and their use with telescopes types of detectors- photographic plates, photo multiplier tube (PMT), charge coupled devices (CCD), detection limits with telescopes.

**UNIT IV Solar system:** Origin and evolution of the solar system: The sun: solar parameters, solar photosphere, solar atmosphere, chromospheres, corona, solar activity, physical characteristics of sun-rotation, magnetic field, granulation, sunspots, other chromatic activities, Inner planets Jovian planets, dwarf planets.  
**Asteroids:** classification, origin, Comets: discovery and designation, physical nature, classification, origin, Meteors and meteorites. Star formation and evolution, end states of star: supernova, Neutron star and Black hole.

**UNIT V General relativity and Cosmology:** Gravity and curved space time, equivalence principle, inertial and gravitational mass, general theory of relativity, test of general relativity: gravitational spectral shift, deflection of starlight, delay of radar echoes, precession of perihelion of mercury, Expansion of universe Hubble law cosmic background radiation, total no of blackbody photons, Big bang cosmology, neutrino decoupling, deuterium formation, helium abundance, photon decoupling, Big-bang feature, neutrino background gravity waves, helium abundance, anti matter Red shift and the expansion of universe, matter density of the universe and the deceleration parameter, Doppler red shift, gravitational red shift and cosmological red shift. Critical density of universe and its future evidence of dark matter and dark energy.

**Recommended Books and references:**

1. Modern Astrophysics, B.W. Carroll and D.A. Ostlie, Addison-Wesley Publishing co.
2. The physical universe: an introduction to astronomy, F. Shu, Mill Valley: University Science Books
3. Fundamentals of Astronomy (fourth Edition), H. Karttunen et al. Springer
4. Text book of spherical astronomy, W.M. Smart

5. An Introduction to Cosmology, J. V. Narlikar, Cambridge university press
6. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
7. An Introduction to Astrophysics, B. Basu, T Chattopadhyay and S.N. Biswas. PHI learning private limited

#### **DISCIPLINE SPECIFIC ELECTIVES 4 (PHD 6.21(b))**

##### **ATMOSPHERIC PHYSICS**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I General features of Earth's atmosphere:** Thermal structure of the Earth's Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations, including RS/RW, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms. *(12 Hours)*
- UNIT II Atmospheric Dynamics:** Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics. *(12 Hours)*
- UNIT III Atmospheric Waves:** Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a non homogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration *(12 Hours)*
- UNIT IV Atmospheric Radar and Lidar:** Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques. *(12 Hours)*
- UNIT V Atmospheric Aerosols:** Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars. *(12 Hours)*

##### **Recommended Books and References:**

- Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
- The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3<sup>rd</sup>edn. 2002.
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
- Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014

**DISCIPLINE SPECIFIC ELECTIVES 4 (PHD 6.22(b))**  
**ATMOSPHERIC PHYSICS**

*Practical Credit: 2*

*Scilab/C++ based simulations experiments based on Atmospheric Physics problems like*

1. Numerical Simulation for atmospheric waves using dispersion relations
  - (a) Atmospheric gravity waves (AGW)
  - (b) Kelvin waves
  - (c) Rossby waves, and mountain waves
2. Offline and online processing of radar data
  - (a) VHF radar,
  - (b) X-band radar, and
  - (c) UHF radar
3. Offline and online processing of LIDAR data
4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.
5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique
6. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change

***Recommended Books and References:***

1. Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – J.T. Houghton; Cambridge Univ. Press; 3<sup>rd</sup>edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014

**DISCIPLINE SPECIFIC ELECTIVES 4 (PHD 6.21(C))**  
**PHYSICS OF EARTH**

*Theory Credit: 5*

*Teaching Hours: 75*

*Tutorials: 1*

**UNIT I     **The Earth and the Universe:****

- (a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences.
- (b) General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.

**UNIT II     **Structure****

- (a) The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior?
- (b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.

- (c) The Atmosphere: variation of temperature, density and composition with altitude, clouds.
- (d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers.
- (e) The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms.

**UNIT III Dynamical Processes:**

- (a) The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes: types products and distribution.
- (b) The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, wind – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.

**UNIT IV Evolution:** Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent.

1. Time line of major geological and biological events.
2. Origin of life on Earth.

**UNIT V** Energy and particle fluxes incident on the Earth.

The Cosmic Microwave Background.

The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones.

Climate: Earth's temperature and greenhouse effect. Paleoclimate and recent climate changes. The Indian monsoon system.

Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state.

Role of the biosphere in shaping the environment.

Future of evolution of the Earth and solar system: Death of the Earth.

**Disturbing the Earth – Contemporary dilemmas**

- (a) Human population growth.
- (b) Atmosphere: Green house gas emissions, climate change, air pollution.
- (c) Hydrosphere: Fresh water depletion.
- (d) Geosphere: Chemical effluents, nuclear waste.
- (e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

**Recommended Books and References:**

1. Planetary Surface Processes, H. Jay Melosh, Cambridge University Press, 2011.
2. Consider a Spherical Cow: A course in environmental problem solving, John Harte. University Science Books
3. Holme's Principles of Physical Geology. 1992. Chapman & Hall.
4. Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

## SKILL ENHANCEMENT COURSE

### SKILL ENHANCEMENT COURSE 1 (PHS 3.12(a)) BASIC INSTRUMENTATION SKILLS

Practical Credit: 2

Teaching Hours: 30

*This course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.*

**Basic of Measurement:** Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. **Multimeter:** Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

**Electronic Voltmeter:** Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. **AC millivoltmeter:** Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.

**Cathode Ray Oscilloscope:** Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only- no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance.

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

**Signal Generators and Analysis Instruments:** Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

**Impedance Bridges & Q-Meters:** Block diagram of bridge. working principles of basic(balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges.

**Digital Instruments:** Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.

**Digital Multimeter:** Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution.

#### **The test of lab skills will be of the following test items:**

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.

8. Trouble shooting a circuit
9. Balancing of bridges

**Laboratory Exercises:**

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/ universal bridge.

**Open Ended Experiments:**

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

**Recommended Books and References:**

1. Performance and design of AC machines - M G Say ELBS Edn.
2. A text book in Electrical Technology - B L Theraja - S Chand and Co.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Electronic Devices and circuits, S. Salivahanan& N. S.Kumar, 3<sup>rd</sup> Ed., 2012, Tata Mc-Graw Hill
7. Electronic circuits: Handbook of design and applications, U. Tietze, Ch. Schenk, 2008, Springer
8. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

**SKILL ENHANCEMENT COURSE 1 (PHS 3.12(b))  
PHYSICS WORKSHOP SKILL**

*Practical Credit: 2*

*Teaching Hours: 30*

*The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode*

**Introduction:** Measuring units. conversion to SI and CGS. Familiarization with meterscale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.

**Mechanical Skill:** Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet

using blade. Smoothing of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.

**Electrical and Electronic Skill:** Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay.

**Introduction to prime movers:** Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment.

**Recommended Books and References:**

- A text book in Electrical Technology - B L Theraja – S. Chand and Company.
- Performance and design of AC machines – M.G. Say, ELBS Edn.
- Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
- Workshop Processes, Practices and Materials, Bruce J Black 2005, 3<sup>rd</sup>Edn., Editor Newnes [ISBN: 0750660732]
- New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]

**SKILL ENHANCEMENT COURSE 2 (PHS 4.12(a))  
COMPUTATIONAL PHYSICS**

*Practical Credit: 2*

*Teaching Hours: 30*

*The aim of this course is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.*

- *Highlights the use of computational methods to solve physical problems*
- *Use of computer language as a tool in solving physics problems (applications)*
- *Course will consist of hands on training on the Problem solving on Computers.*

**Introduction:** Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor. **Algorithms and Flowcharts:** Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of  $\sin(x)$  as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

**Scientific Programming:** Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

**Control Statements:** Types of Logic (Sequential, Selection, Repetition), Branching Statements



(Logical **IF**, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

### **Programming:**

1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using  $\exp(x)$  series evaluated at  $x=1$

**Scientific word processing: Introduction to LaTeX:** TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. **Equation representation:** Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

**Visualization:** Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

### **Hands on exercises:**

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
6. To write program to open a file and generate data for plotting using Gnuplot.
7. Plotting trajectory of a projectile projected horizontally.
8. Plotting trajectory of a projectile projected making an angle with the horizontally.
9. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

### **Recommended Books and References:**

1. Introduction to Numerical Analysis, S.S. Sastry, 5<sup>th</sup>Edn., 2012, PHI Learning Pvt. Ltd.
2. Computer Programming in Fortran 77". V. Rajaraman (Publisher: PHI).
3. LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
4. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)

5. Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
6. Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi(1999)
7. A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
8. Elementary Numerical Analysis, K.E. Atkinson, 3<sup>rd</sup>Edn., 2007, Wiley India Edition.

## **SKILL ENHANCEMENT COURSE 2 (PHS 4.12(b)) RADIATION SAFETY**

*Practical Credit: 2*

*Teaching Hours: 30*

*The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics*

**Basics of Atomic and Nuclear Physics:** Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.

**Interaction of Radiation with matter: Types of Radiation:** Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, **Interaction of Photons** - Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, **Interaction of Charged Particles:** Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), **Interaction of Neutrons-** Collision, slowing down and Moderation.

**Radiation detection and monitoring devices: Radiation Quantities and Units:** Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC).

**Radiation detection:** Basic concept and working principle of *gas detectors* (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), *Scintillation Detectors* (Inorganic and Organic Scintillators), *Solid States Detectors* and *Neutron Detectors*, *Thermoluminescent Dosimetry*.

**Radiation safety management:** *Biological effects of ionizing radiation*, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.

**Application of nuclear techniques:** Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. *Industrial Uses:* Tracing, Gauging, Material Modification, Sterization, Food preservation.

**Experiments:**

- 1) Study the background radiation levels using Radiation meter

**Characteristics of Geiger Muller (GM) Counter:**

- 2) Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
- 3) Study of counting statistics using background radiation using GM counter.
- 4) Study of radiation in various materials (e.g. K<sub>2</sub>SO<sub>4</sub> etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
- 5) Study of absorption of beta particles in Aluminum using GM counter.
- 6) Detection of  $\alpha$  particles using reference source & determining its half life using spark counter
- 7) Gamma spectrum of Gas Light mantle (Source of Thorium)

**Recommended Books and References:**

1. W.E. Burcham and M. Jobs – Nuclear and Particle Physics – Longman (1995)
2. G.F. Knoll, Radiation detection and measurements
3. Thermoluminescence Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
4. W.J. Meredith and J.B. Massey, “Fundamental Physics of Radiology”. John Wright and Sons, UK, 1989.
5. J.R. Greening, “Fundamentals of Radiation Dosimetry”, Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
6. Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001
7. A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
8. NCRP, ICRP, ICRU, IAEA, AERB Publications.
9. W.R. Hendee, “Medical Radiation Physics”, Year Book – Medical Publishers Inc. London, 1981

*Revised*  
SYLLABUS FOR  
Bachelor of Science (Honours)

**STATISTICS**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)



### COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Descriptive Statistics and Probability Theory (Theory)	STC 1.11	4
		Descriptive Statistics (Practical)	STC 1.12	2
	Core 2	Calculus (Theory)	STC 1.21	5
		Calculus (Tutorial)		1
II	Core 3	Probability Distributions and Correlation Analysis (Theory)	STC 2.11	4
		Probability Distributions and Correlation Analysis (Practical)	STC 2.12	2
	Core 4	Algebra (Theory)	STC 2.21	5
		Algebra (Tutorial)		1
III	Core 5	Sampling Distributions (Theory)	STC 3.11	4
		Sampling Distributions (Practical)	STC 3.12	2
	Core 6	Survey Sampling & Indian Official Statistics (Theory)	STC 3.21	4
		Survey Sampling & Indian Official Statistics (Practical)	STC 3.22	2
	Core 7	Mathematical Analysis (Theory)	STC 3.31	5
		Mathematical Analysis (Tutorial)		1
	Skill Enhancement Course 1	Statistical-Data Analysis Using Software Packages (Practical)	STS 3.12	2
IV	Core 8	Statistical Inference (Theory)	STC 4.11	4
		Statistical Inference (Practical)	STC 4.12	2
	Core 9	Linear Models (Theory)	STC 4.21	4
		Linear Models (Practical)	STC 4.22	2
	Core 10	Statistical Quality Control (Theory)	STC 4.31	4
		Statistical Quality Control (Practical)	STC 4.32	2
Skill Enhancement Course 2	Statistical Techniques for Research Methods	STS 4.11(a)	2	
V	Core 11	Stochastic Processes and Queuing Theory (Theory)	STC 5.11	4
		Stochastic Processes and Queuing Theory (Practical)	STC 5.12	2
	Core 12	Statistical Computing Using C/C++ Programming (Theory)	STC 5.21	4
		Statistical Computing Using C/C++ Programming (Practical)	STC 5.22	2
	Discipline Specific Elective 1	Operations Research (Theory)	STD 5.11	4
		Operations Research (Practical)	STD 5.12	2
	Discipline Specific Elective 2	Time Series Analysis (Theory)	STD 5.21	4
		Time Series Analysis (Practical)	STD 5.22	2
VI	Core 13	Design of Experiments (Theory)	STC 6.11	4
		Design of Experiments (Practical)	STC 6.12	2
	Core 14	Multivariate Analysis and Index Numbers (Theory)	STC 6.21	4
		Multivariate Analysis and Index Numbers (Practical)	STC 6.22	2
	Discipline Specific Elective 3	Demography (Theory)	STD 6.11	4
		Demography (Practical)	STD 6.12	2

	Discipline Specific Elective 4	Econometrics (Theory)	STD 6.21(a)	4
		OR Project Work	STD 6.21(b)	6
		Econometrics (Practical)	STD 6.22(a)	2

## SEMESTER-I

### CORE 1 (STC 1.11)

#### DESCRIPTIVE STATISTICS AND PROBABILITY THEORY

*Theory Credit: 4*

- UNIT I** Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement-nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram and ogives, consistency and independence of data with special reference to attributes.
- UNIT II:** Measures of Central Tendency: Definition and requisite characteristics, Arithmetic mean, geometric mean and harmonic mean; Median, Mode and their merits, demerits and properties; Quartiles, deciles and percentiles.
- UNIT III** Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, Sheppard's corrections for moments; Skewness and kurtosis.
- UNIT IV** Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.
- UNIT V** Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, bivariate transformations with illustrations.

#### **Recommended Books and References:**

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

### CORE 1 (STC 1.12)

#### DESCRIPTIVE STATISTICS

*Practical Credits: 2*

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.



**CORE 2 (STC 1.21)  
CALCULUS**

*Theory Credit 5*

*Tutorial Credit: 1*

**UNIT I** Differential Calculus: Limits of function, continuous functions, properties of continuous functions, partial differentiation and total differentiation. Indeterminate forms: L-Hospital's rule, Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions.

**UNIT II** Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems. Jacobian of transformation and related problems.

**UNIT III** Integral Calculus: Review of integration and definite integral. Differentiation under integral sign, double and multiple integral, change of order of integration, transformation of variables. Beta and Gamma functions: properties and relationship between them.

**UNIT IV** Differential Equations: Exact differential equations, Integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations solvable for x, y, q, Equations of the first degree in x and y, Clairaut's equations. Higher Order Differential Equations: Linear differential equations of order n, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals, Linear differential equations with non-constant coefficients.

**UNIT V** Formation and solution of a partial differential equations. Equations easily integrable. Linear partial differential equations of first order. Non-linear partial differential equation of first order and their different forms. Charpit's method. Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals. Non-homogeneous partial differential equations with constant coefficients. Classification of second order linear partial differential equations.

***Recommended Books and References:***

1. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14<sup>th</sup> Edition - 1997).
2. Gorakh Prasad: Integral Calculus, Pothishala Pvt. Ltd., Allahabad (14<sup>th</sup> Edition -2000).
3. Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt. Ltd., New Delhi (2<sup>nd</sup> Edition -2004).
4. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.
5. S.C. Gupta & V.K.Kapoor(2015) : Fundamental of Mathematical Statistics. Sultan Chand & Co. New Delhi

## SEMESTER-II

### CORE 3 (STC 2.11)

#### PROBABILITY DISTRIBUTIONS AND CORRELATION ANALYSIS

*Theory Credit: 4*

- UNIT I** Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations.
- UNIT II** Standard discrete probability distributions: Binomial, Poisson, geometric, negative binomial, Hypergeometric,
- UNIT III** Standard continuous probability distributions: uniform, normal, exponential, beta and gamma along with their properties and limiting/approximation cases.
- UNIT IV** Correlation and regression: Definition, scatter diagram, product moment correlation coefficient and rank correlation coefficient. Method of least square and Curve fitting (fitting of polynomials and exponential curves). Regression analysis: line of regression, regression coefficients and their properties.
- UNIT V** Multiple and partial correlation (3 variables only). Properties of residual. Plane of regression. Intraclass correlation and correlation ratio  
Theory of attributes: Introduction, class and class frequencies, consistency of data, independence of attributes, association of attributes, Yule's coefficient of association, coefficient of colligation.

#### **Recommended Books and References:**

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.
4. S.C. Gupta & V.K.Kapoor(2015): Fundamental of Mathematical Statistics. Sultan Chand & Co. New Delhi.

### CORE 3 (STC 2.12)

#### PROBABILITY DISTRIBUTIONS AND CORRELATION ANALYSIS

*Practical Credits: 2*

#### **List of Practical**

1. Fitting of binomial distributions for  $n$  and  $p = q = \frac{1}{2}$ .
2. Fitting of binomial distributions for given  $n$  and  $p$ .
3. Fitting of binomial distributions after computing mean and variance.
4. Fitting of Poisson distributions for given value of  $\lambda$ .
5. Fitting of Poisson distributions after computing mean.

6. Fitting of negative binomial.
7. Fitting of suitable distribution.
8. Application problems based on binomial distribution.
9. Application problems based on Poisson distribution.
10. Application problems based on negative binomial distribution.
11. Problems based on area property of normal distribution.
12. To find the ordinate for a given area for normal distribution.
13. Application based problems using normal distribution.
14. Fitting of normal distribution when parameters are given.
15. Fitting of normal distribution when parameters are not given.
16. Fitting of polynomials, exponential curves.
17. Karl Pearson correlation coefficient.
18. Correlation coefficient for a bivariate frequency distribution.
19. Lines of regression, angle between lines and estimated values of variables.
20. Spearman rank correlation with and without ties.
21. Partial and multiple correlations.
22. Planes of regression and variances of residuals for given simple correlations.

#### **CORE 4 (STC 2.21)**

##### **ALGEBRA**

*Theory Credit 5*

*Tutorial Credit 1*

- UNIT I** Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients of any polynomial equation. Solutions of cubic and biquadratic equations when some conditions on roots of equations are given. Evaluation of the symmetric polynomials and roots of cubic and biquadratic equations.
- UNIT II** Algebra of matrices - A review, theorems related to triangular, idempotent, involutory and nilpotent matrices, symmetric and skew symmetric matrices, Hermitian and skew Hermitian matrices and orthogonal matrices. Trace of a matrix, transpose of a matrix, unitary, adjoint and inverse of a matrix and related properties.
- UNIT III** Determinants of Matrices: Definition, properties and applications of determinants for 3<sup>rd</sup> and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, Circulant determinants and Vandermonde determinants for n<sup>th</sup> order, Jacobi's Theorem, product of determinants. Use of determinants in solution to the system of linear equations, row reduction and echelon forms, the matrix equations  $AX=B$ , solution sets of linear equations, linear independence, Applications of linear equations.
- UNIT IV** Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Generalized inverse (concept with illustrations), Partitioning of matrices and simple properties. Solutions of linear homogenous and non homogenous equation.
- UNIT V** Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem. Characteristic roots and

Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms.

**Recommended Books and References:**

1. Lay David C.: Linear Algebra and its Applications, Addison Wesley, 2000.
2. Schaum's Outlines: Linear Algebra, Tata McGraw-Hill Edition, 3<sup>rd</sup> Edition, 2006.
3. Krishnamurthy V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).
4. Jain P.K. and Khalil Ahmad: Metric Spaces, Narosa Publishing House, New Delhi, 1973
5. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International, 1997.
6. Gupta S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons, 2008.
7. Artin M.: Algebra. Prentice Hall of India, 1994.
8. Datta K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.
9. Hadley G.: Linear Algebra. Narosa Publishing House (Reprint), 2002.
10. Searle S.R.: Matrix Algebra Useful for Statistics. John Wiley & Sons., 1982.

## SEMESTER-III

### CORE 5 (STC 3.11) SAMPLING DISTRIBUTIONS

Theory Credit: 4

- UNIT I** Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter relations, Chebyshev's inequality, W.L.L.N., S.L.L.N. and their applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T. and Liapunov Theorem (without proof).
- UNIT II** Order Statistics: Introduction, distribution of the  $r^{\text{th}}$  order statistic, smallest and largest order statistics. Joint distribution of  $r^{\text{th}}$  and  $s^{\text{th}}$  order statistics, distribution of sample median and sample range.
- UNIT III** Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses (simple and composite), Type I and Type II errors, their probabilities and critical region, level of significance and p-value, power of a test. Large sample tests for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches.
- UNIT IV** Exact sampling distribution: Definition and derivation of p.d.f. of  $\chi^2$  with  $n$  degrees of freedom (d.f.) using m.g.f., nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of  $\chi^2$  distribution. Tests of significance and confidence intervals based on distribution.
- UNIT V** Exact sampling distributions: Student's and Fishers t-distribution, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Snedecore's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Distribution of  $1/F(n_1, n_2)$ . Relationship between t, F and  $\chi^2$  distributions. Test of significance and confidence Intervals based on t and F distributions.

#### **Recommended Books and References:**

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): *An Outline of Statistical Theory*, Vol. I, 4th Edn. World Press, Kolkata.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): *An Introduction to Probability and Statistics*. 2<sup>nd</sup>Edn. (Reprint) John Wiley and Sons.
3. Hogg, R.V. and Tanis, E.A. (2009): *A Brief Course in Mathematical Statistics*. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K. (2001): *Statistics-Principles and Methods*, 4<sup>th</sup>Edn. John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): *Introduction to the Theory of Statistics*, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd.

**CORE 5 (STC 3.12)**  
**SAMPLING DISTRIBUTIONS**

*Practical Credits: 2*

**List of Practical**

1. Testing of significance and confidence intervals for single proportion and difference of two proportions
2. Testing of significance and confidence intervals for single mean and difference of two means and paired tests.
3. Testing of significance and confidence intervals for difference of two standard deviations.
4. Exact Sample Tests based on Chi-Square Distribution.
5. Testing if the population variance has a specific value and its confidence intervals.
6. Testing of goodness of fit.
7. Testing of independence of attributes.
8. Testing based on 2 X 2 contingency table without and with Yates' corrections.
9. Testing of significance and confidence intervals of an observed sample correlation coefficient.
10. Testing and confidence intervals of equality of two population variances

**CORE 6 (STC 3.21)**  
**SURVEY SAMPLING AND INDIAN OFFICIAL STATISTICS**

*Theory Credit: 4*

**UNIT I** Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.

**UNIT II** Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision, post stratification and its performance. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates ( $N=n \times k$ ). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

**UNIT III** Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling.

**UNIT IV** Two stage and multistage sampling, two phase and multi phase sampling (concept only); PPS Sampling, estimation of population total, mean and variance.

**UNIT V** Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance. Indian agricultural statistics, Industrial statistics. Concept of National Accounts Statistics (GDP, NDP, GNP and NNP).

**Recommended Books and References:**

1. Cochran W.G. (1984): Sampling Techniques (3<sup>rd</sup> Ed.), Wiley Eastern.
2. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok, C. (1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of Agricultural Statistics
3. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
4. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
5. Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.
6. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.
7. <http://mospi.nic.in/>

**CORE 6 (STC 3.22)**

**SURVEY SAMPLING AND INDIAN OFFICIAL STATISTICS**

*Practical Credits: 2*

**List of Practical**

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of above two methods relative to SRS
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.

**CORE 7 (STC 3.31)**

**MATHEMATICAL ANALYSIS**

*Theory Credit 5*

*Tutorial Credit 1*

**UNIT I** Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field. Bounded and unbounded sets, neighborhoods and limit points, Supremum and infimum, derived sets, open and closed sets,

sequences and their convergence, limits of some special sequences and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.

**UNIT II** Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's  $n^{\text{th}}$  root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only). Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence.

**UNIT-III** Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with Lagrange's and Cauchy's form of remainder (without proof). Taylor's and Maclaurin's series expansions of  $\sin x$ ,  $\cos x$ ,  $e^x$ ,  $\log(1+x)$

**UNIT IV** Numerical Analysis: Factorial, finite differences and interpolation. Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae. Solution of difference equations of first order.

**UNIT V** Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eighths rule, Weddle's rule with error terms. Stirling's approximation to  $n!$ . Solutions of transcendental equations: Iteration method, regula-falsi and Newton-Raphson method.

**Recommended Books and References:**

1. Malik S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi, 1994.
2. Somasundram D. and Chaudhary B.: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1987.
3. Gupta S.L. and Nisha Rani: Principles of Real Analysis, Vikas Publ. House Pvt. Ltd., New Delhi, 1995.
4. Appostol T.M.: Mathematical Analysis, Second Edition, Narosa Publishing House, NewDelhi, 1987.
5. Shanti Narayan: A course of Mathematical Analysis, 12<sup>th</sup> revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi, 1987.
6. Singal M.K. and Singal A.R.: A First Course in Real Analysis, 24<sup>th</sup> Edition, R. Chand & Co., New Delhi, 2003.
7. Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis(3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
8. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and Real Analysis, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
9. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.
10. Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.
11. Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Delhi.



## SEMESTER-IV

### CORE 8 (STC 4.11) STATISTICAL INFERENCE

*Theory Credit: 4*

- UNIT I** Estimation: Concepts of estimator and estimate, criterion of a good estimator: consistency, unbiasedness, efficiency and sufficiency. Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE).
- UNIT II** Cramer-Rao inequality and MVB estimators (statement and applications), Rao-Blackwell theorem. Interval estimation- confidence interval and confidence limits.
- UNIT III** Methods of Estimation: Method of maximum likelihood estimation, method of moments, method of minimum Chi-square, basic idea of Bayes' estimators.
- UNIT IV** Best critical region, most powerful test, uniformly most powerful test, Neyman Pearson Lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof).
- UNIT V** Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogorov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

#### **Recommended Books and References:**

1. Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2<sup>nd</sup>Edn. (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
5. Mood A.M, Graybill F.A. and Boes D.C.: Introduction to the Theory of Statistics, McGraw Hill.
6. Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
7. Snedecor G.W and Cochran W.G.(1967) Statistical Methods. Iowa State University Press.

### CORE 8 (STC 4.12) STATISTICAL INFERENCE

*Practical Credits: 2*

#### **List of Practical**

1. Unbiased estimators (including unbiased but absurd estimators)
2. Consistent estimators, efficient estimators and relative efficiency of estimators.
3. Cramer-Rao inequality and MVB estimators
4. Sufficient Estimators – Factorization Theorem, Rao-Blackwell theorem, Complete Sufficient estimators

5. Lehman-Scheffe theorem and UMVUE
6. Maximum Likelihood Estimation
7. Asymptotic distribution of maximum likelihood estimators
8. Estimation by the method of moments, minimum Chi-square
9. Type I and Type II errors
10. Most powerful critical region (NP Lemma)
11. Uniformly most powerful critical region
12. Unbiased critical region
13. Power curves
14. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis
15. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis
16. Asymptotic properties of LR tests
17. Test for randomness based on total number of runs,
18. Kolmogorov Smirnov test for one sample.
19. Sign test: one sample, two samples, large samples.
20. Wilcoxon-Mann-Whitney U-test
21. Kruskal-Wallis test

**CORE 9 (STC 4.21)**  
**LINEAR MODELS**

*Theory Credit: 4*

- UNIT I** Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance.
- UNIT II** Regression analysis: Test for the relationship between two variables, linearity of regression, test for polynomial regression, test for multiple linear regression model, test for the homogeneity of a group of regression coefficients.
- UNIT III** Analysis of variance (ANOVA): Introduction and assumptions. Definitions of fixed, random and mixed effect models, analysis of variance in one-way and two-way classified data with one and two observations per cell for fixed effect model
- UNIT IV** Analysis of Covariance (ANCOVA): Introduction, layout, statistical analysis and computational short cuts for one way and twoway classified data with single observation per cell.
- UNIT V** Econometrics: Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, structural and reduced forms. General linear model (GLM) (concept only). Multicollinearity: Introduction and concepts, detection of multicollinearity, concept of generalized least squares estimation, Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

**Recommended Books and References:**

1. Weisberg, S. (2005). Applied Linear Regression (Third edition). Wiley.
2. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.

3. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.
4. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4<sup>th</sup> Edition, McGraw Hill Companies.

**CORE 9 (STC 4.22)**  
**LINEAR MODELS**

*Practical Credits: 2*

**List of Practical**

1. Estimability when X is a full rank matrix and not a full rank matrix
2. Distribution of Quadratic forms
3. Simple Linear Regression
4. Multiple Regression
5. Tests for Linear Hypothesis
6. Bias in regression estimates
7. Lack of fit
8. Analysis of Variance of a one way classified data
9. Analysis of Variance of a two way classified data with one observation per cell
10. Analysis of Covariance of a one way classified data
11. Analysis of Covariance of a two way classified data

**CORE 10 (STC 4.31)**  
**STATISTICAL QUALITY CONTROL**

*Theory Credit: 4*

- UNIT I** Quality: Definition, dimensions of quality, historical perspective of quality control and improvements starting from World War II, historical perspective of Quality Gurus and Quality Hall of Fame. Quality system and standards: Introduction to ISO quality standards, Quality registration. Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation.
- UNIT II** Statistical Control Charts- Construction and Statistical basis of 3- $\sigma$  Control charts, Rational Sub-grouping, Control charts for variables: X-bar & R-chart, X-bar & s-chart.
- UNIT III** Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.
- UNIT IV** Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.
- UNIT V** Likelihood ratio(LR) test- tests for mean and variance of one, two and several independent normal population; Sequential Analysis: Wald's Sequential probability

ratio test (SPRT) for simple vs simple hypotheses. Fundamental relations among  $\alpha$ ,  $\beta$ , A and B, determination of A and B in practice. Wald's fundamental identity and the derivation of operating characteristics (OC) and average sample number (ASN) functions, examples based on normal, Poisson, binomial and exponential distributions.

**Recommended Books and References:**

1. Montgomery, D. C. (2009): Introduction to Statistical Quality Control, 6<sup>th</sup> Edition, Wiley India Pvt. Ltd.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8<sup>th</sup> Edn. The World Press, Kolkata.
3. Mukhopadhyay, P (2011): Applied Statistics, 2<sup>nd</sup> edition revised reprint, Books and Allied(P) Ltd.
4. Montgomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3<sup>rd</sup> Edition reprint, Wiley India Pvt. Ltd.
5. Hoyle, David (1995): ISO Quality Systems Handbook, 2<sup>nd</sup> Edition, Butterworth Heinemann Publication.
6. Fundamentals of Mathematical Statistics (2011): Gupta S.C. and Kapoor V.K., Sultan Chand and Co., New Delhi
7. Fundamentals of Applied Statistics (2011): Gupta S.C. and Kapoor V.K., Sultan Chand and Co., New Delhi

**CORE 10 (STC 4.32)**

**STATISTICAL QUALITY CONTROL**

*Practical Credits: 2*

**List of Practical**

1. Construction and interpretation of statistical control charts X-bar & R-chart X-bar & s-chart np-chart p-chart c-chart u-chart
2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves
3. Calculation of process capability and comparison of 3-sigma control limits with specification limits.
4. Use a case study to apply the concept of six sigma application in DMAIC: practical application.
5. SPRT procedure
6. OC function and OC curve
7. ASN function and ASN curve

## SEMESTER-V

### CORE 11 (STC 5.11) STOCHASTIC PROCESSES AND QUEUING THEORY

*Theory Credit: 4*

- UNIT I** Probability Distributions: Generating functions, Bivariate probability generating function. Stochastic Process: Introduction, Stationary Process. Hazard and Survival functions
- UNIT II** Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system, graph theoretic approach.
- UNIT III** Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process.
- UNIT IV** Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof). Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.
- UNIT V** Demand Analysis: Demand and supply functions, Price elasticity of demand and supply, income elasticity of demand; Types of data required for estimating elasticity: family budget data and time series data; Pareto's law of income distribution; Engel's law and Engel's curve; Lorentz curve.

#### **Recommended Books and References:**

10. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
11. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
12. Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
13. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
14. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I, 3<sup>rd</sup> Edition, Wiley International.

### CORE 11 (STC 5.12) STOCHASTIC PROCESSES AND QUEUING THEORY

*Practical Credits: 2*

#### **List of Practical**

5. Calculation of transition probability matrix
6. Identification of characteristics of reducible and irreducible chains.
7. Identification of types of classes
8. Identification of ergodic transition probability matrix
9. Stationarity of Markov chain and graphical representation of Markov chain
10. Computation of probabilities in case of generalizations of independent Bernoulli trials

11. Calculation of probabilities for given birth and death rates and vice versa
12. Calculation of probabilities for Birth and Death Process
7. Calculation of probabilities for Yule Furry Process
8. Computation of inter-arrival time for a Poisson process.
9. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity.
10. Calculation of generating function and expected duration for different amounts of stake.
11. Computation of probabilities and expected duration between players.
12. Fitting of demand curve.
13. Fitting of Pareto's curve.

## **CORE 12 (STC 5.21)**

### **STATISTICAL COMPUTING USING C/C++ PROGRAMMING**

*Theory Credit: 4*

- UNIT I** History and importance of C/C++. Components, basic structure programming, character set, C/C++ tokens, Keywords and Identifiers and execution of a C/C++ program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constants, overflow and underflow of data. Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression.
- UNIT II** Implicit and explicit type conversions in expressions, library functions. Managing input and output operations: reading and printing formatted and unformatted data. Decision making and branching - if...else, nesting of if...else, else if ladder, switch, conditional operator.
- UNIT III** Looping in C/C++: for, nested for, while, do...while, jumps in and out of loops. Arrays: Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings: Declaring and initializing string variables, reading and writing strings from Terminal (using scanf and printf only).
- UNIT IV** User- defined functions: A multi-function program using user-defined functions, definition of functions, return values and their types, function prototypes and calls. Category of Functions : no arguments and no return values, arguments but no return values , arguments with return values, no arguments but returns a value, functions that return multiple values. Recursion function, Inline function, Passing arrays to functions, Storage class of Variables.
- UNIT V** Pointers: Declaration and initialization of pointer variables, accessing the address of a variable, accessing a variable through its pointer, pointer expressions, pointer increments/decrement and scale factor. Pointers and arrays, arrays of pointers, pointers as function arguments, functions returning pointers. Structure: Definition and declaring, initialization, accessing structure members, copying and comparison of structure variables, array of structures, structure pointers. Dynamic memory allocation functions: malloc, calloc and free. Pre processors: Macro substitution, macro with argument

File inclusion in C/C++: Defining and opening a file (only r, w and a modes), closing a file, I/O operations on files-fscanf and fprintf functions.

**Recommended Books and References:**

6. Kernighan, B.W. and Ritchie, D. (1988): C Programming Language, 2<sup>nd</sup> Edition, Prentice Hall.
7. Balagurusamy, E. (2011): Programming in ANSI C, 6<sup>th</sup> Edition, Tata McGraw Hill.
8. Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2<sup>nd</sup> Edition, Tata McGraw Hill

**CORE 12 (STC 5.22)**

**STATISTICAL COMPUTING USING C/C++ PROGRAMMING**

*Practical Credits: 2*

**List of Practical**

7. Plot of a graph  $y = f(x)$
8. Roots of a quadratic equation (with imaginary roots also)
9. Sorting of an array and hence finding median
10. Mean, Median and Mode of a Grouped Frequency Data
11. Variance and coefficient of variation of a Grouped Frequency Data
12. Preparing a frequency table
13. Value of  $n!$  using recursion
14. Random number generation from uniform, exponential, normal (using CLT) and gamma distribution, calculate sample mean and variance and compare with population parameters.
15. Matrix addition, subtraction, multiplication Transpose and Trace
16. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit
17. Chi-square contingency table
18. t-test for difference of means
19. Paired t-test
20. F-ratio test
21. Multiple and Partial correlation.
22. Compute ranks and then calculate rank correlation (without tied ranks)
23. Fitting of lines of regression

## SEMESTER-VI

### CORE 13 (STC 6.11) DESIGN OF EXPERIMENTS

*Theory Credit: 4*

- UNIT I** Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency,
- UNIT II** Missing plot technique: analysis of RBD and LSD with one and two missing observations. Split plot design- concept and analysis.
- UNIT III** Incomplete Block Designs: Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD, Intra Block analysis, complimentary BIBD, Residual BIBD, Dual BIBD, Derived BIBD.
- UNIT IV** Factorial experiments: advantages, notations and concepts,  $2^2$ ,  $2^3$ ,  $2^n$  ( $n \leq 5$ ) and  $3^2$  factorial experiments – design and analysis; Advantages of factorial over simple experiment with example.
- UNIT V** Confounding in Factorial experiment: Concept of confounding in a design of experiment, confounding subgroups, determination of suitable confounding subgroups, complete and partial confounding with examples for  $2^n$  ( $n \leq 5$ ); Orthogonality of a design: Distinction between orthogonality and confounding.

#### **Recommended Books and References:**

8. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
9. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
10. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8<sup>th</sup>Edn. World Press, Kolkata.
11. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
12. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

### CORE 13 (STC 6.12) DESIGN OF EXPERIMENTS

*Practical Credits: 2*

#### **List of Practical**

5. Analysis of a CRD
6. Analysis of an RBD
7. Analysis of an LSD
3. analysis of an RBD with one and two missing observation
4. Analysis of an LSD with one missing observation
5. Intra Block analysis of a BIBD



6. Analysis of  $2^2$  and  $2^3$  factorial in CRD and RBD
7. Analysis of  $2^2$  and  $2^3$  factorial in LSD
8. Analysis of a completely confounded two level factorial design in 2 blocks
9. Analysis of a completely confounded two level factorial design in 4 blocks
10. Analysis of a partially confounded two level factorial design
11. Analysis of a single replicate of a  $2^n$  design
12. Analysis of a fraction of  $2^n$  factorial design

#### **CORE 14 (STC 6.21)**

#### **MULTIVARIATE ANALYSIS AND INDEX NUMBERS**

*Theory Credit: 4*

**UNIT I** Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.

Multivariate Data: Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions.

**UNIT II** Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance-covariance matrix. Multiple and partial correlation coefficient and their properties.

**UNIT III** Educational and Psychological Statistics: Scaling of individuals for items in terms of difficulty, Z-score, standard score normalized scores, t-score and percentile score; Scaling of ratings in terms of normal probability curve; Test theory, Methods of estimating test reliability; Effect of test length on reliability of a test, validity of test scores, Intelligent quotient and its construction.

**UNIT IV** Index Numbers-I: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa.

**UNIT V** Index Numbers-II: Cost of living (Consumer price) index number, problems in the construction of consumer price index number and its uses; Wholesale price index number. Index of Industrial Production, agricultural production.

#### **Recommended Books and References:**

5. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3<sup>rd</sup>Edn., John Wiley
6. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
7. Kshirsagar, A.M. (1972): Multivariate Analysis, 1<sup>st</sup>Edn. Marcel Dekker.
8. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6<sup>th</sup>Edn., Pearson & Prentice Hall
9. Mukhopadhyay, P.: Mathematical Statistics.
10. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4<sup>th</sup> Edition. Marcel Dekker, CRC.
11. Fundamentals of Applied Statistics (2011): Gupta S.C. and Kapoor V.K., Sultan Chand and Co., New Delhi

**CORE 14 (STC 6.22)**

**MULTIVARIATE ANALYSIS AND INDEX NUMBERS**

*Practical Credits: 2*

**List of Practical**

4. Bivariate Normal Distribution and Multivariate Normal Distribution
5. Discriminant Analysis and Principal Components Analysis
6. Factor Analysis
7. Calculate price and quantity index numbers using simple and weighted average of price relatives.
8. To calculate the Chain Base and consumer price index numbers.

## DISCIPLINE SPECIFIC ELECTIVE

### DISCIPLINE SPECIFIC ELECTIVE 1 (STD 5.11) OPERATIONS RESEARCH

*Theory Credit: 4*

- UNIT I** Introduction to Operations Research, phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. Simplex method for solving L.P.P. Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method. Post-optimality analysis
- UNIT II** Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem.
- UNIT III** Game theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. Networking: Shortest route and minimal spanning tree problem.
- UNIT IV** Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks.
- UNIT V** Network Analysis: Idea of network node, activities, dummy activity, construction of network diagram; CPM-Network scheduling using CPM, determination of different types of floats and slacks, determination of Critical path; PERT; Basic definition of PERT and its usefulness; brief idea of optimistic time, pessimistic time and most likely time (PERT calculations are not required).

#### **Recommended Books and References:**

1. Taha, H. A. (2007): Operations Research: An Introduction, 8<sup>th</sup> Edition, Prentice Hall of India.
2. KantiSwarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13<sup>th</sup> Edition, Sultan Chand and Sons.
3. Hadley, G: (2002): Linear Programming, Narosa Publications
4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research-Concepts and cases, 9<sup>th</sup> Edition, Tata McGraw Hill

### DISCIPLINE SPECIFIC ELECTIVE 1 (STD 5.12) OPERATIONS RESEARCH

*(Using TORA/WINQSB/LINGO)*

*Practical Credit 2*

#### **List of Practical**

1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex

- technique and Charne's Big M method involving artificial variables.
2. Identifying Special cases by Graphical and Simplex method and interpretation
    - a. Degenerate solution
    - b. Unbounded solution
    - c. Alternate solution
    - d. Infeasible solution
  3. Post-optimality
    - a. Addition of constraint
    - b. Change in requirement vector
    - c. Addition of new activity
    - d. Change in cost vector
  4. Allocation problem using Transportation model
  5. Allocation problem using Assignment model
  6. Networking problem
    - a. Minimal spanning tree problem
    - b. Shortest route problem
  7. Problems based on game matrix
    - a. Graphical solution to  $m \times 2 / 2 \times n$  rectangular game
    - b. Mixed strategy
  8. To find optimal inventory policy for EOQ models and its variations
  9. To solve all-units quantity discounts model.
  10. Problems related to Network analysis.

**DISCIPLINE SPECIFIC ELECTIVE 2 (STD 5.21)**  
**TIME SERIES ANALYSIS**

*Theory Credit: 4*

- UNIT I** Introduction to times series data, application of time series from various fields, Components of a times series, Decomposition of time series. Trend: Estimation of trend by free hand curve method, method of semi averages, fitting a various mathematical curve, and growth curves.
- UNIT II** Trend Cont.: Method of moving averages. Detrending. Effect of elimination of trend on other components of the time series. Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend,
- UNIT III** Seasonal Component cont: Ratio to Moving Averages and Link Relative method, Deseasonalization. Cyclic Component: Harmonic Analysis. Multicollinearity: Nature, Estimation of parameters and detection of multicollinearity.
- UNIT IV** Autocorrelation and Autoregression: Moving average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2) – Yule-Walker equations. Stationary Time series: Weak stationarity, autocorrelation function and correlogram of moving average.
- UNIT V** Random Component: Variate component method. Forecasting: Exponential smoothing methods, Short term forecasting methods: Brown's discounted regression, Box-Jenkins method and Bayesian forecasting.

**Recommended Books and References:**

1. Kendall M.G. (1976): Time Series, Charles Griffin.
2. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
3. Mukhopadhyay P. (2011): Applied Statistics, 2<sup>nd</sup> ed. Revised reprint, Books and Allied

**DISCIPLINE SPECIFIC ELECTIVE 2 (STD 5.22)  
TIME SERIES ANALYSIS**

*Practical Credit: 4*

**List of Practical**

1. Fitting and plotting of modified exponential curve
2. Fitting and plotting of Gompertz curve
3. Fitting and plotting of logistic curve
4. Fitting of trend by Moving Average Method
5. Measurement of Seasonal indices Ratio-to-Trend method
6. Measurement of Seasonal indices Ratio-to-Moving Average method
7. Measurement of seasonal indices Link Relative method
8. Calculation of variance of random component by variate difference method
9. Forecasting by exponential smoothing
10. Forecasting by short term forecasting methods.

**DISCIPLINE SPECIFIC ELECTIVE 3 (STD 6.11)  
DEMOGRAPHY**

*Theory Credit: 4*

- UNIT I** Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.  
Migration: definition and kind of migration, estimation of migration rates, components of migration.
- UNIT II** Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates.
- UNIT III** Stationary and Stable population, Central Mortality Rates and Force of Mortality, Life (Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables. Double and multiple decrement life table, indirect estimation of life expectancy, model life tables.
- UNIT IV** Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method. Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

**UNIT V** Migration: Definition and kind of migration, estimation of migration rates, components of migration, migration streams, rural to urban migration, internal and international migration, differential migration, population distribution.

**Recommended Books and References:**

- 61 Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
- 62 Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9<sup>th</sup> Edition, World Press.
- 63 Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
- 64 Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3<sup>rd</sup> Edition. Prentice Hall of India Pvt. Ltd.
- 65 Keyfitz N., Beckman John A.: Demogrphy through Problems S-Verlag New york.
- 66 Bhende A.A. Kanitkar Tara: Principles of Population Studies, Himalayan Publishing House, Mumbai-400004.

**DISCIPLINE SPECIFIC ELECTIVE 3 (STD 6.12)  
DEMOGRAPHY**

*Practical Credit: 2*

**List of Practical**

1. To calculate CDR and Age Specific death rate for a given set of data
2. To find Standardized death rate by:- (i) Direct method (ii) Indirect method
3. To construct a complete life table
4. To fill in the missing entries in a life table
5. To calculate probabilities of death at pivotal ages and use it construct abridged life table using (i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method
6. To calculate CBR, GFR, SFR, TFR for a given set of data
7. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data
8. Calculate GRR and NRR for a given set of data and compare them
9. To calculate the probability of dying from a particular cause of death (multiple decrement life table).

**DISCIPLINE SPECIFIC ELECTIVE 4 (STD 6.21(a))  
ECONOMETRICS**

**UNIT I** Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, structural and reduced forms. General linear model (GLM). Estimation under linear restrictions.

**UNIT II** Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity, specification error.

**UNIT III** Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

**UNIT IV** Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Autoregressive and Lag models, Dummy variables, Qualitative data.

**Recommended Books and References:**

1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4<sup>th</sup> Edition, McGraw Hill Companies.
2. Johnston, J. (1972): Econometric Methods, 2<sup>nd</sup> Edition, McGraw Hill International.
3. Koutsoyiannis, A. (2004): Theory of Econometrics, 2<sup>nd</sup> Edition, Palgrave Macmillan Limited,
- 61 Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4<sup>th</sup> Edition, John Wiley & Sons.

**DISCIPLINE SPECIFIC ELECTIVE 4 (STD 6.21(a))  
ECONOMETRICS**

**List of Practical**

1. Problems based on estimation of General linear model
2. Testing of parameters of General linear model
3. Forecasting of General linear model
4. Problems concerning specification errors
5. Problems related to consequences of Multicollinearity
6. Diagnostics of Multicollinearity
7. Problems related to consequences of Autocorrelation (AR(I))
8. Diagnostics of Autocorrelation
9. Estimation of problems of General linear model under Autocorrelation
10. Problems related to consequences Heteroscedasticity
11. Diagnostics of Heteroscedasticity
12. Estimation of problems of General linear model under Heteroscedastic distance terms
13. Problems related to General linear model under (Aitken Estimation )
14. Problems on Autoregressive and Lag models.

**DISCIPLINE SPECIFIC ELECTIVE 4 (STD 6.21(b))  
PROJECT WORK**

*Credit-6*

**Objective:** The aim of the course is to initiate students to write and present a statistical report, under the supervision of a faculty, on some area of human interest. The project work will provide hands on training to the students to deal with data emanating from some real life situation and propel them to dwell on some theory or relate it to some theoretical concepts.

## SKILL ENHANCEMENT ELECTIVE

### SKILL ENHANCEMENT COURSE 1 (STS 3.12)

#### STATISTICAL-DATA ANALYSIS USING SOFTWARE PACKAGES

*Practical Credit: 2*

*This course will review and expand upon core topics in statistics and probability, particularly by initiating the beneficiaries of the course to at least one of the software packages viz., SPSS, Minitab, Matlab, for statistical computing.*

- UNIT I** Learn how to load data, plot a graph viz. histograms (equal class intervals and unequal class intervals), box plot, stem-leaf, frequency polygon, pie chart, ogives with graphical summaries of data
- UNIT II** Generate automated reports giving detailed descriptive statistics, correlation and lines of regression.
- UNIT III** Random number generation and sampling procedures. Fitting of polynomials and exponential curves.
- UNIT IV** Application Problems based on fitting of suitable distribution, Normal probability plot.
- UNIT V** Simple analysis and create and manage statistical analysis projects, import data, code editing, Basics of statistical inference in order to understand hypothesis testing and compute p-values and confidence intervals.

#### **Recommended Books and References:**

1. Moore, D.S. and McCabe, G.P. and Craig, B.A. (2014): Introduction to the Practice of Statistics, W.H. Freeman
2. Cunningham, B.J (2012): Using SPSS: An Interactive Hands-on approach
3. Cho, M.J., Martinez, W.L. (2014) Statistics in MATLAB: A Primer, Chapman and Hall/CRC

### SKILL ENHANCEMENT COURSE (STS 4.11)

#### STATISTICAL TECHNIQUES FOR RESEARCH METHODS

*Theory Credit: 2*

*Statistical Techniques provide scientific approaches to develop the domain of human knowledge largely through empirical studies. The course aims at enabling students understand basic concepts and aspects related to research, data collection, analyses and interpretation.*

- UNIT I** Introduction: Meaning, objection and motivation in research, types of research, research approach, significance of research. Research problems: definition, selection and necessity of research problems.
- UNIT II** Research design and measurement and scaling technique: Meaning of research design, need for research design, features of a good design, different research designs. Developing a research plan.



- UNIT III** Develop a questionnaire, collect survey data pertaining to a research problem (such as gender discriminations in private v/s government sector, unemployment rates, removal of subsidy, impact on service class v/s unorganized sectors), interpret the results and draw inferences.
- UNIT IV** Survey Methodology and Data Collection, inference and error in surveys, the target populations, sampling frames and coverage error, methods of data collection, non-response, questions and answers in surveys.
- UNIT V** Processing, Data Analysis and Interpretation: Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation.

***Recommended Books and References:***

1. Kothari, C.R. (2009): Research Methodology: Methods and Techniques, 2<sup>nd</sup> Revised Edition reprint, New Age International Publishers.
2. Kumar, R (2011): Research Methodology: A Step - by - Step Guide for Beginners, SAGE publications.

*Revised*  
SYLLABUS FOR  
Bachelor of Science (Honours)

**ZOOLOGY**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)



### COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
<b>I</b>	Core 1	Non-chordates I: Protista to Pseudocoelomates (Theory)	ZOC 1.11	4
		Non-chordates I: Protista to Pseudocoelomates (Practical)	ZOC 1.12	2
	Core 2	Principles of Ecology (Theory)	ZOC 1.21	4
		Principles of Ecology (Practical)	ZOC 1.22	2
<b>II</b>	Core 3	Non-chordates II: Coelomates (Theory)	ZOC 2.11	4
		Non-chordates II: Coelomates (Practical)	ZOC 2.12	2
	Core 4	Cell Biology (Theory)	ZOC 2.21	4
		Cell Biology (Practical)	ZOC 2.22	2
<b>III</b>	Core 5	Diversity of Chordates (Theory)	ZOC 3.11	4
		Diversity of Chordates (Practical)	ZOC 3.12	2
	Core 6	Physiology: Controlling and Coordinating Systems (Theory)	ZOC 3.21	4
		Physiology: Controlling and Coordinating Systems (Practical)	ZOC 3.22	2
	Core 7	Fundamentals of Biochemistry (Theory)	ZOC 3.31	4
		Fundamentals of Biochemistry (Practical)	ZOC 3.32	2
	Skill Enhancement Course 1	Apiculture OR Sericulture	ZOS 3.11(a) ZOS 3.11(b)	2
	<b>IV</b>	Core 8	Comparative Anatomy of Vertebrates (Theory)	ZOC 4.11
Comparative Anatomy of Vertebrates (Practical)			ZOC 4.12	2
Core 9		Physiology: Life Sustaining Systems (Theory)	ZOC 4.21	4
		Physiology: Life Sustaining Systems (Practical)	ZOC 4.22	2
Core 10		Biochemistry of Metabolic Processes (Theory)	ZOC 4.31	4
		Biochemistry of Metabolic Processes (Practical)	ZOC 4.32	2
Skill Enhancement Course 2		Medical Diagnostics OR Aquarium Fish Keeping	ZOS 4.11(a) ZOS 4.11(b)	2
<b>V</b>		Core 11	Molecular Biology (Theory)	ZOC 5.11
	Molecular Biology (Practical)		ZOC 5.12	2
	Core 12	Principles of Genetics (Theory)	ZOC 5.21	4
		Principles of Genetics (Practical)	ZOC 5.22	2
	Discipline Specific Elective 1	Biology of Insects (Theory) OR Animal Behaviour and Chronobiology (Theory)	ZOD 5.11(a) ZOD 5.11(b)	4
		Biology of Insects (Practical)	ZOD 5.12(a)	2

		OR Animal Behaviour and Chronobiology (Practical)	ZOD 5.12(b)		
	Discipline Specific Elective 2	Parasitology (Theory) OR Reproductive Biology (Theory)	ZOD 5.21(a) ZOD 5.21(b)	4	
		Parasitology (Practical) OR Reproductive Biology (Practical)	ZOD 5.22(a) ZOD 5.22(b)	2	
<b>VI</b>		Core 13	Developmental Biology (Theory)	ZOC 6.11	4
			Developmental Biology (Practical)	ZOC 6.12	2
	Core 14	Evolutionary Biology (Theory)	ZOC 6.21	4	
		Evolutionary Biology (Practical)	ZOC 6.22	2	
	Discipline Specific Elective 3	Fish and Fisheries (Theory) OR Wildlife Conservation and Management (Theory)	ZOD 6.11(a) ZOD 6.11(b)	4	
		Fish and Fisheries (Practical) OR Wildlife Conservation and Management (Practical)	ZOD 6.12(a) ZOD 6.12(b)	2	
		Discipline Specific Elective 4	Immunology (Theory) OR Endocrinology (Theory)	ZOD 6.21(a) ZOD 6.21(b)	4
			Immunology (Practical) OR Endocrinology (Practical)	ZOD 6.22(a) ZOD 6.22(b)	2

## SEMESTER - I

### CORE 1 (ZOC 1.11)

#### NON-CHORDATES I: PROTISTS TO PSEUDOCOELOMATES

Theory Credit: 4

##### UNIT I **Protista, Parazoa and Metazoa**

General characteristics and Classification up to classes  
Morphological study of *Euglena*, *Amoeba* and *Paramecium*  
Life cycle and pathogenicity of *Plasmodium vivax*  
Mode of locomotion and Reproduction in Protista

##### UNIT II **Porifera**

General characteristics and Classification up to classes  
Reproduction and development in sponges: sycon, leucosolenia.  
Structural organization of sycon.  
Canal system and spicules in sponges

##### UNIT III **Cnidaria**

General characteristics and Classification up to classes  
Metagenesis in *Obelia*  
Reproduction in Aurelia  
Polymorphism in Cnidaria  
Corals and coral reefs

##### UNIT IV **Ctenophora and Platyhelminthes**

General characteristics and Evolutionary significance of Ctenophora  
General characteristics and Classification up to classes of Platyhelminthes  
Life cycle and pathogenicity of *Fasciola hepatica*

##### UNIT V **Nemathelminthes**

General characteristics and Classification up to classes  
Life cycle, and pathogenicity of *Ascaris lumbricoides* and *Ancylostomaduodenali*  
Parasitic adaptations in helminthes

**Note:** Classification to be followed from "Barnes, R.D. (1982). Invertebrate Zoology, \V Edition"

### CORE 1 (ZOC 1.12)

#### NON-CHORDATES I: PROTISTS TO PSEUDOCOELOMATES

Practical Credit: 2

1. Study of whole mount of *Amoeba*, *Monocystic* and *Trypanosoma*.
2. Binary fission and Conjugation in *Paramecium*
3. Culture of *Paramecium* and *Euglena*.
4. Study of *Sycon*(T.S. and L.S.), *Hyalonema*, *Spongilla*, *Obelia*, *Physalia*, *Gorgonia*
5. One specimen/slide of any ctenophore
6. Study of adult *Fasciola hepatica*, *Taenia solium* and their life cycles (Slides/microphotographs)
7. Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs).

8. Temporary mounting of Spicules and Gemmules.

**Note:** Classification to be followed from “Ruppert and Barnes (2006) *Invertebrate Zoology*, 8th edition, Holt Saunders International Edition”

**Recommended Books and References:**

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
3. Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson

**CORE 2 (ZOC 1.21)**

**PRINCIPLES OF ECOLOGY**

*Theory Credit: 4*

**UNIT I Introduction to Ecology**

Concept of Species; sympatric and Allopatric  
Law of limiting factors: Liebig's law of minimum and Shelford's law of Tolerance.  
History of ecology, Autecology and synecology, Levels of organization, Laws of limiting factors, Study of physical factors

**UNIT II Population**

Unitary and Modular populations  
Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion  
Exponential and logistic growth, equation and patterns, r and K strategies  
Population regulation - density-dependent and independent factors

**UNIT III Community**

Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, Ecotone and edge effect; Ecological - Aquatic and terrestrial.  
Theories pertaining to climax community

**UNIT IV Ecosystem**

Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies  
Biogeochemical cycle of Nitrogen and Carbon.

**UNIT V Applied Ecology**

Wildlife Conservation and Management: Strategies, Threats, Acts, Methods.  
Human modified ecosystem

**CORE 2 (ZOC 1.22)**  
**PRINCIPLES OF ECOLOGY**

*Practical Credit: 2*

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, Measurement of area, temperature, turbidity/penetration of light, determination of pH, and Dissolved Oxygen content (Winkler's method), Chemical Oxygen Demand and free CO<sub>2</sub>
4. Field Study

***Recommended Books and References:***

1. Colviniaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc.
2. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
3. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
4. Robert Leo Smith Ecology and field biology Harper and Row publisher
5. Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Pres



## SEMESTER - II

### CORE 3 (ZOC 2.11)

#### NON-CHORDATES II: COELOMATES

*Theory Credit: 4*

##### UNIT I **Introduction to Coelomates**

Evolution and types of coelom and metamerism,  
Significance of Coelom and Metamerism,  
Level of organization.

##### UNIT II **Annelida and Onychophora**

General characteristics and Classification of Annelida up to classes  
Excretion in Annelida. Locomotion in Annelida, Economic importance of Annelida  
General characteristics and Evolutionary significance of Onychophora

##### UNIT III **Arthropoda**

General characteristics and Classification up to classes  
Vision and Respiration in Arthropoda  
Metamorphosis in Insects  
Social life in bees and termites

##### UNIT IV

##### **Mollusca**

General characteristics and Classification up to classes  
Respiration in Mollusca  
Torsion and detorsion in Gastropoda  
Pearl formation in bivalves  
Evolutionary significance of trochophore larva

##### UNIT V

##### **Echinodermata**

General characteristics and Classification up to classes  
Water-vascular system in Asteroidea  
Larval forms in Echinodermata  
Affinities with Chordates

**Note:** Classification to be followed from “Ruppert and Barnes (2006) Invertebrate Zoology, 8th edition, Holt Saunders International Edition”

### CORE 3 (ZOC 2.12)

#### NON-CHORDATES II: COELOMATES

*Practical Credit: 2*

1. Study of following specimens:

Annelids - *Aphrodite*, *Nereis*, *Heteronereis*, *Sabella*, *Serpula*, *Chaetopterus*,  
*Pheretima*, *Hirudinaria*

Arthropods - *Limulus*, *Palamnaeus*, *Palaemon*, *Daphnia*, *Balanus*, *Sacculina*,  
*Cancer*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx*, *Periplaneta*, termites and honey bees

Onychophora - *Peripatus*

Molluscs - *Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus*

Echinodermates - *Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria and Antedon*

2. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm
3. T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm
4. Mount of mouth parts and dissection of digestive system and nervous system of *Periplaneta*\*
5. To submit a Project Report on life cycle of *Anopheles/Culex/Housefly*

**Note:** Classification to be followed from “Ruppert and Barnes (2006) *Invertebrate Zoology*, 8th edition, Holt Saunders International Edition”

#### **Recommended Books and References:**

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition
2. Barnes, R.S.K., Calow, P., Olive, P. J. W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
3. Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson

#### **CORE 4 (ZOC 2.21) CELL BIOLOGY**

*Theory Credit: 4*

##### **UNIT I Overview of Cells and Plasma Membrane**

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions  
Various models of plasma membrane structure  
Transport across membranes: Active and Passive transport, Facilitated transport  
Cell junctions: Tight junctions, Desmosomes, Gap junctions

##### **UNIT II Endomembrane System**

Structure and Functions: Endoplasmic Reticulum, Golgi Apparatus, Lysosomes  
Protein sorting and Transport system (ER, Golgi Apparatus, Lysosome)

##### **UNIT III Mitochondria, Peroxisomes and Cytoskeleton**

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis  
Mitochondrial Respiratory Chain, Chemo-osmotic hypothesis; Peroxisomes;  
Cytoskeleton: Structure and Functions: Microtubules, Microfilaments and Intermediate filaments

##### **UNIT IV Nucleus**

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus  
Chromatin: Euchromatin and Heterochromatin and packaging (nucleosome)

##### **UNIT V Cell Division and Cell Signaling**

Mitosis, Meiosis and their significance, Cell cycle and its regulation and check points, GPCR and Role of second messenger (cAMP)

**CORE 4 (ZOC 2.22)**  
**CELL BIOLOGY**

*Practical Credit: 2*

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis
2. Study of various stages of meiosis.
3. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
4. Preparation of slide:
  - i DNA by Feulgen reaction
  - ii DNA and RNA by MGP
  - iii Mucopolysaccharides by PAS reaction
  - iv Proteins by Mercurobromophenol blue/Fast Green

**Recommended Books and References:**

1. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell*. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
5. Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). *Molecular Biology of the Cell*, V Edition, Garland publishing Inc., New York and London.

## SEMESTER – III

### CORE 5 (ZOC 3.11) DIVERSITY OF CHORDATA

Theory Credit: 4

#### UNIT I Introduction to Chordates and Protochordata

General characteristics and outline classification of chordate. General characteristics of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata.

#### UNIT II Origin of Chordata and Agnatha

Echinoderm theory of origin of chordates. Theories of Chordate Ancestry External morphology, habit and habitat of petromyzon. Advanced features of vertebrates over Protochordata. General characteristics and classification of cyclostomes up to class.

#### UNIT III Pisces and Amphibia

General characteristics of Chondrichthyes and Osteichthyes, classification of Pisces up to order; Migration, Osmoregulation and Parental care in fishes. Origin of *Tetrapoda* (Evolution of terrestrial ectotherms); General characteristics and classification of Amphibia up to order; Parental care in Amphibians.

#### UNIT IV Reptilia and Aves

General characteristics and classification of Reptilia up to order; Affinities of *Sphenodon*; Poison apparatus and Biting mechanism in snakes. General characteristics and classification of Aves up to order, *Archaeopteryx* – a connecting link; Principles and aerodynamics of flight, Flight adaptations and Migration in birds

#### UNIT V Mammals and Zoogeography

General characters and classification of mammals up to order; Affinities of Ootheria; Adaptive radiation with reference to locomotory appendage. Distribution of vertebrates in different Zoogeographical realms

### CORE 5 (ZOC 3.12) DIVERSITY OF CHORDATA

Practical Credit: 2

#### 1. Protochordata

*Balanoglossus*, *Herdmania*, *Branchiostoma*, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions.

#### 2. Agnatha

*Petromyzon*, *Myxine*

### 3. Fishes

*Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetrodon/ Diodon, Anabas, Flat fish*

### 4. Amphibia

*Ichthyophis/ Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandra*

### 5. Reptilia

*Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus*  
Key for Identification of poisonous and non-poisonous snakes

### 6. Aves

Study of six common birds from different orders. Types of beaks and claws

### 7. Mammalia

*Sorex, Bat (Insectivorous and Frugivorous), Funambulus, Loris, Herpestes, Erinaceous.*  
Power point presentation on study of any two animals from two different classes by students (may be included if dissections not given permission)

Classification from Young, J. Z. (2004) to be followed

#### **Recommended Books and References:**

1. Young, J. Z. (2004). *The Life of Vertebrates*. III Edition. Oxford university press.
2. Pough H. *Vertebrate life*, VIII Edition, Pearson International.
3. Darlington P.J. *The Geographical Distribution of Animals*, R.E. Krieger Pub Co.
4. Hall B.K. and Hallgrimsson B. (2008). *Strickberger's Evolution*. IV Edition. Jones and Bartlett Publishers Inc.

#### **CORE 6 (ZOC 3.21)**

#### **ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS**

*Theory Credit: 4*

#### **UNIT I**

##### **Tissues Bone and Cartilage**

Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue. Structure and types of bones and cartilages, Ossification, bone growth and resorption

#### **UNIT II**

##### **Nervous System**

Structure of neuron, resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission and, Neuromuscular junction; Reflex action and its types - reflex arc.

#### **UNIT III**

##### **Muscle**

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, summation and tetanus

#### **UNIT IV**

##### **Reproductive System**

Histology of testis and ovary; Physiology of male and female reproduction; Puberty, Methods of contraception in male and female

**UNIT V Endocrine System**

Histology of endocrine glands - pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; Hypothalamus (neuroendocrine gland) - neuroendocrine control of anterior pituitary and endocrine system.

**CORE 6 (ZOC 3.22)**

**ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS**

*Practical Credit: 2*

- \* 1. Recording of simple muscle twitch with electrical stimulation (or Virtual)
- 2. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
- 3. Preparation of temporary mounts: Squamous epithelium and Striated muscle fibres
- 4. Study of permanent slides of Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid
- 5. Microtomy: Preparation of permanent slide of any five mammalian (Goat/whiterat) tissues
- 6. Dissection of Endocrine Glands in albino mice.
- 7. Dissection of reproduction system in albino mice

*(\*Subject to UGC guidelines)*

**Recommended Books and References:**

- 1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Harcourt Asia PTE Ltd. /W.B. Saunders Company.
- 2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons
- 3. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.

**CORE 7 (ZOC 3.31)**

**FUNDAMENTALS OF BIOCHEMISTRY**

*Theory Credit: 4*

**UNIT I Carbohydrates**

Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates

**UNIT II Lipids**

Structure, properties and functional significance of saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids

**UNIT III Proteins**

**Amino acids:** Structure, Classification and General properties of  $\alpha$ -amino acids; Physiological importance of essential and non-essential  $\alpha$ -amino acids

**Proteins:** Bonds stabilizing protein structure; Levels of organization in proteins; Denaturation; Introduction to simple and conjugate proteins

**UNIT IV Nucleic Acids**

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids  
Curves: Base pairing, Denaturation and Renaturation of DNA  
Types of DNA and RNA, Complementarity of DNA, Hypo-  
Hyperchromaticity of DNA

**UNIT V Enzymes**

Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Multi-substrate reactions; Enzyme inhibition; Regulation of enzyme action

**CORE 7 (ZOC 3.32)**

**FUNDAMENTALS OF BIOCHEMISTRY**

*Practical Credit: 2*

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Paper chromatography of amino acids.
3. Action of salivary amylase under optimum conditions.
4. Effect of pH, temperature and inhibitors on the action of salivary amylase.
5. Demonstration of proteins separation by SDS-PAGE.
6. Calorimetric estimation of Glucose.

**Recommended Books and References:**

1. Cox, M.M and Nelson, D.L. (2008). *Lehninger's Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). *Biochemistry*, VI Edition, W.H. Freeman and Co., New York.
3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). *Harper's Illustrated Biochemistry*, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
4. Hames, B.D. and Hooper, N.M. (2000). *Instant Notes in Biochemistry*, II Edition, BIOS Scientific Publishers Ltd., U.K.
5. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). *Molecular Biology of the Gene*, VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub.

## SEMESTER – IV

### CORE 8 (ZOC 4.11)

#### COMPARATIVE ANATOMY OF VERTEBRATES

*Theory Credit: 4*

##### UNIT I Integumentary System and Skeletal System

Structure, functions and derivatives of integument

Overview of axial and appendicular skeleton

##### UNIT II Digestive System and Respiratory System

Alimentary canal and associated glands, dentition

Skin, gills, lungs and air sacs; Accessory respiratory organs

##### UNIT III Circulatory System and Urinogenital System

General plan of circulation, evolution of heart and aortic arches

Succession of kidney, Evolution of urinogenital ducts

##### UNIT IV Nervous System

Comparative account of brain

Autonomic nervous system, Spinal cord, Cranial nerves in mammals

##### UNIT V Sense Organs

Classification of receptors

Brief account of visual and auditory receptors in man

### CORE 8 (ZOC 4.12)

#### COMPARATIVE ANATOMY OF VERTEBRATES

*Practical Credit: 2*

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Disarticulated skeleton of Frog, *Varanus*, Fowl, Rabbit
3. Mammalian skulls: One herbivorous and one carnivorous animal
4. Dissection of mice to study arterial and urinogenital system (subject to permission)
5. Study of structure of any two organs (heart, lung, kidney, eye and ear) from video recording (may be included if dissection not permitted)
6. Project on skeletal modifications in vertebrates (may be included if dissection not permitted)

#### **Recommended Books and References:**

1. Kardong, K.V. (2005) *Vertebrates' Comparative Anatomy, Function and Evolution*. IV Edition. McGraw-Hill Higher Education
2. Kent, G.C. and Carr R.K. (2000). *Comparative Anatomy of the Vertebrates*. IX Edition. The McGraw-Hill Companies
3. Hilderbrand, M and Gaslow G.E. *Analysis of Vertebrate Structure*, John Wiley and Sons
4. Walter, H.E. and Sayles, L.P; *Biology of Vertebrates*, Khosla Publishing House



## **CORE 9 (ZOC 4.21)**

### **ANIMAL PHYSIOLOGY: LIFE SUSTAINING SYSTEMS**

*Theory Credit: 4*

#### **UNIT I      Physiology of Digestion**

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorption of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract.

#### **UNIT II      Physiology of Respiration**

Histology of trachea and lung; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration

#### **UNIT III     Renal Physiology**

Structure of kidney and its functional unit; Mechanism of urine formation; Regulation of water balance; Regulation of acid-base balance

#### **UNIT IV     Blood**

Components of blood and their functions; Structure and functions of haemoglobin  
Haemostasis: Blood clotting system, Kallikrein-Kininogen system, Complement system & Fibrinolytic system, Haemopoiesis  
Blood groups: Rh factor, ABO and MN

#### **UNIT V     Physiology of Heart**

Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers. Origin and conduction of cardiac impulses  
Cardiac cycle; Cardiac output and its regulation, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure and its regulation

## **CORE 9 (ZOC 4.22)**

### **ANIMAL PHYSIOLOGY: LIFE SUSTAINING SYSTEMS**

*Practical Credit: 2*

1. Determination of ABO Blood group and Rh factor.
2. Enumeration of red blood cells using haemocytometer
3. Estimation of haemoglobin using Sahli's haemoglobinometer
4. Preparation of haemin and haemochromogen crystals
5. Recording of blood pressure using a sphygmomanometer
6. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney

#### **Recommended Books and References:**

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Harcourt Asia PTE Ltd. W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,

- Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
- Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills

### **CORE 10 (ZOC 4.31)**

#### **BIOCHEMISTRY OF METABOLIC PROCESSES**

*Theory Credit: 4*

##### **UNIT I Overview of Metabolism**

Catabolism *vs* Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways, Shuttle systems and membrane transporters; ATP as "Energy Currency of cell"; coupled reactions; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms

##### **UNIT II Carbohydrate Metabolism**

Sequence of reactions and regulation of glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis

##### **UNIT III Lipid Metabolism**

$\beta$ -oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms; Biosynthesis of palmitic acid; Ketogenesis

##### **UNIT IV Protein Metabolism**

Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids

##### **UNIT V Oxidative Phosphorylation**

Redox systems; Review of mitochondrial respiratory chain, Inhibitors and uncouplers of Electron Transport System

### **CORE 10 (ZOC 4.32)**

#### **BIOCHEMISTRY OF METABOLIC PROCESS**

*Practical Credit: 2*

- Estimation of total protein in given solutions by Lowry's method.
- Detection of SGOT and SGPT or GST and GSH in serum/ tissue
- To study the enzymatic activity.
- To perform the Acid and Alkaline phosphatase assay from serum/ tissue.
- Calorimetric estimation of Protein.

##### **Recommended Books and References:**

- Cox, M.M and Nelson, D.L. (2008). *Lehninger Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). *Biochemistry*, VI Edition, W.H. Freeman and Co., New York.

3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). *Harper's Illustrated Biochemistry*, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
4. Hames, B.D. and Hooper, N.M. (2000). *Instant Notes in Biochemistry*, II Edition, BIOS Scientific Publishers Ltd., U.K.

## SEMESTER - V

### CORE 11 (ZOC 5.11) MOLECULAR BIOLOGY

Theory Credit: 4

#### UNIT I Nucleic Acids and DNA Replication

Watson and Crick model of DNA; DNA as a genetic material. DNA Replication in prokaryotes and eukaryotes, Semi-conservative, bidirectional and semi-discontinuous replication, RNA priming, replication of telomeres

#### UNIT II Transcription

RNA polymerase and transcription Unit, mechanism of transcription in prokaryotes and eukaryotes, synthesis of rRNA and mRNA, transcription factors

#### UNIT III Translation

Genetic code, Degeneracy of the genetic code and Wobble Hypothesis; Process of protein synthesis in prokaryotes; Inhibitors of protein synthesis; Difference between prokaryotic and eukaryotic translation

#### UNIT IV Post Transcriptional Modifications and Processing of Eukaryotic RNA

Structure of globin mRNA; Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing, Processing of tRNA

#### UNIT V Gene Regulation and DNA Repair Mechanisms

Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from *lac* operon and *trp* operon; Transcription regulation in eukaryotes; Pyrimidine dimerization and mismatch repair

### CORE 11 (ZOC 5.12) MOLECULAR BIOLOGY

Practical Credit: 2

1. Study of Polytene chromosomes from Chironomous / *Drosophila* larvae
2. Preparation of liquid culture medium (LB) and raise culture of *E. coli*
3. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking
4. Demonstration of antibiotic sensitivity/resistance of *E. coli* to antibiotic pressure and interpretation of results
5. Quantitative estimation of DNA and RNA.
6. Study and interpretation of electron micrographs/ photograph showing
  - (a) DNA replication
  - (b) Transcription
  - (c) Split genes

#### Recommended Books and References:

1. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell*. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
2. Francisco.

3. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter: *Molecular Biology of the Cell*, IV Edition.
4. Cooper G. M. and Robert E. Hausman R. E. *The Cell: A Molecular Approach*, V Edition, ASM Press and Sinauer Associates.
5. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
6. Karp, G. (2010) *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons. Inc.
7. Lewin B. (2008). *Gene XI*, Jones and Bartlett
8. McLennan A., Bates A., Turner, P. and White M. (2015). *Molecular Biology IV* Edition. GS, Taylor and Francis Group, New York and London.

## **CORE 12 (ZOC 5.21)**

### **PRINCIPLES OF GENETICS**

*Theory Credit: 4*

#### **UNIT I Mendelian Genetics and its Extension**

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked, sex-influenced and sex-limited characters inheritance.

#### **UNIT II Linkage, Crossing Over and Chromosomal Mapping**

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization.

#### **UNIT III Mutations**

Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations: CLB method, attached X method.

#### **UNIT IV Sex Determination and Extra-chromosomal Inheritance**

Chromosomal mechanisms of sex determination in *Drosophila* and *Man* Criteria for extra-chromosomal inheritance, Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces*, Infective heredity in *Paramecium* and Maternal effects

#### **UNIT V Polygenic Inheritance, Recombination in Bacteria and Viruses and Transposable Genetic Elements**

Polygenic inheritance with suitable examples; Conjugation, Transformation and Transduction in Bacteriophage Transposons in bacteria, Transposons in humans

**CORE 12 (ZOC 5.22)**  
**PRINCIPLES OF GENETICS**

*Practical Credit: 2*

1. To study the Mendelian laws and gene interactions.
2. Chi-square analyses using seeds/beads/*Drosophila*.
3. Linkage maps based on data from *Drosophila* crosses.
4. Study of human karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.

**Recommended Books and References:**

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India
2. Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. V Edition. John Wiley and Sons Inc
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*. X Edition. Benjamin Cummings
4. Russell, P. J. (2009). *Genetics- A Molecular Approach*. III Edition. Benjamin Cummings
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. *Introduction to Genetic Analysis*. IX Edition. W. H. Freeman and Co
6. Fletcher H. and Hickey I. (2015). *Genetics*. IV Edition. GS, Taylor and Francis Group, New York and London.

## SEMESTER - VI

### CORE 13 (ZOC 6.11) DEVELOPMENTAL BIOLOGY

Theory Credit: 4

#### UNIT I Introduction

Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division

#### UNIT II Early Embryonic Development

Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps (including Techniques); Early development of frog and chick upto gastrulation; Embryonic induction and organizers

#### UNIT III Late Embryonic Development

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta)

#### UNIT IV Post Embryonic Development

Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories

#### UNIT V Implications of Developmental Biology

Teratogenesis: Teratogenic agents and their effects on embryonic development; *In vitro* fertilization, Stem cell (ESC), Amniocentesis

### CORE 13 (ZOC 6.12) DEVELOPMENTAL BIOLOGY

Practical Credit: 2

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)
3. Study of the developmental stages and life cycle of *Drosophila* from stock culture
4. Study of different sections of placenta (photomicrograph/slides)
5. Project report on *Drosophila* culture/chick embryo development

**Recommended Books and References:**

1. Gilbert, S. F. (2010). *Developmental Biology*, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
2. Balinsky B. I. and Fabian B. C. (1981). *An Introduction to Embryology*, V Edition, International Thompson Computer Press
3. Carlson, R. F. *Patten's Foundations of Embryology*
4. Kalthoff (2008). *Analysis of Biological Development*, II Edition, McGraw-Hill Publishers
5. Lewis Wolpert (2002). *Principles of Development*. II Edition, Oxford University Press

**CORE 14 (ZOC 6.21)**

**EVOLUTIONARY BIOLOGY**

*Theory Credit: 4*

- UNIT I** Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism Evidences of Evolution, geological time scale, evolution of horse, Sources of variations: Heritable variations and their role in evolution
- UNIT II** Population genetics: Hardy-Weinberg Law, Factor influencing H-W equilibrium, Natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, Genetic Drift, Role of Migration and Mutation in changing allele frequencies
- UNIT III** Product of evolution: Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches
- UNIT IV** Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular analysis of human origin
- UNIT V** Phylogenetic trees, Multiple sequence alignment, construction of phylogenetic trees, interpretation of trees



**CORE 14 (ZOC 6.22)**  
**EVOLUTIONARY BIOLOGY**

*Practical Credit: 2*

1. Study of fossils from models/ pictures
2. Study of homology and analogy from suitable specimens
3. Study and verification of Hardy-Weinberg Law by chi square analysis
4. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies
5. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.
6. Construction of phylogenetic trees with the help of bioinformatics tools (ClustalX, Phylip, NJ) and its interpretation.

***Recommended Books and References:***

1. Ridley, M (2004) Evolution III Edition Blackwell publishing
2. Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition. Jones and Barlett Publishers.
3. Campbell, N.A. and Reece J.B (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.
4. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
5. Snustad. S Principles of Genetics.
6. Pevsner, J (2009). Bioinformatics and Functional Genomics. II Edition Wiley-Blackwell

## DISCIPLINE CENTRIC ELECTIVE COURSES

### DISCIPLINE SPECIFIC ELECTIVE 1 (ZOD 5.11(a)) BIOLOGY OF INSECTA

*Theory Credit: 4*

#### **UNIT I Introduction and Insect Taxonomy**

General Features of Insects  
Distribution and Success of Insects on the Earth  
Basis of insect classification; Classification of insects up to orders

#### **UNIT II General Morphology of Insects**

External Features; Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits  
Thorax: Wings and wing articulation, Types of Legs adapted to diverse habitat  
Abdominal appendages and genitalia

#### **UNIT III Physiology of Insects**

Structure and physiology of Insect body systems - Integumentary, digestive, excretory, circulatory, respiratory, endocrine, reproductive, and nervous system  
Sensory receptors  
Growth and metamorphosis

#### **UNIT IV Insect Society**

Group of social insects and their social life  
Social organization and social behaviour (w.r.t. any one example)

#### **UNIT V Insect Plant Interaction and Vectors**

Host-plant selection by phytophagous insects, Insects as plant pests  
Insects as mechanical and Biological vectors, Brief discussion on houseflies and mosquitoes as important insect vectors

### DISCIPLINE SPECIFIC ELECTIVE 1 (ZOD 5.12(a)) BIOLOGY OF INSECTA

*Practical Credit: 2*

1. Study of one specimen from each insect order
2. Study of different kinds of antennae, legs and mouth parts of insects
3. Study of head and sclerites of any one insect
4. Study of insect wings and their venation.
5. Study of insect spiracles
6. Methodology of collection, preservation and identification of insects.
7. Morphological studies of various castes of *Apis*
8. Study of any three insect pests and their damages
9. Study of any three beneficial insects and their products
10. Field study of insects and submission of a project report on the insect diversity

**Recommended Books and References:**

1. A general text book of entomology, Imms , A. D., Chapman & Hall, UK
2. The Insects: Structure and function, Chapman, R. F., Cambridge University Press, UK
3. Principles of Insect Morphology, Snodgrass, R. E., Cornell Univ. Press, USA
4. Introduction to the study of insects, Borror, D. J., Triplehorn, C. A., and Johnson, N. F., M Saunders College Publication, USA
5. The Insect Societies, Wilson, E. O., Harward Univ. Press, UK
6. Host Selection by Phytophagous insects, Bernays, E. A., and Chapman, R. F., Chapman and Hall, New York, USA
7. Physiological system in Insects, Klowden, M. J., Academic Press, USA
8. The Insects, An outline of Entomology, Gullan, P. J. , and Cranston, P. S., Wiley Blackwell, UK
9. Insect Physiology and Biochemistry, Nation, J. L., CRC Press, USA

**DISCIPLINE SPECIFIC ELECTIVE 1 (ZOD 5.11(b))  
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY**

*Theory Credit: 4*

**UNIT I Introduction to Animal Behaviour**

Origin and history of Ethology; Brief profiles of Karl Von Frish, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen, Proximate and ultimate causes of behaviour, Methods and recording of a behaviour

**UNIT II Patterns of Behaviour**

Stereotyped Behaviours (Orientation, Reflexes); Individual Behavioural patterns; Instinct vs. Learnt Behaviour; Associative learning, classical and operant conditioning, Habituation, Imprinting.

**UNIT III Social and Sexual Behaviour**

Social Behaviour: Concept of Society; Communication and the senses; Altruism; Insects' society with Honey bee as example; Foraging in honey bee and advantages of the waggle dance. Sexual Behaviour: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Sexual conflict in parental care.

**UNIT IV Introduction to Chronobiology**

Historical developments in chronobiology; Biological oscillation: the concept of Average, amplitude, phase and period. Adaptive significance of biological clocks

**UNIT V Biological Rhythm and Clocks**

Types and characteristics of biological rhythms: Short- and Long- term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic and non-photic zeitgebers; Circannual rhythms; Photoperiod and regulation seasonal reproduction of vertebrates; Role of melatonin. Relevance of biological clocks; Chronopharmacology, Chronomedicine, Chronotherapy.

**DISCIPLINE SPECIFIC ELECTIVE 1 (ZOD 5.12(b))  
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY**

*Practical Credit: 2*

1. To study nests and nesting habits of the birds and social insects.
2. To study the behavioural responses of wood lice to dry and humid conditions.
3. To study geotaxis behaviour in earthworm.
4. To study the phototaxis behaviour in insect larvae.
5. Visit to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report.
6. Study and actogram construction of locomotor activity of suitable animal models.
7. Study of circadian functions in humans (daily eating, sleep and temperature patterns).

**Recommended Books and References:**

1. David McFarland, Animal Behaviour, Pitman Publishing Limited, London, UK.
2. Manning, A. and Dawkins, M. S, An Introduction to Animal Behaviour, Cambridge, University Press, UK.
3. John Alcock, Animal Behaviour, Sinauer Associate Inc., USA.
4. Paul W. Sherman and John Alcock, Exploring Animal Behaviour, Sinauer Associate Inc., Massachusetts, USA.
5. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. DeCoursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
6. Insect Clocks D.S. Saunders, C.G.H. Steel, X., Afopoulou (ed.)R.D. Lewis. (3rdEd) 2002 Baren and Noble Inc. New York, USA
7. Biological Rhythms: Vinod Kumar (2002) Narosa Publishing House, Delhi/ Springer-Verlag, Germany.

**DISCIPLINE SPECIFIC ELECTIVE 2 (ZOD 5.21(a))  
PARASITOLOGY**

*Theory Credit: 4*

**UNIT I Introduction to Parasitology**

Brief introduction of Parasitism, Parasite, Parasitoid and Vectors (mechanical and biological vector) Host parasite relationship

**UNIT II Parasitic Protists**

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Entamoeba histolytica*, *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani*, *Plasmodium vivax*

**UNIT III Parasitic Platyhelminthes**

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Fasciolopsis buski*, *Schistosoma haematobium*, *Taenia solium* and *Hymenolepis nana*

**UNIT IV Parasitic Nematodes**

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides*, *Ancylostomaduodenale*, *Wuchereria bancrofti* and *Trichinella spiralis*. Study of

structure, lifecycle and importance of *Meloidogyne*(root knot nematode), *Pratylenchus*(lesionnematode)

#### **UNIT V Parasitic Arthropoda**

Biology, importance and control of ticks, mites, *Pediculus humanus*(head and body louse), *Xenopsyllacheopsis* and *Cimex lectularius*

#### **DISCIPLINE SPECIFIC ELECTIVE 2 (ZOD 5.22(a)) PARASITOLOGY**

*Practical Credit: 2*

1. Study of life stages of *Entamoeba histolytica*, *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani* and *Plasmodium vivax* through permanent slides/micro photographs
2. Study of adult and life stages of *Fasciolopsis buski*, *Schistosoma haematobium*, *Taenia solium* and *Hymenolepis nana* through permanent slides/micro photographs
3. Study of adult and life stages of *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Wuchereria bancrofti* and *Trichinella spiralis* through permanent slides/micro photographs
4. Study of plant parasitic root knot nematode, *Meloidogyne* from the soil sample
5. Study of *Pediculus humanus* (Head louse and Body louse), *Xenopsyllacheopsis* and *Cimex lectularius* through permanent slides/ photographs
6. Study of monogenea from the gills of fresh/marine fish [Gills can be procured from fish market as by product of the industry]
7. Study of nematode/cestode parasites from the intestines of Poultry bird [Intestine can be procured from poultry/market as a byproduct]
8. Submission of a brief report on parasitic vertebrates

#### **Recommended Books and References:**

1. Arora, D. R and Arora, B. (2001) *Medical Parasitology*. II Edition. CBS Publications and Distributors
2. E.R. Noble and G.A. Noble (1982) *Parasitology: The biology of animal parasites*. V Edition, Lea & Febiger
3. Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) *Biology of Disease*. Taylor and Francis Group
4. Parija, S. C. Textbook of medical parasitology, protozoology & helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributors, Medical Books Publishers, Chennai, Delhi
5. Rattan Lal Ichhpujani and Rajesh Bhatia. *Medical Parasitology*, III Edition, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi
6. Meyer, Olsen & Schmidt's *Essentials of Parasitology*, Murray, D. Dailey, W.C. Brown Publishers
7. K. D. Chatterjee (2009). *Parasitology: Protozoology and Helminthology*. XIII Edition, CBS Publishers & Distributors (P) Ltd.

**DISCIPLINE SPECIFIC ELECTIVE 2 (ZOD 5.21(b))  
REPRODUCTIVE BIOLOGY**

*Theory Credit: 4*

**UNIT I Reproductive Endocrinology**

Gonadal hormones and mechanism of hormone action, steroids, glycoprotein hormones, and prostaglandins, hypothalamo – hypophyseal – gonadal axis, regulation of gonadotrophin secretion in male and female; Reproductive System: Development and differentiation of gonads, genital ducts, external genitalia, mechanism of sex differentiation.

**UNIT II Functional anatomy of male reproduction**

Outline and histological of male reproductive system in rat and human; Testis: Cellular functions, germ cell, stem cell renewal; Spermatogenesis: kinetics and hormonal regulation; Androgen synthesis and metabolism; Epididymal function and sperm maturation; Accessory glands functions; Sperm transportation in male tract

**UNIT III Functional anatomy of female reproduction**

Outline and histological of female reproductive system in rat and human; Ovary: folliculogenesis, ovulation, corpus luteum formation and regression; Steroidogenesis and secretion of ovarian hormones; Reproductive cycles (rat and human) and their regulation, changes in the female tract;

**UNIT IV Fertilization**

Ovum transport in the fallopian tubes; Sperm transport in the female tract, fertilization; Hormonal control of implantation; Hormonal regulation of gestation, pregnancy diagnosis, foeto – maternal relationship; Mechanism of parturition and its hormonal regulation; Lactation and its regulation

**UNIT V Reproductive Health**

Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technology: sex selection, sperm banks, frozen embryos, in vitro fertilization, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST; Modern contraceptive technologies; Demographic terminology used in family planning

**DISCIPLINE SPECIFIC ELECTIVE 2 (ZOD 5.22(b))  
REPRODUCTIVE BIOLOGY**

*Practical Credit: 4*

1. Study of animal house: set up and maintenance of animal house, breeding techniques, care of normal and experimental animals.
2. Examination of vaginal smear rats from live animals.
3. Surgical techniques: principles of surgery in endocrinology. Ovariectomy, hysterectomy, castration and vasectomy in rats.
4. Examination of histological sections from photomicrographs/ permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems; Sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.
5. Human vaginal exfoliate cytology.
6. Sperm count and sperm motility in rat

7. Study of modern contraceptive devices

**Recommended Books and References:**

1. Austin, C.R. and Short, R.V. reproduction in Mammals. Cambridge University Press.
2. Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company.
3. Knobil, E. et al. (eds). The Physiology of Reproduction. Raven Press Ltd.
4. Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population Information Programme.

**DISCIPLINE SPECIFIC ELECTIVE 3 (ZOD 6.11 (a))  
FISH AND FISHERIES**

*Theory Credit: 4*

**UNIT I Introduction and Classification:**

General description of fish; Account of systematic classification of fishes (uptoclasses); Classification based on feeding habit, habitat and manner of reproduction.

**UNIT II Morphology and Physiology:**

Types of fins and their modifications; Locomotion in fishes; Hydrodynamics; Types of Scales, Use of scales in Classification and determination of age of fish; Gills and gas exchange; Swim Bladder: Types and role in Respiration, buoyancy; Osmoregulation in Elasmobranchs; Reproductive strategies (special reference to Indian fishes); Electric organs; Bioluminescence; Mechanoreceptors; Schooling; Parental care; Migration

**UNIT III Fisheries**

Inland Fisheries; Marine Fisheries; Environmental factors influencing theseasonal variations in fish catches in the Arabian Sea and the Bay of Bengal; Fishing crafts and Gears; Depletion of fisheries resources; Application of remotesensing and GIS in fisheries; Fisheries law and regulations

**UNIT IV Aquaculture**

Sustainable Aquaculture; Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of fish; Management of finfish hatcheries; Preparation and maintenance of fish aquarium; Preparation of compound diets for fish; Role of water quality in aquaculture; Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish, Fishery by-products

**UNIT V Fish in research**

Transgenic fish, Zebrafish as a model organism in research

**DISCIPLINE SPECIFIC ELECTIVE 3 (ZOD 6.12 (a))  
FISH AND FISHERIES**

*Practical Credit: 2*

1. Morphometric and meristic characters of fishes
2. Study of *Petromyzon*, *Myxine*, *Pristis*, *Chimaera*, *Exocoetus*, *Hippocampus*, *Gambusia*, *Labeo*, *Heteropneustes*, *Anabas*
3. Study of different types of scales (through permanent slides/ photographs).
4. Study of crafts and gears used in Fisheries
5. Water quality criteria for Aquaculture: Assessment of pH, conductivity, Totalsolids, Total dissolved solids
6. Study of air breathing organs in *Channa*, *Heteropneustes*, *Anabas* and *Clarias*
7. Demonstration of induced breeding in Fishes (video)
8. Demonstration of parental care in fishes (video)
9. Project Report on a visit to any fish farm/ pisciculture unit/Zebrafish rearing Lab.

**Recommended Books and References:**

1. Q Bone and R Moore, Biology of Fishes, Talyor and Francis Group, CRC Press, U.K.
2. D. H. Evans and J. D. Claiborne, The Physiology of Fishes, Taylor and Francis Group, CRC Press, UK von der Emde, R.J. Mogdans and B.G. Kapoor. The Senses of Fish: Adaptations for the Reception of Natural Stimuli, Springer, Netherlands
3. C.B.L. Srivastava, Fish Biology, Narendra Publishing House
4. J.R. Norman, A history of Fishes, Hill and Wang Publishers
5. S.S. Khanna and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra Publishing House

**DISCIPLINE SPECIFIC ELECTIVE 3 (ZOD 6.11(b))  
WILD LIFE CONSERVATION AND MANAGEMENT**

*Theory Credit: 4*

**UNIT I Introduction to Wild Life**

Values of wild life - positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies.

**UNIT II Evaluation and management of wild life**

Habitat analysis, Physical parameters: Topography, Geology, Soil and water; Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

**UNIT III Management of habitats**

Setting back succession; Grazing logging; Mechanical treatment; Advancing the successional process; Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats

**UNIT IV Population estimation and management**

Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, Hair identification, Pug marks and census method. Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animal



**UNIT V      Protected areas**

Estimation of carrying capacity; Eco tourism / wild life tourism in forests; Concept of climax persistence; Ecology of perturbation. National parks & sanctuaries, Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India; Management challenges in Tiger reserve.

**DISCIPLINE SPECIFIC ELECTIVE 3 (ZOD 6.12(b))  
WILD LIFE CONSERVATION AND MANAGEMENT**

*Practical Credit: 4*

1. Identification of flora, mammalian fauna, avian fauna, herpeto-fauna
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses)
3. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers etc.
4. Demonstration of different field techniques for flora and fauna
5. PCQ, Ten tree method, Circular, Square & rectangular plots, Parker's 2 Step and other methods for ground cover assessment, Tree canopy cover assessment, Shrub cover assessment.
6. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences)

**Recommended Books and References:**

1. Caughley, G., and Sinclair, A.R.E. (1994). *Wildlife Ecology and Management*. Blackwell Science.
2. Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). *People and Wildlife, Conflict or Co-existence?* Cambridge University.
3. Bookhout, T.A. (1996). *Research and Management Techniques for Wildlife and Habitats*, 5 th edition. The Wildlife Society, Allen Press.
4. Sutherland, W.J. (2000). *The Conservation Handbook: Research, Management and Policy*. Blackwell Sciences
5. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). *Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory*. Blackwell Publishing.

**DISCIPLINE SPECIFIC ELECTIVE 4 (ZOC 6.21(a))  
IMMUNOLOGY**

*Theory Credit: 4*

**UNIT I      Overview of Immune System and Antigens**

Historical perspective of Immunology, Early theories of Immunology, Cells and organs of the Immune system  
Important features of Immunogens, Adjuvants, haptens and epitopes;  
Factors influencing immunogenicity

**UNIT II Innate and Adaptive Immunity**

Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral), Passive: Artificial and natural Immunity, Active: Artificial and natural Immunity, Immune dysfunctions (brief account of autoimmunity with reference to AIDS).

**UNIT III Immunoglobulins**

Structure and functions of different classes of immunoglobulins, Antigen-antibody interactions, Immunoassays (Principles of ELISA and RIA), Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis

**UNIT IV Major Histocompatibility Complex and Cytokines**

Structure and functions of MHC molecules; Endogenous and exogenous pathways of antigen processing and presentation; Properties and functions of cytokines, Therapeutics Cytokines

**UNIT V Complement System, Hypersensitivity and Vaccines**

Components and pathways of complement activation. Gell and Coombs' classification and brief description of various types of Hypersensitivities; Various types of vaccines (in use and in development).

**DISCIPLINE SPECIFIC ELECTIVE 4 (ZOC 6.22(a))  
IMMUNOLOGY**

*Practical Credit: 2*

- 1\*. Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/photographs
3. Preparation of stained blood film to study various types of blood cells.
4. Enumeration of total count of WBC.
5. Demonstration of:
  - a. ELISA
  - b. Immunoelectrophoresis

*\* The experiments can be performed depending upon usage of animals in UG courses.*

**Recommended Books and References:**

1. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). *Immunology*, VI Edition. W.H. Freeman and Company.
2. David, M., Jonathan, B., David, R. B. and Ivan R. (2006). *Immunology*, VII Edition, Mosby, Elsevier Publication.
3. Abbas, K. Abul and Lechtman H. Andrew (2003.) *Cellular and Molecular Immunology*. V Edition. Saunders Publication.

**DISCIPLINE SPECIFIC ELECTIVE 4 (ZOD 5.21(b))  
ENDOCRINOLOGY**

*Theory Credit: 4*

**UNIT I Introduction to Endocrinology**

Classification, Characteristic and Transport of Hormones, Neurosecretions and Neurohormones, Regulation of neuroendocrine glands.

**UNIT II Epiphysis and Hypothalamus**

Structure of pineal gland, Secretions and their functions in biological rhythms and reproduction.

Structure of hypothalamus, Hypothalamic nuclei and their functions, Feedback mechanisms.

**UNIT III Pituitary glands**

Structure of pituitary gland, Hormones and their functions, Hypothalamohypophysial portal system, Disorders of pituitary gland.

**UNIT IV Peripheral Endocrine Glands**

Structure, Hormones, Functions and Regulation of Thyroid gland, Parathyroid, Adrenal, Pancreas, Ovary and Testis Hormones in homeostasis, Disorders of endocrine glands

**UNIT V Regulation of Hormone Action**

Hormone action at Cellular level: Hormone receptors, transduction and regulation  
Hormone action at Molecular level: Molecular mediators, Genetic control of hormone action.

**DISCIPLINE SPECIFIC ELECTIVE 4 (ZOD 6.22(b))  
ENDOCRINOLOGY**

*Practical Credit: 2*

1. Dissect and display of Endocrine glands in laboratory bred rat\*
2. Study of the permanent slides of all the endocrine glands
3. Compensatory ovarian/ adrenal hypertrophy *in vivo* bioassay in laboratory bred rat\*
4. Demonstration of Castration/ ovariectomy in laboratory bred rat\*
5. Estimation of plasma level of any hormone using ELISA
6. Designing of primers of any hormone

**Recommended Books and References:**

1. General Endocrinology C. Donnell Turner Pub- Saunders Toppan
2. Endocrinology: An Integrated Approach; Stephen Nussey and Saffron Whitehead.
3. Oxford: BIOS Scientific Publishers; 2001.
4. Hadley, M.E. and Levine J.E. 2007. Endocrinology, 6th Edition. Pearson Prentice-Hall, Pearson Education Inc., New Jersey.
5. Vertebrate Endocrinology by David O. Norris,

## SKILL ENHANCEMENT COURSES

### SKILL ENHANCEMENT COURSE 1 (ZOS 3.11(a)) APICULTURE

Theory Credit:2

- UNIT I            Biology of Bees**  
History, Classification and Biology of Honey Bees  
Social Organization of Bee Colony
- UNIT II           Rearing of Bees**  
Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth  
Bee Pasturage  
Selection of Bee Species for Apiculture  
Bee Keeping Equipment  
Methods of Extraction of Honey (Indigenous and Modern)
- UNIT III          Diseases and Enemies**  
Bee Diseases and Enemies  
Control and Preventive measures
- UNIT IV          Bee Economy**  
Products of Apiculture Industry and its Uses (Honey, Bees Wax, Propolis), Pollen  
etc
- UNIT V           Entrepreneurship in Apiculture**  
Bee Keeping Industry – Recent Efforts, Modern Methods in employing artificial  
Beehives for cross pollination in horticultural gardens

#### **Recommended Books and References:**

1. Prost, P. J. (1962). *Apiculture*. Oxford and IBH, New Delhi.
2. Bisht D.S., *Apiculture*, ICAR Publication.
3. Singh S., *Beekeeping in India*, Indian council of Agricultural Research, NewDelhi.

### SKILL ENHANCEMENT COURSE 1 (ZOS 3.11(b)) SERICULTURE

Theory Credit:2

- UNIT I            Introduction**  
Sericulture: Definition, history and present status; Silk route  
Types of silkworms, Distribution and Races  
Exotic and indigenous races  
Mulberry and non-mulberry Sericulture
- UNIT II           Biology of Silkworm**  
Life cycle of *Bombyx mori*  
Structure of silk gland and secretion of silk

**UNIT III Rearing of Silkworms**

Selection of mulberry variety and establishment of mulberry garden  
Rearing house and rearing appliances  
Disinfectants: Formalin, bleaching powder, RKO  
Silkworm rearing technology: Early age and Late age rearing  
Types of mountages  
Spinning, harvesting and storage of cocoons

**UNIT IV Pests and Diseases**

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates  
Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial  
Control and prevention of pests and diseases

**UNIT V Entrepreneurship in Sericulture**

Prospectus of Sericulture in India: Sericulture industry in different states, employment, potential in mulberry and non-mulberry sericulture. Visit to various sericulture centres.

**Recommended Books and References:**

1. Manual on Sericulture; Food and Agriculture Organisation, Rome 1976
2. Handbook of Practical Sericulture: S.R. Ullal and M.N. Narasimhanna CSB, Bangalore
3. Silkworm Rearing and Disease of Silkworm, 1956, Ptd. By Director of Ptg., Stn. & Pub. Govt. Press, Bangalore
4. Appropriate Sericultural Techniques; Ed. M. S. Jolly, Director, CSR & TI, Mysore.
5. Handbook of Silkworm Rearing: Agriculture and Technical Manual-1, Fuzi Pub. Co. Ltd., Tokyo, Japan 1972.
6. Manual of Silkworm Egg Production; M. N. Narasimhanna, CSB, Bangalore 1988.
7. Silkworm Rearing; Wupang—Chun and Chen Da-Chung, Pub. By FAO, Rome 1988.
8. A Guide for Bivoltine Sericulture; K. Sengupta, Director, CSR & TI, Mysore 1989.
9. Improved Method of Rearing Young age silkworm; S. Krishnaswamy, reprinted CSB, Bangalore, 1986.

**SKILL ENHANCEMENT COURSE 2 (ZOC 4.11(a))****MEDICAL DIAGNOSTICS**

*Theory Credit: 2*

**UNIT I Diagnostics Methods Used for Analysis of Blood**

Introduction to Medical Diagnostics and its Importance, Blood composition, Preparation of blood smear and Differential Leucocyte Count (D.L.C) using Leishman's stain, Platelet count using haemocytometer, Erythrocyte Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.)

**UNIT II Diagnostic Methods Used for Urine Analysis**

Urine Analysis: Physical characteristics; Abnormal constituents

**UNIT III Non-infectious Diseases**

Causes, types, symptoms, complications, diagnosis and prevention of Diabetes (Type I and Type II), Hypertension (Primary and secondary), Testing of blood glucose using Glucometer/Kit

**UNIT IV Infectious Diseases**

Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis

**UNIT V Tumours**

Types (Benign/Malignant), Detection and metastasis; Medical imaging: X-Ray of Bonefracture, PET, MRI and CT Scan (using photographs).

**Recommended Books and References:**

1. Park, K. (2007), *Preventive and Social Medicine*, B.B. Publishers
2. Godkar P.B. and Godkar D.P. *Textbook of Medical Laboratory Technology*, II Edition, Bhalani Publishing House
3. Cheesbrough M., *A Laboratory Manual for Rural Tropical Hospitals, A Basis for Training Courses*
4. Guyton A.C. and Hall J.E. *Textbook of Medical Physiology*, Saunders
5. Robbins and Cortan, *Pathologic Basis of Disease*, VIII Edition, Saunders
6. Prakash, G. (2012), *Lab Manual on Blood Analysis and Medical Diagnostics*, S. Chand and Co. Ltd.

**SKILL ENHANCEMENT COURSE 2 (ZOS 4.11(b))**

**AQUARIUM FISH KEEPING**

*Theory Credit: 2*

**UNIT I Introduction to Aquarium Fish Keeping**

The potential scope of Aquarium Fish Industry as a Cottage Industry, Exotic and Endemic species of Aquarium Fishes

**UNIT II Biology of Aquarium Fishes**

Common characters and sexual dimorphism of Fresh water and Marine Aquarium fishes such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish and Butterfly fish

**UNIT III Food and feeding of Aquarium fishes**

Use of live fish feed organisms. Preparation and composition of formulated fish feeds

**UNIT IV Fish Transportation**

Live fish transport - Fish handling, packing and forwarding techniques.

**UNIT V Maintenance of Aquarium**

General Aquarium maintenance – budget for setting up an Aquarium Fish Farm as a Cottage Industry



*Revised*  
SYLLABUS FOR  
Bachelor of Science (Honours)

**GENERIC ELECTIVES**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)





**GENERIC ELECTIVE  
ANTHROPOLOGY**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Foundation of Physical Anthropology (Theory)	ANG 1.11	4
		Foundation of Physical Anthropology (Practical)	ANG 1.12	2
<b>II</b>	Generic Elective 2	Foundation of Social Anthropology (Theory)	ANG 2.11	4
		Foundation of Social Anthropology (Practical)	ANG 2.12	2
<b>III</b>	Generic Elective 3	Foundation of Archaeological Anthropology (Theory)	ANG 3.11	4
		Foundation of Archaeological Anthropology (Practical)	ANG 3.12	2
<b>IV</b>	Generic Elective 4	Tools & Techniques of Research Methods	ANG 4.11	4
		Tools & Techniques of Research Methods (Practical)	ANG 4.12	2

**GENERIC ELECTIVE 1(ANG1.11)  
FOUNDATION OF PHYSICAL ANTHROPOLOGY**

*Theory Credit: 4*

*Teaching hours: 60*

- UNIT I** Introduction to Physical Anthropology:  
a) Aim & Scope, branches and its relationship with other biological sciences.  
b) Concept of evolution; different theories of evolution, factors responsible for evolution, Lamarckism, Darwinism, neo-synthetic theory.
- UNIT II:** a) Fossil evidences of human evolution: Australopithecine, pithecanthropine, Cro-magnon, Neanderthal man & modern man  
b) Mans palce in animal kingdom; order primate-classification & main characteristics, comparative anatomy of Man & apes, changes in human skeleton as a result of erect posture.
- UNIT III** Human genetics: concept of cell & cell division, mendel's law of inheritance, single & multiple factor inheritance, sex-linked inheritance, ABO & Rh inheritance.
- UNIT IV** Race & Human variation: concept of race & racism, UNESCO statement on race, factors responsible for race formation, criteria for racial classification, major races of the world.
- UNIT V** Concept of growth & development, factors affecting growth & development, methods, stages, nutrition, mal-nutrition & under -nutrition.

**GENERIC ELECTIVE 1 (ANG1.12)  
FOUNDATION OF PHYSICAL ANTHROPOLOGY**

*Practical Credit: 2*

*Teaching Hours: 30*

1. **Anthropometric Instruments.** Anthropometer, Sliding & Spreading Callipers, Weighing machine, measuring tape.
2. **Somatometry:** Head length and breadth, Total and upper facial height, Stature, Sitting Height vertex, Nasal length & breadth, Bi-acromial breadth, bi-gonial breadth, bi-zygomatic breath, horizontal circumference of head.
3. **Indices:** 1. Cephalic 2. Nasal 3. Total facial 4. Upper facial 5. Relative sitting height. Measurements on five subjects.
4. **Somatoscopy:** Skin colour, Hair (form, texture,colour), Eye (form, slit, colour& eyebrows), Nose (bridge, root), malar prominence, forehead (height and shape), chin form, ear (attachment & shape).

**Recommended Books and References:**

1. Introduction to Physical Anthropology----- -B.M.DAS
2. Anthropology: The study of man-----INDRANI BASU ROY
3. Man and his works----- HERSKOVITS
4. Fundamentals of Physical Anthropology-----R.M.SARKAR
5. Olivia. Practical Anthropology
6. Sen, Tulika - Anthropometry
7. Singh, I P and Bhasin, M.K. Anthropometry
8. B.R.K. Shukla &Rastogi-----physical anthropology and human genetics.
9. Janusch, J.Buettner-----origins of man.

10. Das, B.M & Ranjan – Physical Anthropology Practical
11. Nath, P – Physical Anthropology
12. Barua, Saumitra – Human Genetics :An Anthropological perspective
13. Ahluwalia, B.Karvita – Genetics
14. Stern, curt – Principles of Human Genetics
15. Winchester, M.A – Genetics
16. Jannusch, J.Buettner – origins of Man
17. Hootan, E.A - up from the Ape
18. Comas, J – Manual of Physical Anthropology
19. Sarkar, R.M – Fundamentals of Physical Anthropology

### **GENERIC ELECTIVE 2 (ANG2.11)**

#### **FOUNDATION OF SOCIAL & CULTURAL ANTHROPOLOGY**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I** Meaning and scope of Socio-Cultural Anthropology. Relation with other social sciences.

**UNIT II** Social Institutions:

- a) Definition of Marriage. Laws of marriage – Endogamy, Exogamy, Hyper-gamy, Hypo-gamy, Incest taboo. Types of marriage- Monogamy, Polygamy, Polyandry, Polygyny, preferential marriage – cross, parallel, Levirate and Sororate, prescribed marriage – matrilineal cross cousin marriage, patrilineal cross cousin marriage.
- b) Definition of Family. Types of Family based on structure, blood relation, marriage, residence and succession, rule of inheritance
- c) Kinship- Descent and Descent groups, Lineage, Clan, Phratry and Moiety. Kinship Usages, Kinship terminology.

**UNIT III** Religion and Magic:

- a) Definition and functions of Religion. Theories of origin of Religion- Animism, Animatism, Manaism and Totemism.
- b) Definition and types of Magic.
- c) Relation between Magic, Religion and Science.
- d) Magico-religious functionaries – Priests, Shaman, Sorcerer and Witch.

**UNIT IV** Culture. Definition and characteristics of Culture. Aspects of culture-Material and Non- material culture.

**UNIT V** Economic Institutions:Principles of production, distribution, and consumption in simple and complex societies; various forms of exchange: barter, trade and market.

### **GENERIC ELECTIVE 2 (ANG2.12)**

#### **FOUNDATION OF SOCIAL & CULTURAL ANTHROPOLOGY**

*Practical Credit: 2*

*Teaching Hours: 30*

Drawing, Identification and Description of Technological Implements of Food gathering, Hunting, Fishing and Agriculture.

**Recommended Books and References:**

1. Ember C R. et al (2011). *Anthropology*. New Delhi: Dorling Kindersley
2. Frazer James (1911). *The Golden Bough*. London: Macmillan
3. Madan T. N. and Majumdar D.N. (1987) *An Introduction to Social Anthropology*. New Delhi: National Publishing House.
4. Mair Lucy (1972). *An Introduction to Social Anthropology*. New Delhi: Oxford University Press
5. Malinowski Bronislaw (). *Magic, Science and Religion*.
6. Kroeber A.L. (1923). *Anthropology*. New York: Harcourt, Brace.
7. Roy IndraniBasu (2003). *Anthropology The Study of Man*. New Delhi: S.Chand& Company Ltd.
8. Scupin Raymond and DeCorse Christopher R. (). *Anthropology: A Global Perspective*.
9. Sharma R.N. (). *Social and Cultural Anthropology*. Delhi: Surjeet Publications
10. Tylor E.B. (1871). *Primitive Culture: Researches into the Development of Mythology, Philosophy, Religion, Language, Art and Customs*. London:J.Murray.

**GENERIC ELECTIVE3 (ANG3.11)**

**FOUNDATION OF ARCHEOLOGICAL ANTHROPOLOGY**

*Theory Credit: 4*

*Teaching hours: 60*

- UNIT I** Introduction: Definition and Scope of Archaeological Anthropology. Relationship with other Disciplines.
- UNIT II** Chronology and Dating Method: Absolute Dating Method (Radio Carbon, Potassium-Argon, Thermoluminescence, Dendrochronology, paleo magnetism), Relative Dating (Flurine-Nitrogen Analysis, Stratigraphy, Typology)
- UNIT III** Pleistocene Environment: The Great Ice Age – Glacial and Inter-glacial, Pluvial and Inter-pluvial
- UNIT IV** Introduction to pre-history and its major sub-divisions (Paleolithic, Mesolithic and neolithic)
- UNIT V** Technology and Typology of Prehistoric Tools

**GENERIC ELECTIVE3(ANG3.12)**

**FOUNDATION OF ARCHEOLOGICAL ANTHROPOLOGY**

*Practical Credit: 2*

*Teaching hours: 30*

**Practical**

1. Identification Between: Man Made Tool and Natural Stone, Core Tool – Flake Tool and Blade Tool.
2. Sketching, Description and Identification of Two Prehistoric Tools from Each Period (Paleolithic - Lower, Middle and Upper, Mesolithic and Neolithic)

**Recommended Books and References:**

1. Childe Gordon, Man makes Himself
2. Cole Sonia. The Neolithic Revolution

- |                             |   |
|-----------------------------|---|
| 3. Jain, K.C.               | Prehistory to Proto history of India        |
| 4. Roy, IndraniBasu.        | Anthropology: The study of Man              |
| 5. Hole F. and R.F. Heizer. | An Introduction to Prehistoric Archaeology. |
| 6. Reddy, V. Rami.          | Paleolithic and Mesolithic culture          |
| 7. Reddy V. Rami.           | Neolithic and Post Neolithic culture        |
| 8. Oaklet, K.P.             | Man the Tool maker                          |

#### **GENERIC ELECTIVE4(ANG4.11)**

#### **TOOLS & TECHNIQUES OF RESEARCH METHODOLOGY**

*Theory Credit: 4*

*Teaching hours: 60*

**UNIT I** 1. Scientific method in anthropology: survey and review of literature, statement of problem, Definition of theory and concept, variable, facts, data, research designs. Synopsis. Hypothesis: Definition, types & formulation of hypothesis, roles of hypothesis in research.

**UNIT II** Quantitative and qualitative data, Nature and use, Probability and Sampling techniques, types of Sampling

**UNIT III** Techniques of data collection: interview, observation, Use of survey Schedules and Questionnaires. Difference between Schedule and Questionnaire. Case study and genealogy/pedigree method.

**UNIT IV** Statistical methods:  
 1. Median, mode, standard deviation, standard error, tests of significance and chi-square.  
 2. Processing of data: classification, tabulation and presentation through diagrams, histograms, pie-chart, and analysis of data.

**UNIT V:** Use of Library and secondary data, Report Writing.,

#### **Recommended Books and References:**

- |                              |   |
|------------------------------|---|
| 1. Russel, Bernard, H        | Research Methods in Anthropology. Rawat.  |
| 2. Goode, J & Hatt, P.K 1952 | Methods of social research, Mc graw Hill, Kogakusha, Tokyo                      |
| 3. Young, P.V. 1966          | Scientific social survey and research method. Prentice hall. of India, N.Delhi. |
| 4. Hans Raj 1979             | Theory & Practice in social research, Subject publications, Delhi.              |

#### **GENERIC ELECTIVE 4 (ANG4.12)**

#### **TOOLS & TECHNIQUES OF RESEARCH METHODOLOGY**

*Practical Credit: 2*

*Teaching hours: 30*

1. Preparation of questionnaire and schedule.
2. Graphical and diagrammatic presentation of data.

**GENERIC ELECTIVE  
BOTANY**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Biodiversity (Microbes, Algae, Fungi and Archegoniate) (Theory)	BOG 1.11	4
		Biodiversity (Microbes, Algae, Fungi and Archegoniate) (Practical)	BOG 1.12	2
<b>II</b>	Generic Elective 2	Plant Ecology and Taxonomy (Theory)	BOG 2.11	4
		Plant Ecology and Taxonomy (Practical)	BOG 2.12	2
<b>III</b>	Generic Elective 3	Plant Anatomy and Embryology (Theory)	BOG 3.11	4
		Plant Anatomy and Embryology (Practical)	BOG 3.12	2
<b>IV</b>	Generic Elective 4	Economic Botany and Biotechnology (Theory)	BOG 4.11	4
		Economic Botany and Biotechnology (Practical)	BOG 4.12	2

**GENERIC ELECTIVE 1 (BOG 1.11)**  
**BIODIVERSITY (MICROBES, ALGAE, FUNGI AND ARCHEGONIATE)**

Theory Credit: 4

Teaching Hours: 60

**UNIT I      Microbes (12 hours)**

Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV, HIV); Economic importance. Bacteria– Discovery, General characteristics and cell structure; Reproduction– vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

**UNIT II      Algae (12 hours)**

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following: *Nostoc*, *Chlamydomonas*, *Fucus*, *Polysiphonia*. Economic importance of algae.

**UNIT III     Fungi (12 hours)**

Introduction- General characteristics, ecology and significance, nutrition, reproduction and classification; True Fungi. Life cycle of *Penicillium*, *Alternaria* (Ascomycota), *Puccinia*, *Agaricus*(Basidiomycota). General account and significance of lichens and Mycorrhizae (ectomycorrhiza and endomycorrhiza)

**UNIT IV     Introduction to Archegoniate & bryophytes (12 hours)**

Unifying features of archegoniates, Transition to land habit, Alternation of generations. Bryophytes-General characteristics, adaptations to land habit, classification, range of thallus organization. Morphology, anatomy and reproduction of *Marchantia* and *Funaria*. (Developmental details not to be included). Ecology and economic importance of bryophytes with special mention of *Sphagnum*.

**UNIT V      Pteridophytes & Gymnosperms (12 hours)**

*Pteridophytes*- General characteristics, classification, Early land plants (*Cooksonia* and *Rhynia*). Morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris*. (Developmental details not to be included). Heterospory and seed habit, stellar evolution. Ecological and economical importance of Pteridophytes. *Gymnosperms*- General characteristics; Classification. Morphology, anatomy and reproduction of *Cycas* and *Pinus* (Developmental details not to be included). Ecological and economical importance.

**GENERIC ELECTIVE 1 (BOG 1.12)**  
**BIODIVERSITY (MICROBES, ALGAE, FUNGI AND ARCHEGONIATE)**

Practical Credit: 2

1. EMs/ Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
2. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.
3. Gram staining



4. Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas*(electron micrographs), *Fucus* and *Polysiphonia* through temporary preparations and permanent slides. (\**Fucus*- Specimen and permanent slides)
5. *Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides.
6. *Alternaria*: Specimens/photographs and tease mounts.
7. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on Wheat and permanent slides of both the hosts.
8. *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills of *Agaricus*.
9. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
10. Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs)
11. *Marchantia*- morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
12. *Funaria*- morphology, w.m. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, l.s. capsule and protonema.
13. *Selaginella*- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus, w.m. microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
14. *Equisetum*- morphology, t.s. internode, l.s. strobilus, t.s. strobilus, w.m. sporangiophore, w.m. spores (wet and dry)(temporary slides); t.s. rhizome (permanent slide).
15. *Pteris*- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores(temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).
16. *Cycas*- morphology (coralloid roots, bulbil, leaf), t.s. coralloid root, t.s. rachis, v.s. leaflet, v.s. microsporophyll, w.m. spores (temporary slides), l.s. ovule, t.s. root (permanent slide).
17. *Pinus*- morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m. dwarf shoot, t.s. needle, t.s. stem, , l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), l.s. female cone, t.l.s. & r.l.s. stem (permanent slide).

**Recommended Books and References:**

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
8. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

**GENERIC ELECTIVE 2 (BOG 2.11)**  
**PLANT ECOLOGY AND TAXONOMY**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Ecological factors (12 hours)**

Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes, epiphytes, halophytes and xerophytes

**UNIT II Plant communities, ecosystem & Phytogeography (12 hours)**

Characters; Ecotone and edge effect; Succession; Processes and types  
*Ecosystem*- Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids, Productivity; Biogeochemical cycling; Cycling of carbon and nitrogen  
*Phytogeography*- Principle biogeographical zones of India with special reference to North-East India; Endemism, Red Data list and Hot spots.

**UNIT III Introduction to Plant taxonomy, Taxonomic hierarchy & Botanical nomenclature (12 hours)**

Identification, Nomenclature and Classification. Functions of Herbarium, important herbaria and botanical gardens of the world and India; Ranks, categories and taxonomic groups  
*Botanical nomenclature* - Principles and rules (ICN); Ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

**UNIT IV Angiosperm taxonomy (12 hours)**

General characteristics of the following families- Magnoliaceae, Brassicaceae, Fabaceae, Asteraceae, Solanaceae, Lamiaceae, Liliaceae, Orchidaceae & Poaceae.

**UNIT V Classification, Biometrics, numerical taxonomy and cladistics (12 hours)**

Types of classification-artificial, natural and phylogenetic. Bentham and Hooker Biometrics, numerical taxonomy and cladistics- Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

**GENERIC ELECTIVE 2 (BOG 2.12)**  
**PLANT ECOLOGY AND TAXONOMY**

*Practical Credit: 2*

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/ hygrometer, rain gauge and lux meter.
2. Determination of pH, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.
3. Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats.
4. (a) Study of morphological adaptations of hydrophytes, epiphytes, halophytes and xerophytes

- (b) Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Balanophora*), Epiphytes (*Dendrobium/ Cymbidium*), Predation (Insectivorous plants)
- Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (species to be listed)
  - Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law
  - Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Brassicaceae- *Brassica, Alyssum/ Iberis*; Asteraceae- *Bidens, Sonchus/ Launaea, Vernonia/Ageratum, Eclipta/Tridax*; Solanaceae- *Solanum sp., Withania*; Lamiaceae -*Salvia, Leucus*; Liliaceae – *Lilium/ Asphodelus / Allium*.
  - Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

**Recommended Books and References:**

- Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
- Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
- Simpson, M.G. (2006). *Plant Systematics*. Elsevier Academic Press, San Diego, CA, U.S.A.
- Singh, G. (2012). *Plant Systematics: Theory and Practice*. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.

**GENERIC ELECTIVE 3 (BOG 3.11)  
PLANT ANATOMY AND EMBRYOLOGY**

Theory Credit: 4

Teaching Hours: 60

**UNIT I Meristematic and permanent tissues (12 hours)**

Root and shoot apical meristems; Simple and complex tissues. Structure of dicot and monocot root stem and leaf.

**UNIT II Secondary Growth (12 hours)**

Vascular cambium– structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood)

**UNIT III Adaptive and protective systems (12 hours)**

Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

**UNIT IV Structural organization of flower- Pollination and fertilization (12 hours)**

Structure of a typical flower. Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac. Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms.

**UNIT V Embryo and endosperm: Apomixis and polyembryony (12 hours)**

Endosperm types, structure and functions; Dicot and monocot embryo. Apomixis and polyembryony- Definition, types and Practical applications

**GENERIC ELECTIVE 3 (BOG 3.12)**  
**PLANT ANATOMY AND EMBRYOLOGY**

*Practical Credit: 2*

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: *Zea mays*; Dicot: *Helianthus*; Secondary: *Helianthus* (temporary slide preparation and Permanent slides).
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*; Secondary: *Helianthus* (temporary slide preparation and Permanent slides).
5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem)
7. Structure of anther (young and mature), tapetum (amoeboid and secretory) (Permanent slides).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac Development (Permanent slides/ photographs).
10. Ultrastructure of mature egg apparatus cells through electron micrographs.
11. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (Photographs and specimens).
12. Dissection of embryo/ endosperm from developing seeds.
13. Calculation of percentage of germinated pollen in a given medium.

**Recommended Books and References:**

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

**GENERIC ELECTIVE 4 (BOG 4.11)**  
**ECONOMIC BOTANY AND PLANT BIOTECHNOLOGY**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Origin of Cultivated Plants: Cereals (12 hours)**

Concept of centres of origin, their importance with reference to Vavilov's work.  
Rice, Maize & Wheat- Origin, morphology, uses

**UNIT II Legumes & Spices (12 hours)**

General account with special reference to Gram and Soyabean  
*Spices*- General account with special reference to ginger, clove and black pepper  
(Botanical name, family, part used, morphology and uses)

**UNIT III Beverages: Oils and Fats: Fibre Yielding Plants (12 hours)**

Tea (morphology, processing, uses)  
*Oils and Fats*- General description with special reference to groundnut/ mustard  
*Fibre Yielding Plants*- General description with special reference to Cotton (Botanical name, family, part used, morphology and uses)

**UNIT IV Plant tissue culture (12 hours)**

Micropropagation; haploid production through androgenesis and gynogenesis; brief account of embryo and endosperm culture with their applications

**UNIT V Recombinant DNA Techniques (12 hours)**

Blotting techniques: Northern, Southern and Western Blotting, DNA Fingerprinting; Molecular DNA markers i.e. RAPD, RFLP; DNA sequencing, PCR. Hybridoma and monoclonal antibodies, ELISA and Immunodetection. Molecular diagnosis of human disease, Human gene Therapy.

**GENERIC ELECTIVE 4 (BOG 4.12)**

**ECONOMIC BOTANY AND PLANT BIOTECHNOLOGY**

*Practical Credit: 2*

1. Study of economically important plants: Rice, maize, Wheat, Gram, Soybean, Black pepper, Ginger, Mustard, Clove Tea, Cotton, Groundnut through specimens, sections and microchemical tests
2. Familiarization with basic equipments in tissue culture.
3. Study through photographs: Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation.
4. Study of molecular techniques: PCR, Blotting techniques, ELISA/ PAGE.

***Recommended Books and References:***

1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4<sup>th</sup> edition.
2. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.

**GENERIC ELECTIVE  
CHEMISTRY**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Conceptual Organic Chemistry (Theory)	CHG 1.11	4
		Chemistry Generic Practical I (Practical)	CHG 1.12	2
<b>II</b>	Generic Elective 2	Biochemistry, Bio-inorganic and Environmental Chemistry (Theory)	CHG 2.11	4
		Chemistry Generic Practical II (Practical)	CHG 2.12	2
<b>III</b>	Generic Elective 3	Chemical Bonding, Transition Metals and Coordination Chemistry (Theory)	CHG 3.11	4
		Chemistry Generic Practical III (Practical)	CHG 3.12	2
<b>IV</b>	Generic Elective 4	Physical Chemistry for Biosciences (Theory)	CHG 4.11	4
		Chemistry Generic Practical IV (Practical)	CHG 4.12	2

**GENERIC ELECTIVE 1(CHG 1.11)**  
**CONCEPTUAL ORGANIC CHEMISTRY (THEORY)**

*Theory Credit: 4*

**UNIT I Fundamentals of Organic Chemistry** (12 hours)

Electronic Displacements: Inductive effect, Electromeric effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Hybridization: Structure and shape of simple molecules CH<sub>4</sub>, NH<sub>3</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>2</sub>  
Reactive Intermediates: Nucleophiles and electrophiles, Carbocations, Carbanions and free radicals and the factors affecting their stability.

**UNIT II Stereochemistry** (12 hours)

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations, Conformation and Configuration  
Geometrical Isomerism: Requirements for a molecule to show geometrical isomerism, Cis-Trans, E & Z notation along with CIP rules for geometrical isomers.  
Optical Isomerism: Optical activity, chirality, enantiomerism, diastereoisomerism, racemic mixtures, resolution. Relative and absolute configuration: D/L nomenclature system for configuration of carbohydrates. Threo & Erythro designation. R and S - configuration (upto two chiral centres).

**UNIT III Addition Reactions** (12 hours)

Alkenes and Alkynes: Hydrogenation, addition of halogens, Hydrohalogenation (Markovnikov's and anti-Markovnikov's addition), hydration, hydroxylation, hydroboration-oxidation, ozonolysis. Reactivity of alkenes vs alkynes  
Aldehydes and ketones: (formaldehyde, acetaldehyde, benzaldehyde, acetone) Addition of sodium bisulphite, hydrogen cyanide and alcohols. Addition- elimination reactions with ammonia and its derivatives  
Name Reactions: Aldol, cross Aldol, Cannizzaro, cross Cannizzaro, Claisen,

**UNIT IV Substitution & Elimination Reactions** (12 hours)

Free radical substitution reactions: halogenations of alkanes, mechanism of halogenations  
Name Reactions: Wurtz reaction, Kolbes reaction, Corey -House reaction  
Nucleophilic substitution reactions: Alkyl halides-substitution of halogen by some common nucleophile, mechanism of SN1 and SN2 reactions  
Elimination Reactions  
Alkyl halides (dehydrohalogenation, Saytzeff's rule), vicinal dihalides (dehalogenation), Alcohols (dehydration), Elimination vs substitution

**UNIT V Electrophilic Substitution, Oxidation & Reduction Reactions** (12 hours)

Aromaticity: Benzenoids and Hückel's rule.  
Electrophilic Substitution Reactions:  
Aromatic compounds: General mechanism of electrophilic substitution reactions (nitration, halogenation, sulphonation, Friedel Crafts alkylation and acylation), ortho/para & meta-director, directive influence of substituents  
Oxidation Reaction  
Aromatic side chain (Alkyl benzene): Oxidation with potassium permanganate, potassium dichromate  
Reduction Reactions  
Simple carboxylic acids and its derivatives: Lithium aluminium hydride, sodium-ethanol and Rosenmund reduction.

**Recommended Books and References:**

1. I. L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
2. R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Pearson Education.
3. ArunBahl and B. S. Bahl: *Advanced Organic Chemistry*, S. Chand
4. Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry*, Orient Longman.
5. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*; Wiley: London, 1994.
6. T. W. Graham Solomon's *Organic Chemistry*, John Wiley and Sons.
7. P.S. Kalsi, *Stereochemistry, Conformation and Mechanism*, John Wiley and Sons.
8. D. Nasipuri, *Stereochemistry of Organic Compounds*, New Age International Publishers.
9. Madan, Tuli and Malik, *Selected topics of Inorganic, Organic & Physical chemistry*
10. R.L. Madan *Chemistry for Degree Students*, S.Chand & Company Ltd
11. O.P. Agarwal *Organic Chemistry Reaction and Reagents* Goel Publishing House, Meerut

**GENERIC ELECTIVE 1(CHG 1.12)****CHEMISTRY- GENERIC ELECTIVE PRACTICAL I**

*Practical Credit: 2*

Qualitative semi micro analysis of mixtures containing 2 anions and 2 cations and 1 interfering radical. Emphasis should be given to the understanding of the chemistry of different reactions

The following radicals are suggested:

$\text{CO}_3^{2-}$ ,  $\text{NO}_2^-$ ,  $\text{S}_2^-$ ,  $\text{SO}_3^{2-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{CH}_3\text{COO}^-$ ,  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ ,  $\text{NO}_3^-$ ,  $\text{BO}_3^{3-}$ ,  $\text{C}_2\text{O}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  $\text{NH}_4^+$ ,  $\text{K}^+$ ,  $\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Bi}^{3+}$ ,  $\text{Sn}^{2+}$ ,  $\text{Sb}^{3+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$

**Recommended Books and References:**

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

**GENERIC ELECTIVE 2(CHG 2.11)****BIOCHEMISTRY, BIO-INORGANIC AND ENVIRONMENTAL CHEMISTRY**

*Theory Credit: 4*

*Teaching Hours: 60*

**UNIT I Carbohydrates (12 hours)**

Classification of carbohydrates, reducing and non-reducing sugars, General properties of Glucose, open chain structure. Epimers, mutarotation and anomers. Structure of glucose. Haworth projections. structure of disachharides (sucrose, maltose) and polysachharides (starch and cellulose) excluding their structure elucidation.

**UNIT II Amino Acids, Peptides and Proteins (12 hours)**

Classification of Amino Acids, Zwitterion structure and Isoelectric point. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides, Synthesis of simple peptides (uptodipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.



**UNIT III Lipids (12 hours)**

Introduction to lipids, classification.

Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids.

**UNIT IV Bioinorganic Chemistry (12 hours)**

Essential and trace elements in biological systems, Metalloporphyrins, chlorophyll, heme proteins (hemoglobin, myoglobin); role of cobalt in vitamin B<sub>12</sub>; Enzymes; Metalloenzymes (Zn) and their characteristics and functions; Non-complexing cations in biochemical processes (Na and K), Role of metals and non-metals in metabolism; metal and non-metal deficiency and toxicity.

Biological role of alkali and alkaline earth metal ions with special reference to Ca<sup>2+</sup>. Nitrogen fixation.

**UNIT V Environmental Chemistry (12 hours)**

Composition of the atmosphere, photochemical reactions in the atmosphere, vehicle exhausts and photochemical smog, metallic pollutants—Hg and Pb; acid rain carbon monoxide and its effects, - suspended particulate matter – size and effects on health, dual role of ozone in the atmosphere tropospheric ozone and stratospheric ozone, ozone hole, carbon dioxide and other gases responsible for global warming, Measures to control air pollution, Quality of water drinking and other purposes. Permissible limits. Common water pollutants—organic and inorganic. Heavy metals and their toxic effects. Pollution of water through use of chemical fertilizers. Measures taken to control water pollution.

**Recommended Books and References:**

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt.Ltd.(Pearson Education).
3. Finar, I. L. *Organic Chemistry (Volume 2)*, Dorling Kindersley (India) Pvt.Ltd.(Pearson Education).
4. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry 7<sup>th</sup> Ed.*, W. H. Freeman.
5. Berg, J. M., Tymoczko, J. L. & Stryer, L. *Biochemistry 7<sup>th</sup> Ed.*, W. H. Freeman.
6. Madan, Tuli and Malik, selected topics of inorganic, organic & physical chemistry

**GENERIC ELECTIVE 2(CHG 2.12)****GENERIC ELECTIVE PRACTICAL II**

*Practical Credit: 2*

1. Detection of extra elements present in organic compound, saturation & unsaturation, Aromatic & non aromatic.
2. Functional group test for nitro, amine, amide, alcohols, carboxylic acids, phenols and carbonyl compounds

**Recommended Books and References:**

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education(2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry:Preparation and Quantitative Analysis*, University Press (2000).
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry:Qualitative Analysis*, University Press (2000).

**GENERIC ELECTIVE 3 (CHG 3.11)****CHEMICAL BONDING, TRANSITION METAL & COORDINATION CHEMISTRY**

Theory Credit:4

Teaching Hours: 60

**UNIT I The covalent bond and the structure of molecules (12 hours)**

Valence bond approach, Concept of resonance in various inorganic compounds, Hybridization and structure, equivalent and non-equivalent hybrid orbitals, VSEPR model for predicting shapes of molecules and ions containing lone pairs, sigma and pi bonds.

**UNIT II Molecular Orbital Approach & Intermolecular forces: (12 hours)**

LCAO method, symmetry and overlap for s-s, s-p and p-p combinations, MO treatment of homonuclear diatomic molecules of 2<sup>nd</sup> period (B<sub>2</sub>, C<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub>, F<sub>2</sub>) and heteronuclear di-atomic molecules (CO, NO) and their ions.

Intermolecular forces: van der Waals forces, Hydrogen bonding and its applications, effects of these forces on melting point, boiling point and solubility.

**UNIT III Transition Elements (3d series) (12 hours)**

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

**UNIT IV Coordination Chemistry (12 hours)**

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature.

**UNIT V Crystal Field Theory (12 hours)**

Crystal field effect, Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for *Oh* and *Td* complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

**Recommended Books and References:**

1. James E. Huheey, "Inorganic Chemistry: Principles of structure and reactivity", Prentice Hall, IV Edition.
2. D. S. Shriver and P.A. Atkins, "Inorganic Chemistry", Oxford University Press, IV Edition.
3. Alan G. Sharpe, "Inorganic Chemistry", University of Cambridge, III Edition.
4. J. D. Lee, "A New Concise Inorganic Chemistry", ELBS IV Edition
5. Grey L. Miessler and Donald A. Tarr, "Inorganic Chemistry", Prentice Hall, III Edition.
6. B. Douglas, D. H. McDaniel and J. J. Alexander, "Concepts and Models of Inorganic Chemistry", John Wiley and Sons, III Edition.
7. Rodgers, G.E. *Inorganic & Solid State Chemistry*, Cengage Learning India Ltd., 2008.

**GENERIC ELECTIVE 3(CHG 3.12)  
CHEMISTRY GENERIC PRACTICAL III**

Practical Credit: 2

1. Determination of the heat of neutralization of a strong acid by a strong base.
2. Determination of the molecular weight by Rast's method.
3. Determination of the solubility of a salt ( $\text{BaCl}_2$ ) at two different temperatures and to determine the heat of solution.
4. Verification of Hardy-Schulze law: Preparation and coagulation of arsenic sulphide ( $\text{As}_2\text{S}_3$ ) sol using  $\text{NaCl}$ ,  $\text{BaCl}_2$  and  $\text{AlCl}_3$  solutions.
5. To study the kinetics of iodination of acetone.
6. Determination of enthalpy of hydration of copper sulphate.

Any other experiment carried out in the class.

**Recommended Books and References:**

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R.Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.*; W.H. Freeman & Co.: New York (2003).

**GENERIC ELECTIVE 4(CHG 4.11)  
PHYSICAL CHEMISTRY FOR THE BIOSCIENCES**

Practical Credit: 4

Teaching Hours: 60

**UNIT I    Chemical Energetics (12 hours)**

Review of the Laws of Thermodynamics.

Thermochemical equation and the laws. Concept of standard state and standard enthalpies of formation, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data.

Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

**UNIT II Chemical Equilibrium and Chemical Kinetics (12 hours)**

Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between  $\Delta G$  and  $\Delta G^\circ$ , Le Chatelier's principle. Relationships between  $K_p$ ,  $K_c$  and  $K_x$  for reactions involving ideal gases.

Chemical Kinetics: The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero and first order reactions. Half-life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

**UNIT III Ionic Equilibria (12 hours)**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of

ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis - calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts - applications of solubility product principle.

**UNIT IV Phase rule and its application (12 hours)**

Definition of its following terms: - phase, component, degrees of freedom, derivation of the phase rule, phase equilibrium and metastable equilibrium, phase diagram involving one system (sulphur). Phase equilibria of two component systems, solid-liquid equilibria, simple eutectic Pb-Ag systems and desilverization of lead, ideal liquid mixtures, azeotropes (ethanol-water systems), Nernst distribution law (elementary idea only).

**UNIT V Electrochemistry and Photochemistry (12 Lecturers)**

Electrical transport - conduction in metals and in solutions; specific conductance and equivalent conductance, measurement of equivalent conductance, variation of specific and equivalent conductance with dilution, Kohlrausch law, Migration of ions, transport number. Arrhenius theory of electrolyte dissociation and its limitations.

Photochemistry: Laws of photochemistry. Fluorescence and phosphorescence. Quantum efficiency and reasons for high and low quantum yields. Primary and secondary processes in photochemical reactions. Photochemical and thermal reactions.

**Recommended Books and References:**

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 9th Ed., Oxford University Press (2011).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Chang, R. *Physical Chemistry for the Biosciences*. University Science Books (2005).

**GENERIC ELECTIVE 4(CHG 4.12)**  
**GENERIC ELECTIVE PRACTICAL IV**

*Practical Credit: 2*

**Titrations involving redox reactions:**

1. Standardization of  $\text{KMnO}_4$  solution (standard solution of Mohr's salt to be prepared).
2. Determination of concentration of Fe(II) in Mohr's salt and/or  $\text{K}_2\text{Cr}_2\text{O}_7$  using diphenylamine/N-phenylanthranilic acid as internal indicator (standard solution of  $\text{K}_2\text{Cr}_2\text{O}_7$  and /or Mohr's salt to be prepared).
2. Determination of concentration of Fe(II) in  $\text{FeCl}_3$  and/or  $\text{K}_2\text{Cr}_2\text{O}_7$  using diphenylamine/N-phenylanthranilic acid as internal indicator (standard solution of  $\text{K}_2\text{Cr}_2\text{O}_7$  / $\text{KMnO}_4$  to be prepared)
4. Determination of iron content in ores / alloys using appropriate redox titration

**Gravimetric Analysis:**

- i. Estimation of nickel (II) using Dimethylglyoxime (DMG).
- ii. Estimation of copper as  $\text{CuSCN}$
- iii. Estimation of iron as  $\text{Fe}_2\text{O}_3$  by precipitating iron as  $\text{Fe}(\text{OH})_3$ .

**Recommended Books and References:**

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.

**GENERIC ELECTIVE  
COMPUTER SCIENCE**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Computer Fundamentals (Theory)	CSG 1.11	4
		Computer Fundamentals (Practical)	CSG 1.12	2
<b>II</b>	Generic Elective 2	Office Automation Tools (Theory)	CSG 2.11	4
		Office Automation Tools (Practical)	CSG 2.12	2
<b>III</b>	Generic Elective 3	HTML Programming (Theory)	CSG 3.11	4
		HTML Programming (Practical)	CSG 3.12	2
<b>IV</b>	Generic Elective 4	Web & E-Commerce Technologies (Theory)	CSG 4.11	4
		Web & E-Commerce Technologies (Practical)	CSG 4.12	2

**GENERIC ELECTIVE 1 (CSG 1.11)  
COMPUTER FUNDAMENTALS**

*Theory Credit: 4*

**UNIT I Introduction to Computer:**

Introduction to Computer:-Definition, Characteristics, Capabilities and Limitations. Introduction to Operating System. Components of a Computer System- Control Unit, ALU, input/output functions and characteristics. Memory Introduction, Classifications- Volatile Memory and Non- Volatile , Flash Memory, ROM, RAM, EPROM, PROM, EEPROM other types of memory.

**UNIT II Data Representation:**

Number systems and character representation, binary arithmetic.

**UNIT III Devices:**

Input, Output Units: Computer Keyboard, Pointing Devices: Mouse, Trackball, Touch Panel, and Joystick, Light Pen, Scanners, Various types of Monitors, Touch-sensitive screens, Optical Recognition System, Pen based systems, Digitizers, MICR, OCR, OMR, Bar-code Reader, digital camera. Impact and Non- Impact Printers- Daisy Wheel, Dot Matrix, Line Printer, Chain Printer, Comb Printers, Non Impact Printers- DeskJet, Laser Printer, Thermal Transfer Printer, Barcode Printers, Electro static printers and plotters.

**UNIT IV Computer Organization and Architecture:**

C.P.U., registers, system bus, main memory unit, cache memory, SMPS, Motherboard, Ports and Interfaces, expansion cards, ribbon cables, memory chips, processors

**UNIT V Overview of Emerging Technologies:**

Bluetooth, cloud computing, big data, data mining, mobile computing and embedded systems.

***Recommended Books and References:***

1. Computer Fundamentals – B. Ram – New Age International Publishers
2. C.S. French "Data Processing and Information Technology", BPB Publications
3. P.K "Sinha Computer Fundamentals", BPB Publications
4. S.K. Basandra, "Computers Today", Galgotia Publications.

**GENERIC ELECTIVE 1 (CSG 1.12)  
COMPUTER FUNDAMENTALS (PRACTICAL)**

*Practical Credit: 2*

**GENERIC ELECTIVE 2 (CSG 2.11)**  
**OFFICE AUTOMATION TOOLS**

*Theory Credit: 4*

- UNIT I** Ms word: Starting word - Parts of word window - formatting features - menus, commands, Toolbars - File menu, Edit, view, insert, Format and tool menus - Working with text, tables - checking spelling and Grammars.
- UNIT II** Mail merge concept - creating main document, data source, Adding fields - Remarks fields Macros - Creating templates and working with templates.
- UNIT III** MS - Excel: Excel Basics - Creating Work Sheets - Formulas - Functions - Charts - Coping Data, between worksheets - Case studies pay bill, profit and loss accounts etc.
- UNIT IV** Power point - Making presentation with Ms power points - working with power point - organization chart - inserting chart from excel.
- UNIT V** Ms-Access: Introduction - creating a new Database - saving the database - Forms - Reports.

***Recommended Books and References:***

1. **“Microsoft Office 365: Connect and Collaborate Virtually Anywhere, Anytime”** by Katherine Murray
2. **Office 2010:**Vasu Jain

**GENERIC ELECTIVE 2 (CSG 2.12)**  
**OFFICE AUTOMATION TOOLS(PRACTICAL)**

*PracticalCredit: 2*

**GENERIC ELECTIVE 3 (CSG 3.11)**  
**HTML PROGRAMMING**

*Theory Credit: 4*

- UNIT I** **Introduction:**Basic HTML Concepts, HTML, HEAD, TITLE, BODY, Paragraphs, Lists, Formatted and Unformatted Text, Hyperlink, Font (Size, Color),image,Attributes,Lists, ordered and unordered.
- UNIT II** **Links:**Introduction, Relative Links, Absolute Links,Link Attributes,Using the ID Attribute to Link Within a Document.
- UNIT III** **Images:**Putting an Image on a Page,Web Graphic Format GIF, JPEG, PNG, Inline Images Using Images as Links,Putting an Image in the Background. Working with Divs and Layers,1 Placing <div> tags, Creating Layers, Modifying a Layer



**UNIT IV Tables:**Creating a Table,Table Headers,Captions,Spanning Multiple Columns Styling Table.

**UNIT V Forms:**Basic Input and Attributes,Other Kinds of Inputs,Styling forms with CSS.

**Recommended Books and References:**

1. Introduction to **HTML** and CSS --O'Reilly

**GENERIC ELECTIVE 3 (CSG 3.12)  
HTML PROGRAMMING**

*PracticalCredit: 2*

**GENERIC ELECTIVE 4 (CSG 4.11)  
WEB AND E-COMMERCE TECHNOLOGIES**

*Theory Credit: 4*

**UNIT I An introduction to Electronic commerce:** What is E-Commerce (Introduction And Definition), Main activities E-Commerce, Goals of E-Commerce, Technical Components of E-Commerce, Functions of E-Commerce, Advantages and disadvantages of E-Commerce, Scope of E-Commerce, Electronic Commerce Applications.

**UNIT II The Internet and WWW:** Evolution of Internet, Domain Names and Internet Organization (.edu, .com, .mil, .gov, .net etc.) , Types of Network, Internet Service Provider, World Wide Web, Internet & Extranet, Role of Internet in B2B Application, building own website, Cost, Time, Reach, Registering a Domain Name, Web promotion, Target email, Baner, Exchange, Shopping Bots.

**UNIT III Internet Security:** Secure Transaction, Computer Monitoring, Privacy on Internet, Corporate Email privacy, Computer Crime( Laws , Types of Crimes), Threats, Attack on Computer System, Software Packages for privacy, Hacking, Computer Virus( How it spreads, Virus problem, virus protection, Encryption and Decryption, Secret key Cryptography, DES, Public Key Encryption, RSA, Authorisation and Authentication, Firewall, Digital Signature.

**UNIT IV Electronic Data Exchange:** Introduction, Concepts of EDI and Limitation, Applications of EDI, Disadvantages of EDI, EDI model,Electronic Payment System: Introduction, Types of Electronic Payment System, Payment Types, Value Exchange System, Credit Card System, Electronic Fund Transfer, Paperless bill, Modern Payment Cash, Electronic Cash.

**UNIT V Planning for Electronic Commerce:** Planning Electronic Commerce initiates, Linking objectives to business strategies, Measuring cost objectives, Comparing benefits to Costs, Strategies for developing electronic commerce web sites.

***Recommended Books and References:***

1. E-Commerce Concepts, Models, Strategies: G.S.V.Murthy Himalaya Publishing House
2. E-Commerce:-Kamlesh K Bajaj and Debjani Nag
3. Electronic commerce:-Gray P. Schneider
4. E-Commerce, Fundamentals & Applications: Chand (Wiley)

**GENERIC ELECTIVE 4 (CSG 4.12)  
WEB AND E-COMMERCE TECHNOLOGIES**

*Practical Credit: 2*

**GENERIC ELECTIVE  
ECONOMICS**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Introductory Microeconomics	ECG 1.11	6
<b>II</b>	Generic Elective 2	Introductory Macroeconomics	ECG 2.11	6
<b>III</b>	Generic Elective 3	(a) Indian Economy-I OR (b) Money and Banking OR (c) Environmental Economics	ECG 3.11(a) ECG 3.11(a) ECG 3.11(a)	6
<b>IV</b>	Generic Elective 4	(a) Indian Economy-II OR (b) Economic History of India 1857-1947 OR (c) Public Finance	ENG 4.11(a) ENG 4.11(a) ENG 4.11(a)	6

**GENERIC ELECTIVE 1 (ECG 1.11)**  
**INTRODUCTORY MICROECONOMICS**

**1. Exploring the subject matter of Economics**

Why study economics? Scope and method of economics; the economic problem: scarcity and choice; the question of what to produce, how to produce and how to distribute output; science of economics; the basic competitive model; prices, property rights and profits; incentives and information; rationing; opportunity sets; economic systems; reading and working with graphs.

**2. Supply and Demand: How Markets Work, Markets and Welfare**

Markets and competition; determinants of individual demand/supply; demand/supply schedule and demand/supply curve; market versus individual demand/supply; shifts in the demand/supply curve, demand and supply together; how prices allocate resources; elasticity and its application; controls on prices; taxes and the costs of taxation; consumer surplus; producer surplus and the efficiency of the markets.

**3. The Households**

The consumption decision - budget constraint, consumption and income/price changes, demand for all other goods and price changes; description of preferences (representing preferences with indifference curves); properties of indifference curves; consumer's optimum choice; income and substitution effects; labour supply and savings decision - choice between leisure and consumption.

**4. The Firm and Perfect Market Structure**

Behaviour of profit maximizing firms and the production process; short run costs and output decisions; costs and output in the long run.

**5. Imperfect Market Structure**

Monopoly and anti-trust policy; government policies towards competition; imperfect competition.

**6. Input Markets**

Labour and land markets - basic concepts (derived demand, productivity of an input, marginal productivity of labour, marginal revenue product); demand for labour; input demand curves; shifts in input demand curves; competitive labour markets; and labour markets and public policy.

**Recommended Books and References:**

1. Karl E. Case and Ray C. Fair, *Principles of Economics*, Pearson Education Inc., 8<sup>th</sup> Edition, 2007.
2. N. Gregory Mankiw, *Economics: Principles and Applications*, India edition by South Western, a part of Cengage Learning, Cengage Learning India Private Limited, 4<sup>th</sup> edition, 2007.
3. Joseph E. Stiglitz and Carl E. Walsh, *Economics*, W.W. Norton & Company, Inc., New York, International Student Edition, 4<sup>th</sup> Edition, 2007.

**GENERIC ELECTIVE2(ECG 2.11)  
INTRODUCTORY MACROECONOMICS**

**1. Introduction to Macroeconomics and National Income Accounting**

Basic issues studied in macroeconomics; measurement of gross domestic product; income, expenditure and the circular flow; real versus nominal GDP; price indices; national income accounting for an open economy; balance of payments: current and capital accounts.

**2. Money**

Functions of money; quantity theory of money; determination of money supply and demand; credit creation; tools of monetary policy.

**3. Inflation**

Inflation and its social costs; hyperinflation.

**4. The Closed Economy in the Short Run**

Classical and Keynesian systems; simple Keynesian model of income determination; IS-LM model; fiscal and monetary multipliers.

**Recommended Books and References:**

1. Dornbusch, Fischer and Startz, *Macroeconomics*, McGraw Hill, 11<sup>th</sup> edition, 2010.
2. N. Gregory Mankiw. *Macroeconomics*, Worth Publishers, 7<sup>th</sup> edition, 2010.
3. Olivier Blanchard, *Macroeconomics*, Pearson Education, Inc., 5<sup>th</sup> edition, 2009.
4. Richard T. Froyen, *Macroeconomics*, Pearson Education Asia, 2<sup>nd</sup> edition, 2005.
5. Andrew B. Abel and Ben S. Bernanke, *Macroeconomics*, Pearson Education, Inc., 7<sup>th</sup> edition, 2011.
6. Errol D'Souza, *Macroeconomics*, Pearson Education, 2009.
7. Paul R. Krugman, Maurice Obstfeld and Marc Melitz, *International Economics*, Pearson Education Asia, 9<sup>th</sup> edition, 2012.

**GENERIC ELECTIVE 3 (ECG 3.11(a))  
INDIAN ECONOMY-I**

**1. Economic Development since Independence**

Major features of the economy at independence; growth and development under different policy regimes—goals, constraints, institutions and policy framework; an assessment of performance—sustainability and regional contrasts; structural change, savings and investment.

**2. Population and Human Development**

Demographic trends and issues; education; health and malnutrition.

**3. Growth and Distribution**

Trends and policies in poverty; inequality and unemployment.

**4. International Comparisons**

**Recommended Books and References:**

1. Jean Dreze and Amartya Sen, 2013. *An Uncertain Glory: India and its Contradictions*, Princeton University Press.
2. Pulapre Balakrishnan, 2007, The Recovery of India: Economic Growth in the Nehru Era, *Economic and Political Weekly*, November.

3. Rakesh Mohan, 2008, —Growth Record of Indian Economy: 1950-2008. A Story of Sustained Savings and Investment, *Economic and Political Weekly*, May.
4. S.L. Shetty, 2007, —India's Savings Performance since the Advent of Planning, in K.L. Krishna and A. Vaidyanathan, editors, *Institutions and Markets in India's Development*.
5. Himanshu, 2010, —Towards New Poverty Lines for India, *Economic and Political Weekly*, January.
6. Jean Dreze and Angus Deaton, 2009, —Food and Nutrition in India: Facts and Interpretations, *Economic and Political Weekly*, February.
7. Himanshu. 2011, —Employment Trends in India: A Re-examination, *Economic and Political Weekly*, September.
8. Rama Baru et al, 2010, —Inequities in Access to Health Services in India: Caste, Class and Region, *Economic and Political Weekly*, September.
9. Geeta G. Kingdon, 2007, —The Progress of School Education in India, *Oxford Review of Economic Policy*.
10. J.B.G. Tilak, 2007, —Post Elementary Education, Poverty and Development in India, *International Journal of Educational Development*.
11. T. Dyson, 2008, —India's Demographic Transition and its Consequences for Development in Uma Kapila, editor, *Indian Economy Since Independence*, 19<sup>th</sup> edition, Academic Foundation.
12. Kaushik Basu, 2009, —China and India: Idiosyncratic Paths to High Growth, *Economic and Political Weekly*, September.
13. K. James, 2008, —Glorifying Malthus: Current Debate on Demographic Dividend in India, *Economic and Political Weekly*, June.
14. Reetika Khera, 2011, —India's Public Distribution System: Utilisation and Impact *Journal of Development Studies*.
15. Aniruddha Krishna and Devendra Bajpai, 2011, —Lineal Spread and Radial Dissipation: Experiencing Growth in Rural India, 1992-2005, *Economic and Political Weekly*, September.
16. Kaushik Basu and A. Maertens, eds, 2013, *Oxford Companion to Economics*, Oxford University Press.

### **GENERIC ELECTIVE 3 (ECG 3.11(b))**

#### **MONEY AND BANKING**

##### **1. Money**

Concept, functions, measurement; theories of money supply determination.

##### **2. Financial Institutions, Markets, Instruments and Financial Innovations**

a. Role of financial markets and institutions; problem of asymmetric information – adverse selection and moral hazard; financial crises.

b. Money and capital markets: organization, structure and reforms in India; role of financial derivatives and other innovations.

##### **3. Interest Rates**

Determination; sources of interest rate differentials; theories of term structure of interest rates; interest rates in India.

##### **4. Banking System**

a. Balance sheet and portfolio management.

b. Indian banking system: Changing role and structure; banking sector reforms.

## **5. Central Banking and Monetary Policy**

Functions, balance sheet; goals, targets, indicators and instruments of monetary control; monetary management in an open economy; current monetary policy of India.

### **Recommended Books and References:**

1. F. S. Mishkin and S. G. Eakins, *Financial Markets and Institutions*, Pearson Education, 6<sup>th</sup> edition, 2009.
2. F. J. Fabozzi, F. Modigliani, F. J. Jones, M. G. Ferri, *Foundations of Financial Markets and Institutions*, Pearson Education, 3<sup>rd</sup> edition, 2009.
3. L. M. Bhole and J. Mahukud, *Financial Institutions and Markets*, Tata McGraw Hill, 5<sup>th</sup> edition, 2011.
4. M. Y. Khan, *Indian Financial System*, Tata McGraw Hill, 7<sup>th</sup> edition, 2011.
5. Various latest issues of R.B.I. Bulletins, Annual Reports, Reports on Currency and Finance and Reports of the Working Group, IMF Staff Papers.

## **GENERIC ELECTIVE 3(ECG 3.11(c)) ENVIRONMENTAL ECONOMICS**

### **1. Introduction**

Key environmental issues and problems, economic way of thinking about these problems, basic concepts from economics; Pareto optimality and market failure in the presence of externalities; property rights and other approaches.

### **2. The Design and Implementation of Environmental Policy**

Overview, Pigouvian taxes and effluent fees, tradable permits, implementation of environmental policies in India and international experience; transboundary environmental problems; economics of climate change.

### **3. Environmental Valuation Methods and Applications**

Valuation of non-market goods and services--theory and practice; measurement methods; cost-benefit analysis of environmental policies and regulations.

### **4. Sustainable Development**

Concepts; measurement; perspectives from Indian experience

### **Recommended Books and References:**

1. Roger Perman, Yue Ma, Michael Common, David Maddison and James McGilvray, *Natural Resource and Environmental Economics*, Pearson Education/Addison Wesley, 4<sup>th</sup> edition, 2011.
2. Charles Kolstad, *Intermediate Environmental Economics*, Oxford University Press, 2<sup>nd</sup> edition, 2010.
3. Robert N. Stavins (ed.), *Economics of the Environment: Selected Readings*, W.W. Norton, 6<sup>th</sup> edition, 2012.
4. Robert Solow, "An Almost Practical Step toward Sustainability," Resources for the Future 40th anniversary lecture, 1992.
5. Kenneth Arrow et al., "Are We Consuming Too Much?" *Journal of Economic Perspectives*, 18(3): 147-172, 2004.
6. IPCC (Intergovernmental Panel on Climate Change), Fifth Assessment Report (forthcoming 2014).

**GENERIC ELECTIVE 4 (ECG 4.11(a))  
INDIAN ECONOMY-II**

**1. Macroeconomic Policies and Their Impact**

Fiscal Policy; trade and investment policy; financial and monetary policies; labour regulation.

**2. Policies and Performance in Agriculture**

Growth; productivity; agrarian structure and technology; capital formation; trade; pricing and procurement.

**3. Policies and Performance in Industry**

Growth; productivity; diversification; small scale industries; public sector; competition policy; foreign investment.

**4. Trends and Performance in Services**

**Recommended Books and References:**

1. Shankar Acharya, 2010, –Macroeconomic Performance and Policies 2000-8, in Shankar Acharya and Rakesh Mohan, editors, *India's Economy: Performances and Challenges: Development and Participation*, Oxford University Press.
2. Rakesh Mohan, 2010, –India's Financial Sector and Monetary Policy Reforms, in Shankar Acharya and Rakesh Mohan, editors, *India's Economy: Performances and Challenges: Development and Participation*, Oxford University Press.
3. Pulapre Balakrishnan, Ramesh Golait and Pankaj Kumar, 2008, –Agricultural Growth in India Since 1991, *RBI DEAP Study no. 27*.
4. Kunal Sen, 2010, –Trade, Foreign Direct Investment and Industrial Transformation in India, in Premachandra Athukorala, editor, *The Rise of Asia*, Routledge.
5. A. Ahsan, C. Pages and T. Roy, 2008, –Legislation, Enforcement and Adjudication in Indian Labour Markets: Origins, Consequences and the Way Forward, in D. Mazumdar and S. Sarkar, editors, *Globalization, Labour Markets and Inequality in India*, Routledge.
6. Dipak Mazumdar and Sandeep Sarkar, 2009, –The Employment Problem in India and the Phenomenon of the 'Missing Middle', *Indian Journal of Labour Economics*.
7. J. Dennis Rajakumar, 2011, –Size and Growth of Private Corporate Sector in Indian Manufacturing, *Economic and Political Weekly*, April.
8. Ramesh Chand, 2010, Understanding the Nature and Causes of Food Inflation, *Economic and Political Weekly*, February.
9. Bishwanath Goldar, 2011, Organised Manufacturing Employment: Continuing the Debate, *Economic and Political Weekly*, April.
10. Kaushik Basu and A. Maertens, eds, 2013. *The New Oxford Companion to Economics in India*, Oxford University Press.

**GENERIC ELECTIVE 4 (ECG 4.11(b))  
ECONOMIC HISTORY OF INDIA 1857-1947**

**1. Introduction: Colonial India: Background and Introduction**

Overview of colonial economy.

**2. Macro Trends**

National Income; population; occupational structure.



### **3. Agriculture**

Agrarian structure and land relations; agricultural markets and institutions – credit, commerce and technology; trends in performance and productivity; famines.

### **4. Railways and Industry**

Railways; the de-industrialisation debate; evolution of entrepreneurial and industrial structure; nature of industrialisation in the interwar period; constraints to industrial breakthrough; labor relations.

### **5. Economy and State in the Imperial Context**

The imperial priorities and the Indian economy; drain of wealth; international trade, capital flows and the colonial economy – changes and continuities; government and fiscal policy.

#### **Recommended Books and References:**

1. Lakshmi Subramanian, “*History of India 1707-1857*”, Orient Blackswan, 2010, Chapter 4.
2. Sumit Guha, 1991, ‘Mortality decline in early 20<sup>th</sup> century India’, *Indian Economic and Social History Review (IESHR)*, pp 371-74 and 385-87.
3. Tirthankar Roy, *The Economic History of India 1857-1947*, Oxford University Press, 3rd edition, 2011.
4. J. Krishnamurty, *Occupational Structure*, Dharma Kumar (editor), *The Cambridge Economic History of India*, Vol. II, (henceforth referred to as CEHI), 2005, Chapter 6.
5. Irfan Habib, *Indian Economy 1858-1914*, A People’s History of India, Vol.28, Tulika, 2006.
6. Ira Klein, 1984, –When Rains Fail: Famine relief and mortality in British India, *IESHR* 21.
7. Jean Dreze, *Famine Prevention in India in Dreze and Sen (eds.) Political Economy of Hunger*, WIDER Studies in Development Economics, 1990, pp.13-
8. John Hurd, *Railways*, CEHI, Chapter 8, pp.737-761.
9. Rajat Ray (ed.), *Entrepreneurship and Industry in India*, 1994.
10. AK Bagchi, –Deindustrialization in India in the nineteenth century: Some theoretical implications, *Journal of Development Studies*, 1976.
11. MD Morris, *Emergence of an Industrial Labour Force in India*, OUP 1965, Chapter 11, Summary and Conclusions.
12. K.N. Chaudhuri, *Foreign Trade and Balance of Payments*, CEHI, Chapter 10.
13. B.R. Tomlison, 1975, *India and the British Empire 1880-1935*, IESHR, Vol.XII.
14. Dharma Kumar, *The Fiscal System*, CEHI, Chapter 12.
15. Basudev Chatterjee, *Trade, Tariffs and Empire*, OUP 1992, Epilogue.

#### **Background reading for students:**

- Irfan Habib, *Indian Economy 1858-1914* (A People’s History of India), Vol.28, Tulika 2006.
- Daniel Thorner, *Agrarian Prospect in India*, 1977.

### **GENERIC ELECTIVE 4(ECG 4.11(c))**

#### **PUBLIC FINANCE**

##### **Part 1:**

##### **Theory**

1. Overview of Fiscal Functions, Tools of Normative Analysis, Pareto Efficiency, Equity and the Social Welfare.
2. Market Failure, Public Good and Externalities.
3. Elementary Theories of Product and Factor Taxation (Excess Burden and Incidence).

##### **Part 2: Issues from Indian Public**

## **Finance**

4. Working of Monetary and Fiscal Policies.
5. Current Issues of India's Tax System.
6. Analysis of Budget and Deficits
7. Fiscal Federalism in India
8. State and Local Finances

### **Recommended Books and References:**

1. Musgrave, R.A. and P.B. Musgrave, *Public Finance in Theory and Practice*, Mc-GrawHill, 1989.
2. Mahesh Purohit , “*Value Added Tax: Experience of India and Other Countries*”, Gayatri Publications, 2007.
3. Kaushik Basu, and A. Maertens (ed.), *The Oxford Companion to Economics in India*, Oxford University Press, 2007.
4. M.M Sury, *Government Budgeting in India*, Commonwealth Publishers, 1990.
5. Shankar Acharya, “Thirty years of tax reform” in India, *Economic and Political Weekly*, May 2005.
6. Government of India, *Report of the 13<sup>th</sup> Finance Commission*.
7. *Economic Survey*, Government of India (latest).
8. *State Finances: A Study of Budgets*, Reserve Bank of India (latest).

**GENERIC ELECTIVE  
ENGLISH**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Academic Writing & Composition	ENG 1.11	6
<b>II</b>	Generic Elective 2	Media & Communication Skills	ENG 2.11	6
<b>III</b>	Generic Elective 3	Contemporary India: Women & Empowerment	ENG 3.11	6
<b>IV</b>	Generic Elective 4	Language, Literature & Culture	ENG 4.11	6

**GENERIC ELECTIVE 1 (ENG 1.11)**  
**ACADEMIC WRITING AND COMPOSITION**

*Theory Credit: 6*

**UNIT I** Introduction to the Writing Process and Conventions of Academic Writing

**UNIT II** Writing in one's own words: Summarizing and Paraphrasing

**UNIT III** Critical Thinking: Syntheses, Analyses, and Evaluation

**UNIT IV** Structuring an Argument: Introduction, Interjection, and Conclusion

**UNIT V** Citing Resources; Editing, Book and Media Review

***Recommended Books and References:***

1. Liz Hamp-Lyons and Ben Heasley, *Study writing: A Course in Writing Skills for Academic Purposes* (Cambridge: CUP, 2006).
2. Renu Gupta, *A Course in Academic Writing* (New Delhi: Orient BlackSwan, 2010).
3. Ilona Leki, *Academic Writing: Exploring Processes and Strategies* (New York: CUP, 2nd edn, 1998).
4. Gerald Graff and Cathy Birkenstein, *They Say/I Say: The Moves That Matter in Academic Writing* (New York: Norton, 2009).

**GENERIC ELECTIVE 2 (ENG 2.11)**  
**MEDIA AND COMMUNICATION SKILLS**

*Theory Credit: 6*

**UNIT I Introduction to Mass Communication**

1. Mass Communication and Globalization
2. Forms of Mass Communication  
Topics for Student Presentations:
  - a. Case studies on current issues Indian journalism
  - b. Performing street plays
  - c. Writing pamphlets and posters, etc.

**UNIT II Advertisement**

1. Types of advertisements
2. Advertising ethics
3. How to create advertisements/storyboards  
Topics for Student Presentations:
  - a. Creating an advertisement/visualization
  - b. Enacting an advertisement in a group
  - c. Creating jingles and taglines

**UNIT III Media Writing**

1. Scriptwriting for TV and Radio

**UNIT IV** Writing News Reports and Editorials  
Editing for Print and Online Media

Topics for Student Presentations:

- a. Script writing for a TV news/panel discussion/radio programme/hosting radioprogrammes on community radio
- b. Writing news reports/book reviews/film reviews/TV program reviews/interviews
- c. Editing articles
- d. Writing an editorial on a topical subject

**UNIT V Introduction to Cyber Media and Social Media**

1. Types of Social Media
2. The Impact of Social Media
3. Introduction to Cyber Media

**GENERIC ELECTIVE 3 (ENG 3.11)**

**CONTEMPORARY INDIA: WOMEN AND EMPOWERMENT**

*Theory Credit: 6*

**UNIT I** Social Construction of Gender (Masculinity and Femininity), Patriarchy

**UNIT II** Women and Law, Women and the Indian Constitution,

**UNIT III** Personal Laws(Customary practices on inheritance and Marriage), (Supplemented by workshop on legal awareness)

**UNIT IV** Women and Environment: State interventions

**UNIT V** Domestic violence, Female foeticide, sexual harassment

**GENERIC ELECTIVE 4 (ENG 4.11)**

**LANGUAGE, LITERATURE AND CULTURE**

*Theory Credit: 6*

Four essays to be studied from the prescribed text

*An Anthology of Writings on Diversities in India*, Editorial Board: Department of English, University of Delhi (In the press)

**GENERIC ELECTIVE  
GEOGRAPHY**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Introduction to Physical Geography (Theory)	GGG 1.11	4
		Thematic Cartography (Practical)	GGG 1.12	2
<b>II</b>	Generic Elective 2	Human Geography (Theory)	GGG 2.11	4
		General Cartography (Practical)	GGG 2.12	2
<b>III</b>	Generic Elective 3	Geography of India (Theory)	GGG 3.11	4
		Introduction to Statistical Methods (Practical)	GGG 3.12	2
<b>IV</b>	Generic Elective 4	Regional Geography of Northeast India and Nagaland (Theory)	GGG 4.11	4
		Presentation (Practical)	GGG 4.12	2

**GENERIC ELECTIVE 1 (GGG 1.11)**  
**INTRODUCTION TO PHYSICAL GEOGRAPHY**

*Theory Credit: 4*

*Teaching Hours: 60*

**Objective:** *The objective of this paper is to understand the origin of the Earth and its various landforms. The inter-relation of various branches of geography with other branches of natural and social science.*

- UNIT I** Physical geography: nature and scope; Branches of Physical Geography; interrelations of geography with physical science and social sciences.
- UNIT II** Geomorphic Processes: Weathering, Mass Wasting, Cycle of Erosion (Davis)
- UNIT III** Forces affecting Earth's crust (endogenetic and exogenetic forces); Major landforms (Types and classification of Mountains and Plains)
- UNIT IV** Origin and types of rocks; classification of igneous, sedimentary and metamorphic rocks.
- UNIT V** Soils: process of soil formation and soil types

**Recommended Books and References:**

1. Bryant, H. Richard (2001): **Physical Geography Made Simple**, Rupa and Company, New Delhi.
2. Bunnett, R.B. (2003): **Physical Geography in Diagrams**, Fourth GCSE edition, Pearson Education (Singapore) Private Ltd.
3. Hugget, R.J. (2003): **Fundamentals of Geomorphology**, Routledge, London.
4. Monkhouse, F.J. (1979): **Physical Geography**, Methuen, London.
5. Negi, B.S. (2000): **Physical Geography**, Kedar Nath Ram Nath, Meerut.
6. Singh, S. (2003): **Physical Geography**, Prayag Pustak Bhawan, Allahabad. (2007): **Physical Geography**, Lakshmi Narain Agarwal, Agra.
7. Sharma, Y.K. (2007): **Physical Geography**, Lakshmi Narain Agarwal, Agra.
8. Strahler, A.N. and Strahler, A.M. (1992): **Modern Physical Geography**, John Wiley and Sons, New York.
9. Thornbury, W.D. (1960): **Principles of Geomorphology**, John Wiley & Sons, New York.
10. Wooldrige, S.H and Morgan, R.S. (1959): **The Physical Basis of Geography** –An Outline of Geomorphology, Longman Green & Co., London

**GENERIC ELECTIVE 1 (GGG 1.12)**  
**THEMATIC CARTOGRAPHY**

*Practical Credit: 2*

*Teaching Hours: 30*

- UNIT I** Concept of map and types of maps.
- UNIT II** Types of scale; preparation of scale: simple, comparative and diagonal.
- UNIT III** Enlargement and Reduction of map by graphical method, combination of maps of different scales.
- UNIT IV** Viva voce and Practical Notebook.

**Recommended Books and References:**

9. Binch, T.W. (1968): **Maps: Topographical and Statistical**, Clarendon Press, Oxford.
10. Khan, Md. Z.A. (1998): **Text Book of Practical Geography**, Concept Publishing, New Delhi.
11. Lowmberg, J.F. and Aldrich, F.T. (1979): **Introduction to Geographical Methods and Techniques**, Charles Marlin, Columbus.
12. Mishra, R.P. and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi.
13. Mohammad, N. (2008): **Practical Work in Geography**, Sunflower Publishers, New Delhi.
14. Sarkar, A.K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata.
15. Singh, L.R. (2006): **Fundamentals of Practical Geography**, Sharda Pustak Bhawan, Allahabad.
16. Singh, R.L. and Singh, Rana P.B. (1993): **Elements of Practical Geography**, Kalyani Publishers, New Delhi.

**GENERIC ELECTIVE 2 (GGG 2.11)  
HUMAN GEOGRAPHY**

*Theory Credit: 4*

*Teaching Hours: 60*

**Objective:** *To acquaint the students with the nature of man- environment relationship and to make them understand the spatial distribution of different racial groups.*

**UNIT I** Human Geography-meaning, nature and scope; branches of Human geography.

**UNIT II** Man-environment dynamic relationships; determinism and possibilism.

**UNIT III** Physical, economic and social factors influencing spatial distribution of world population, distribution and density of population

**UNIT IV** Concept of over population, under population and optimum population; Migration: types and consequences.

**UNIT V** Settlement: Geographical factors influencing human settlement; rural and urban settlement (Types and patterns)

**Recommended Books and References:**

10. Beyman, E.F. (1995): **Human Geography – Culture, Connections and Landscape**, Prentice Hall, New Jersey.
11. Hazra, Jayati et al., (1977): **Dimensions of Human Geography**, Rawat Publications, Jaipur.
12. Hopkins, I. (1982): **An Introduction to Human Geography**, Widenfield and Nicolson, London.
13. Hussain, M. (1994): **Human Geography**, Rawat Publications, Jaipur.
14. James, R. (2010): **The Cultural Landscape – An Introduction to Human Geography**, Prentice Hall of India, New Delhi.
15. Leong Goh Cheng (2003): **Physical and Human Geography**, Oxford University Press, New Delhi.
16. Norton, W. (1995): **Human Geography**, Oxford University Press, New York.



17. Singh, L.R. (2005): **Fundamentals of Human Geography**, Sharda Pustak Bhawan, Allahabad.
18. Stoddard, R.H., Wishart, D.J. and Blouet, B.W.: **Human Geography**, Prentice-Hall, Englewood Cliffs, New Jersey.

**GENERIC ELECTIVE 2 (GGG 2.12)  
GENERAL CARTOGRAPHY**

*Practical Credit: 2*

*Teaching Hours: 30*

- UNIT I** The nature and scope of cartography, developments and trend, traditional versus modern cartography
- UNIT II** Diagrammatic population data presentation by Line, bar, circle
- UNIT III** Representation of population data: Distribution, density and growth by dots and proportionate circles; Age-sex pyramid.
- UNIT IV** Viva voce and Practical Note book.

**Recommended Books and References:**

7. Kanetker, T.P. and Kulkarni, S.V. (1967): **Surveying and Levelling**, (Vol I and II), V.G. Prakashan, Poona
8. Mishra, R.P. and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi.
9. Sarkar, A. K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata
10. Singh, L.R. (2006): **Fundamentals of Practical Geography**, Sharda Pustak Bhawan, Allahabad.
11. Steers, J. A. (1965): **An Introduction to the Study of Map Projection**, University of London Press, London
12. Talukdar, S. (2008): **Introduction to Map Projection**, EBH Publishers, Guwahati.

**GENERIC ELECTIVE 3 (GGG 3.11)  
GEOGRAPHY OF INDIA**

*Theory Credit: 4*

*Practical Hours: 60*

**Objectives:** *Aims and presenting a comprehensive, integrated and empirically based profile of India so as to sensitize the students with development issues, policies and programmes designed to regional development.*

- UNIT I** Physiographic features, Climate, soil
- UNIT II** Population characteristics: population growth, distribution and density, sex ratio
- UNIT III** Agriculture: agricultural development, modernisation of Indian agriculture (Green Revolution, yellow revolution), Agricultural Trade (Wheat, Rice)

**UNIT IV** Transport: Roads and railways, air transport and pipe transport

**UNIT V** Industry: Industrial development and Indian economy, distribution of major industries (cotton textile, Iron Steel and cement industries).

**Recommended Books and References:**

11. Gautam, A. (2006): **Advanced Geography of India**, Sharda Pustak Bhawan, Allahabad.
12. Gopal Singh (1992): **AGeography of India**, Atma Ram & Sons, Lucknow.
13. Khullar, D.R. (2007): **A Comprehensive Geography**, Kalyani Publishers, New Delhi.
14. Kundee, A. (1992): **Urban Development Urban Research in India**, Khanna Pub.l, New Delhi.
15. Nag, P. and Gupta, S.S. (1992): **Geography of India**, Concept Publishing Company, New Delhi.
16. Premi, M.K. (2007): **Population of India**, NBT, New Delhi.
17. Singh, J. (2003): **India: A Comprehensive Systematic Geography**, GyanodayaPrakashan, Gorakhpur.
18. Singh, R.L. (ed.) (1971): **India: A Regional Geography**, National Geographical Society of India, Varanasi.
19. Srinivasan, K.andVlassoff, M.(2001): **Population and Development Nexus in India, Challenges for the new Millenium**, Tata Mc GrawHill, New Delhi.
20. Tiwari, R.C. (2007): **Geography of India**, PrayagPustak Bhawan, Allahabad.

**GENERIC ELECTIVE 3 (GGG 3.12)**

**INTRODUCTION TO STATISTICAL METHOD**

*Practical Credit: 2*

*Teaching Hours: 30*

**UNIT I** Sampling- Types and their Uses

**UNIT II** Statistical methods: Measures of central tendency (Mean, Median and Mode), Measures of dispersion (Mean deviation, Quartile deviation and Standard deviation)

**UNIT III** Chorochromatic mapping of population data (Density, Sex ratio, Literacy rate)

**UNIT IV** Practical notebook and viva voce.

**Recommended Books and References:**

9. Talukdar, S. (2008): **Introduction to Map Projection**, EBH Publishers, Guwahati
10. Sarkar, A. K. (1997): **Practical Geography: A Systematic Approach**, Orient Longman, Kolkata
11. Singh, L.R. (2006): **Fundamentals of Practical Geography**, Sharda Pustak Bhawan, Allahabad.
12. Steers, J. A. (1965): **An Introduction to the Study of Map Projection**, University of London Press, London
13. Mishra, R.P.and Ramesh A. (1989): **Fundamentals of Cartography**, Concept Publishing Company, New Delhi

**GENERIC ELECTIVE 4 (GGG 4.11)**  
**REGIONAL GEOGRAPHY OF NORTHEAST INDIA AND NAGALAND**

*Theory Credit: 4*

*Teaching Hours: 60*

**Objective:** *To understand the geographical settings of North-East India with special reference to Nagaland and analyze the regions potentiality for sustainable development.*

- UNIT I** Northeast India: Locational significance; Physical characteristics- Physiography, climate, soil and natural vegetation
- UNIT II** Population of NE India: Growth, Distribution and Density, Age-Sex composition, Rural-Urban composition
- UNIT III** Economic basis of NE India: Agriculture, Industries, Transport and communication system; Socio-economic problems
- UNIT IV** Nagaland: Locational significance, physiography, Population growth and distribution
- UNIT V** Economic Attributes of Nagaland: Tourism and its potential, Problems and prospects of various economic activities, Biodiversity and its conservation issues

**Recommended Books and References:**

1. Bhagabati, A.K.(ed): **Biodiversity of Assam**, Eastern Book House, Guwahati.
2. Bhattacharyya, N.N.(2005): **North East India: A systematic Geography**, Rajesh Pub. New Delhi.
3. Gopal Krishnan, R. : **Geography of North East India**
4. **Gopal Krishnan R. (1991): North-East India: Land, People and Economy, Vikash Publishing House, New Delhi.**
5. Sebu, Sonyhulo (2013): **Geography of Nagaland**, Spectrum Publications Guwahati, Delhi.
6. Singh, S. (1994): **Agricultural Development in India : A Regional Analysis**, Kaushal Publ., Shillong.
7. Taher, M. and Ahmed, P.(1988): **Geography of North East India**, Mani Manik Prakash, Guwahati.

**GENERIC ELECTIVE 4 (GGG 4.12)**  
**PAPER PRESENTATION**

*Practical Credit: 2*

*Teaching Hours: 30*

**NOTE:** Students will be assigned topics based on the theory paper for presentation. They would be assessed on the following:

- a) Report writing
- b) Presentation
- c) Viva-voce

**GENERIC ELECTIVE  
GEOLOGY**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Essentials of Geology (Theory)	GLG 1.11(a)	4
		OR Earth Surface Processes (Theory)	GLG 1.11(b)	
		Essentials of Geology (Practical)	GLG 1.12(a)	2
		OR Earth Surface Processes (Practical)	GLG 1.12(b)	
<b>II</b>	Generic Elective 2	Rocks and Minerals (Theory)	GLG 2.11(a)	4
		OR Soils: Present and Past (Theory)	GLG 2.11(b)	
		Rocks and Minerals (Practical)	GLG 2.12(a)	2
		OR Soils: Present and Past (Practical)	GLG 2.12(b)	
<b>III</b>	Generic Elective 3	Fossils and their Applications (Theory)	GLG 3.11(a)	4
		OR Earth Resources (Theory)	GLG 3.11(b)	
		Fossils and their Applications (Practical)	GLG 3.12(a)	2
		OR Earth Resources (Practical)	GLG 3.12(b)	
<b>IV</b>	Generic Elective 4	Natural Hazards and Disaster Management (Theory)	GLG 4.11(a)	4
		OR Nuclear Waste Management (Theory)	GLG 4.11(b)	
		Natural Hazards and Disaster Management (Practical)	GLG 4.12(a)	2
		OR Nuclear Waste Management (Practical)	GLG 4.12(b)	

**GENERIC ELECTIVE 1 (GLG 1.11(a))  
ESSENTIALS OF GEOLOGY**

*Theory Credit: 4*

- UNIT I** Introduction to geology, scope, sub-disciplines and relationship with other branches of sciences
- UNIT II** Earth in the solar system, origin  
Earth's size, shape, mass, density, rotational and evolutionary parameters  
Solar System- Introduction to Various planets - Terrestrial Planets and Jovian Planets  
Internal constitution of the earth - core, mantle and crust
- UNIT III** Convections in the earth's core and production of magnetic field. Origin and composition of hydrosphere and atmosphere
- UNIT IV** Origin of biosphere, Origin of oceans, continents and mountains
- UNIT V** Age of the earth; Radioactivity and its application in determining the age of the Earth, rocks, minerals and fossils

**GENERIC ELECTIVE (GLG 1.12(a))  
ESSENTIALS OF GEOLOGY**

*Practical Credit: 2*

1. Study of major geomorphic features and their relationships with outcrops through physiographic models.
2. Study of topographic sheets and preparation of physiographic description of an area
3. Study of soil profile of any specific area
4. Study of distribution of major litho stratigraphic units on the map of India
5. Study of distribution of major dams on map of India and their impact on river systems
6. Study of major ocean currents of the World
7. Study of seismic profile of a specific area and its interpretation

***Recommended Books and References:***

1. Holmes' Principles of Physical Geology. 1992. Chapman & Hall.
2. Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment., Cambridge University Press.
3. Gross, M.G., 1977. *Oceanography: A view of the Earth*, Prentice Hall.

**GENERIC ELECTIVE (GLG 1.11(b))  
EARTH SURFACE RESOURCES**

*Theory Credit: 4*

- UNIT I** Historical development in concepts, terrestrial relief, scales in geomorphology.

- UNIT II** Weathering and formation of soils, karst and speleology, slope and catchment erosion processes, fluvial, aeolian, glacial, peri-glacial and coastal processes and resultant landforms, , Water and sediment flux in river systems, Morphometric analysis of drainage basin and geomorphology-hydrology relationship.
- UNIT III** Techniques for measuring rates of processes: sediment budgeting, rock magnetism, isotope geochemical tracers, cosmogenic nuclides, OSL & C-14 dating.
- UNIT IV** Controlling factors (tectonics, climate, sea level changes and anthropogenic) and surface Processes Climate change and geomorphic response of fluvial systems of arid and humid regions. Geomorphic response to tectonics, sea level/base level change, anthropogenic affects. Introduction to Anthropocene.
- UNIT V** Spatial & temporal scales, geomorphic system, connectivity, buffering, magnitude-frequency concept, time lag, sensitivity, equilibrium, threshold, non-linearity & complexities. Mega geomorphology and process interrelationship. Surface processes and natural hazards; Applied aspects of geomorphology; Introduction to planetary geomorphology.

**COURSE (GEOL 1.12(b))  
EARTH SURFACE RESOURCES**

*Practical Credit: 2*

Mapping of different landforms and interpretation of surface processes  
Exercises on hill slope development, fluvial channel, sediment erosion and transport, sediment budgeting, aggradation and degradation events, drainage basin, drainage morphometry  
Basic exercises on computation of rate for different surface processes

**Recommended Books and References:**

1. Alien, P.A., 1997. *Earth Surface Processes*, Blackwell publishing.
2. Bloom, A.L., 1998. *Geomorphology: A Systematic Analysis of Late Cenozoic Landforms*, Pearson Education.
3. Bridge, J.S. and Demicco, R.V., 2008. *Earth Surface Processes, Landforms and Sediment Deposits*, Cambridge University Press.
4. Esterbrook, D.J., 1992. *Surface Processes and Landforms*, MacMillan Publ.
5. Kale, V.S. and Gupta A 2001 *Introduction to Geomorphology*, Orient Longman Ltd.
6. Leeder, M. and Perez-Arlucea M 2005 *Physical processes in earth and environmental sciences*, Blackwell' publishing.
7. Summerfield M A 1991 *Global Geomorphology* Prentice Hall.
8. Wilcock, P.R., Iverson R M (2003) *Prediction in geomorphology* ' AGU Publication.

**GENERIC ELECTIVE (GLG 2.11(a))  
ROCKS AND MINERALS**

*Theory Credit: 4*

- UNIT I** Minerals-Definitions, Physical properties of minerals: Color, Lustre, transparency and translucency, form, hardness, fracture, streak, cleavage, specific gravity.

- UNIT II** Study of Petrological microscope, nature of light, Isotropic and Anisotropic substances, Refractive Index, Interference color, Extinction, Pleochroism absorption, twinning.
- UNIT III** Crystal: definition and characteristics- face, edge, solid angle, zone, zone axis, interfacial angle parameters and indices. Crystallographic axes, axial ratio and symmetry, common crystal forms.
- UNIT IV** Rocks- Definitions and types, Igneous rock- magma generation and differentiation, Metamorphic rocks- chemical system and types of metamorphism
- UNIT V** Sedimentary rocks: sedimentary processes- physical, chemical and biological weathering, transportation, diagenesis. Genetic classification of sedimentary rocks.

**GENERIC ELECTIVE (GLG 2.12(a))  
ROCKS AND MINERALS**

*Practical Credit: 2*

1. Study of physical properties of minerals
2. Introduction to optical microscopy
3. Study of optical properties of minerals
4. Study of physical properties of rocks
5. Study of optical properties of rock under thin sections
6. Understanding crystal symmetry via wooden models
7. Stereographic projection of mineral faces
8. Mineral formula calculation
9. Crystal chemical calculation
10. Introduction to analytical techniques for rock and mineral study.

***Recommended Books and References:***

1. Earth Materials- Introduction to Mineralogy and Petrology, Cornelis Klein and Anthony Philpotts, Cambridge University Press, 2013.
2. Understanding Earth (Sixth Edition), John Grotzinger and Thomas H. Jordan, 2010, W.H. Freeman and company, New York.

**GENERIC ELECTIVE (GLG 2.11(b))  
SOILS: PRESENT AND PAST**

*Theory Credit: 4*

- UNIT I** Soil forming processes: Physical weathering, loosening and particle size reduction; pressure release; thermal expansion; growth of foreign crystal.
- UNIT II** Soil structures; horizons; roots; Fe-Mn mottles and concretions; pedogenic carbonate. Introduction to paleopedology and paleosols; role of factors controlling paleosol formation- parent material, climate, vegetation, topography, time.

- UNIT III** Introduction to soil taxonomy and paleosol taxonomy. Micromorphology: Thin section analysis of paleosols. Geochemistry: molecular ratios; chemical weathering indices.
- UNIT IV** Diagenetic overprinting in fossil soils: compaction; oxidation of organic matter; cementation; Illitization. Geological record of fossil soils.
- UNIT V** Pleistocene-Holocene paleosols- human impact on landscape and soils, climate change, neotectonics. Paleosols and non-marine sequence stratigraphy based on paleopedology and sedimentology of fluvial successions.

**GENERIC ELECTIVE (GLG 2.12(B))**

**SOILS: PRESENT AND PAST**

*Practical Credit: 2*

1. Micromorphic detailing of the paleosols- structure, horizonation, color, rhizcretions, Pedogenic carbonate etc.
2. Particle size analysis and clay mineral analysis of the paleosols
3. Micromorphological analysis- thin section preparation, description, and interpretation
4. Geochemical analysis- bulk geochemistry, molecular ratios and weathering indices
5. Field trip to examine modern and fossil soils- field characterization and sampling procedures

**Recommended Books and References:**

1. Retallack, G.J. (2001) *Soils of the Past: An Introduction to Paleopedology* (2nd edition): Oxford, Blackwell Science, Ltd., 416 p.
2. Birkeland, P.W. (1999) *Soil and Geomorphology*. Oxford University Press (430 pp.). reconstruction using paleosols. *Earth-Science Reviews* 95, 1–52.
5. Stoops, G. (2003) *Guidelines for analysis and distribution of soil and regolith thin sections*. SoilSci. Soc. Am., Madison, Wisconsin, 184 pp.
7. Bhattacharyya T., Sarkar, D., Pal, D. K. (Eds.) **Soil Survey Manual**. NBSSLUP Publication No

**GENERIC ELECTIVE (GLG 3.11(a))**

**FOSSILS AND THEIR APPLICATION**

*Theory Credit: 4*

- UNIT I** Definition of fossil, Types, fossilization processes (taphonomy), modes of fossil preservation, fossils sampling techniques, uses of fossils
- UNIT II** Definition of species, speciation, methods of description and naming of fossils, code of systematic nomenclature
- UNIT III** Brief introduction of important fossils groups: invertebrate, vertebrate, microfossils, spore, pollens and plant fossils. Important age-diagnostic fossiliferous horizons of India
- UNIT IV** Principles and methods of paleoecology, application of fossils in the study of paleoecology, paleobiogeography and paleoclimate



**UNIT V** Morphological study and geological distribution of the following classes: brachiopoda, lamellibranchia, gastropoda and cephalopoda.

**GENERIC ELECTIVE (GLG 3.12(a))  
FOSSILS AND THEIR APPLICATIONS**

*Practical Credit: 2*

1. Study of fossils showing various modes of fossilization
2. Distribution of age diagnostic fossils in India
3. Biostratigraphic correlation

**Recommended Books and References:**

1. Schoch, R.M. 1989. Stratigraphy, Principles and Methods. VanNostrand Reinhold.
2. Clarkson, E.N.K. 1998. Invertebrate Paleontology and Evolution George Allen&Unwin
3. Prothero, D.R. 1998. Bringing fossils to life - An introduction to Paleobiology, McGraw Hill.
4. Benton, M.J. 2005. Vertebrate paleontology (3rd edition). Blackwell Scientific, Oxford.
5. Colbert's Evolution of the Vertebrates: A History of the Backboned Animals Through Time, Edwin H. Colbert, Michael Morales, Eli C. Minkoff, John Wiley & Sons, 1991.

**GENERIC ELECTIVE (GLG 3.11(B))  
EARTH RESOURCES**

*Theory Credit: 4*

**UNIT I** Resource and reserve definitions; mineral, energy and water resources.

**UNIT II** Definition of Energy: Primary and Secondary Energy. Difference between Energy, Power and Electricity. Renewable and Non-Renewable Sources of Energy.

**UNIT III** Major Types and Sources of Energy: Natural Oil and Gas, Coal and Nuclear Minerals. Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass based power and energy.

**UNIT IV** Ground water resources and its role in economic development of a country. Impact of urbanization on groundwater.

**UNIT V** Metallic and non-metallic mineral deposits and their conservation. The concept and significance of Renewability: Social, Economic, Political and Environmental Dimension of Energy.

**GENERIC ELECTIVE (GLG 3.12(b))  
EARTH RESOURCES**

*Practical Credit: 2*

1. Plotting of major Indian oil fields on map of India
2. Problems related to hydroelectric power generation
3. Problems related to assessment of possible oil exploration site from geological maps
4. Problems related to energy demand projection of India and possible mitigation pathways
5. Problems related to bio fuel

***Recommended Books and References:***

1. Energy and the Environment by Fowler, J.M 1984. McGraw-Hill
2. Global Energy Perspectives by Nebojsa Nakicenovic 1998, Cambridge University Press.
3. Energy Resources and Systems: Fundamentals and Non-Renewable Resources by Tushar K. Ghosh and M. A. Prelas. 2009, Springer

**GENERIC ELECTIVE (GLG 4.11(a))  
NATURAL HAZARDS AND DISASTER MANAGEMENT**

*Theory Credit: 4*

- UNIT I** The Lithosphere and Related Hazards  
Atmospheric Hazards, Hydrosphere and Related Hazards
- UNIT II** Types of disaster: natural and manmade - cyclone, flood, land slide, land subsidence, fire and earthquake, tsunami and volcanic eruption
- UNIT III** Disaster management, mitigation, and preparedness, Techniques of monitoring and design against the disasters, Management issues related to disaster
- UNIT IV** Risk, Vulnerability and Hazard, Mitigation through capacity building, Pre-disaster risk & vulnerability reduction, Post disaster recovery & rehabilitation
- UNIT V** Prevention and rehabilitation: Emergency alert System, Management, Bhopal Gas leak disaster. Disaster related infrastructure development

**GENERIC ELECTIVE (GLG 4.12(a))  
NATURAL HAZARDS AND DISASTER MANAGEMENT**

*Practical Credit: 2*

Trainings in first aid, relief, rescue and mock drill.

The course will also include discussions on topics assigned to students based on their interest.

***Recommended Books and References:***

1. Bell, F.G., 1999. Geological Hazards, Routledge, London.
2. Bryant, E., 1985. Natural Hazards, Cambridge University Press.
3. Smith, K., 1992. Environmental Hazards. Routledge, London.

4. Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International

**GENERIC ELECTIVE (GLG 4.11(b))  
NUCLEAR WASTE**

*Theory Credit: 4*

- UNIT I** Nuclear reactors and generation of nuclear waste, nuclear fuel cycle.
- UNIT II** Basic concepts about nuclear wastemanagement. Classification, composition and types of nuclear waste, their sources and characteristics.
- UNIT III** Introduction to immobilization and vitrification processes. Nuclear waste forms and containments. Immobilization of nuclear waste in synthetic glasses and natural glass/rocks (acidic: obsidian, rhyolite and basic: nephiliniite and basaltic).
- UNIT IV** Glass/rock characterization and its long-term performance assessment. Geochemistry of glass/rock-water interaction-solution and neoformed mineral chemistry.
- UNIT V** Nuclear waste confinement and safe disposal in deep geological repository. Application of clays as natural barrier.

**GENERIC ELECTIVE (GLG 4.12(b))  
NUCLEAR WASTE**

*Practical Credit: 2*

1. Determination of physical properties such as hardness, durability, melting and pouring temperatures.
2. Chemical characterization of synthetic and natural glass.
3. Mathematical modeling and extrapolation of synthetic glass alterations.
4. Mathematical modelling and extrapolation of natural acidic (obsidian, rhyolite) and Basic (nephilinite and basaltic) glasses.
5. Determination of rate of alteration and recognition of neo-formed minerals.
6. Calculation of retention coefficient for glass residue.

**Recommended Books and References:**

1. Saling, J. (2001). Radioactive waste management. CRC Press.
2. Ojovan, M. I., & Lee, W. E. (2013). An introduction to nuclear waste immobilisation. Newnes.
3. T.G. Wolery: reaction path modeling of aqueous geochemical systems.
4. Bethke, C. M. (2007). Geochemical and biogeochemical reaction modeling. Cambridge University Press.

**GENERIC ELECTIVE  
MATHEMATICS**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
I	Generic Elective 1	Calculus (Theory) OR Object Oriented Programming in C++ OR Finite Element Methods	MAG 1.11(a)  MAG 1.11(b)  MAG 1.11(c)	5  4  5
		Calculus (Tutorial) OR Object Oriented Programming in C++(Practical) OR Finite Element Methods (Tutorial)	  MAG 1.12(b)	1  2  1
		Algebra (Theory) OR Mathematical Finance (Theory) OR Econometrics (Theory)	MAG 2.11(a)  MAG 2.11(b)  MAG 2.11(c)	5
		Algebra (Tutorial) OR Mathematical Finance (Tutorial) OR Econometrics (Tutorial)		1
		Vectors and Analytical Geometry (Theory) OR Cryptography and Network Security (Theory) OR Information Security (Theory)	MAG 3.11(a)  MAG 3.11(a)  MAG 3.11(a)	5
III	Generic Elective 3	Vectors and Analytical Geometry (Tutorial) OR Cryptography and Network Security (Tutorial) OR Information Security (Tutorial)		1
		Differential Equations and Higher Trigonometry (Theory) OR Applications of Algebra (Theory) OR Combinatorial Mathematics (Theory)	MAG 4.11(b)  MAG 4.11(b)  MAG 4.11(a)	5
IV	Generic Elective 4	Differential Equations and Higher Trigonometry (Tutorial) OR Applications of Algebra (Tutorial) OR Combinatorial Mathematics (Tutorial)		1

**GENERIC ELECTIVE 1 (MAG 1.11(a))**  
**CALCULUS**

*Theory Credit: 5*

*Tutorial Credit: 1*

- UNIT I** Successive differentiation:  $n^{\text{th}}$  derivative of functions. Formation of equation involving derivatives. Leibnitz formula for the  $n^{\text{th}}$  order derivative of a product. The meaning of derivative. Meaning of the sign of the differential coefficients. Rate of change of variables, velocity and acceleration
- UNIT II** Rolle's theorem, Mean value theorems (statement and proof), applications on inequality. application based on theory of equations and numerical analysis need to be done). Indeterminate forms (l'Hospital's Rule) (Proof & Problems). Asymptotes.
- UNIT III** Taylor's theorem, (Cauchy's form of remainder, Lagrange's form of remainder) Maclaurin theorem. (Proof and problems) Expansion of functions, Limits using Taylors theorem. (as applications)
- UNIT IV** (All the integrals can be definite and indefinite ones). Integrals of irrational functions. Properties of definite integrals (Proof and problems). Reduction formulas (Both definite and indefinite integrals need to be done). Bernoulli's formula (Integration by parts). Improper integrals, Comparison test for improper integrals. Beta and Gamma functions. Applications of Beta and Gamma functions in evaluating some definite integrals.
- UNIT V** Cylindrical Coordinates.Spherical Coordinates. Quadrature (Cartesian, polar coordinate, Parametric curves). Volume of solid of revolution(methods of cylinder, Method of rings), Length of curve. Area of surface of revolution (Cartesian,Parametric curves, polar coordinates.), Theorems of Pappus – Guldinus.

***Recommended Books and References:***

1. A Text book on Differential Calculus by A.K. Sharma
2. Differential Calculus by Ghosh &Maity
3. A Text book on Integral Calculus by A.K. Sharma
4. Integral Calculus by Ghosh &Maity

**GENERIC ELECTIVE 1 (MAG 1.11(b))**  
**OBJECT ORIENTED PROGRAMMING IN C++**

- UNIT I** OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages,
- UNIT II** Object-based programming languages C++: Brief History of C++, Structure of a C++ program, Difference between C and C++ - cin, cout, new, delete operators, ANSI/ISO Standard C++, Comments, Working with Variables and const Qualifiers. Enumeration, Arrays and Pointer.
- UNIT III** Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value, Using Reference variables with Functions.

**UNIT IV** Abstract data types, Class Component, Object & Class, Constructors Default and Copy Constructor, Assignment operator deep and shallow coping, Access modifiers – private, public and protected. Implementing Class Functions within Class declaration or outside the Class declaration. instantiation of objects, Scope resolution operator, Working with Friend Functions, Using Static Class members.

**UNIT V** Understanding Compile Time Polymorphism function overloading Rules of Operator Overloading (Unary and Binary) as member function/friend function, Implementation of operator overloading of Arithmetic Operators, Overloading Output/Input, Prefix/Postfix Increment and decrement Operators, Overloading comparison operators, Assignment, subscript and function call Operator, concepts of namespaces.

*Practical to be performed in lab.*

**Recommended Books and References:**

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, *Mastering C++*, TMH, 1997.
2. S. B. Lippman and J. Lajoie, *C++ Primer, 3rd Ed.*, Addison Wesley, 2000.
3. Bruce Eckel, *Thinking in C++, 2nd Ed.*, President, Mindview Inc., Prentice Hall.
4. D. Parasons, *Object Oriented Programming with C++*, BPB Publication.
5. Bjarne Stroustrup, *The C++ Programming Language, 3rd Ed.*, Addison Welsley

**GENERIC ELECTIVE 1 (MAG 1.11(c))**

**FINITE ELEMENT METHODS**

**UNIT I** Introduction to finite element methods, comparison with finite difference methods, Methods of weighted residuals, collocations, least squares and Galerkin's method. Variational formulation of boundary value problems equivalence of Galerkin and Ritz methods.

**UNIT II** Applications to solving simple problems of ordinary differential equations.

**UNIT III** Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system.

**UNIT IV** Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly, discretization with curved boundaries

**UNIT V** Interpolation functions, numerical integration, and modeling considerations. Solution of two dimensional partial differential equations under different Geometric conditions

**Recommended Books and References:**

1. J.N. Reddy, *Introduction to the Finite Element Methods*, Tata McGraw-Hill, 2003.
2. K.J. Bathe, *Finite Element Procedures*, Prentice-Hall, 2001.
3. R.D. Cook, D.S. Malkus and M.E. Plesha, *Concepts and Applications of Finite Element Analysis*, John Wiley and Sons, 2002.
4. Thomas J.R. Hughes, *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*, Dover Publication, 2000.
5. George R. Buchanan, *Finite Element Analysis*, McGraw Hill, 1994.

## **GENERIC ELECTIVE 2 (MAG 2.11(a))**

### **ALGEBRA**

*Theory Credit: 5*

*Tutorial Credit: 1*

#### **UNIT I Sequence**

The Bounds of a set. Greatest Lower Bound (GLB or Infimum), Least Upper Bound (LUB or Supremum) of a set. Triangle inequality ( $|x \pm y| \leq |x| + |y|$ ,  $|x \pm y| \geq ||x| - |y||$ ). Definition of a sequence. Types of sequences. Limit of sequence. Convergence and divergence of a sequence. Algebra on the limits of converging sequences. Result on convergence of bounded monotonic sequence to be discussed. Examples and counter examples need to be discussed.

#### **UNIT II Series**

Definition of a series. Sum of a series. Convergence and divergence of a series.  $\lim_{n \rightarrow \infty} u_n = 0$  where  $u_n$  is the  $n^{\text{th}}$  term of a convergent series. Counter example. Tests for convergence of a series. Comparison test, Ratio test, Integral test. Absolute and conditional convergence. Alternating series test.

#### **UNIT III Theory of Equations**

Definition of polynomial and algebraic equation. Degree of an equation. Remainder theorem. Even and odd functions. Number of real roots of even and odd functions depending on their values at two different points. Descartes rule of signs. (Proof is not necessary).  $n^{\text{th}}$  degree equation cannot have more than  $n$  roots. Equations with real coefficients will have complex roots and irrational roots occurring in conjugate pair. Relation between the roots and coefficients. Symmetric functions of roots. Sum of the powers of roots of an equation. Transformations of equations. Reciprocal equations. Removal of terms, Cardan's Method.

#### **UNIT IV Abstract Algebra**

Binary operation. Definitions of Associativity, Commutativity, Identity, and Inverse. Problems. Definition of a Group. Finite and infinite groups. Abelian group. Cyclic group. Examples. Subgroup. Characterisation of subgroup. Union and intersection of subgroups.

**UNIT V** Order of an element, Order of a Subgroup. Examples on integer modulo  $p$  and permutation group on 3,4 symbols to be discussed. Cosets. Properties of cosets. Lagrange's Theorem on finite group. Number of generator of a finite cyclic group.

#### **Recommended Books and References:**

1. Higher Algebra by Ghosh & Maity
2. Algebra and Trigonometry by G.C. Sharma & Madhu Jain
3. A Text Book on Modern Algebra by R. S. Aggarwa

**GENERIC ELECTIVE 2 (MAG 2.11(b))**  
**MATHEMATICAL FINANCE**

- UNIT I** Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), comparison of NPV and IRR. Bonds, bond prices and yields,
- UNIT II** Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value, floating-rate bonds, immunization, convexity, puttable and callable bonds.
- UNIT III** Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance,
- UNIT IV** Diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints), Two fund theorem, risk free assets, One fund theorem,
- UNIT V** Capital market line, Sharpe index. Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen's index.

**Recommended Books and References:**

1. David G. Luenberger, *Investment Science*, Oxford University Press, Delhi, 1998.
2. John C. Hull, *Options, Futures and Other Derivatives*, 6th Ed., Prentice-Hall India, Indian reprint, 2006.
3. Sheldon Ross, *An Elementary Introduction to Mathematical Finance*, 2nd Ed., Cambridge University Press, USA, 2003.

**GENERIC ELECTIVE 2 (MAG 2.11(c))**  
**ECONOMETRICS**

- UNIT I** Statistical Concepts Normal distribution; chi-square, t and F-distributions; estimation of parameters; properties of estimators; testing of hypotheses: defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors; power of a test; tests for comparing parameters from two samples.
- UNIT II** Simple Linear Regression Model: Two Variable Case Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit; tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem; forecasting.
- UNIT III** Multiple Linear Regression Model Estimation of parameters; properties of OLS estimators; goodness of fit -  $R^2$  and adjusted  $R^2$ ; partial regression coefficients; testing hypotheses – individual and joint; functional forms of regression models; qualitative (dummy) independent variables.



**UNIT IV** Violations of Classical Assumptions: Consequences, Detection and Remedies  
Multicollinearity; heteroscedasticity;

**UNIT V** Serial correlation. Specification Analysis Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors.

**Recommended Books and References:**

1. Jay L. Devore, *Probability and Statistics for Engineers*, Cengage Learning, 2010.
2. John E. Freund, *Mathematical Statistics*, Prentice Hall, 1992.
3. Richard J. Larsen and Morris L. Marx, *An Introduction to Mathematical Statistics and its Applications*, Prentice Hall, 2011.
4. D. N. Gujarati and D.C. Porter, *Essentials of Econometrics*, McGraw Hill, 4th Ed., International Edition, 2009.
5. Christopher Dougherty, *Introduction to Econometrics*, Oxford University Press, 3rd Ed., Indian edition, 2007.

**GENERIC ELECTIVE 3 (MAG 3.11(a))  
VECTORS & ANALYTICAL GEOMETRY**

*Theory Credit: 5*

*Tutorial Credit: 1*

**UNIT I** Functions of Several Variables. Vector Functions. Calculus with Vector Functions. Limits and continuity. Vector derivative. Tangent, Normal and Binormal Vectors. Arc Length with Vector Functions. Curvature. Velocity and Acceleration. Definition of vector field. Divergence and Curl.

**UNIT II** Line Integral: Definition of line integral. Line integral with respect to  $x$ ,  $y$  and  $z$ . Line integrals of vector fields. The fundamental theorem for line integrals. Conservative vector field. Independence of path. Green's theorem. Area as a line integral. Green's theorem for multiply connected regions. Alternative forms of Green's theorem.

**UNIT III** Normal derivatives. Surface integration. Flux integrals. Integrals over parametrically defined surfaces. Stokes theorem. Theoretical applications of Stokes' theorem. Physical interpretation of Stokes' theorem. Divergence Theorem (Gauss Theorem). Application. Physical interpretation of divergence. (Proofs of Green's, Stokes, Gauss's theorem is not required)

**UNIT IV** **2 - D Geometry**  
Change of axis. Removal of  $xy$  term. Invariants. General equation of 2<sup>nd</sup> degree represents a conic. Tangent to an ellipse. Auxiliary circle, Director circle. Chord of contact. Pole, Polar of an ellipse. Conjugate line with respect to an ellipse. Eccentric angle. Properties of an ellipse. Chord in terms of middle point. Conjugate diameter, properties.

**UNIT V** **3 - D Geometry**  
Introduction. The 3-D Coordinate System. Equations of Lines. Equations of Planes. Quadric Surfaces

**Recommended Books and References:**

1. *A text book of Vector Analysis by Shanti Narayan*
2. *Vector Calculus by G.C Sharma, A.R. Vasishtha*
3. *Analytical Geometry by B. Das*

**GENERIC ELECTIVE 3 (MAG 3.11(b))  
CRYPTOGRAPHY AND NETWORK SECURITY**

- UNIT I** Public Key Cryptography Principles & Applications, Algorithms: RSA, Message Authentication: One way Hash Functions: Message Digest, MD5, SHA1. Public Key Infrastructure: Digital Signatures, Digital Certificates, Certificate Authorities.
- UNITII** Network Attacks: Buffer Overflow, IP Spoofing, TCP Session Hijacking, Sequence Guessing, Network Scanning: ICMP, TCP sweeps, Basic Port Scans; Denial of Service Attacks: SYN Flood, Teardrop attacks, land, Smurf Attacks.
- UNITIII** IP security Architecture: Overview, Authentication header, Encapsulating Security Pay Load, combining Security Associations, Key Management. Virtual Private Network Technology: Tunneling using IPSEC.
- UNITIV** Requirements, Secure Socket Layer, and Secure Electronic Transactions, Network Management Security: Overview of SNMP Architecture- SNMPV1, SNMPV3.Firewall Characteristics & Design Principles,
- UNITV** Types of Firewalls: Packet Filtering Router, Application Level Gateway or Proxy, Content Filters, Bastion Host.

**Recommended Books and References:**

1. W. Stallings, *Networks Security Essentials: Application & Standards*, Pearson Education, 2000.
2. TCP/IP Protocol Suite, *Behrouz A. Forouzan, Data Communication and Networking*, Tata McGraw Hill.
3. W. Stallings, *Cryptography and Network Security, Principles and Practice*, Pearson Education, 2000.

**GENERIC ELECTIVE 3 (3.11(c))  
INFORMATION SECURITY**

- UNIT I** Overview of Security: Protection versus security; aspects of security–data integrity, data availability, privacy; security problems, user authentication, Orange Book.
- UNIT II** Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer over flow; system threats- intruders; communication threats- tapping and piracy.
- UNIT III** Cryptography: Substitution, transposition ciphers, symmetric-key algorithms-Data Encryption Standard, advanced encryption standards, public key encryption - RSA; Diffie Hellman key exchange, ECC cryptography, Message Authentication- MAC, hash functions.

- UNIT IV** Digital signatures: Symmetric key signatures, public key signatures, message digests, public key infrastructures.
- UNIT V** Security Mechanisms: Intrusion detection, auditing and logging, tripwire, system-call monitoring.

**Recommended Books and References:**

1. W. Stallings, *Cryptography and Network Security Principles and Practices*, 4th Ed., Prentice Hall of India, 2006.
2. C. Pfleeger and S.L. Pfleeger, *Security in Computing*, 3rd Ed., Prentice-Hall of India, 2007.
3. D. Gollmann, *Computer Security*, John Wiley and Sons, NY, 2002.
4. J. Piwprzyk, T. Hardjono and J. Seberry, *Fundamentals of Computer Security*, SpringerVerlag Berlin, 2003.
5. J.M. Kizza, *Computer Network Security*, Springer, 2007. 6. M. Merkow and J. Breithaupt, *Information Security: Principles and Practices*, Pearson Education, 2006.

**GENERIC ELECTIVE 4 (MAG 4.11(a))**

**DIFFERENTIAL EQUATIONS**

*Theory Credit: 5*

*Tutorial Credit: 1*

- UNIT I** Differential equations. Equations reducible to homogeneous forms. Bernoulli's equation. Linear equation of 2<sup>nd</sup> order with constant coefficients. Higher order homogeneous equations.
- UNIT II** Exact differential equations. Equations of the first order but of higher degree. Singular solutions.
- UNIT III** Linear equations of second order. Ordinary simultaneous equations. Total Differential Equations, Integration in Series.
- UNIT IV** **Higher Trigonometry**  
Polar form of a complex number. DeMoivre's Theorem. Solutions of equations. Expansion of  $\sin n\theta$ ,  $\cos n\theta$  and  $\tan n\theta$  in terms of powers of  $\sin\theta$ ,  $\cos\theta$  and  $\tan\theta$ . Expansion of  $\sin^n\theta$  and  $\cos^n\theta$  in terms of multiple angle of  $\theta$  of sine and cosine. Series for  $\sin\theta$  and  $\cos\theta$  in powers of  $\theta$ .
- UNIT V** Exponential series for complex quantities, Circular functions for complex angles. Hyperbolic functions. Period of circular functions and Hyperbolic functions. Inverse circular functions and Hyperbolic functions. Logarithm of a complex quantity. Gregory Series. Summation of series.

**Recommended Books and References:**

1. A text book of Differential Equation by N.M.Kapoor
2. Differential Equation by Dr. S. Balachandra Rao &H.R.Anuradha
3. Higher Trigonometry by S.L. Loney

**GENERIC ELECTIVE 4 (MAG 4.11(b))****APPLICATIONS OF ALGEBRA**

- UNIT I** Balanced incomplete block designs (BIBD): definitions and results, incidence matrix of a BIBD, construction of BIBD from difference sets, construction of BIBD using quadratic residues, difference set families, construction of BIBD from finite fields.
- UNIT II** Coding Theory: introduction to error correcting codes, linear codes, generator and parity check matrices, minimum distance, Hamming Codes, decoding and cyclic codes.
- UNIT III** Symmetry groups and color patterns: review of permutation groups, groups of symmetry and action of a group on a set; colouring and colouring patterns, Polya theorem and pattern inventory, generating functions for non-isomorphic graphs.
- UNIT IV** Special types of matrices: idempotent, nilpotent, involution, and projection triangular matrices, circulant matrices, Vandermonde matrices, Hadamard matrices, permutation and doubly stochastic matrices, Frobenius- König theorem, Birkhoff theorem. Positive Semi-definite matrices: positive semi-definite matrices, square root of a positive semi-definite matrix, a pair of positive semi-definite matrices, and their simultaneous diagonalization. Symmetric matrices and quadratic forms: diagonalization of symmetric matrices, quadratic forms, constrained optimization, singular value decomposition, and applications to image processing and statistics.
- UNIT V** Applications of linear transformations: Fibonacci numbers, incidence models, and differential equations. Least squares methods: Approximate solutions of system of linear equations, approximate inverse of an  $m \times n$  matrix, solving a matrix equation using its normal equation, finding functions that approximate data. Linear algorithms: LDU factorization, the row reduction algorithm and its inverse, backward and forward substitution, approximate inverse and projection algorithms.

**Recommended Books and References:**

1. I. N. Herstein and D. J. Winter, *Primer on Linear Algebra*, Macmillan Publishing Company, New York, 1990.
2. S. R. Nagpaul and S. K. Jain, *Topics in Applied Abstract Algebra*, Thomson Brooks and Cole, Belmont, 2005.
3. Richard E. Klima, Neil Sigmon, Ernest Stitzinger, *Applications of Abstract Algebra with Maple*, CRC Press LLC, Boca Raton, 2000.
4. David C. Lay, *Linear Algebra and its Applications*. 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
5. Fuzhen Zhang, *Matrix theory*, Springer-Verlag New York, Inc., New York, 1999.

**GENERIC ELECTIVE 4 (MAG 4.11(c))  
COMBINATORIAL MATHEMATICS**

- UNIT I** Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers
- UNIT II** Principle of Inclusion and Exclusion, Derangements, Inversion formulae Generating functions: Algebra of formal power series,
- UNIT III** Generating function models, Calculating generating functions, Exponential generating functions.  
Recurrence relations: Recurrence relation models, Divide and conquer relations, Solution of recurrence relations, Solutions by generating functions.
- UNIT IV** Integer partitions, Systems of distinct representatives.  
Polya theory of counting: Necklace problem and Burnside's lemma, Cyclic index of a permutation group, Polya's theorems and their immediate applications.
- UNIT V** Latin squares, Hadamard matrices, Combinatorial designs:  $t$  designs, BIBDs, Symmetric designs.

***Recommended Books and References:***

1. J.H. van Lint and R.M. Wilson, A Course in Combinatorics, 2nd Ed., Cambridge University Press, 2001.
2. V. Krishnamurthy, Combinatorics, Theory and Application, Affiliated East-West Press 1985.
3. P.J. Cameron, Combinatorics, Topics, Techniques, Algorithms, Cambridge University Press, 1995.
4. M. Jr. Hall, Combinatorial Theory, 2nd Ed., John Wiley & Sons, 1986.
5. S.S. Sane, Combinatorial Techniques, Hindustan Book Agency, 2013.
6. R.A. Brualdi, Introductory Combinatorics, 5th Ed., Pearson Education Inc., 2009.

**Generic Elective  
PHYSICS**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Mechanics (Theory)	PHG 1.11	4
		Mechanics(Practical)	PHG 1.12	2
<b>II</b>	Generic Elective 2	Electricity and Magnetism(Theory)	PHG 2.11	4
		Electricity and Magnetism(Practical)	PHG 2.12	2
<b>II</b>	Generic Elective 3	Elements of Modern Physics(Theory)	PHG 3.11	4
		Elements of Modern Physics(Practical)	PHG 3.12	2
<b>IV</b>	Generic Elective 4	Waves and Optics(Theory)	PHG 4.11	4
		Waves and Optics(Practical)	PHG 4.12	2

**GENERIC ELECTIVE 1 (PHG 1.11)**  
**MECHANICS**

*Theory Credit:4*

*Teaching Hours: 60*

- UNIT I**    **Vectors:** Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.  
**Laws of Motion:** Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.
- UNIT II**    **Ordinary Differential Equations:** 1<sup>st</sup> order homogeneous differential equations. 2<sup>nd</sup> order homogeneous differential equations with constant coefficients.  
**Oscillations:** Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.
- UNIT III**    **Momentum and Energy:** Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.  
**Rotational Motion:** Angular velocity and angular momentum. Torque. Conservation of angular momentum.
- UNIT IV**    **Gravitation:** Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.  
**Special Theory of Relativity:** Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.
- UNIT V**    **Elasticity:** Hooke's law - Stress-strain diagram - Elastic moduli - Relation between elastic constants - Poisson's Ratio - Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum - Determination of Rigidity modulus and moment of inertia -  $\eta$  and  $\sigma$  by Searles method.

**Note:** *Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate.*

**Recommended Books and References:**

1. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley
2. Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
3. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

## **GENERIC ELECTIVE 1 (PHG 1.12)**

### **MECHANICS**

*Practical Credit: 2*

*Teaching Hours: 60*

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine  $g$  by Bar Pendulum.
8. To determine  $g$  by Kater's Pendulum.
9. To study the Motion of a Spring and calculate (a) Spring Constant, (b)  $g$ .

#### **Recommended Books and References:**

- 1 Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- 2 Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers.
- 3 A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11<sup>th</sup> Edition, 2011, Kitab Mahal, New Delhi.

## **GENERIC ELECTIVE 2 (PHG 2.11)**

### **ELECTRICITY AND MAGNETISM**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** **Vector Analysis:** Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).
- UNIT II** **Electrostatics:** Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential.
- UNIT III** Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.
- UNIT IV** **Magnetism:** Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro-magnetic materials.



**UNIT V Electromagnetic Induction:** Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

**Maxwell's equations and Electromagnetic wave propagation:** Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.

**Recommended Books and References:**

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
2. Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

**GENERIC ELECTIVE 2 (PHG 2.12)  
ELECTRICITY AND MAGNETISM**

*Practical Credit: 2*

*60 Lectures*

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
  - (i) Measurement of charge and current sensitivity
  - (ii) Measurement of CDR
  - (iii) Determine a high resistance by Leakage Method
  - (iv) To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster's Bridge.
9. To verify the Thevenin and Norton theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems

**Recommended Books and References:**

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11<sup>th</sup> Ed. 2011, Kitab Mahal

**GENERIC ELECTIVE 3 (PHG 3.11)**  
**ELEMENTS OF MODERN PHYSICS**

*Theory Credit: 4*

*Teaching Hours: 60*

- UNIT I** Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.  
Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence;
- UNIT II** Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.
- UNIT III** One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier.
- UNIT IV** Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.  
Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle.
- UNIT V** Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy. Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half-life;  $\alpha$  decay;  $\beta$  decay - energy released, spectrum and Pauli's prediction of neutrino;  $\gamma$ -ray emission.

***Recommended Books and References:***

1. Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
2. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2009, PHI Learning
3. Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill
4. Quantum Physics, Berkeley Physics, Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
5. Modern Physics, R.A. Serway, C.J. Moses, and C.A.Moyer, 2005, Cengage Learning

**GENERIC ELECTIVE 3 (PHG 3.12)**  
**ELEMENTS OF MODERN PHYSICS**

*Practical Credit: 2*

*Teaching Hours: 60*

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the ionization potential of mercury.

4. To determine value of Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser and measure its intensity variation using Photosensor & compare with incoherent source – Na.
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
9. To determine the value of  $e/m$  by (a) Magnetic focusing or (b) Bar magnet.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.

**Recommended Books and References:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11<sup>th</sup> Edition, 2011, Kitab Mahal, New Delhi.

**GENERIC ELECTIVE 4 (PHG 4.11)**

**WAVES AND OPTICS**

*Theory Credit:4*

*Teaching Hours: 60*

**UNIT I Superposition of Two Collinear Harmonic oscillations:** Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

**Superposition of Two Perpendicular Harmonic Oscillations:** Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.

**Waves Motion- General:** Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.

**UNIT II Fluids:** Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of liquid with temperature- lubrication.

**Sound:** Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.

**UNIT III Wave Optics:** Electromagnetic nature of light. Definition and Properties of wavefront. Huygens Principle.

**Interference:** Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

**UNIT IV Michelson's Interferometer:** (1) Idea of form of fringes (no theory needed),

(2) Determination of wavelength, (3) Wavelength difference, (4) Refractive index, and (5) Visibility of fringes.

**Polarization:** Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

**UNIT V Diffraction:** Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

**Recommended Books and References:**

1. Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
2. Principles of Optics, B.K. Mathur, 1995, Gopal Printing
3. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications
4. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley

**GENERIC ELECTIVE 4 (PHG 4.12)  
WAVES AND OPTICS**

*Practical Credit: 2*

*Teaching Hours: 60*

1. To investigate the motion of coupled oscillators.
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify  $\lambda^2 - T$  Law.
3. To study Lissajous Figures.
4. Familiarization with Schuster's focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Refractive Index of the Material of a Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a Prism using Mercury Light
8. To determine the value of Cauchy Constants.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
14. To determine the Resolving Power of a Plane Diffraction Grating.
15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

**Recommended Books and References:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11<sup>th</sup> Edition, 2011, Kitab Mahal, New Delhi.

**GENERIC ELECTIVE  
STATISTICS**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Statistical Methods (Theory)	STG 1.11	4
		Statistical Methods (Practical)	STG 1.12	2
<b>II</b>	Generic Elective 2	Introductory Probability(Theory)	STG 2.11	4
		Introductory Probability(Practical)	STG 2.12	2
<b>II</b>	Generic Elective 3	Basics of Statistical Inference(Theory)	STG 3.11	4
		Basics of Statistical Inference(Practical)	STG 3.12	2
<b>IV</b>	Generic Elective 4	Applied Statistics(Theory)	STG 4.11	4
		Applied Statistics(Practical)	STG 4.12	2

**GENERIC ELECTIVE 1 (STG 1.11)**  
**STATISTICAL METHODS**

*Theory Credit: 4*

**UNIT I** Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.

**UNIT II** Measures of Central Tendency: arithmetic mean, geometric mean, harmonic mean, median and mode with properties and merit, demerits, quartiles, deciles and percentiles.

**UNIT III** Measures of Dispersion: range, quartile deviation, mean deviation and standard deviation, their definitions and properties, uses and merits, demerits, absolute and relative measures of dispersions, Raw and central moments and their relations, Sheppard's correction for moments and factorial moments, Measures of skewness and kurtosis.

**UNIT IV** Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

**UNIT V** Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.

***Recommended Books and References:***

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

**GENERIC ELECTIVE 1 (STG 1.12)**  
**STATISTICAL METHODS**

*Practical Credit: 2*

**PRACTICAL/ LAB WORK**

**List of Practical**

1. Graphical representation of data
2. Problems based on measures of central tendency
3. Problems based on measures of dispersion
4. Problems based on combined mean and variance and coefficient of variation
5. Problems based on moments, skewness and kurtosis
6. Finding the class frequencies of attributes, examine the independency of attributes.
7. Checking consistency of data and finding association among attributes.

**GENERIC ELECTIVE 2 (STG 2.11)**  
**INTRODUCTORY PROBABILITY**

*Theory Credit: 4*

- UNIT I** Correlation and regression: Definition, scatter diagram, product moment correlation coefficient and rank correlation coefficient. Method of least square and Curve fitting (fitting of polynomials and exponential curves). Regression analysis: line of regression, regression coefficients and their properties.
- UNIT II** Multiple and partial correlation (3 variables only), Properties of residual, Plane of regression.
- UNIT III** Random Variables: Discrete and continuous random variables, p.m.f., p.d.f. ,c.d.f. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function. Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers
- UNIT IV** Standard discrete probability distributions: Binomial, Poisson, hypergeometric and geometric.
- UNIT V** Standard continuous probability distributions: uniform, normal and exponential.

**Recommended Books and References:**

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi

**GENERIC ELECTIVE 2 (STG 2.12)**  
**INTRODUCTORY PROBABILITY**

*Practical Credit: 2*

**PRACTICAL/LAB. WORK:**

**List of Practical**

1. Fitting of binomial distributions for  $n$  and  $p = q = \frac{1}{2}$  given
2. Fitting of binomial distributions for  $n$  and  $p$  given
3. Fitting of binomial distributions computing mean and variance
4. Fitting of Poisson distributions for given value of  $\lambda$
5. Fitting of Poisson distributions after computing mean
6. Application problems based on binomial distribution
7. Application problems based on Poisson distribution
8. Problems based on area property of normal distribution
9. To find the ordinate for a given area for normal distribution

10. Application based problems using normal distribution
11. Fitting of normal distribution when parameters are given
12. Fitting of normal distribution when parameters are not given
13. Karl Pearson correlation coefficient
14. Partial and multiple correlations
15. Spearman rank correlation with and without ties.
16. Correlation coefficient for a bivariate frequency distribution
17. Lines of regression, angle between lines and estimated values of variables.

**GENERIC ELECTIVE 3 (STG 3.11)**  
**BASICS OF STATISTICAL INFERENCE**

*Theory Credit: 4*

- UNIT I** Estimation Theory: parameter and statistic, estimator and estimate, properties of good estimator – consistency, unbiasedness, efficiency and sufficiency; Method of Maximum Likelihood Estimation (MLE).
- UNIT II** Testing of hypothesis: Hypothesis, Null and alternative hypothesis, Simple and Composite hypothesis, Type I and Type II errors, level of significance, p-value, power of a test, Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
- UNIT III** Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction, t-test for one and two sample mean, Tests for the significance of correlation coefficient; Non parametric tests: test of randomness, run test, Sign test, median test, Sign test for symmetry, Mann-Whitney-Wilcoxon U test.
- UNIT IV** Sample Survey: census and survey, basic principles of sample survey, principal steps in sample survey, sampling and non-sampling error, types of sampling-simple random sampling-with and without replacement, stratified random sampling and systematic sampling (concept only).
- UNIT V** Analysis of variance, one-way and two-way classification with one observation per cell, Design of experiment: treatment, plot and block, basic principles of design of experiments, completely randomized design (CRD) and randomized block design (RBD).

**Recommended Books and References:**

1. Daniel, Wayne W., Bio-statistics: A Foundation for Analysis in the Health Sciences. John Wiley (2005).
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II (2005).
3. Dass, M. N. & Giri, N. C.: Design and analysis of experiments. John Wiley.
4. Dunn, O.J Basic Statistics: A primer for the Biomedical Sciences.(1964, 1977) by John Wiley.
5. Bancroft, Holdon Introduction to Bio-Statistics (1962) P.B. Hoebar New York.
6. Goldstein, A Biostatistics-An introductory text (1971). The Macmillan New York.



**GENERIC ELECTIVE 3 (STG 3.12)**  
**BASICS OF STATISTICAL INFERENCE**

*Practical Credit: 2*

**PRACTICAL/LAB WORK**

**List of Practical**

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Z-test, t-test
8. Sign test for median.
9. Sign test for symmetry.
10. Wilcoxon two-sample test.
11. Analysis of Variance of a one way and two way classified data
12. Analysis of a CRD and RBD
13. Problems on SRS and Stratified random sampling

**GENERIC ELECTIVE 4 (STG 4.11)**  
**APPLIED STATISTICS**

*Theory Credit: 4*

- UNIT I** Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series, Methods of measuring trend, Measurement of seasonal variations by method of ratio to trend.
- UNIT II** Index numbers: Definition, Criteria for a good index number, Construction of index numbers, different types of index numbers, Time and Factor reversal test, consumer price index number, Uses and limitations of index numbers.
- UNIT III** Statistical Quality Control (SQC): definition, purpose and importance of SQC, Causes of variations in quality: chance and assignable, general theory of control charts, process and product control, Control charts for variables: X- bar and R-charts, Control charts for attributes: p and c-charts
- UNIT IV** Demographic Methods: Introduction, measurement of population, rates and ratios of vital events, Measurement of mortality: CDR, SDR, IMR, standardized death rates. Life (mortality) tables: definition of its main functions and uses, Measurement of fertility: CBR, GFR, and TFR.
- UNIT V** Demand Analysis: Demand and supply functions, Price elasticity of demand and supply, income elasticity of demand; Pareto's law of income distribution; Engel's law and Engel's curve.

**Recommended Books and References:**

1. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9<sup>th</sup> Edition World Press, Kolkata.
3. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Applied Statistics, 4<sup>th</sup> Edition(Reprint), Sultan Chand & Sons
4. Montgomery, D. C. (2009): Introduction to Statistical Quality Control, 6<sup>th</sup> Edition, Wiley India Pvt. Ltd.

**GENERIC ELECTIVE 4 (STG 4.12)  
APPLIED STATISTICS**

*Practical Credit: 2*

**PRACTICAL/LAB WORK****List of Practical**

1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend values and comparing with given data graphically.
2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically.
3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation.
4. Construction of wholesale price index number, fixed base index number and consumer price index number with interpretation
5. Construction and interpretation of  $\bar{X}$  & R-chart
6. Construction and interpretation p-chart (fixed sample size) and c-chart
7. Computation of measures of mortality
8. Construction of life table
9. Computation of measures of fertility and population growth
10. Problems on demand and supply functions.

**GENERIC ELECTIVE  
TENYIDIE**

SEMESTER	COURSE	COURSE NAME	COURSECODE	CREDIT
<b>I</b>	GenericElective 1	Learning and Writing of Tenyidie(Theory)	TNG 1.11	4
		Tenyidie speaking and Listening(Practical)	TNG 1.12	2
<b>II</b>	GenericElective 2	Composition &CommunicationSkills of Tenyidie (Theory)	TNG 2.11	4
		Writing of Poetry and copy editing (Practical)	TNG 2.12	2
<b>III</b>	GenericElective 3	Language & Work Culture ofTenyimia (Theory)	TNG 3.11	4
		Project & Presentation (Practical)	TNG 3.12	2
<b>IV</b>	GenericElective 4	Abstract of Tenyidie(Theory)	TNG 4.11	4
		Field trip report writing	TNG 4.12	2

**GENERIC ELECTIVE 1 (TNG 1.11)**  
**LEARNING AND WRITING OF TENYIDIE**

*Theory Credit: 4*

*Pethakecū Tei: Bavüdo 60*

Thuo 100: Perhe Kephrükeliethuo 70 – (khese thuo 31.5); Petse Kephrükeliethuo 30 (khese thuo 13.5) Puotei: Bavüdo 3.

**Kemerü Mhirü:** Kepethamia kehoupuorei shüphrüchie chiekeshüko nu puo kemevi kicüpuo puo se parlie vi shi le menuo di kephrünuomia ki pushülie.

*Zatse (unit) I-V yopuo la thuo-14 ba phre. Pethakecū zatse puo ketsa nu rei bavüdo 12 petha phretuo.*

**UNIT I.** Tenyidie sedekeliethuo Dze (Introduction to Tenyidie )

**UNIT II.** Khuthuzho (Spelling and Word Division)

**UNIT III.** Kekiepfhephra mu Kekhokeke pfhephra (Sound and Tone)

**UNIT IV.** Keriekimia Dzeyie (Folklore)

**UNIT V.** Thedze Kedzü (Short Stories)

**GENERIC ELECTIVE 1 (TNG 1.12)**

*Practical Credit: 2*

*Pethakecū Tei: Bavüdo 30*

1. Tenyidie Kepu mu Kerünyü  
(Tenyidie Speaking and Listening)

**Ngulieketuo Leshüdako (Suggested Reading):**

- |                        |                   |
|------------------------|-------------------|
| 1. Tenyidie Dze        | : Shürhozelie     |
| 2. Tenyidie Khuthuzho  | : D.Kuolie        |
| 3. Diechie             | : Shürhozelie     |
| 4. Tenyimia Dzeyie     | : Rüzhükhrie      |
| 5. Noudo Dze           | : Dino & Viswedel |
| 6. Tenyimia Diemvü Dze | : Beilieü         |

**GENERIC ELECTIVE 2 (TNG 2.11)**  
**COMPOSITION AND COMMUNICATION SKILLS OF TENYIDIE LANGUAGE**

*Theory Credit: 4*

*Pethakecū Tei: Bavüdo 60*

Thuo 100: Perhe Kephrükeliethuo 70 – (khese thuo 31.5); Petse Kephrükeliethuo 30 (khese thuo 13.5) Puotei: Bavüdo 3.

**Kemerü Mhirü:** Kepethamia kehoupuorei shüphrüchie chiekeshüko nu puo

kemevi kicüpuo puo se parlie vi shi le menuo di kephrünuomia ki pushülie.

*Zatse (unit) I-V yopuo la thuo-14 ba phre. Pethakecü zatse puo ketsa nu rei bavüdo 12 petha phretuo.*

- UNIT I.** Kelieshie & Kepesikeshü (Advertisement & Notice)
- UNIT II.** Phreikie (Invitation)
- UNIT III.** Rüchüdie (Dialogue Writing)
- UNIT IV.** Ese (Essay)
- UNIT V.** Leshü - Kethuzho (Letter Writing: Formal & Informal )

**GENERIC ELECTIVE 2 (TNG 2.12)**

*Practical Credit: 2*

*Pethakecü Tei: Bavüdo 30*

1. Geizo Zokecü mu Khune Kemhiekcü  
(Writing of Poetry and Copy Editing)

***Ngulieketuo Leshüdako (Suggested Reading):***

1. Diezho mu Kezo Mhathu – Mhieneirielie Vakha
2. Diemvü rhitho Bodeko – D. Kuolie
3. Funtional Grammar and Spoken and  
Written Communication in English – Bikram K Das

**GENERIC ELECTIVE 3 (TNG 3.11)**

**LANGUAGE AND WORK CULTURE OF TENYIMIA**

*Theory Credit: 4*

*Pethakecü Tei: Bavüdo 60*

Thuo 100: Perhe Kephrukeliie thuo 70 – (khese thuo 31.5); Petse Kephrukeliethuo 30 (khese thuo 13.5) Puotei: Bavüdo 3.

**Kemerü Mhirü:** Kepethamia kehoupuorei shüphrüchie chiekeshüko nu puo kemevi kicüpuo puo se parlie vi shi le menuo di kephrünuomia ki pushülie.

*Zatse (unit) I-V yopuo la thuo-14 ba phre. Pethakecü zatse puo ketsa nu rei bavüdo 12 petha phretuo.*

- UNIT I.** Tenyimia mu Tenyidie (Tenyimia and Tenyidie)
- UNIT II.** Thenyi Kemeyieko (Major Festivals)
- UNIT III.** Nacünanyüko (Rituals)

**UNIT IV.** Rūna zho (Village System)

**UNIT V.** Mhathomhachü (Work Culture)

**GENERIC ELECTIVE 3 (TNG 3.12)**

*Practical Credit: 2*

*Pethakecū Tei: Bavüdo 30*

1. Mhachiethu mu Kepukecū  
(Project and Presentation)

***Ngulieketuo Leshüdako (Suggested Reading):***

- |                         |                      |
|-------------------------|----------------------|
| 1. Tenyimia Kelhou Dze  | : Neichüriazo Chücha |
| 2. Tenyimia Kelhou Bode | : Vikielie Sorhie    |
| 3. Zhozho               | : Khrieü Sekhose     |

**GENERIC ELECTIVE 4 (TNG 4.11)**

**ABSTRACT OF TENYIDIE**

*Theory Credit: 4*

*Pethakecū Tei: Bavüdo 60*

Thuo 100: Perhe Kephrükeliethuo 70 – (khese thuo 31.5); Petse Kephrükeliethuo 30 (khese thuo 13.5) Puotei: Bavüdo 3.

**Kemerü Mhirü:** Kepethamia kehoupuorei shüphrüchie chiekeshüko nu puo kemevi kicüpuo puo se parlie vi shi le menuo di kephrünuomia ki pushülie.

*Zatse (unit) I-V yopuo la thuo-14 ba phre. Pethakecū zatse puo ketsa nu rei bavüdo 12 petha phretuo.*

**UNIT I.** Keriekimia Geizo (Ancient Poetry)

**UNIT II** U teiki Geizo (Modern Poetry)

**UNIT III.** Rüsie (Drama)

**UNIT IV.** Tenyidie tsie thau (Present Development of Tenyidie)

**UNIT V** Diesouko (Idiomatic Expression)

**GENERIC ELECTIVE 4 (TNG 4.12)**

*Practical Credit: 2*

*Pethakecū Tei: Bavüdo 30*

1. U Tsiepfumia kelhou mu Thedzethese chütuoketa chüko kemeho mu Rükhruo mhathu.  
(Field Trip report writing)

***Ngulieketuo Leshüdako (Suggested Reading):***

1. Üca 53 : Shürhozelie
2. Tenyimia Mhaphruo Geizoko : D.Kuolie
3. Mehoviü Morüsa Rüsie : Shürhozelie
4. Diemvü thete zho : D.Kuolie
5. Structural Description of Tenyidie : D. Kuolie
6. Diesouko : Rüzühkhrie Sekhose

**GENERIC ELECTIVE  
ZOOLOGY**

<b>SEMESTER</b>	<b>COURSE</b>	<b>COURSE NAME</b>	<b>COURSE CODE</b>	<b>CREDIT</b>
<b>I</b>	Generic Elective 1	Aquatic Biology (Theory) OR Animal Diversity (Theory)	ZOG 1.11(a) ZOG 1.11(b)	4
		Aquatic Biology (Practical) OR Animal Diversity (Practical)	ZOG 1.12(a) ZOG 1.12(b)	2
<b>II</b>	Generic Elective 2	Environmental and Public Health (Theory) OR Insect Vectors and Diseases (Theory)	ZOG 2.11(a) ZOG 2.11(b)	4
		Environmental and Public Health (Practical) OR Insect Vectors and Diseases (Practical)	ZOG 2.12(a) ZOG 2.12(b)	2
<b>III</b>	Generic Elective 3	Human Physiology (Theory) OR Exploring the Brain: Structure and Function (Theory)	ZOG 3.11(a) ZOG 3.11(b)	4
		Human Physiology (Practical) OR Exploring the Brain: Structure and Function (Practical)	ZOG 3.12(a) ZOG 3.12(b)	2
<b>IV</b>	Generic Elective 4	Food, Nutrition and Health (Theory) OR Animal Cell Biotechnology (Theory)	ZOG 4.11(a) ZOG 4.11(b)	4
		Food, Nutrition and Health (Practical) OR Animal Cell Biotechnology (Practical)	ZOG 4.12(a) ZOG 4.12(b)	2



**GENERIC ELECTIVE COURSES 1 (ZOG 1.11(A))  
AQUATIC BIOLOGY**

*Theory Credits: 4*

- UNIT I      Aquatic Biomes**  
Brief introduction of the aquatic biomes: Freshwater ecosystem (lakes, wetlands, streams and rivers), estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone.
- UNIT II      Freshwater Biology-I**  
**Lakes:** Origin and classification, Lake as an Ecosystem, Lake morphometry, Physico-chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Nutrient Cycles in Lakes- Nitrogen, Sulphur and Phosphorous
- UNIT III      Freshwater Biology-II**  
**Streams:** Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes.
- UNIT IV      Marine Biology**  
Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms, Coral reefs, Sea weeds.
- UNIT V      Management of Aquatic Resources**  
Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation (legislations), Sewage treatment Water quality assessment- BOD and COD.

**GENERIC ELECTIVE COURSES 1 (ZOG 1.12(A))  
AQUATIC BIOLOGY**

*Practical Credits: 2*

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.
3. Determine the amount of Turbidity/transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates & bicarbonates) in water collected from a nearby lake/ water body.
4. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.
5. Project Report/Field Study.

**Recommended Books and References:**

1. Anathakrishnan : Bioresources Ecology 3rd Edition
2. Goldman : Limnology, 2nd Edition
3. Odum and Barrett : Fundamentals of Ecology, 5th Edition
4. Pawlowski: Physicochemical Methods for Water and Wastewater Treatment, 1<sup>st</sup> Edition
  - Wetzel : Limnology, 3rd edition

- Trivedi and Goyal : Chemical and biological methods for water pollution studies
- Welch : Limnology Vols. I-II

**GENERIC ELECTIVE COURSES 1 (ZOG 1.11(b))**  
**ANIMAL DIVERSITY**

*Theory Credits: 4*

**UNIT I Protista, Porifera, Radiata and Aceolomates**

General characters of Protozoa; Life cycle of Plasmodium  
 General characters and canal system in Porifera  
 General characters of Cnidarians and polymorphism  
 General characters of Helminthes; Life cycle of *Taenia solium*

**UNIT II Pseudocoelomates, Coelomate Protostomes**

General characters of Nemethehelminthes; Parasitic adaptations  
 General characters of Annelida ; Metamerism.

**UNIT III Arthropoda, Mollusca, Coelomate Deuterostomes**

General characters. Social life in insects.  
 General characters of mollusca; Pearl Formation  
 General characters of Echinodermata, Water Vascular system in Starfish.

**UNIT IV Protochordata, Pisces, Amphibia**

Salient features of protochordates  
 Osmoregulation and Migration of Fishes  
 General characters, Adaptations for terrestrial life and Parental care in Amphibia.

**UNIT V Reptiles, Aves and Mammalia**

Amniotes; Origin of reptiles. Terrestrial adaptations in reptiles.  
 The origin of birds; Flight adaptations  
 Early evolution of mammals; Primates; Dentition in mammals.

**GENERIC ELECTIVE COURSES 1 (ZOG 1.12(b))**  
**ANIMAL DIVERSITY**

*Practical Credits: 2*

1. Study of following specimens:  
**Non Chordates:** *Euglena, Noctiluca, Paramecium, Sycon, Physalia, Tubipora, Metridium, Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, Limulus, Hermitcrab, Daphnia, Millipede, Centipede, Beetle, Chiton, Dentalium, Octopus, Asterias, and Antedon.*  
**Chordates:** *Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Ichthyophis/Uraeotyphlus, Salamander, Rhacophorus Draco, Uromastix, Naja, Viper, model of Archaeopteryx, any three common birds-(Crow, duck, Owl), Squirrel and Bat.*
2. Study of following Permanent Slides:  
 Cross section of Sycon, Sea anemone and *Ascaris*(male and female). T. S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine. Bipinnaria and Pluteus larva.
3. Temporary mounts of

- Septal & pharyngeal nephridia of earthworm.
  - Unstained mounts of Placoid, cycloid and ctenoid scales.
4. Dissections of
- Digestive and nervous system of Cockroach.
  - Urinogenital system of Rat

**Recommended Books and References:**

1. Barnes, R.D. (1992). Invertebrate Zoology. Saunders College Pub. USA.
2. Ruppert, Fox and Barnes (2006) Invertebrate Zoology. A functional Evolutionary Approach 7th Edition, Thomson Books/Cole
3. Campbell & Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
4. Kardong, K. V. (2002). Vertebrates Comparative Anatomy. Function and Evolution. Tata McGraw Hill Publishing Company. New Delhi.
5. Raven, P. H. and Johnson, G. B. (2004). Biology, 6th edition, Tata McGraw Hill Publications. New Delhi.

**GENERIC ELECTIVE COURSES 2 (ZOG 2.11(a))  
ENVIRONMENT AND PUBLIC HEALTH**

*Theory Credits: 4*

**UNIT I Introduction**

Sources of Environmental hazards, hazard identification and accounting, fate of toxic and persistent substances in the environment, dose Response Evaluation, exposure Assessment.

**UNIT II Climate Change**

Greenhouse gases and global warming, Acid rain, Ozone layer destruction, Effect of climate change on public health

**UNIT III Pollution**

Air, water, noise pollution sources and effects, Pollution control

**UNIT IV Waste Management Technologies**

Sources of waste, types and characteristics, Sewage disposal and its management, Solid waste disposal, Biomedical waste handling and disposal, Nuclear waste handling and disposal, Waste from thermal power plants, Case histories on Bhopal gas tragedy, Chernobyl disaster.

**UNIT V Diseases**

Causes, symptoms and control of tuberculosis, Asthma, Cholera, Minamata disease, typhoid

**GENERIC ELECTIVE COURSES 2 (ZOG 2.12(A))  
ENVIRONMENT AND PUBLIC HEALTH**

*Practical Credits: 2*

1. To determine pH, Cl, SO<sub>4</sub>, NO<sub>3</sub> in soil and water samples from different locations.
2. Determine the hardness of water in the given sample.
3. Determine the organic carbon in Soil.

**Recommended Books and References:**

1. Cutter, S.L., Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi, 1999.
2. Kolluru Rao, Bartell Steven, Pitblado R and Stricoff "Risk Assessment and Management Handbook", McGraw Hill Inc., New York, 1996.
3. Kofi Asante Duah "Risk Assessment in Environmental management", John Wiley and sons, Singapore, 1998.
4. Kasperson, J.X. and Kasperson, R.E. and Kasperson, R.E., Global Environmental Risks, V.N. University Press, New York, 2003.
5. Joseph F Louvar and B Diane Louver Health and Environmental Risk Analysis fundamentals with applications, Prentice Hall, New Jersey 1997.

**GENERIC ELECTIVE COURSES 2 (ZOG 2.11(b))  
INSECT VECTORS AND DISEASES**

*Theory Credits: 4*

**UNIT I Concept of Vectors**

Morphological features of insects, Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits.

Brief introduction of Carrier and Vectors (mechanical and biological vector), Reservoirs, Host-vector relationship, Vectorial capacity, Adaptations as vectors, Host Specificity

**UNIT II Dipteran as Disease Vectors**

Dipterans as important insect vectors – Mosquitoes, Sand fly, Houseflies; Study of mosquito-borne diseases – Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis;

Study of sand fly-borne diseases – Visceral Leishmaniasis, Cutaneous Leishmaniasis, Phlebotomus fever; Control of Sand fly

Study of house fly as important mechanical vector, Myiasis, Control of house fly

**UNIT III Siphonaptera as Disease Vectors**

Fleas as important insect vectors; Host-specificity, Study of Flea-borne diseases – Plague, Typhus fever; Control of fleas

**UNIT IV Siphunculata as Disease Vectors**

Human louse (Head, Body and Pubic louse) as important insect vectors; Study of louse-borne diseases – Typhus fever, Relapsing fever, Trench fever, Vagabond's disease, Phthiriasis; Control of human louse

**UNIT V      Hemiptera as Disease Vectors**

Bugs as insect vectors; Blood-sucking bugs; Chagas disease, Bed bugs as mechanical vectors, Control and prevention measures

**GENERIC ELECTIVE COURSES 2 (ZOG 2.12(b))  
INSECT VECTORS AND DISEASES**

*Practical Credits: 2*

1. Study of different kinds of mouth parts of insects
2. Study of following insect vectors through permanent slides/ photographs:  
*Aedes, Culex, Anopheles, Pediculus humanus capitis, Pediculus humanus corporis, Phthirus pubis, Xenopsyllacheopsis, Cimex lectularius, Phlebotomus argentipes, Musca domestica*, through permanent slides/ photographs
3. Study of different diseases transmitted by above insect vectors
4. Submission of a project report on any one of the insect vectors and disease transmitted

***Recommended Books and References:***

1. Imms, A.D. (1977). *A General Text Book of Entomology*. Chapman & Hall, UK
2. Chapman, R.F. (1998). *The Insects: Structure and Function*. IV Edition, Cambridge University Press, UK
3. Pedigo L.P. (2002). *Entomology and Pest Management*. Prentice Hall Publication
4. Mathews, G. (2011). *Integrated Vector Management: Controlling Vectors of Malaria and Other Insect Vector Borne Diseases*. Wiley-Blackwell

**GENERIC ELECTIVE COURSES 3 (ZOG 3.11(a))  
HUMAN PHYSIOLOGY**

*Theory Credits: 4*

**UNIT I      Digestion and Absorption of Food**

Structure and function of digestive glands; Digestion and absorption of carbohydrates, fats and proteins; Nervous and hormonal control of digestion (*in brief*)

**UNIT II      Functioning of Excitable Tissue (Nerve and Muscle)**

Structure of neuron, Propagation of nerve impulse (myelinated and non-myelinated nerve fibre); Structure of skeletal muscle, Mechanism of muscle contraction (Sliding filament theory), Neuromuscular junction

**UNIT III      Respiratory Physiology**

Ventilation, External and internal Respiration, Transport of oxygen and carbon dioxide in blood, Factors affecting transport of gases.

**UNIT IV      Renal and Cardiovascular Physiology**

Functional anatomy of kidney, Mechanism and regulation of urine formation. Structure of heart, Coordination of heartbeat, Cardiac cycle, ECG

## **UNIT V Endocrine and Reproductive Physiology**

Structure and function of endocrine glands (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, and testes), Brief account of spermatogenesis and oogenesis, Menstrual cycle

## **GENERIC ELECTIVE COURSES 3 (ZOG 3.12(a))**

### **HUMAN PHYSIOLOGY**

*Practical Credits: 2*

1. Preparation of temporary mounts: Neurons and Blood film.
2. Preparation of haemin and haemochromogen crystals.
3. Estimation of haemoglobin using Sahli's haemoglobinometer.
4. Examination of permanent histological sections of mammalian oesophagus, stomach, duodenum, rectum, lung, kidney, thyroid, pancreas, adrenal, testis, ovary.

### **Recommended Books and References:**

1. Tortora, G.J. and Derrickson, B.H. (2009). *Principles of Anatomy and Physiology*, XII Edition, John Wiley and Sons, Inc. □
2. Widmaier, E.P., Raff, H. and Strang, K.T. (2008). *Vander's Human Physiology*, XI Edition, McGraw Hill.
3. Guyton, A.C. and Hall, J.E. (2011). *Textbook of Medical Physiology*, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company. □
4. Marieb, E. (1998). *Human Anatomy and Physiology*, IV Edition, Addison-Wesley.
5. Kesar, S. and Vashisht, N. (2007). *Experimental Physiology*, Heritage Publishers.
6. Prakash, G. (2012). *Lab Manual on Blood Analysis and Medical Diagnostics*, S. Chand and Company Ltd. □

## **GENERIC ELECTIVE COURSES 3 (ZOG 3.11(b))**

### **EXPLORING THE BRAIN: STRUCTURE AND FUNCTION**

*Theory Credits: 4*

#### **UNIT I Introduction:**

Early and Nineteenth century views of the Brain; Neuroscience today; Neurons – Soma, Axon, Dendrite; Classification of Neurons; Glia – Astrocytes, Myelinating Glia, Non-neuronal cells

**UNIT II Evolution and Adaptation of Brain:** Brain evolution and behavioral adaptation; Theories of brain evolution – involving addition of structure or areas, involving new formation and reorganization of circuits.

#### **UNIT III Organization of the Brain:**

Anatomical references, Cerebrum, cerebellum, brain stem, spinal cord; Cranial nerves, Meninges, ventricular system; CT and MRI imaging of the brain. Formation of neural tube, Primary brain vesicles; Differentiation of forebrain, midbrain and hindbrain. Cerebral cortex – neocortical evolution and structure-function relationship

**UNIT IV Chemical Control of Brain and Behaviour:** Structure and connection of thesecretory hypothalamus; Diffuse modulatory systems of the brain – noradrenergic,serotonergic, dominergic and cholinergic system; Drugs and diffuse modulatory systems.

**UNIT V Rhythms and Mental illness of the Brain:** Electroencephalogram; Sleep – why do we sleep, Non-REM and REM sleep, neural mechanisms of sleep; Circadian rhythms. Psychosocial and biological approaches to mental illness; Anxiety disorders; Mood disorders; Schizophrenia.

### **GENERIC ELECTIVE COURSES 3 (ZOG 3.12(b))**

#### **EXPLORING THE BRAIN: STRUCTURE AND FUNCTION**

*Practical Credits: 2*

1. Dissection and study of Drosophila nervous system using GFP reporter.
2. Observation and quantitation of Drosophila photoreceptor neurons in healthy and diseased condition.
3. Project work/ Home assignment

#### **Recommended Books and References:**

1. Neuroscience: Exploring the Brain by Mark F. Bear, Barry W. Connors and Michael A. Paradiso.
2. Comparative vertebrate Neuroanatomy by Ann B. Butler and William Hoods.

### **GENERIC ELECTIVE COURSES 4 (ZOG 4.11(a))**

#### **FOOD, NUTRITION AND HEALTH**

*Theory Credits: 4*

#### **UNIT I Basic concept of food and nutrition**

Food Components and food-nutrients  
Concept of a balanced diet, nutrient needs and dietary pattern for various Groups adults, pregnant and nursing mothers, infants, school children, adolescents and elderly

#### **UNIT II Nutritional Biochemistry:**

Definition and Classification of Carbohydrates, Lipids, Proteins; their dietary sourcesand roles  
Vitamins- Fat-soluble and Water-soluble vitamins- their dietary source and importance  
Minerals- Iron, calcium, phosphorus, iodine, selenium and zinc: their biologicalfunctions

#### **UNIT III Health-I**

Introduction to health- Definition and concept of health  
Major nutritional Deficiency diseases- Protein Energy Malnutrition (kwashiorkorand marasmus), Vitamin A deficiency disorders, Iron deficiency disorders, Iodinedeficiency disorders- their causes, symptoms, treatment, prevention andgovernment programmes.

#### UNIT IV Health-II

Life style related diseases- hypertension, diabetes mellitus, and obesity- their causes and prevention through dietary and lifestyle modifications.  
Social health problems- smoking, alcoholism, drug dependence and Acquired Immuno Deficiency Syndrome (AIDS) - their causes, treatment and prevention  
Common ailments- cold, cough, and fevers, their causes and treatment

#### UNIT V Food hygiene:

Transmission, causative agent, sources of infection, symptoms and prevention of Food and Water borne infections: **Bacterial infection:** Cholera, typhoid fever, dysentery; **Viral infection:** Hepatitis, Poliomyelitis, **Protozoan infection:** amoebiasis, giardiasis; **Parasitic infection:** taeniasis and ascariasis.

#### GENERIC ELECTIVE COURSES 4 (ZOG 4.12(a)) FOOD, NUTRITION AND HEALTH

*Practical Credits: 2*

1. To detect adulteration in a) Ghee b) Sugars c) Tea leaves and d) Turmeric
3. Estimation of Lactose in milk
4. Ascorbic acid estimation in food by titrimetry
5. Estimation of Calcium in foods by titrimetry
6. Study of the stored grain pests from slides/ photograph (*Sitophilus oryzae*, *Trogoderma granarium*, *Callosobruchus chinensis* and *Tribolium castaneum*): their identification, habitat and food sources, damage caused and control. Preparation of temporary mounts of the above stored grain pests.
7. Project- Undertake computer aided diet analysis and nutrition counseling for different age groups.

OR

Identify nutrient rich sources of foods (**fruits and vegetables**), their seasonal availability and price

OR

Study of nutrition labeling on selected foods

#### **Recommended Books and References:**

1. Mudambi, SR and Rajagopal, MV. Fundamentals of Foods, Nutrition and Diet Therapy; Fifth Ed; 2007; New Age International Publishers
2. Srilakshmi B. Nutrition Science; 2002; New Age International (P) Ltd.
3. Srilakshmi B. Food Science; Fourth Ed; 2007; New Age International (P) Ltd.
4. Swaminathan M. Handbook of Foods and Nutrition; Fifth Ed; 1986; BAPPCO.
5. Bamji MS, Rao NP, and Reddy V. Text Book of Human Nutrition; 2009; Oxford & IBH Publishing Co. Pvt Ltd.
6. Wardlaw GM, Hampl JS. Perspectives in Nutrition; Seventh Ed; 2007; McGraw Hill.
7. Lakra P, Singh MD. Textbook of Nutrition and Health; First Ed; 2008; Academic Excellence.
8. Manay MS, Shadaksharaswamy. Food-Facts and Principles; 1998; New Age International (P) Ltd.
9. Gibney et al. Public Health Nutrition; 2004; Blackwell Publishing



**GENERIC ELECTIVE COURSES 4 (ZOG 4.11(b))  
ANIMAL CELL BIOTECHNOLOGY**

*Theory Credit: 4*

**UNIT I     **Techniques in Gene manipulation****

Concept and Scope of Biotechnology; Outline process of genetic engineering and recombinant DNA technology, Isolation of genes, Concept of restriction and modification: Restriction endonucleases, DNA modifying enzymes  
Cloning Vectors: Plasmids, Phage vectors, Cosmids, Phagemids, BAC, YAC, HAC. Shuttle and Expression Vectors. Construction of Genomic libraries and cDNA libraries Transformation techniques: microbial, plants and animals.

**UNIT II     **Animal cell Culture****

Basic techniques in animal cell culture and organ culture, Primary Culture and Cell lines, Culture media- Natural and Synthetic, Stem cells, Cryopreservation of cultures. Agarose and Polyacrylamide Gel Electrophoresis, Southern, Northern and Western blotting, DNA sequencing: Sanger method, Polymerase chain reaction, DNA Fingerprinting and DNA microarrays.

**UNIT III    **Fermentation****

Different types of Fermentation: Submerged & Solid state; batch, Fed batch & Continuous; Stirred tank, Air Lift, Fixed Bed and Fluidized. Downstream Processing: Filtration, centrifugation, extraction, chromatography, spray drying and lyophilization.

**UNIT IV     **Transgenic Animal Technology****

Production of transgenic animals: nuclear transplantation, Retroviral method, DNA microinjection method, Dolly and Polly.

**UNIT V     **Application in Health****

Development of recombinant Vaccines, Hybridoma technology, Gene Therapy. Production of recombinant Proteins: Insulin and growth hormones. Bio safety Physical and Biological containment.

**GENERIC ELECTIVE COURSES 4 (ZOG 4.12(b))  
ANIMAL CELL BIOTECHNOLOGY**

*Practical Credit: 2*

1. Packing and sterilization of glass and plastic wares for cell culture.
2. Preparation of culture media.
3. Preparation of genomic DNA from *E. coli*/animals/ human.
4. Plasmid DNA isolation (pUC 18/19) and DNA quantitation using agarose gel electrophoresis (by using lambda DNA as standard).
5. Restriction digestion of lambda ( $\lambda$ ) DNA using EcoR1 and Hind III.
6. Preparation of competent cells and Transformation of *E. coli* with plasmid DNA using CaCl<sub>2</sub>, Selection of transformants on X-gal and IPTG (Optional).
7. Techniques: Western Blot, Southern Hybridization, DNA Fingerprinting, PCR, DNA Microarrays

**Recommended Books and References:**

1. Animal Cells Culture and Media, D.C. Darling and S.J. Morgan, 1994. BIOS Scientific Publishers Limited.
2. Methods in Cell Biology, Volume 57, Jennie P. Mathur and David Barnes, 1998. Animal Cell Culture Methods Academic Press.
3. P.K. Gupta: Biotechnology and Genomics, Rastogi publishers (2003).
4. B.D. Singh: Biotechnology, Kalyani publishers, 1998 (Reprint 2001).
5. T.A. Brown: Gene cloning and DNA analysis: An Introduction, Blackwell Science (2001).
6. Bernard R. Click & Jack J. Pasternak: Molecular Biotechnology, ASM Press, Washington (1998).
7. Methods in Gene Biotechnology, W. Wu, M.J. Welsh, P.B. Kaufman & H.H. Zhang, 1997, CRC Press, New York
8. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An introduction to genetic analysis. IX Edition. Freeman & Co., N.Y., USA



*Revised*  
SYLLABUS FOR  
Bachelor of Science (Honours)

**ABILITY ENHANCEMENT  
COMPULSORY COURSE**

THREE YEAR DEGREE COURSE  
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)



## ABILITY ENHANCEMENT COMPULSORY COURSE

**AECC (ECA 1.11)**

### **ENGLISH COMMUNICATION**

*Theory Credits: 2*

**UNIT I Introduction**

Theory of Communication, Types and Modes of Communication

**UNIT II Language of Communication**

Verbal and Non-verbal (Spoken and Written)

Personal, Social and Business

Barriers and Strategies

Intra-personal, Inter-personal and Group Communication

**UNIT III Speaking Skills**

Monologue

Dialogue

Group Discussion

Effective Communication/Miscommunication

Interview

Public Speech

**UNIT IV Reading and Understanding**

Close Reading

Comprehension

Summary Paraphrasing

Analysis and Interpretation

**UNIT V Writing Skills**

Documenting (Including Working Bibliography, Footnotes)

Letter Writing (Job application with CV)

**Recommended Books and References:**

1. *Fluency in English part II*, OUP, 2006.
2. *Business English*, Pearson, 2008
3. *Language, Literature and Creativity*, Orient Blackswan, 2013.
4. *Language Through Literature*. Ed. Dr Gauri Mishra, Dr Ranjan Kaul, Dr Brati Biswas
5. *MLA Handbook for Writers of Research Papers* (5<sup>th</sup> Edn) Joseph Gibaldi, EWP, 2000.

**AECC (TEA 1.11)**  
**TENYIDIE**

*Theory Credits: 2*

**Kemerü Mhirü:** *Kepethamia kehoupuorei shüphrüchie chiekeshüko nu puo kemevi kicüpuo puo se parlie vi shi le menuo di kephrünuomia ki pushülie.*

**ZATSE I Keriekimia teikijü lisi** – thuo 14 (Pethakecü tei – bavüdo 9) Pede Ketsokecü yopuo la thuo 10 mu petse ketsokecü la thuo 4.

1. *Kerheimvü* - Shürhozelie Liezietsu

**ZATSE II Tenyimia Kelhouzho Dze** – thuo 14 (Pethakecü tei – bavüdo 9) Pede Ketsokecü yopuo la thuo 10 mu petse ketsokecü la thuo 4.

1. *Tenyimia Kelhou dze* - Neichüriazo Chücha

**ZATSE III Noudo Dze** – thuo 14 (Pethakecü tei – bavüdo 9) Pede Ketsokecü yopuo la thuo 10 mu petse ketsokecü la thuo 4.

1. *Kedietho Capi* - Kekhrievö-ü Yhome

**ZATSE IV Geizo** – thuo 14 (Pethakecü tei – bavüdo 9) Pede ketsokecü yopuo la thuo 10 mu petse ketsokecü la thuo 4.

1. Tso-o mu Terhuopudiü

2. Tsuse

3. Thenu nie we

4. Tehoubo (Haigwang)

5. Shüphrü tei kevi (Medo)

6. U tsiepfumia (D. Kuolie)

**ZATSE V Tenyidie khuthu dze** – thuo 14 (Pethakecü tei – bavüdo 9) Pede Ketsokecü yo puo la thuo 10. Mu petse ketsokecü la thuo 4.

1. Tenyidie Khuthuzho - D. Kuolie

***Kephrüdako:***

- |                          |                              |                    |
|--------------------------|------------------------------|--------------------|
| 1. Shürhozelie Liezietsu | : <i>Kerheimvü</i>           | - UAP, Kohima 2006 |
| 2. Neichüriazo           | : <i>Tenyimia Kelhou dze</i> | - UAP, Kohima 2008 |
| 3. Kekhrievöü Yhome      | : <i>Kedietho Capi</i>       | - UAP, Kohima 2002 |
| 4. Shürhozelie Liezietsu | : <i>Ûca 53</i>              | - UAP, Kohima 2006 |
| 5. Shürhozelie Liezietsu | : <i>U Teiki Geizo</i>       | - UAP, Kohima 1989 |
| 6. D. Kuolie             | : <i>Tenyidie Khuthuzho</i>  | - UAP, Kohima 2006 |

**AECC (ESA 2.11)**  
**ENVIRONMENTAL SCIENCE**

*Credits: 2*

**UNIT I Introduction to environmental studies (2 lectures)**

- Multidisciplinary nature of environmental studies;
- Scope and importance; Concept of sustainability and sustainable development.

**UNIT II Ecosystems (6 lectures)**

- What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems:
  - a) Forest ecosystem
  - b) Grassland ecosystem
  - c) Desert ecosystem
  - d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

**UNIT III Natural Resources: Renewable and Non-renewable Resources (8 lectures)**

- Land resources and land use change; Land degradation, soil erosion and desertification.
- Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.
- Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state).
- Energy resources: Renewable and nonrenewable energy sources, use of alternate energy sources, growing energy needs, case studies.

**UNIT IV Biodiversity and Conservation (8 lectures)**

- Levels of biological diversity: genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots
- India as a mega-biodiversity nation; Endangered and endemic species of India
- Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.
- Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

**UNIT V Environmental Pollution (8 lectures)**

- Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution
- Nuclear hazards and human health risks
- Solid waste management: Control measures of urban and industrial waste.
- Pollution case studies.

**UNIT VI Environmental Policies & Practices(7 lectures)**

- Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture
- Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD).



- Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.

#### **UNIT VII Human Communities and the Environment (6 lectures)**

- Human population growth: Impacts on environment, human health and welfare.
- Resettlement and rehabilitation of project affected persons; case studies.
- Disaster management: floods, earthquake, cyclones and landslides.
- Environmental movements: Chipko, Silent valley, Bishnois of Rajasthan.
- Environmental ethics: Role of Indian and other religions and cultures in environmental conservation.
- Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).

#### **UNIT VIII Field work (Equal to 5 lectures)**

- Visit to an area to document environmental assets: river/ forest/ flora/fauna, etc.
- Visit to a local polluted site-Urban/Rural/Industrial/Agricultural.
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge, etc.

#### **Recommended Books and References:**

1. Carson, R. 2002. *Silent Spring*. Houghton Mifflin Harcourt.
2. Gadgil, M., & Guha, R. 1993. *This Fissured Land: An Ecological History of India*. Univ. of California Press.
3. Gleeson, B. and Low, N. (eds.) 1999. *Global Ethics and Environment*, London, Routledge.
4. Gleick, P. H. 1993. *Water in Crisis*. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.
5. Groom, Martha J., Gary K. Meffe, and Carl Ronald Carroll. *Principles of Conservation Biology*. Sunderland: Sinauer Associates, 2006.
6. Grumbine, R. Edward, and Pandit, M.K. 2013. Threats from India's Himalaya dams. *Science*, 339: 36-37.
7. McCully, P. 1996. *Rivers no more: the environmental effects of dams* (pp. 29-64). Zed Books.
8. McNeill, John R. 2000. *Something New Under the Sun: An Environmental History of the Twentieth Century*.
9. Odum, E.P., Odum, H.T. & Andrews, J. 1971. *Fundamentals of Ecology*. Philadelphia: Saunders.
10. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2011. *Environmental and Pollution Science*. Academic Press.
11. Rao, M.N. & Datta, A.K. 1987. *Waste Water Treatment*. Oxford and IBH Publishing Co. Pvt. Ltd.
12. Raven, P.H., Hassenzahl, D.M. & Berg, L.R. 2012. *Environment*. 8th edition. John Wiley & Sons.
13. Rosencranz, A., Divan, S., & Noble, M. L. 2001. *Environmental law and policy in India. Tripathi 1992*.
14. Sengupta, R. 2003. *Ecology and economics: An approach to sustainable development*. OUP.
15. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. *Ecology, Environmental Science and Conservation*. S. Chand Publishing, New Delhi.
16. Sodhi, N.S., Gibson, L. & Raven, P.H. (eds). 2013. *Conservation Biology: Voices from the Tropics*. John Wiley & Sons.
17. Thapar, V. 1998. *Land of the Tiger: A Natural History of the Indian Subcontinent*.
18. Warren, C. E. 1971. *Biology and Water Pollution Control*. WB Saunders.
19. Wilson, E. O. 2006. *The Creation: An appeal to save life on earth*. New York: Norton.
20. World Commission on Environment and Development. 1987. *Our Common Future*. Oxford University Press.



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**M.Sc.**

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*Revised*  
SYLLABUS FOR  
Master of Science

**ANTHROPOLOGY**

SEMESTER SYSTEM



## COURSE STRUCTURE

SEMESTER	COURSE CODE	COURSE NAME	CREDITS
<b>I</b>	MANC1.11	Core Course in Physical Anthropology	4
	MANC1.21	Core Course in Socio cultural Anthropology	4
	MANC1.31	Introduction to European and African Prehistory and issues in Archaeology	4
	MANC1.12	Core Course in Physical Anthropology (Practical)	2
	MANC1.22	Core Course in Socio cultural Anthropology (Practical)	2
	MANC1.32	Introduction to European and African Prehistory and issues in Archaeology(Practical)	2
<b>II</b>	MANC2.11	Human Origin and Evolution	4
	MANC2.21	Ethnography: Theory and Methods	2
	MANC2.31	Asian Prehistoric Archaeology	4
	MANO2.11	Research method (Open)	6
	MANC2.12	Human Origin and Evolution(Practical)	2
<b>SPECIALIZATION</b>			
<b>III</b>	<b>Specialization Physical/Biological</b>		
	MANC3.11	Human genetics and variation	4
	MANC3.21	Human growth and development	4
	MANC3.31	Palaeoanthropology	2
	MANO3.11	Human Ecology, Adaptation and Demography (Open)	6
	MANC3.41	Fieldwork*	2
	<b>Specialization Social/Cultural</b>		
	MANO3.11	Human Ecology, Adaptation and Demography(Open)	6
	MANC3.41	Fieldwork*	2
	MANC3.51	Anthropology of India	4
MANC3.61	Economy and Culture	4	
MANC3.71	Anthropology of North-East India	2	
<b>IV</b>	<b>Specialization Physical/Biological</b>		
	MANC4.11	Forensic anthropology	4
	MANC4.21	Dental anthropology	2
	MANC4.31	Physiological anthropology	4
	MANC4.41	Dissertation and Viva voce	6
	MANC4.12	Forensic anthropology (Practical)	2
	<b>Specialization Social/Cultural</b>		
	MANC4.41	Dissertation and Viva voce	6
MANC4.51	Theories in Anthropology	4	
MANC4.61	Development Anthropology	4	
MANC4.71	Culture, Health and Medicine	4	

*\*Theoretical & methodological preparation for this paper begins in the 2<sup>nd</sup> semester with the course no **MANC 2.21**. Supervisors for this paper are allotted in the beginning of the 3<sup>rd</sup> semester, & the students leave for fieldwork training soon after the 3<sup>rd</sup> semester examination.*

## SEMESTER - I

### MANC1.11

#### CORE COURSE IN PHYSICAL ANTHROPOLOGY

*Theory Credits: 4*

*This paper aims to impart knowledge on the basics of biological anthropology, its scope and its applications to other areas. The paper also introduces the students to the evolution of man, man's place in the animal kingdom and the human life course from an anthropological perspective.*

- UNIT I** a) Definition, scope, history and development of physical anthropology with reference to India. Relationship with other branches of anthropology and other cognate sciences.  
b) Evolution: microevolution and macroevolution, evidences for human evolution.
- UNIT II** Application of Biological Anthropology (Basic concepts): Anthropology of Sports, Nutritional Anthropology, Forensic Anthropology, Applied Human Genetics, DNA Technology and Medicine, Defense Services and Ergonomics, Applications in Industries
- UNIT III** Origin of life-forms and transformation, geological ages, theories of evolution (Lamarckism, Neo-Lamarckism, Darwinism, Neo-Darwinism, Synthetic theory), phylogenetic development of man, biological future of man.
- UNIT IV** Processes and principles of human evolution: Parallelism and convergence, morphology and speciation, irreversibility, adaptive radiation in primates, orthogenesis, cladogenesis.

### MANC1.12

#### CORE COURSE IN PHYSICAL ANTHROPOLOGY

*Practical Credit: 2*

**Somatometry:** Introduction, application: Anthropometry: Introduction and scope, anthropometric instruments.

**Somatometric measurements** - height, sitting height, bi-acromial diameter, head length, head breadth, bigonial breadth, nasal height, nasal breadth, nasal depth, mouth breadth, physiognomic facial height, morphological facial height, morphological superior facial height, physiognomic ear length, physiognomic ear breadth, horizontal circumference of head and body weight.

**Somatometric indices** – body mass index, relative sitting height (cormic) index, relative biacromial breadth index, cephalic index, total facial index, morphological upper facial index, fronto-parietal index, fronto-zygomatic index, nasal index, transverse cephalic index, and jugo-mandibular index

**Auxological measurements:** Stature, sitting height vertex, body weight, height acromion, height ilio-spinale, height ilio-cristale, trunk height, height sternale, chest circumference, chest depth, chest breadth, biacromial diameter, bio-cristal diameter, maximum hip breadth, upper-arm length, fore-arm length, hand length, hand breadth, leg length, foot length, foot breadth, humerus bicondylar breadth and femur bicondylar breadth.



**Indices:** Ponderal Index, relative sitting height, relative biacromial diameter, relative bicristal diameter, chest girth, acromo-iliac index, acromo-chest index, inter-bicondylar index, index of hand and index of foot.

**Measurements of body composition:** Skinfold measurement on biceps, triceps, sub-scapular, supra-iliac and calf. *Indices* - body mass index, conical index, body fat percentage, fat mass and fat free mass; Somatotyping techniques and analyses.

**Somatoscopic observations:** Skin color, hair (color, form and texture), eye (color, eye fold and eye slit), nose (nasal root, nasal bridge, nasal septum, and nasal tip), lips, chin and prognathism.

#### **Recommended Books and References:**

1. Ashley-Montagu, M.E. 1961. *An Introduction to Physical Anthropology*. Illinois: Charles C. Thomas.
2. Bhasin V. and M.K. Bhasin. 2007. *Anthropology Today: Trends, Scope and Applications*. New Delhi: Kamla Raj Enterprise.
3. Buettner-Janusch, J. 1966. *Origins of Man*. New Delhi: Wiley Eastern Pvt. Ltd.
4. Das, B.M. 1997. *Outline of Physical Anthropology*. Allahabad: Kitab Mahal.
5. Das ,B.M. and R. Deka. 2001. *Physical Anthropology: Practicals*. Allahabad: Kitab Mahal.
6. Harrison, G.A. et al. 1988. *Human Biology*. Oxford: Clarendon Press.
7. Katz S. H. 1975. *Biological Anthropology: Readings from Scientific American*. San Francisco: W.H. Freeman and Co.
8. Lasker, G.W. 1976. *Physical Anthropology*. New York: Holt, Rinehart and Wiston.
9. Lewin, R. 1984. *Human Evolution*. New York: Freeman.
10. Molnar, S. 1992. *Human Variation: Races, Types, and Ethnic Groups*. New Jersey: Prentice-Hall, Inc.
11. Park, M. A. 1996. *Biological Anthropology*. California: Mayfield Publishing Company.
12. Poirier, F.E., W.A.Stini and K.B.Wreden. 1990. *In Search of Ourselves: An Introduction to Physical Anthropology*, 4<sup>th</sup> edition. New Jersey: Prentice Hall.
13. Sarkar, R.M. 2004. *Fundamentals of Physical Anthropology*. Kolkata: Book World Publishers.
14. Shukla, B.R.K. and S. Ratogi. 2002. *Physical Anthropology and Human Genetics - An Introduction*. Delhi: PalakaPrakashan.
15. Shukla, B.R.K. and S. Ratogi. 2003. *Laboratory Manual of Physical Anthropology (Anthropometry and Osteology)*. Lucknow: Bharat Book Centre.
16. Singh, I.P. and M.K.Bhasin. 1989. *Anthropometry*. New Delhi: Kamla Raj Enterprises.
17. Weiner, J. S. and J.A. Lourie. 1981. *Practicals in Human Biology*. London: Academic Press.

#### **MANC1.21**

#### **CORE COURSE IN SOCIAL AND CULTURAL ANTHROPOLOGY**

*Theory Credits:4*

*This course aims at developing an overall understanding of the distinctiveness of anthropology as an academic discipline, its linkages with other subject areas both within and outside anthropology. The course develops in-depth discussions on the major themes and concerns of social and cultural anthropology ranging from the concept of culture, related theories and terms, organization of culture and society to an overview of major social institutions.*

**UNIT I** Introduction: Aim, scope and historical development of social and cultural anthropology, relationship with other branches of anthropology .

**UNIT II** Concept of Society: Social structure, social organization, social institution, social function.  
Types of social institution: Family, marriage and kinship

- UNIT III** Religion and magic:
- A.** Anthropological approach to religion: Evolutionary, psychological and functional
  - B.** Atheism, monotheism and polytheism
  - C.** Sacred and profane, sacred complex

- UNIT IV** Culture:
- A.** Definition, characteristics, aspects of culture (material and non-material)
  - B.** Importance of preserving culture: Role of museum in preserving culture, conserving and preserving of museum artifacts.

**Recommended Books and References:**

1. Auge, M 1998 – ‘*A sense of the other*’, Cambridge university Press
2. 1999- ‘*An anthropology for Contemporary worlds*, Cambridge University Press.
3. Beattie, J, 1966- ‘*Other Cultures*’ London .RPK
4. Ember, C.R and M.Ember, 1981- *Cultural Anthropology* ,New Jersey ,Prentice-Hall
5. Eller, J.D. 2016 *Cultural Anthropology: Global Forces Local Lives*
6. Fox, R. 1967: *An Anthropological Kinship and Marriage Perspective*. Harmondsworth: Penguin Books.
7. Keesing, Felix 1958 *Cultural Anthropology*. New York: Rinehart.
8. Kuper, A 1999 *Culture: An Anthropologists Account*. London: Harvard University Press
9. Leach, E.R. 1961 *Rethinking Anthropology*. London: Athlone Press
10. 1986 *Social Anthropology*. Glasgow: Fontana Press
11. Needham, R 1962 ‘*Structure and Sentiments*’. Chicago: U Press
12. Williams, R 1990 *Cultural Anthropology*. New Jersey: Prentice Hall
13. Rebecca L. Stein Frankle and Phillip L. Stein 2005 *Anthropology of Religion, Magic and Witchcraft*
14. Bennett, Clinton 1990 *In Search of the sacred: Anthropology and the study of religions*. London : cassell
15. Evans Pritchard, E E. 1965. *theories of primitive religion* .Oxford: Clarendon
16. Cunningham, Graham. 1999. *Religion and magic :Approaches and theories*. New York University Press.
17. James George Frazer .1890. *the golden bough*.
18. Robert Lumley *The museum time machine: Putting cultures on display (co-media)* -
19. Susan Pearce. *On collecting: An investigation into collecting in the European tradition (collecting cultures)*
20. *Re-inventing the museum: Historical and contemporary perspective on the paradigm shift* – Anderson Gail
21. *Liberating culture: Cross-cultural perspective on museum curation and heritage preservation* – Chirstina Kreps
22. *Perspective on objects: Centered learning in museum* – Scott G. Paris
23. *Intangible natural heritage: New perspectives on natural objects (Routledge studies in heritage)* – Eric Dorfman
24. *History from things: Essays on material culture* – Stephan Lubar
25. *Using primary sources: Hands-on instructional exercises* – Anne Badde
26. *Museums and communities: Changing dynamics (on museum)* – Deborah Tranter
27. *Biographical objects: How things tell stories of peoples’ lives* – Janet Hoskins
28. *Social life of things: Commodities in cultural perspective (Cambridge studies on social and cultural anthropology)* – Arjun Appadurai

## **MANC1.22**

### **CORE COURSE IN SOCIAL AND CULTURAL ANTHROPOLOGY**

*Practical Credit: 2*

**Museum study:** At the beginning of the semester the supervisor in consultation with the department may select/identify museum objects. Students will be made to do a thorough study on the cultural implication / history/ background on the object and prepare a full inventory along with photographs, line drawing /sketch. The student will write their report within a minimum of 3000 words under the supervisor and submit the same for evaluation against 2 credits.

#### **Recommended Books and References:**

1. The museum time machine: Putting cultures on display (co-media) - Robert Lumley
2. On collecting: An investigation into collecting in the European tradition (collecting cultures) – Susan Pearce.
3. Re-inventing the museum: Historical and contemporary perspective on the paradigm shift – Anderson Gail
4. Liberating culture: Cross-cultural perspective on museum curation and heritage preservation – Chirstina Kreps
5. Perspective on objects: Centered learning in museum – Scott G. Paris
6. Intangible natural heritage: New perspectives on natural objects ( Routledge studies in heritage) – Eric Dorfman
7. History from things: Essays on material culture – Stephan Lubar
8. Using primary sources: Hands-on instructional exercises – Anne Badde
9. Museums and communities: Changing dynamics (on museum) – Deborah Tranter
10. Biographical objects: How things tell stories of peoples' lives – Janet Hoskins
11. Social life of things: Commodities in cultural perspective (Cambridge studies on social and cultural anthropology) – Arjun Appadurai

## **MANC1.31**

### **INTRODUCTION TO EUROPEAN AND AFRICAN PREHISTORYAND CORE ISSUES IN ARCHAEOLOGY**

*Theory Credit: 4*

*The paper deals with the time perspective in Anthropology. The main focus of the paper is to highlight the anthropological perspectives of archaeological material in order to throw light on the emergence and evolution of human cultures. It indicates the relevance of palaeo-environment, chronology, typo-technologies and culture-construct which also establishes the relationship of archaeological anthropology with Earth sciences, physical and life sciences. The course aims at projecting the anthropological significance of archaeological data in the understanding of humanevolution with a practical component on lithic technology.*

**UNIT I** Introduction: scope and aims, historical development, major branches, interpretation of archaeological materials (subsistence pattern, settlement pattern, religious pattern).

**UNIT II** Tools and techniques: Recording, excavation, exploration, dating methods - three-age system, RDM (stratigraphy, seriation, dating by association), ADM (C14, Argon and TL techniques), palaeo-ecology and zonal concept.

**UNITIII** Palaeolithic Africa: Lower palaeolithic culture, middle palaeolithic culture, upper palaeolithic culture.

**UNITIV** European Prehistory: Lower palaeolithic culture, middle palaeolithic culture, upper palaeolithic culture and Mesolithic cultures.

### **MANC 1.32**

## **INTRODUCTION TO EUROPEAN AND AFRICAN PREHISTORY AND CORE ISSUES IN ARCHAEOLOGY**

*Practical Credits: 2*

Laboratory study of stone tools: identification and classification of stone tools, identification of rocks and minerals used for making prehistoric tools, typo-technological study with representative drawings of stone tools (five tools from each period) – chronological, cultural and functional analysis of tools.

### **Recommended Books and References:**

1. Agarwal, D.P. 1984. *The Archaeology of India*. New Delhi: Select Book Syndicate.
2. Andrefsky, Jr. W. 2005. *Lithics: Macroscopic Approaches to Analysis*. Cambridge University Press.
3. Bahn, P.G. 1999. *Cambridge Illustrated History of Archaeology*. Cambridge: University Press.
4. Bhattacharya, D.K. 1989. *An Outline of Indian Prehistory*. New Delhi: Popular Prakashan.
5. Bhattacharya D.K. (1996). *Palaeolithic Europe*. Netherlands, Humanities Press.
6. Champion et al. (1984). *Prehistoric Europe*. New York, Academic Press.
7. Daniel, G. 1981. *A Short History of Archaeology*. London: Thames and Hudson Ltd.
8. David, N. and C. Kramer. 2001. *Ethnoarchaeology in Action*. Cambridge: University Press.
9. Fagan B.M. (1983). *People of Earth: An Introduction*. Boston, Little, Brown & Company.
10. Fagan, B.M. 1988. *In the Beginning*. Illinois: Scott Foresman & Co.
11. Hodder, Ian and S. Hutson. 2003. *Reading the Past*. Cambridge: University Press.
12. Hodges, H. 1971. *Artefacts: An Introduction to Early Materials and Technology*. London: John Baker.
13. Hole, F. and R.F. Heizer. 1973. *An Introduction to Prehistoric Archaeology*. New York: Holt, Rinehart and Winston.
14. Phillipson D. W. (2005). *African Archaeology*. Cambridge, Cambridge University Press.
15. Pollock, S. 1999. *Ancient Mesopotamia*. Cambridge: University Press.
16. Oakley, K.P. 1975. *Man as Toolmaker*. London: British Museum.
17. Renfrew, C. and E. Zubrow. 1994. *The Ancient Mind: Elements of Cognitive Archaeology*. Cambridge: Univ. Press.
18. Roskam, Steve. 2001. *Excavation*. Cambridge: University Press.
19. Sankalia, H.D. 1964. *Stone Age Tools: Their Techniques, Names, Probable Functions*. Pune: DCPRI.
20. Semenov, S.A. 1976. *Prehistoric Technology*. Wiltshire: Moonraker Press.
21. Trigger, B. G. 1990. *A History of Archaeological Thought*. Cambridge: University Press.
22. Yellen, J. E. 1977. *Archaeological Approaches to the Present: Models for Reconstructing the Past*. New York: Academic Press.
23. Sanford, R.M and T. W. Neumann. 2001. *Cultural Resources Archaeology: An Introduction*. London: Rowman and Littlefield Pub. Inc.

## SEMESTER - II

### MANC2.11

#### HUMAN ORIGIN AND EVOLUTION

*Theory Credits: 4*

*Evolution as a process had also brought about series of anatomical changes on all forms of life. Modern man is but a product of this process. Mans attempts in piecing together his pasts have yielded useful sequences in explaining hominid evolution. This course would focus on these transition stages from the earliest to the present.*

- UNIT I** Modern theories on human evolution: Punctuated equilibrium theory, multiregional continuity and Out of Africa hypothesis, Neanderthal DNA.
- UNITII** Classification and characteristics of primates, relationship of man to higher primates like chimpanzee, gibbon, orangutan and gorilla, primate behavior.
- UNITIII** Anatomical changes in human skeleton due to erect posture and bipedal gait - skull, vertebral column, thorax, pelvic girdle, femur, hand and foot- evolution of teeth and brain.
- UNITIV** Concept of race, controversies on race, racial criteria and formation races, racial classification of Indian population - Sarkar, Guha and Risley.

### MANC2.12

#### HUMAN ORIGIN AND EVOLUTION

*PracticalCredit: 2*

*This practical paper helps the student to understand the gross anatomy of the human skeleton. The work is done on actual skeletal material. The student is enabled to acquire knowledge of the human skeleton that is essential in the pursuit of careers and research in human evolution, human growth & development, forensic sciences, primatology and applied para-medical sciences.*

**Osteology:** Introduction and scope, shape and functions of bones. Identification, drawing and description of bones of human skeleton – skull (5 views), vertebrae, sternum, scapula, clavicle, humerus, radius, ulna, hip bone, femur, tibia and fibula. Disarticulated skull bones

**Genetic markers:** ABO, Rh blood systems, total hemoglobin estimation, total blood count - RBC and WBC, serum proteins and red blood cell enzymes.

**Physiological tests** - Pulse rate, body temperature, blood glucose test and blood pressure.

#### **Recommended Books and References:**

1. Bishop, C. W. 1989. *Evolution of Mankind*. Delhi: Akashdeep Publishing House.
2. Buettner-Janusch, J. 1966. *Origins of Man*. New Delhi: Wiley Eastern Pvt. Ltd.
3. Cachel. S. 2006. *Primate and Human Evolution*. Cambridge: Cambridge University Press.
4. Ciochon, Rusell L. 1985. *Primate evolution and human origins*. California: The Benjamin/Cummings Publishing.
5. Conroy G. C. 1997. *Reconstructing Human Origins: A Modern Synthesis*. New York: W.W. Norton & Company.

6. Crawford, M.H. (ed.). 2006. *Anthropological Genetics*. Cambridge: Cambridge University Press.
7. Futuyma, D. J. 1998. *Evolutionary Biology*, Massachusetts: Sinauer Associates Inc.
8. Henke, W. and T. Ian (eds). 2007. *Handbook of Palaeoanthropology*. NY: Springer
9. Hooton, E. A. 1965. *Up from the Ape*. New York: Macmillan.
10. Jolly, C. J. and F. Plog. 1987. *Physical Anthropology and Archaeology*. New York: Knopf.
11. Lewin, R. 1984. *Human Evolution*. New York: Freeman.
12. Lewin R. and R. Foley. 2003. *Principles of Human Evolution*. Oxford: Blackwell Publishing.
13. Montagu, M.F.A. 1961. *An Introduction to Physical Anthropology*. Illinois: Crowell
14. Poirier F. E. 1993. *Understanding Human Evolution*. New Jersey: Prentice Hall
15. Reddy R.V. 1992. *Physical Anthropology, Evolution and Genetics of man*. Tirupati: V. Indira.
16. Relethford J. H. 2001. *Genetics and the Search for Modern Human Origins*. New York: John Wiley & Sons Inc. Publications.
17. Sarkar, R.M. 2004. *Fundamentals of Physical Anthropology*. Kolkata: Book World Publishers.
18. Smith, F.H. and F. Spencer. 1984. *The Origins and Evolution of Modern Humans*. New York: Allan Liss.
19. Strickberger M. W. 2000. *Evolution*, 3<sup>rd</sup> edition. New York: Jones & Barlett Publishers.
20. Tattersall, I. 1995. *Fossil Trail: How We Know, What We Think, We Know About Human Evolution*. New York: Oxford University Press.
21. Volpe, P.E. 1989. *Understanding Evolution*. New Delhi: Universal Book Stall.

## **MANC2.21**

### **ETHNOGRAPHY: THEORY AND METHODS**

*Theory Credits:2*

*Ethnography is central to Social and cultural anthropology. Over the years, there has been rich and varied development in ethnographic research in different academic disciplines including Anthropology. The Course aims at developing critical understanding on the nature of ethnography and ethnographic methods in contemporary social sciences with insights into different theoretical schools of thought. The students will also be introduced to some important areas where ethnography has been successfully applied.*

**UNIT I** Concept and definition of Ethnography, nature of ethnographic studies, history and development of ethnographic studies (Malinowski and Franz Boas), approaches to ethnography- community studies, ethnography and symbolic interactionism, semiotic and semantic, orientalism.

**UNIT II** Tools of ethnography  
**A.** Preparing for the field, literature review, site selection, learning the language, rapport establishment, participant observation, ethnographic interviewing, narrative analysis, technical aids.  
**B.** Analysis and writing of ethnographic data

#### **Recommended Books and References:**

1. Malinowski, B. *Argonauts of Western Pacific*
2. Mead, Margaret: *Coming of Age in Samoa*
3. Clifford J and G.E Marcus : *Writing Cultures: The poetics and politics of Ethnography*
4. Atkinson P, A.Coffey, S. delamont; J. Loafland and L Loafland : *Handbook of Ethnography*
5. Burawoy M. et al. : *Ethnography Unbound: Power and Resistance in the modern Metropolis*
6. O'reilly, K : *Ethnographic methods*

7. Brewer, J D . 2010 *Ethnography* .New Delhi, Rawat publications.
8. Campbell, Elizabeth . 2015 *Doing Ethnography* today. UK wiley Blackwell.
9. Antonius C G M Robben & Jeffrey A Sluka .2012 . *Ethnographic Fieldwork* : an anthropological reader . UK wiley Blackwell

## **MANC2.31**

### **ASIAN PREHISTORIC ARCHAEOLOGY**

*Theory Credits: 4*

- UNIT I** Late Pleistocene Cultures: Ecological background, Skeletal finds, Choukoutinien, Anyathian, Patjitanian, Tampanian, Sohanian and Acheulean development in India.
- UNIT II** Early Holocene Cultures: Ecological background, Hoabinhian culture in South east Asia and Mesolithic cultures of India (Langhnaj, Bagor, Sarainahar Rai, Art).
- UNIT III** Origin and development of food production in West Asia/Near East, Neolithic cultures of India (Mehergarh, Chirand, Koldihawa, Burzahom, Teri); Allied development in North-East India.
- UNIT IV** Chalcolithic and Early Iron Age Cultures: Ahar, Malwa, Jorwe; Beginning of Iron Age - PG Ware culture, NBP Ware culture; Megalithic cultures of India; Allied development in Northeast India.

#### **Recommended Books and References:**

1. Agrawal, D.P. 1982. *The Archaeology of India*. New Delhi: Select Books Syndicate.
2. Agrawal, D.P. and J.S. Kharakwal. 2002. *South Asian Prehistory: A Multidisciplinary Study*. Aryan Books International, New Delhi.
3. Allchin, B and R. Allchin. 1983. *The Rise of Civilization in India and Pakistan*. New Delhi: SBS.
4. Ashraf, A. A. 1990. *Prehistoric Arunachal*. Itanagar: Directorate of Research.
5. Bar-Yosef, O and F.Valla. 1990. The Natufian Culture and the Origin of the Neolithic in the Levant. *Current Anthropology*. Vol. 31. No.4: 433-436.
6. Bhattacharya, D.K. 1989. *An Outline of Indian Prehistory*. New Delhi: Popular.
7. Chang, K.C. 1963. *Archaeology of Ancient China*. London: Yale University Press.
8. Chard, C. S. 1975. *Man in Prehistory*. NY: McGraw-Hill Book Co.
9. Clark, G. 1977. *World Prehistory*. London: Cambridge University Press.
10. Deterra, H. 1937. Cenozoic Cycles in Asia and Their Bearing on Human Prehistory. *Proceedings of the American Philosophical Soc.* Vol.77.No.3: 289-308.
11. Fagan, B.M. 2004. *People of the Earth*. 11<sup>th</sup> ed. Delhi: Pearson Edu.
12. Foote, R.B. 1979. *Prehistory and Protohistory*. Delhi: Leeladevi.
13. Gorman, C. 1969. Hoabinhian: A Pebble Tool Complex with Early Plant associations in Southeast Asia. *Science*. New Series. Vol.163.No.3868: 671-673.
14. Gorman, C. 1971. 'The Hoabinhian and After: Subsistence Patterns in Southeast Asia during the Late Pleistocene and Early Recent Periods' in *World Archaeology*. Vol.2:3:300-320.
15. Hammond, N. 1973. *South Asian Archaeology*. London: Duckworth.
16. Higham, C.F.W. Kennedy, K. A.R. and G.L.Possehl. 1984. *Studies in the Archaeology and Palaeoanthropology of Southeast Asia*. New Delhi: Oxford and IBH Pub. Co.
17. Jamir, T. and M. Hazarika. 2014. *50 Years After Gaojali-Hading: Emerging Perspectives in the Archaeology of Northeast India*. Research India Press.
18. Lal, B.B. 1998. *India: New Light on the Indus Civilization*. New Delhi: ASI.

19. Mishra, V.N. 1973. Bagor- A Late Mesolithic Settlement of Northwest India. *World Archaeology*. Vol. 5. No.1: 92-110.
20. Mishra, V.N. 2001. *Prehistoric Human colonization of India*. J.Biosci.Vol.26:4.
21. Movius, H. L. 1949. Lower Palaeolithic Cultures of Southern and Eastern Asia. In *Transactions of the American Philosophical Society*. Vol. 38. Part 4.
22. Pappu, S. *et al.* 2004. Preliminary report on excavations at the Palaeolithic site of Attirampakkam, Tamil Nadu (1999–2004). *Man and Environment* 29 (2), 1–17.
23. Pappu, S. *et al.* 2011. Early Pleistocene Presence of Acheulian Hominins in South India, *Science* Vol. 331.
24. Sankalia, H.D. 1969. Problems in Indian Archaeology and Methods and Techniques to Tackle Them. *World Archaeology*. Vol.1. No.1: 29-40.
25. Sankalia, H.D.1974. *The Prehistory and Protohistory of India and Pakistan*. Pune: DCPRI.
26. Sharma, A.K. 1996. *Early Man in Eastern Himalayas*. New Delhi: Aryan Books International.
27. Sharma, T.C and D.N Majumdar. 1979. *Eastern Himalayas*. New Delhi: Cosmo Publications.
28. Tan, Ha van. 1997. The Hoabinhian and Before. IPPA, Vol. 3.

## **MANO2.11**

### **RESEARCH METHODS**

#### **(Open Course)**

*Theory Credits:6*

*This course aims at developing a scientific approach to social research as well as exposing the students to the field situation preferably in tribal and rural settings for training in the ethnographic method of field research which is central to anthropology as an academic discipline inquiry.*

- UNIT I** Concept Research, research and theory, formulation of hypothesis, data and types of data; Quantitative and Qualitative Research; Research problem, Null hypothesis; Research ethics; Nature of Anthropological research.
- UNIT II** Research Design/ Research proposal; Ethnographic research and Fieldwork.
- UNIT III** Data Collection: Observation, interview, questionnaire, Survey methods and Sampling techniques; Case studies; Focus group discussion; Oral narratives; Literature review and Bibliography.
- UNIT IV** Data analysis: Mean, Median, Mode, Standard deviation, Measure of association, Tabulation, Diagrammatic representation. Qualitative data analysis: writing about the data, identification of themes (coding), interpreting and organizing the data
- UNIT V** Ethics and Politics of Research
1. Identify, define, and analyze ethical issues in the context of human subject research.
  2. Ethical importance of consent, privacy and confidentiality in research
  3. Issues of academic fraud and plagiarism, conflicts of interest, authorship and publication.
- UNIT VI** Report Writing: Chapterization, preparing a text for submission and publication, concepts of preface, notes (end and footnotes), glossary, prologue and epilogue, appendix, bibliography (annotated) and references cited, review and index.



**Recommended Books and References:**

1. Aier, Anungla , *In search of Story Tellers: Memories of Field Experiences Among the Khamniungan Nagas*, in Chaudhery and Sen (ed) *Field Work Tradition in South East and South Asia*, Sage Pub, New Delhi
2. Garrard E and Dawson A. What is the role of the research ethics committee? Paternalism, inducements, and harm in research ethics. *Journal of Medical Ethics* 2005; 31: 419-23.
3. Bernard H.R. *Research Methods in Anthropology, Qualitative and Quantitative Approaches*. Jaipur: Rawat Publications. 2006.
4. Madrigal L. *Statistics for Anthropology*. Cambridge: Cambridge University Press. 2012.
5. Zar JH. *Biostatistical Analysis*. Prentice Hall. 2010.
6. Michael A. *The Professional Stranger*. Emerald Publishing. 1996.
7. Bernard R. *Research Methods in Anthropology: Qualitative and Quantitative Approaches*. AltaMira Press. 2011.
8. Emerson RM, Fretz RI and Shaw L. *Writing Ethnographic Fieldnotes*. Chicago, University of Chicago Press. 1995.
9. Lawrence NW. *Social Research Methods, Qualitative and Quantitative Approaches*. Boston: Allyn and Bacon. 2000.
10. O'reilly K. *Ethnographic Methods*. London and New York: Routledge. 2005.
11. Patnaik S.M. *Culture, Identity and Development: An Account of Team Ethnography among the Bhil of Jhabua*. Jaipur: Rawat Publications. 2011.
12. Pelto PJ and Pelto GH. *Anthropological Research, The Structure of Inquiry*. Cambridge: Cambridge University Press. 1978.
13. Sarantakos S. *Social Research*. London: Macmillan Press. 1998.
14. Bryman, Alan 2016 *Social Research Methods*. UK Oxford Uni Press.
15. Krishnaswami O.R. and Ranganatham M. 1983 *Methodology of Research in Social Sciences*. Himalaya Publishing House: Mumbai

## SEMESTER - III

### MANC3.11

### HUMAN GENETICS AND VARIATION

*Theory Credits: 4*

- UNIT I** Concept of gene, Watson-Crick model of DNA structure, role of mRNA and rRNA, genetic code, human DNA polymorphism, evidence of human evolution from mtDNA and Y chromosomal DNA haplogroups, neutral theory and its reconciliation to synthetic theory.
- UNIT II** Methods of studying heredity, Mendel's principles of inheritance - autosomal and sex-linked genes, sex-controlled and limited genes, ABO, MN and Rh systems, sex determination, Lyon hypothesis.
- UNIT III** Laws of equilibrium and probability in human genetics - Problems and solutions concerning dominant, recessive, sex-linked and sex-controlled traits - marriage patterns and their genetic consequences in human populations.
- UNITIV** Concept of genetic variation causes of genetic variation between and within human populations with special reference to the role mutation, selection, genetic drift, isolation and gene flow.

#### **Recommended Books and References:**

1. Barua, S. 2002. *Human Genetics*. Kolkata: Classique Books.
2. Boyce, A. J. and C. G. N. Mascie-Taylor. 1996. *Molecular Biology and Human Diversity*. Cambridge: Cambridge University Press.
3. Cavalli-Sforza, L. L. and W.F.Bodmer. 1971. *The Genetics of Human Population*. San Francisco: WH Freeman & Co.
4. Cavalli-Sforza L.L., et al. 1994. *The History and Geography of Human Genes*. Princeton: Princeton University Press.
5. Conroy Glenn C. 1997. *Reconstructing Human Origins: A Modern Synthesis*. New York: London: W.W. Norton & Company.
6. Crawford, M.H. (ed.). 2006. *Anthropological Genetics*. Cambridge: Cambridge University Press.
7. Gislipalson 2007. *Anthropology and the New Genetics*. Cambridge: Cambridge University Press.
8. Griffiths, A. J. F., W.M.Gelbart, J.H.Miller and R.C.Lewontin. 1999. *Introduction to Genetic Analysis*, 7<sup>th</sup> edition. New York: W H Freeman & Co
9. Harrison, G. A. and A.J.Boyce.1972. *The Structure of Human Population*. Oxford: Clarendon Press.
10. Hartl, D.L. 1983. *Human Genetics*. New York: Harper & Row.
11. Hedric, P.W. 1999. *Genetics of Populations*, 2<sup>nd</sup> edition. Massachusetts: Jones and Bartlett Publishers.
12. Kimura, M. 1983. *Neutral Theory of Molecular Evolution*. Cambridge: Cambridge University Press.
13. Malhotra, K. C. (ed.). 1988. *Statistical Methods in Human population Genetics*. Kolkata:ISI
14. Maxson, L.R. and C.H.Daugherty. 1992. *Genetics: A Human Perspective*, 3<sup>rd</sup> edition. Kerper: Wm Charles Brown Publishers
15. Race, R.R. and R.Sanger. 1973. *Blood Groups in Man*. Oxford: Blackwell Scientific.

16. Relethford, J.H. 2001. *Genetics and the Search for Modern Human Origins*. New York: Singapore: Wiley-Liss
17. Rothwell, N.V. 1976. *Human Genetics*. New Delhi: Prentice Hall Pvt. Ltd.
18. Vogel, F. and A.G.Motulsky. 1986. *Human Genetics: Problems and Approaches*. Berlin: Springer-Verlag.

### **MANC3.21**

#### **HUMAN GROWTH AND DEVELOPMENT**

*Theory Credits: 4*

- UNIT I** Concept of growth and development, methods of studying growth and development, stages of growth - prenatal, infant, childhood, adolescence, developmental age and maturity - catch up growth.
- UNIT II** Growth curve (its variation and evolution), assessment of growth and nutritional status, growth and adaptation to stresses of under-nutrition and diseases.
- UNIT III** Factors affecting growth: role of endocrines and hormones, ethnic variation, migration and hybridization, nutrition and socioeconomic factors, secular trend.
- UNIT IV** Human physique and somatotype - Viola, Carter, Sheldon and Kretschmer - Techniques for estimating body composition - anthropometry, metabolic balance technique, energy balance and water displacement.

#### **Recommended Books and References:**

1. Bogin, B. 1999. *Patterns of Human Growth*. Cambridge: Cambridge University Press.
2. Carter, J.E. L. 1980. *The Heath-Carter Somatotype Method*. San Diego: SDSU Syllabus Service.
3. Dasgupta P. and R.Hauspie (eds.) 2001. *Perspectives in Human Growth, Development and Maturation*. New Delhi: Springer.
4. Heath B.H. and J.E. L. Carter. 1990. *Somatotyping: Development and Applications*. Cambridge: Cambridge University Press.
5. Eveleth, P.B. and J.M.Tanner. 1990. *Worldwide Variation in Human Growth*. Cambridge: Cambridge University Press.
6. Forbes, G. B. 1987. *Human Body Composition: Growth, Aging, Nutrition and Activity*. New York: Springer-Verlag.
7. Harrison, G.A. *et al.* 1988. *Human Biology*. Oxford: Oxford University Press.
8. Heyward Vivian H. and D.R. Wagner. 2004. *Applied Body Composition Assessment*. Illinois: Champaign.
9. Himes, J.H. (ed.) 1991. *Anthropometric Assessment of Nutritional Status*. New York: Wiley-Liss.
10. Hooton, E. A. 1965. *Up from the Ape*. New York: Macmillan.
11. Jelliffe, D.B. 1966. *The Assessment of the Nutritional Status of the Community*, WHO Monograph No. 53. Geneva: WHO.
12. Johnson, F.E. 1987. *Nutritional Anthropology*. New York: Wiley-Liss.
13. Mahajan, A. and Nath, S. 1992. *Application Areas of Anthropology*. New Delhi: Reliance Publishing House.
14. Roche, A.F. 1992. *Growth, Maturation and Body Composition*. Cambridge: Cambridge University Press.
15. Tanner, J.M. 1989. *Foetus into Man*. Cambridge: Harvard University Press.

16. Thompson, J.L. *et al.* 2003. *Patterns of Growth and Development in the Genus Homo*. Cambridge: Cambridge University Press.
17. Ulijaszek, S.J. *et al.* 1998. *The Cambridge Encyclopaedia of Human Growth and Development*. Cambridge: Cambridge University Press.

### **MANC3.31**

#### **PALAEOANTHROPOLOGY**

*Theory Credits: 2*

*This course is designed to provide basic knowledge about the fundamental concepts of palaeoanthropology. The paper introduces the subject to the beginners by providing conceptual palaeoanthropological, geological and anthropological knowledge necessary to student with the fundamental concepts and techniques of palaeoanthropology.*

**UNIT I** Historical overview of Paleoanthropological Research: Terminological taxonomic and Chronological problems of fossils, processes of fossilization, preservation and uses of fossils, Geological time scale, Introduction to Palaeo-demography and Palaeo-pathology

**UNIT II** Hominid evolution: Characteristics and phylogenetic position of *Ramaphithecus*, *Australopithecines*, *Homo habilis*, *Homo erectus* and *Neanderthals*.  
Emergence of modern man: Anatomical features and geographical distribution of Cro-Magnon, Grimaldi, Chancelade, Brun, Offnet and Premost.

#### **Recommended Books and References:**

1. Aufderheide, A.C. and C. Rodriguez-Martin. 1998. *The Cambridge Encyclopaedia of Human Paleopathology*. Cambridge: Cambridge University Press.
2. Brace, C.L. 1995. *The Stages of Human Evolution*. New Jersey: John Wiley & Sons.
3. Buettner-Janusch, J. 1966. *Origins of Man*. New York: John Wiley.
4. Cachel. S. 2006. *Primate and Human Evolution*. Cambridge: Cambridge University Press.
5. Das, B.M. 1997. *Outline of Physical Anthropology*. Allahabad: Kitab Mahal.
6. Day, M.H. 1986. *Guide to Fossil Man*. Chicago: University Press.
7. Harrison, G. A. *et al.* 1988 *Human Biology*. Oxford: Oxford University Press.
8. Henke, Winfried, Tattersall, Ian (eds.). 2007. *Handbook of Palaeoanthropology*. NY: Springer
9. Hoppa, R. D. and J. W. Vaupel. 2000. *Paleodemography*. Cambridge: Cambridge Univ. Press.
10. Leakey, R.E. 1981. *The Making of Mankind*. London: Michael Joseph.
11. Lewin, R. 1984. *Human Evolution*. New York: Freeman.
12. Lewin R. and R. Foley. 2003. *Principles of Human Evolution*. Oxford: Blackwell Publishing.
13. Montagu, M.F.A. 1961. *An Introduction to Physical Anthropology*. Illinois: Charles C. Thomas.
14. Poirier, F.E. 1993. *Understanding Human Evolution*. New Jersey: Prentice Hall.
15. Sarkar, R.M. 2004. *Fundamentals of Physical Anthropology*. Kolkata: Book World Publishers.
16. Shukla, B.R.K. and S. Ratogi. 1998. *Physical Anthropology and Human Genetics*. Delhi: PalakaPrakashan.
17. Swedlund, A.C. and G. T .Armelagos. 1976. *Demographic Anthropology*. Dubuque: Wm.C.Brown Co.
18. Walter, H. 2002. *The Primate Fossil Record*. Cambridge: Cambridge University Press.
19. Wolpoff, M.H. 1980. *Paleoanthropology*. New York: Knopf.

### **MANO3.11**

### **HUMAN ECOLOGY, ADAPTATION AND DEMOGRAPHY**

#### **(Open Course)**

*Theory Credits: 6*

*To develop students' understanding of the concept of sustainability and the challenges we face in responding to environmental variables and resolving environmental problems. To examine how societies and the natural environment are intimately related. To develop a thorough understanding of ecosystems and the ways in which different groups interact with their environments. In demography, both biological and socio-cultural dimensions are of much value to anthropology. This course helps in understanding various basic concepts, methods and tools to study the health and dynamics of population.*

#### **PHYSICAL ANTHROPOLOGY**

- A.** Definition, objective, objectives, approaches to the study of human, variety of human eco-system, acclimatization, adaptation homeostasis.
- B.** Man's adaptation in stress condition: High altitude, cold heat, infectious diseases and nutritional requirements.

#### **CULTURAL ANTHROPOLOGY**

- A.** Definition, objectives, cultural ecology - approaches of Julian Steward, Disaster management.
- B.** Relationship between culture and ecology, eco-system, ethno-ecology, population ecology and indigenous vision

#### **DEMOGRAPHY**

- A.** Nutritional requirements of humans, malnutrition, dietary and anthropometric assessment of nutritional status, homeostatic and genetic potential theories.
- B.** Infectious diseases - Nature of infectious diseases, cultural evolution and diseases, human adaptability and diseases, co-evolution of people and diseases.

#### **Recommended Books and References:**

1. Baker, P.T. 1978. *The Biology of High Altitude Peoples*. Cambridge: University Press.
2. Baker, P.T. and J.S.Weiner. 1966. *The Biology of Human Adaptability*. Oxford: Clarendon Press.
3. Bhasin V. and M.K. Bhasin. 2007. *Anthropology Today*. New Delhi: Kamla Raj Enterprise.
4. Chapman, J.L. and M.J.Reiss. 1994. *Ecology: Principles and Applications*. Cambridge: Cambridge University Press.
5. Damon, A. 1975. *Physiological Anthropology*. New York: Oxford University Press.
6. Friscancho, A.R. 1981. *Human Adaptation*. Ann Arbor: University of Michigan Press.
7. Harrison, G.A. and H.Morphy. 1998. *Human Adaptation*. Oxford: Oxford University Press.
8. Harrison, G.A. *et al.* 1988. *Human Biology*. Oxford: Oxford University Press.
9. Himes, J.H. (ed.) 1991. *Anthropometric Assessment of Nutritional Status*. New York: Wiley-Liss.
10. Johnson, F.E. 1987. *Nutritional Anthropology*. New York: Wiley-Liss.
11. Little, M.A. and J.D. Haas. 1989. *Human Population Biology*. New York: Oxford University Press.
12. Malik, S. L. and D. K. Bhattacharya. 1986. *Aspects of Human Ecology*. New Delhi: Northern Book Centre.
13. Marten, G. G. 2001. *Human Ecology*. London: Stylus Publishing.
14. Mascie-Taylor, C.G.N. and B. Bogin. 1995. *Human Variability and Plasticity*. Cambridge: Cambridge University Press.

15. Moran, E.F. (ed.) 1990. *The Ecosystem Approach in Anthropology*. Michigan: University Press
16. Pelto, G.H., P.J. Pelto and E. Messer(eds.). 1989. *Research Methods in Nutritional Anthropology*. Tokyo: The UN University.
17. Roberts, D.F. 1978. *Climate and Human Variability*. California: Cumming.
18. Sukhatme, P.V. (ed.) 1982. *Newer Concepts in Nutrition and Their Implications for Policy*. Pune: Maharashtra Association for the Cultivation Sciences Research Institute.
19. Ulijaszek, S.J. and S. Strickland. 1993. *Nutritional Anthropology: Prospects and Perspectives*. London: Smith Gordon.
20. Willet, W. 2006. *Nutritional Epidemiology*. Oxford: Oxford University Press.
21. NazaREA, Virginia D. 2003 *Ethnoecology: Situated knowledge/located lives*. The University of Arizona Press.

### **MANC3.41 FIELDWORK**

*Credit: 2*

Each student shall have to undergo training for learning and use of different techniques of scientific data collection comprising of maximum 30 days of fieldwork under a supervision of a teacher as nominated by the head of department in a tribal/rural/urban/archaeological site areas. The fieldwork can be a camp based or non camp based one depending on the decision of the teacher. The commencement of fieldwork will be announced by the department. Students failing to complete the fieldwork in a particular year can only clear the paper by completing the fieldwork next year. No separate fieldwork shall be arranged for such students during the same semester. There shall be instructional classes per week for the students by the concern supervisor. The concern supervising teacher shall be the examiner of the paper. The performance of the student will be evaluated on the field notes and fieldwork performance during fieldwork. The final grading will be done by the supervising teacher at the end of the semester.

### **MANC3.51 ANTHROPOLOGY OF INDIA**

*Theory Credits: 4*

*This course aims to impart to students an understanding of the diversities and unity in Indian society, to portray the major segments in India, to disclose the various theoretical perspectives on Indian society and to familiarize them with the issues that confront contemporary India.*

- UNIT I** Approaches to the study of Indian society, culture and civilization - Indological, historical, and anthropological.
- UNIT II** Peopling of India: Indian aboriginals, theory of Aryan migration to India, hypergamy, hypogamy, Racial elements.
- UNIT III** Indian social structure: Purushartha, Varnashram, Caste system, *varna* and *jati*, tribal social structure, caste among non-Hindus (Muslims and Christians), Joint family in India.

**UNITIV** Contribution of some selected Indian Anthropologists: S.C. Roy, S.C. Dube, M.N. Srinivas, L.K.A. Krishna Aiyer, D. N. Majumdar, Iravati Karve, N.K. Bose, L. P. Vidyarthi and Verrier Elwin.

**Recommended Books and References:**

1. Bansal, I.J.S. 1984. *Anthropology in Indian Context*. New Delhi: Today & Tomorrow.
2. Bayly, S. 2001. *Caste, Society and Politics in India from the 18<sup>th</sup> Century to the Modern Age*. Cambridge: University Press.
3. Beteille, A. 1991. *Society and Politics in India*. Delhi: OUP.
4. Chatterjee, S.K. 1951. *Kiratajanakrti: The Indo-Mongoloids*. Calcutta: Royal Asiatic Society of Bengal.
5. Cohn, B. 1971. *India: The Social Anthropology of a Civilization*. London: Prentice-Hall.
6. Danda, A.K. 1995. *Foundations of Anthropology in India*. New Delhi: Inter-India.
7. Danda, A.K. 1996. 'Anthropology in India: In Retrospect and Prospect'. *Journal of Indian Anthropol. Society*, 31:205-215.
8. Dumont, L. 1976. *Homo Hierarchicus*. Delhi: Vikas.
9. Gadgil, M. 1998. *Peopling of India*. Hyderabad: University Press.
10. Heesterman, Jan. 1985. *The Inner Conflict of Tradition*. Chicago: University Press.
11. Inden, R. 1980. *Imagining India*. Oxford: Basil Blackwell.
12. Mandelbaum, D.G. 1972. *Society in India*, 2 Vols. Bombay: Popular.
13. Rudolph, L. and S. Rudolph. 1970. *The Tradition of Modernity*. London: Chicago University Press.
14. Singer, M. 1955. 'The Cultural Pattern of Indian Civilization'. *The Far Eastern Quarterly*, 15(1).
15. Srinivas, M.N. 1987. *Dominant Caste and Other Essays*. Delhi: OUP.
16. Chandrashekara, P V. 2008. *Approach to Indian Anthropology*. New Delhi Cybertech publications.
17. Vidyarthi, L.P. 1985 . *Tribal cultures of India* . New Delhi Concept publications.

**MANC3.61**

**ECONOMY AND CULTURE**

*Theory Credits: 4*

**UNITII** Introduction: Origin and scope of economic anthropology, approaches to the study of economic anthropology, substantivist, formalist and culturalist, tribal and peasant economies.

**UNIT III** Production: Hunting and gathering, pastoralism, shifting cultivation, cottage and village industries.

**UNITIII** Distribution and consumption: Barter and trade; ceremonial exchange, reciprocity, redistribution (Gift, Potlach, Kula Ring, Jajmani system, and Feast of Merit); market exchange.

**UNITIV** Economy and Society: Urbanization, colonization, industrialization, globalisation and their impact on the economies and societies of India.

**Recommended Books and References:**

1. Beals, R.L and H. Hoijer. 1971. *An Introduction to Anthropology*. 4<sup>th</sup>Ed.Macmillan: New York.

2. Belshaw, C. 1975. *Traditional Exchange and Modern Markets*. New Jersey: Prentice-Hall.
3. Danda, A.K. 1994. "Shifting Cultivation in Northeast India". *Journal of the Indian Anthropological Society*, 29 (1 & 2) 59-74.
4. Firth, R. 1975. *Themes in Economic Anthropology*. Tavistock: ASA Series.
5. Forde, D. 1986. *Habitat, Economy and Society*. London: Methuen & Co.
6. Gregory, C.A. 1997. *Savage Money*. New York: Harvard Academic Publishers.
7. Hammond, P.B. 1978. *An Introduction to Cultural and Social Anthropology*. 2<sup>nd</sup> Ed. New York: Macmillan.
8. Hann, C. M. 1998. *Property Relations*. Cambridge: Univ. Press.
9. Harris, M. 1991. *Cultural Anthropology*. 3<sup>rd</sup> ed. New York: Harper & Collins.
10. Hershkovits, M.J. 1975. *Economic Anthropology*. New Delhi: Eurasia Publications.
11. Holton, R. and B. Turner. 1990. *Max Weber on Economy and Society*. London: Sage.
12. Honigman, J. 1997. *Handbook of Social and Cultural Anthropology*. New Delhi/ Jaipur: Rawat.
13. Mauss, Marcel. 2001. *The Gift: The Form and Reason for Exchange in Archaic Societies with an Introduction by Mary Douglas*. London: Routledge.
14. Nair, M.K.S. 1987. *Tribal Economy in Transition*. New Delhi: Inter-India.
15. Nash, M. 1974. *Primitive and Peasant Economic Systems*. San Francisco: Chandler Publications.
16. Plattner, S. 1989. *Economic Anthropology*. Stanford: U Press.
17. Singh, K.S. 1982. *Economies of Tribes and Their Transformation*. New Delhi: Concept.
18. Williams, T.R. 1990. *Cultural Anthropology*. New York: Prentice-Hall.

### **MANC3.71**

#### **ANTHROPOLOGY OF NORTHEAST INDIA**

*Theory Credits: 2*

*This course is designed to create awareness about the north eastern region of India, its diversities and commonalities and distinctiveness. Rich cultural traditions along with the issues and problems faced by the region are addressed. A brief discussion on ethnicity is also introduced with the view to acquaint the students with theoretical background for understanding ethnic relations in a multiethnic region.*

**UNIT I** Orality and ethnic history of the Northeast (with special reference to the state Nagaland): Concept and definition of Folklore oral tradition, myths and legends

**UNIT II** Origin and growth of Physical and socio-cultural anthropology in Northeast India: Pre-independence and post-independence scenario:  
**A.** Kinship studies, Christianity and change, ethnicity and identity, social change and continuity.  
**B.** Growth and development studies, Physical characteristics and variations, population genetics, demography, and studies in the field of nutrition and health.

#### **Recommended Books and References:**

1. Burling, Robbins. 1999. *Rengsanggiri: Family and Kinship in a Garo Village*. Tura: Tura Books.
2. Das, B.M. 1981. *Microevolution*. New Delhi: Concept Publishing Co.
3. Das, B.M. ed. 1974. *Contemporary Anthropological Research in Northeast India*. Dibrugarh: University Publications.



4. Das, F. A. and I. Barua. 1996. *Communities in Northeast India*. New Delhi: Mittal Publications.
5. Elwin, V. 1959. *A Philosophy for NEFA*. Shillong: Govt. Printing.
6. Goswami, M.C. and P.B.Das. 1990. *The People of Arunachal Pradesh: A Physical Survey*. Itanagar: Govt. of Arunachal Pradesh.
7. Hodson, T. C. 1989. *The Naga Tribes of Manipur*. Delhi: Low Price Publications.
8. Khongsdier, R. 2000. *Contemporary Research in Anthropology*. New Delhi: Commonwealth Publishers.
9. Lyall, S.C. 1908. *The Garos*. London: David Nutt.
10. Misra, U. 1988. *North-East India: Quest for Identity*. Guwahati: Omsons Publications.
11. Nakane, C. 1976. *Garos and Khasis: A Comparative Study in Matrilineal System*. The Hague: Mouton.
12. Playfair, A. 1909. *The Garos*. London: David Nutt.
13. Raha, M.K. and A.K.Ghosh. 1998. *North-East India: The Human Interface*. New Delhi: Gyan Pub. House.
14. Sengupta, S. 1997. *Studies in Anthropology: Recent Perspectives*. New Delhi: Inter-India.
15. Singh, B.P. 1987. *The Problem of Change: A Study of Northeast India*. Delhi: OUP.
16. Subba, T.B. and G.C. Ghosh. 2003. *The Anthropology of Northeast India*. New Delhi: Orient Longman.
17. Subba, T.B. 2012. *Northeast India: a handbook of Anthropology*. New Delhi: Orient BlackswanPvt Ltd.
18. Sengupta, S .2012. Tribes of North East India
19. Ahmed, J U (ed) 2010. Development Vision of North – East India. New Delhi Concept publication Co.
20. Dutta, P.C. 2011. Globalisation Growth and inequality in North-East India. Delhi Kalpaz Publication

## SEMESTER - IV

### MANC4.11

#### FORENSIC ANTHROPOLOGY

*Theory Credits: 4*

*The course is an introduction to the basic principles of APA. The main focus of the course is to teach the basic analysis and interpretation of human remains, primarily the determination of personal identity, for the medico-legal profession etc. the identification process seeks to provide information and any other characteristics that may lead to positive identification.*

- UNIT I** Definition and scope of forensic anthropology. Role of forensic anthropologist and odontologist in mass disasters, Crime types, crime scenes, methods of investigation, modes of death, assessment of time since death.
- UNIT II** Forensic osteology: Study of skeletal material: Human and animal remains; age, sex and stature estimation and their medico-legal implications, Discovery and techniques for recovering skeletonized human remains.
- UNIT III** Forensic haemogenetics: Identification and individualization of blood stains; determination of blood groups, sex, age and racial origin from blood stains; identification and individualization of body fluids like semen, saliva, urine, etc.
- UNIT IV** Dermatoglyphics in Forensic Anthropology; classification of finger prints for criminal record purposes. Modern method in crime investigation: DNA finger printing, Iris image, Biometry, Polygraph and Lie Detection Tests.

### MANC 4.12

#### FORENSIC ANTHROPOLOGY

*Practical Credit: 2*

- UNIT I** Dermatoglyphics of palms and fingers, color blindness and PTC taste sensitivity.
- UNIT II** **A. Osteometry and Odontometry**  
*Osteometry:* Direct measurements on scapula, clavicle, humerus, ulna, radius, femur and tibia. Diaptograph tracing and measurements on Scapula, clavicle, humerus, ulna, Radius, femur and tibia.  
*Odontometry:* Measurements on incisors and canines - total length, greatest breadth of crown, maximum anterior-posterior diameter of crown, minimum breadth of crown, height of crown. Measurements on premolars and molars - total tooth height, crown height, actual root length, projected root length, mesio-distal diameter and bucco-lingual diameter. *Indices* - crown index, crown module, incisor-breadth index and lower premolar index.  
**B. Craniometry:** Definition of landmarks, linear and angular measurements.  
**Linear measurements on Skull:**  
Maximum cranial length, maximum cranial breadth, glabella-inion length, nasion-inion length, bi-mastoid diameter, bi-auricular breadth, maximum frontal breadth, minimum frontal breadth, bizygomatic breadth, nasion-prosthion line, nasal height, nasal breadth, orbital height, orbital breadth, palatal length, palatal breadth, maxillo-

alveolar length, maxillo-alveolar breadth, length of foramen magnum, breadth of foramen magnum, frontal chord, parietal chord, occipital chord and horizontal circumference of skull.

**Angular measurements on Skull:** Angles with F.H. plane as base: Facial profile angle, Nasal profile angle, Alveolar profile angle and Metopic angle. Angles with Nasion-Inion plane as base: Frontal angle of Schwalbe, Bregma angle of Schwalbe and Lambda angle of Schwalbe

**Recommended Books and References:**

1. Bhatia, H.M. 1977. *Procedures in Blood Banking and Immuno-haematology*. Bombay: Blood Group Reference Centre.
2. Centre for Cellular Molecular Biology. 2000. 4<sup>th</sup> ADNAT Laboratory manual. Hyderabad: CCMB.
3. Cummins, H. and C. Midlo. 1961. *Finger Prints, Palms and Soles*. New York: Dover Publication Inc.
4. Dacie, J.V. and S.M. Lewis. 1975. *Practical Haematology*. London: Churchill Livingstone.
5. Das, B.M. and R. Deka. 2001. *Physical Anthropology: Practicals*. Allahabad: Kitab Mahal.
6. King, M. 1973. *A Medical Laboratory for Developing Countries*. London: Oxford University Press.
7. Shukla, B.R.K. and S. Ratogi. 2003. *Laboratory Manual of Physical Anthropology (Anthropometry and Osteology)*. Lucknow: Bharat Book Centre.
8. W.H.O. 1980. *Health Laboratory Services in Support of Primary Health Care in Developing Countries*. Series No. 24. New Delhi: WHO.
9. W.H.O. 1980. *Manual of Basic Technique for a Health Laboratory*. Calcutta: Academic Publishers.
10. Walt, R. and G.F. Katharine. 1999. *Molecular Biology Techniques: An Intensive Laboratory Course*. New York: Academic Press.
11. Weiner, J.S. and J.A. Laurie. 1969. *Practical in Human Biology*. Oxford: Blackwell Scientific Publications.
12. Wolf, J. B. 2001. *Applied Molecular Biology: Beginning Laboratory Manual*. Baltimore: University of Maryland
13. Essentials of Forensic Anthropology, Linda .L.Klepinger.2006. Wiley-Liss
14. Introduction to Forensic Anthropology(3rd Ed.) 2007.Steven N Byers
15. Bass, W.M Human Osteology
16. Bhasin, M. K & Surinder Nath Role of forensic Science in the New Millennium
17. Boorman and Dodd Blood Group Serology
18. Bridges, B.C Practical Finger printing
19. Brothwell, D.R (Ed.) Dental Anthropology
20. Chatterjee Finger, Plam and Sole Prints
21. Chatterjee, J.B Haematological Techniques
22. Chaurana Human Osteology
23. Cherril, F.R Finger print systems at Scotland
24. Field Finger Print Hand Book
25. Gilbert, H.R Genetic markers in Human Blood
26. Gupta Medical Jurisprudence
27. Gustafson Forensic Odontology
28. Kind, Stuart & Michael Science against Crime
29. Kirby, L.T DNA Finger Printing : An Introductions
30. Kirk, P.L Crime investigation
31. Krogman The Human Skeleton in Forensic Medicine
32. Lundquist, F & A.S. Curry Methods in Forensic Science
33. Ment Modern trends in Forensic Medicine
34. Modi Text Book of Medical Jurisprudence and Toxicology

35. Najjar, E.L Forensic Anthropology
36. Nicoles Methods in Forensic Science
37. Sharma, B.R Forensic Science in Criminal Investigation and Trials
38. Steward, T.D Forensic Anthropology
39. Surender Nath Introduction to Forensic Anthropology
40. Surender Nath Finger Print Identification
41. Symans, J Crime and Detection
42. Turner Forensic science and Laboratory Techniques
43. Yunis, J.J (Ed.) Biochemical Methods in Red cell Genetics

#### **MANC4.21**

#### **DENTAL ANTHROPOLOGY**

*Theory Credits:2*

**UNITI** Meaning, nature and importance of dental anthropology, its relationship with forensic and medical sciences, evolutionary trends in the dentition of primates and man, Morphology and anatomy of human dentition, structure, function and development of teeth – age and sex determination from human teeth.

**UNITII** Dental pathology in various human groups of the world, variation in eruption pattern of teeth between and within ethnic groups and the factors influencing the patterns, Concepts and development of occlusion, dental arch form.

#### **Recommended Books and References:**

1. Alt, K.W., F.W. Rosing and M. Treschler-Nicola. 1998. *Dental Anthropology*. New York: Springer.
2. Ash, M.M. 1988. *Dental Anatomy, Physiology, and Occlusion*. Philadelphia: W.B. Saunders C.
3. Brothwell, D.R. 1963. *Dental Anthropology*. New York: Pergamon Press.
4. Colyer, J.F. and D. Sprawson. 1974. *Dental Surgery and Pathology*. London: Longman
5. Das, A. K. 1987. *Dental Anatomy and Oral Histology*. Calcutta: Current Books International.
6. Hilson, S. 1990. *Teeth*. Cambridge: Cambridge University Press
7. Hilson, S. 1996. *Dental Anthropology*. Cambridge University Press
8. Kelley, M.A. and C. Larsen. 1991. *Advances in Dental Anthropology*. New York: Wiley-Liss.
9. Keiser, J. A. 1990. *Human Adult Odontometrics*. Cambridge: Cambridge University Press.
10. Rami Reddy, V. 1986. *Dimension of Anthropology: Dentition, Pathology and Crown Morphology*. New Delhi B.R. Publishers
11. Scott, G.R. 1997. *The Anthropology of Modern Human Teeth*. Cambridge: University Press
12. Segal, A.H. 1963. *Morphology of the Anatomy of Human Dentition*. Chicago: Yearbook Medical Publishers
13. Simons, E.L. 1972. *Primate Evolution*. New York: Macmillan.

**MANC4.31**  
**PHYSIOLOGICAL ANTHROPOLOGY**

*Theory Credit: 4*

- UNIT I** Fundamentals of work physiology: Cardio-vascular and respiratory endurance, hemodynamic and exercise (Blood pressure, pulse rate, heart rate and oxygen-transporting system, blood flow, Hb).
- UNIT II** Physical working capacity and physical fitness methodology: Evaluation of responds and adaptation of the body to stress of exercise. Ageing and health related aspects of exercise. Health and fitness: Variations in respiratory functions with age, sex and environment; interrelationship of body measurements with respiratory functions.
- UNIT III** Impact of smoking, alcohol, air pollution and occupation on cardio-respiratory function. Regulation of body weight;energy expenditure and physical activity.
- UNIT IV** Body composition: methods of assessment; environmental and genetic contribution to obesity; treatment and prevention and management; Global prevalence and secular trends in obesity; regulation of body weight- energy expenditure and physical activity.

***Recommended Books and References:***

1. Sherwood, Laurale, 2008. Human physiology: From cells to systems. Brooks Cole.
2. Case, RM, Ed 1985. Variation in human physiology. Manchester University Press.
3. Davson. Huges, Eggleton, M Grace. Lea &Febiger 1968. Principle of human physiology
4. Function Vander, Arthur J; Sherman, James H; Luciano, Dorothis, 1978. Human physiology: The mechanisms of body. Mc Graw-Hill Education.
5. Nageswari,K Sri; Sharma Rajeev, 2006. Practical workbook of human physiology. Jaypee Brothers. Medical publishers.
6. Tudor Hale, 2003. Exercise physiology. John Wiley & Sons Inc, England

**MANC4.41**  
**DISSERTATION & VIVA VOCE**

*Credits: 6*

Each student conducts fieldwork for at least three weeks on a topic of his/her choice and writes a thesis with a minimum of 10,000 words under the supervision of one of the faculty members and the same is submitted for evaluation against 6 credits.

**MANC4.51**  
**THEORIES IN ANTHROPOLOGY**

*Theory Credits: 4*

*The course outlines the major theoretical trends of Anthropology from colonial times to the present. This course summarizes the important theories and examines these theories critically.*

**UNIT I** Theories in Anthropology I: Classical Evolutionism – Tylor, Frazer and Morgan, Historical and Particularism – Boas, Diffusionism – Smith, Perry, Rivers, Ratzel, Frobenius, Schmidt, Wissler and Kroeber, Functionalism – Malinowski, Culture and Personality – Benedict, Mead and Cora Du-Bois.

**UNIT II** Theories in Anthropology II: Neo-Evolutionism – Childe and Steward, Structural-functionalism – Radcliffe-Brown, Firth and Nadel; Structuralism – Levi-Strauss and Leach.

**UNIT III** Theories in Anthropology III: Cognitivism – Goodenough, Tyler, Symbolism and Interpretivism- Schneider, Turner, Douglas and Geertz; Post-modernism – Clifford & Marcus.

**Recommended Books and References:**

1. Barnard, A. 2000. *History and Theory in Anthropology*. Cambridge: University Press.
2. Black, Thomas R. 1999. *Doing Qualitative Research in the Social Sciences*. London: Sage.
3. Bloch, M. 1991. *Language, Anthropology and Cognitive Science*. Man. 26 (2): 183-98.
4. Charon, j. 1992. *Symbolic Interactionism*. New Jersey: Prentice hall.
5. Clifford, J. and G. Nancus. 1986. *Writing Culture: the Poetics and Politics of Ethnography*. Berkeley: Univ. of California Press.
6. Ember, C.R and M. Ember. 1981. *Anthropology*. IIIrd ed. NJ: Prentice-hall.
7. Evans-Pritchard, E. 1981. *History of Anthropological Thought*. New York: Basic Books.
8. Geertz, C. 1974. *Myth, Symbol and Culture*. New York: W. W. Norton.
9. Geertz, C. 1993. *The Interpretation of Culture*. New York: Fontana Press.
10. Goode, W.J. 1973. *Explanation in Social Theory*. New York: OUP.
11. Harris, Marvin. 1968. *Rise of Anthropological Theory*. London: Routledge and Kegan Paul.
12. Hastrup, Kristen. 1995. *A Passage to Anthropology: Between Experience and Theory*. London: Routledge.
13. Hastrup, Kristen and Peter Hastrup. 1994. *Social Experience and Anthropological Knowledge*. London: Routledge.
14. Kaplan, D and R. Manners. 1968. *Theory in Anthropology*. London: Routledge & Kegan.
15. Kuper, A. 1975. *Anthropologist and Anthropology*. Middlesex: Penguin.
16. Layton, Robert. 1998. *An Introduction to Theory in Anthropology*. Cambridge: University Press.
17. Leach, E.R. 1954. *Political Systems of Highland Burma*. Boston: Beacon Press.
18. Lewie, R.H. 1937. *The History of Anthropological Theory*. New York: Rinehart.
19. Levis-Strauss, c. 1963. *Structural Anthropology*. New York: Basic Books.
20. Mann, R.S. 1984. *Anthropological and Sociological Theory*. Jaipur: Rawat.
21. McGee, R.J and R.L.Warms. 1996. *Anthropological Theory*. London: Mayfield Pub.
22. McNeil, Patrick. 1990. *Research Methods*. London: Routledge.
23. Radcliffe-Brown, A.R. 1952. *Structure and Function of Primitive Society*. London: Routledge & Kegan.
24. Rose, Dan. 1990. *Living the Ethnographic Life*. London: Sage Publications.
25. Moore, J.D. 2011 *Introduction to Anthropological Theories and Theorists*. N.Delhi Rawat Publications

**MANC4.61**  
**DEVELOPMENT ANTHROPOLOGY**

*Theory Credits: 4*

*This paper aims to create awareness about the concept of development from the anthropological perspective. It attempts to discuss the relation of anthropology with development and also aims to throw light on the perspective role anthropologists could play in development planning. Moreover, it envisages giving a broad view of the policies and development of the rural poor, Scheduled Castes and Scheduled Tribes.*

- UNIT I** Concepts of development in anthropology, indices of development, development debate, women in development, culture and development, sustainable human development.
- UNIT II** Applied and action Anthropology, application of anthropological knowledge in Planning and development, tribal development, tribal sub-plans and programmes – ITDPs, TRYSEM, LAMPs.
- UNIT III** Emerging issues of development in Northeast India: ethnicity, inequality, insurgency, look east and regionalism.
- UNIT IV** Evaluation and Assessment: Participatory rural appraisal (PRA), Rapid rural appraisal, intervention research, impact analysis.

**Recommended Books and References:**

1. Arce, Alberto and N. Long. 1999. *Anthropology, Development and Modernities*. London: Routledge.
2. Bardhan, P. 1995. *Development and Change*. Delhi: OUP.
3. Cochrane, G. 1971. *Development Anthropology*. Delhi: Kitab Mahal.
4. Desai, A.R. 1984. *India' Path to Development*. Bombay: Popular Prakashan.
5. Dreze, J and A. Sen. 1996. *Indian Development*. New Delhi: Oxford.
6. Dube, S.C. 1990. *Tradition and Development*. New Delhi: Vikas.
7. Hobart, M. 1993. *An Anthropological Critique of Development: The Growth of Ignorance*. London: Routledge.
8. Mair, L. 1984. *Anthropology and Development*. London: Macmillan.
9. Malhotra, R. 1992. *Anthropology of Development*. New Delhi: Mittal.
10. Mathur, H.M. 1977. *Anthropology in Development Process*. New Delhi: Vikas.
11. Mathur, H.M. 1990. *Human Dimension of Development: Perspective from Anthropology*. New Delhi: Concept Publishing House.
12. Mayer, R. 1985. *Policy and Programme Planning*. New Jersey: Prentice-hall.
13. Pathy, J. 1987. *Anthropology of Development*. Delhi: Gian Publishing House.
14. Pitt-David, C. 1976. *Development from Below: Anthropologists and Development Situation*. The Hague: Mouton.
15. So, A.Y. 1990. *Social Change and Development*. New Delhi: Sage Publications.
16. Subba, T. B. 1992. *Ethnicity, State and Development*. New Delhi: Vikas.
17. Vidyarthi, L.P. 1980. *Applied Anthropology and Development in India*. New Delhi: National.
18. Poutney, Lauren and Ferraro, G. 2012. *Cultural Anthropology :An applied perspective*. Ukwadsworth Cengage learning.
19. Patnaik, S .M .2011 *Culture identity and development*. New Delhi, Rawat publications.
20. Lakshmana , C . 2012 .*Globalisation , Develoment and culture* , New Delhi, Rawat publications

## MANC4.71

### CULTURE, HEALTH AND MEDICINE

*Theory Credits: 4*

*Through this paper an attempt has been made to familiarize the students with the basic concepts in ethno-medicine and applied medical anthropology. This paper familiarizes the students with the socio-cultural dimensions of health and illness. India is a classic example of co-existence of several systems of medicine –medical pluralism.*

- UNIT I** Introduction: Scope of medical anthropology, concepts of health, disease and illness, socio-cultural and environmental dimensions of health, occupational and life-style ailments.
- UNIT II** Ethno-medicine: Meaning and scope, ethnomedical practices in India, traditional healers and their predicaments, ethno-psychiatry, normality and abnormality, culture-bound psychological disorders and cultural healing of psychological disorders.
- UNIT III** Medical Pluralism in India: Ayurveda, Siddha, Unani, Naturopathy, Homeopathy and Allopathic medical practices, co-existence of different medical systems.
- UNIT IV** Epidemiology of certain common diseases in India (with special reference to Northeast India): malaria, tuberculosis, leprosy, diabetes, cardio-vascular diseases and STD/AIDs.

#### **Recommended Books and References:**

1. Basu, S. 1994. *Tribal Health in India*. Delhi: Manak Publications.
2. Budd, Susan and Ursula Sharma. 1994. *The Healing Bond: The Patient-Practitioner Relationship and Therapeutic Responsibility*. London: Routledge.
3. Caudill, W. 1953. *Applied Anthropology in Medicine*. Chicago: University of Chicago Press.
4. Chaudhuri, B. 1986. *Tribal Health: Socio-Cultural Dimensions*. New Delhi: Inter-India Publication.
5. Foster, G.M. 1978. *Medical Anthropology*. New York: John Wiley.
6. Freund, P.E.S and M. McGuire. 1995. *Health, Illness and the Social Body*. NJ: Prentice-Hall.
7. Good, Byron J. 1993. *Medicine, Rationality and Experience: An Anthropological Perspective*. Cambridge: Univ. Press.
8. Jose, Boban K. 1998. *Tribal Ethnomedicine: Continuity and Change*. New Delhi: APH Publishing.
9. Landy, D. 1977. *Culture, Disease and Healing*. New York: Macmillan.
10. Leslie, C. 1976. *Asian Medical Systems*. Berkeley: University of California Press.
11. Paul, B.D. 1955. *Culture, Health and Community*. New York: Russel Sage Foundation.
12. Read, M. 1966. *Culture, Health and Disease*. London: Tavistock Publications.
13. Singh, B. and N. Mahanti. 1995. *Tribal Health in India*. New Delhi: Inter-India.
14. Ohtsuka, R. and S.J. Ulijaszek (eds.). 2007. *Health Change in Asia-Pacific Region*. Cambridge: Cambridge University Press.
15. Worsley, P. 1982. 'Non-Western Medical Systems'. *Annual Review of Anthropology*, 11.
16. Young, A. 1982. 'The Anthropology of Illness and Sickness'. *Annual Review of Anthropology*, 11.
17. Poutney, Lauren and Ferraro, G. 2012. *Cultural Anthropology: An applied perspective*. UK: Wadsworth Cengage Learning.
18. Helman, Cecil G. 2007. *Culture, Health and Illness*. 5th edition. CRC Press



*Revised*  
SYLLABUS FOR  
Master of Science

**BOTANY**

SEMESTER SYSTEM



## CORE STRUCTURE

SEMESTER	COURSE CODE	COURSE NAME	CREDIT
<b>I</b>	MBOC 1.11	Mycology, Plant Pathology and Microbiology	4
	MBOC 1.12	Mycology, Plant Pathology and Microbiology (Practical)	2
	MBOC 1.21	Algae, Bryophytes and Pteridophytes	4
	MBOC 1.22	Algae, Bryophytes and Pteridophytes (Practical)	2
	MBOC 1.31	Gymnosperms and Plant Anatomy	4
	MBOC 1.32	Gymnosperms and Plant Anatomy(Practical)	2
<b>II</b>	MBOC 2.11	Plant Taxonomy and Economic Botany	4
	MBOC 2.12	Plant Taxonomy and Economic Botany (Practical)	2
	MBOC 2.21	Plant Biochemistry and Molecular Biology	4
	MBOC 2.22	Plant Biochemistry and Molecular Biology (Practical)	2
	MBOO 2.11	Bioprocess Development	2
	MBOO 2.21	Rights and Issues in Biology	2
	MBOO 2.31	Techniques in Molecular Biology	2
<b>III</b>	MBOC 3.11	Genetics, Cytogenetics and Plant Breeding	4
	MBOC 3.12	Genetics, Cytogenetics and Plant Breeding (Practical)	2
	MBOC 3.21	Plant Physiology	4
	MBOC 3.22	Plant Physiology (Practical)	2
	MBOO 3.11	Biodiversity and Phytogeography	2
	MBOO 3.21	Environmental Pollution and Conservation	2
	MBOO 3.31	Biostatistics	2
<b>IV</b>	MBOC 4.11	Plant Reproductive Biology and Biotechnology	4
	MBOC 4.12	Plant Reproductive Biology and Biotechnology (Practical)	2
	MBOC 4.21	Plant Ecology and Ecosystem Analysis	4
	MBOC 4.22	Plant Ecology and Ecosystem Analysis (Practical)	2
	MBOC 4.31	Project Work	6

### **Broad areas for specialization through Project Work:**

1. Higher Plant Ecology
2. Microbial Ecology
3. Plant Molecular Biology
4. Advanced Plant Physiology
5. Taxonomy and diversity of angiosperms
6. Development and Reproduction of angiosperms
7. Plant Biotechnology
8. Plant Genetics and Cytogenetics
9. Lower plants

## SEMESTER - I

### MBOC 1.11

### MYCOLOGY, PLANT PATHOLOGY AND MICROBIOLOGY

*Theory Credit: 4*

- UNIT I** Recent trends and criteria used in the classification of fungi with reference to vegetative and reproductive structures; Parasexuality; Mushroom cultivation; wood decay fungi and their importance; Fungi in bioremediation
- UNIT II** Symptomology and identification of plant diseases with reference to fungi, bacteria and viruses; Role of enzymes and toxins in pathogenesis; Effect of temperature, pH and moisture on the development of plant diseases; Biological control of plant diseases.
- UNIT III** Microorganisms found in food; food spoilage and food poisoning; Fermentation and food preservation; Role of microbes in industries with reference to production of alcohol and organic acid; Antibiotics; Bio-fertilizers; role of microbes in phosphorous and Sulphur cycles.
- UNIT IV** Effect of environmental factors on microbial growth; various nutritional forms of microorganisms; microbial colonization, succession and climax; Interaction between microbes and roots of higher plants; rhizosphere; different types of mycorrhizal association and their application in forestry and agriculture.

#### **Recommended Books and References:**

1. Alexander, M (1979). *Advances in Microbial Ecology*, Plenum Press.
2. Alexopolous C, J and Mirus, C. W (1983). *Introductory Mycology*, Wiley Eastern.
3. Atlas R. M. and Bartha R (1997) (4th Edition) *Microbial Ecology: Fundamental Applications*. Benjamin/Cummings Science Pub.
4. Blakeman, J. P and Williamson B. (1994). *Ecology of plant pathogens*. CAB International.
5. Creager, J. G., Black, G and Davidson, V. E (1990). *Microbiology: Principles and Applications*, Prentice Hall.
6. George, N. A (1988) *Plant Pathology* (third edition) Academic Press.
7. Harley, H. L and Smith, S. E (1983). *Mycorrhizal symbiosis*. Academic Press.
8. Madigan, M. T., Martinko, J. M and Parker, J (2000). *Brock Biology of Microorganisms*. Prentice Hall International, Inc
9. Mehrotra R.S. (1995). *Plant Pathology*. Tata Mc Graw Hill.
10. Michael J., Carlile, S., Watkinson C and Gooday, G. W. (1994). *The Fungi* (second edition) Academic Press.
11. Mishra, R.R. (1996). *Soil Microbiology*. CBS Publ.
12. Nester E. W., Roberts C. e. and Nester M. T. (1995). *Microbiology: A Human Perspective*. Wm. C. Brown Publisher.
13. Sarbhoy A. K. (2002) *Text Book of Mycology*, ICAR.
14. Tate, R. L (1995). *Soil Microbiology*, John Wiley and Sons Inc.
15. Tortora, G., Berdell, R. R and Case. C. L (1995). *Microbiology – An Introduction*. The Benjamin/Cumming Publishing Company.
16. Van Elsas J. D., Trevors, J. T., Wellington, e. M. H. (1997). *Modern Soil Microbiology*, Marcel Dekker Inc.

## **MBOC 1.12**

### **MYCOLOGY, PLANT PATHOLOGY AND MICROBIOLOGY**

*Practical Credit: 2*

1. Basic instruments and their principles.
2. Isolation and enumeration of microorganisms from soil, litter, water and air.
3. Collection and identification of causal organisms from the diseased plant materials.
4. Calibration of microscope and measurement of dimension of microbial cells.
5. Gram staining of bacteria.
6. Carbohydrate fermentation tests.
7. Measurement of fungal growth by linear and weight determination.
8. Effects of temperature on the growth of microbes.
9. Study of different mycorrhizal association.
10. 9 Enumeration of microorganisms from food spoilage (eg. Bread)

#### **Recommended Books and References:**

1. Aneja K. R. (1996). Experiments in Microbiology, Plant Pathology and Tissue Culture. WishwaPrakashan.
2. Barnett H. L. and Hunter, B. B. (1972). Illustrated genera of imperfect fungi. Burges Publ.
3. Benson H.J. (1990). Microbiological Applications - A Laboratory Manual in General Microbiology. Wm. C. Brown Publishers.
4. Cappuccino J. G. and Sherman N. (1999). Microbiology- A Laboratory Manual (Fourth Edition). Addison Wesley.
5. Domsch K. H., Gams W. and Anderson T. H. (1980). Compendium of soil fungi. Academic Press.
6. Gilman J. C. (1967). A Manual of Soil fungi. Oxford and IBH Publishing Co.
7. Johnson L. F. and Curl E. A. (1972). Methods for Research on the Ecology of soil borne plant pathogens. Burgess Publishing Co.
8. Stevens F. L. (1985). The fungi which cause plant diseases. IBS. Intl.

## **MBOC 1.21**

### **ALGAE, BRYOPHYTES AND PTERIDOPHYTES**

*Theory Credit: 4*

- UNIT I** Algal classification and criteria for classification; Range of thallus organisation, reproduction and life history in major algal classes (Chlorophyta; Chrysophyta-including Phaeophyceae, Xanthophyceae and Bacillariophyceae; Rhodophyta); Diversity of light harvesting pigments, food reserves; Extracellular products and flagellar structures in algae.
- UNIT II** Algal ecology: Distribution of algae in diversified habitats, algae as biological monitor of water pollution; Symbiotic algal associations; Economic importance of algae.
- UNIT III** Origin and classification of Bryophyta; Vegetative and sexual reproduction; Evolution of gametophytes and sporophytes; Economic and ecological importance.
- UNIT IV** Origin of Pteridiophytes: Theories of Algal origin, Bryophycean origin; Classification; Morphological; anatomical and reproductive diversity; Telome theory; Enation theory; Stellar systems in Pteridophytes, Economic importance of Pteridophytes.

## **MBOC 1.22**

### **ALGAE, BRYOPHYTES AND PTERIDOPHYTES**

*Practical Credit: 2*

1. Collection, identification and study of morphological and reproductive features of common Indian fresh water, terrestrial and marine algae.
2. Study of morphology anatomy and reproductive structures of some representatives of Bryophytes.
3. Study of morphology anatomy and reproductive structure of some representative Pteridophytes.

#### **Recommended Books and References:**

1. Chopra R. S. (1975). Taxonomy of Indian Mosses (An Introduction) (Botanical Monograph No. 10). Publications & Information Directorate (CSIR)
2. Clarke C. G. S. and Duckett, J. G. (1979). Bryophyte Systematics. Academic Press.
3. Fritsch F. E. (1945) Structure and Reproduction of Algae. Vol. I & II. Cambridge Univ. Press.
4. Kshyap S. R. (1972). Liverworts of the Western Himalayas and the Panjab Plain. Researchco Publications.
5. Lee F. R. (1980). Phycology. Cambridge Univ, Press.
6. Trainer F. R. (1978). Introductory Phycology. John Wiley & Sons.
7. Morris I. (1986). An Introduction to the Algae. Cambridge Univ. Press.
8. Parihar N. S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot.
9. Parihar N. S. (1991). An introduction to Embryophyta. Vol. II. Pteridophyta. Central Book Depot.
10. Puri P. (1980). Bryophyta. Atma Ram & Sons.
11. Round F. E. (1986). The Biology of Algae. Cambridge Univ. Press.
12. Stewart W. D. P. (1974). Biochemistry and Physiology of algae. Blackwell Scientific Publ.
13. Trainer F. R. (1978). Introductory Phycology. John Wiley & Sons.
14. Watson E. V. (1971). The structure and Life of Bryophytes. Huchthinson Univ. Library.

## **MBOC 1.31**

### **GYMNOSPERMS AND PLANT ANATOMY**

*Theory Credit: 4*

- UNIT I** History and recent systems of classification of gymnosperms; Origin and evolution of gymnosperms; Affinities of gymnosperms with pteridophytes and angiosperms; Distribution of gymnosperms in India; Economic importance of gymnosperms; Salient structural features and affinities of fossil gymnosperms; Pro-gymnosperms; Pteridospermales; Cycadeoidales (Bennettitales); Pentoxylales; Cordaitales.
- UNIT II** Diversity, morphology, anatomy, reproduction and affinities of living gymnosperms: Cycadales, Ginkgoales, Taxales, Coniferales, Ephedrales, Gnetales, Welwitschiales.
- UNIT III** Shoot development- shoot apical meristem; lateral and intercalary meristems-organization, ultrastructure and histochemistry; Differentiation of xylem; Procambium vs vascular cambium, factors influencing the activity of vascular cambium; Wood development in relation to environmental factors; Plant anatomy-current trends and prospects.
- UNIT IV** Leaf development- leaf meristem, histogenesis; Stomatal- ontogeny, classification, ultrastructure of guard cells; Secretary glands, laticifers; Transfer cells; fine structure

of plasmalemma, microtubules and microfibrils; Origin and development of primary and lateral roots, cell fates and cell lineage analysis; Phloem-sieve tubes, sieve cells, differentiation and ultrastructure of cellular organelles; P- protein their morphology and distribution.

### **MBOC 1.32**

### **GYMNOSPERMS AND PLANT ANATOMY**

*Practical Credit: 2*

1. Study of anatomy of vegetative and reproductive parts of gymnosperms: *Pinus* sp. *Cupressus* sp. *Podocarpus* sp. *Cephalotaxus* sp., *Taxus* sp., *Gnetum* sp. (students shall collect specimens, prepare permanent slides and submit in examination).
2. Study of anatomy of vegetative and reproductive parts: *Ginkgo* sp., *Cryptomeriasp* (students shall collect specimens, prepare permanent slides and submit in examination)
3. Study of vegetative and reproductive stages of fossil genera through specimens and permanent slides.
4. Use of paraffin method of micro-technique.
5. Learning technique of making temporary and permanent microscopic preparations.
6. Knowledge and use of photomicrography in anatomical studies.
7. Study of shoot and root apical meristems and lateral meristem.
8. Study of different types of wood.
9. Microscopic examination of different types of leaves to understand the internal structure.
10. Kranz tissue anatomy of C4 plants.

#### **Recommended Books and References:**

1. Andrews H. N. (1961). Studies in palaeobotany. McGraw Hill.
2. Beck B.(ed.)(1988). Origin and evolution of gymnosperms. Columbia University Press.
3. Bhatnagar and Moitra (1996) Gymnosperms. New Age International Press.
4. Buvat R. (1988). Ontogeny, Cell differentiation and Structure of Vascular Plants. Springer-Verlag.
5. Behnke S. (1990). Sieve Elements. Springer-Verlag.
6. Chamberlain C.J. (1934). Gymnosperms, structure and evolution. Univ. of Chicago Press.
7. Arnold C. A. (1947). An Introduction to Palaeobotany. McGraw Hill.
8. Cutter E.G.(1971). Plant Anatomy:Experiment and Interpretation. Vols. 1 & 2. Edward Arnold.
9. Esau K. (1972). Plant Anatomy. John Wiley.
10. FahnA.(1990). Plant Anatomy. Pergmon Press.
11. Gartner (1995). Plant Stems: Physiology and Functional Morphology. Springer-Verlag.
12. Howell S. H. (1998). Molecular Genetics of Plant Development. Cambridge Univ. Press.
13. Iqbal M. (1990). The Vascular Cambium, John Wiley.
14. Iqbal M. (1994). Growth Patterns in Vascular Plants. Timber Press.
15. Johansen D. A. (1940). Plant Microtechnique, 2nd Ed. Tata McGraw-Hill.
16. Mauseth J. D. (1988). Plant Anatomy. The Benjamin Cummings Publ. 6
17. Mattheck C. (1995) Wood- The internal optimization of Trees. Springer-Verlag.
18. Sporne K. R. (1965). The morphology of Gymnosperms. Hutchinson & Co.
19. Steeves T. and Sussex, I. M. (1988). Patterns in Plant Development. Cambridge Univ. Press.
20. Trivedi B. S and Singh D. K. (1965). Structure and reproduction of Gymnosperms. ShashidharMalaviyaPrakashan.

## SEMESTER - II

### MBOC 2.11

#### PLANT TAXONOMY AND ECONOMIC BOTANY

*Theory Credit: 4*

**UNIT I** Concepts and tools of plant taxonomy: Systematics and Plant taxonomy; Taxonomic hierarchy, species concept and its definition, genus, family and other categories; Delimitation of taxa and attribution of rank importance; Plant taxonomy and its relevance in plant conservation; Botanical survey of India, its Herbarium and field methods; Important, Indian and world herbaria; Taxonomic literature; (Floras, taxonomic accounts, revisionary studies); Computer-aided taxonomic studies.

**UNIT II** Systems of Classification, artificial, natural and phylogenetic systems; Merits and demerits of major systems of classification; Linnaeus; Bentham and Hooker, Englerian and Ranalian Schools; Biosystematics; Taxonomic studies of some important families of N.E., Ranunculaceae, Leguminosae (SensuLato), Ericaceae, Asteraceae, Solanaceae, Polygonaceae, Orchidaceae, Poaceae, Rosaceae, Malvaceae, Betulaceae.

**UNIT III** Salient features of International Code of Botanical Nomenclature (ICBN); Principles of the code; Ranks of taxa; Rules of Priority and limitations of principles of priority; Effective and valid publications; Definitions: synonym, basionym, and superfluous name; nomennudum, later homonym, tautonym, legitimate and illegitimate names; Type method and typification; nomenalternatum.

**UNIT IV** Plant Systematics and Economic Botany, Ethnobotany, Diversity of exploited/ underexploited/unexploited plants of economic value of the northeastern region; Use of plants by the tribal societies in northeastern India for subsistence, medicine and cultural and religious rituals; value addition of plants and their products.

### MBOC 2.12

#### PLANT TAXONOMY AND ECONOMIC BOTANY

*Practical Credit: 2*

1. Study of flowering plants in the field with reference to locally available families of monocots and dicots.
2. Field and herbarium methods and preparation of herbarium specimens/museum specimens. (Students are required to submit at least twenty herbarium/museum specimens).
3. Study of flowering plants, description and identification up to family.
4. Practice of handling floras and manuals for identification of taxa (genus and species).
5. Familiarity with taxonomic software.
6. Field trip.

#### **Recommended Books and References:**

1. Cronquist (1968). The evolution and classification of flowering plants. Nelson.
2. Hutchinson J. (1967). Key to the families of the flowering plants of the World. E. Arnold.
3. Heywood V. H. (1968). Modern methods in plant taxonomy. Acad. Press.



4. Henry A. N. and Chandrasbose M. (1979). An aid to international code of Botanical nomenclature. Today & Tomorrow.
5. Jain S. K. and Rao R. R. (1977). A handbook of field and herbarium methods. Today & Tomorrow.
6. Jain S. K. (ed) (1981). Glimpses of Indian ethnobotany. Oxford.
7. Lawrence G. H. M. (1967). Taxonomy of vascular plants. Oxford & IBH.
8. McNeill J. et al. (1993). ICBN- Adopted by the 15th Int. Bot. Congr.
9. Naik V. N. (1990). Introductory plant taxonomy. Longman.
10. Nair P.K.K. (ed) (1980). Modern trends in plant taxonomy. Vikas Publ.
11. Radford A. E. (1986). Fundamentals of Plant Systematics. Harper Row.
12. Sivarajan V. V. (1990). Introduction to principles of plant taxonomy. Oxford & IBH.
13. Takhtajan A. (1969). Flowering plants Origin and dispersal. Oliver & Boyd.
14. Taylor D. W. and Hickey L. (1996). Flowering Plant Origin, Evolution and Phytoeny. Chapman & Hall

## **MBOC 2.21**

### **PLANT BIOCHEMISTRY AND MOLECULAR BIOLOGY**

*Theory Credit: 4*

- UNIT I** Carbohydrates and their derivatives: synthesis and inter-conversions; Lipids: biosynthesis of fatty acids and their regulation; Phospholipids and their role in signal transduction in cells; Amino acids: structure and function, properties of amino acids; Proteins: structure and function, folding and sub-unit assembly, post translational processing, turnover in cells.
- UNIT II** Enzymes: structure of active site, mechanisms of action, kinetics of enzymes catalysed reactions, regulation of enzyme activity; Proteomics: Protein targeting; Protein profiling and its significance; Designing novel proteins; Industrial enzymology: large scale production and purification of enzymes, principles of immobilized enzyme technology.
- UNIT III** Structure o nucleic acids: DNA and its A, B and Z conformations, t-RNA, r-RNAs; DNA replication: machinery and mechanism in prokaryotes and eukaryotes; RNA transcription: machinery and mechanism in prokaryotes and eukaryotes; RNA processing: processing of hnRNA; RNA editing; Genetic code and exceptions to its universality.
- UNIT IV** Translation: machinery and mechanism (tRNA charging, initiation in prokaryotes and eukaryotes, elongation and termination); Regulation of gene expression in prokaryotes and eukaryotes; Recombinant DNA technology: restriction enzymes and construction of hybrid DNA; Gene cloning: cloning vehicles (plasmids, bacteriophages, YAC, BAC); Construction and screening of genomic DNA and cDNA libraries; Polymerase Chain Reaction: principle, primer designing, applications; introduction to RT-PCR.

#### **Recommended Books and References:**

1. Alberts B. et al. (2002). Molecular Biology of the cell. Gerland.
2. Birge,E.A. (2000). Bacterial and bacteriophage genetics. Springer.
3. Brown, T.A. (1989).Genetics a molecular approach. Van Nostrand.
4. Boyer R. (1999). Concept in Biochemistry. Brooks/Cole Publ.

5. Buchanan B.B. et al. (eds) (2004). Biochemistry and Molecular Biology of Plants. Amer. Soc. Plant Physiol.
6. Conn E.E. and Stumpf P.K. (1994). Outlines of Biochemistry. Wiley Eastern.
7. Dennis D.T. (1998). Plant metabolism. Longman.
8. Dey P.M. and Harborne J.B. (1997). Plant Biochemistry. Acad. Press.
9. Heldt H. (1997). Plant Biochemistry and Molecular Biology. Oxford Univ. Press.
10. Lea P.J. and Leagood R.C. (1999). Plant Biochemistry and Molecular Biology. Wiley.
11. Lewin B. (2002). Genes VIII. Oxford.
12. Lodish H. et al. (1996). Molecular Cell Biology. Sc. American Books.
13. Nelson D.L. and Cox M.M. (2000). Lehningers Principles of Biochemistry. Macmillan Worth.
14. Sinden P.R.R. (1994). DNA structure and function. Acad. Press.
15. Stryer L. (1993). Biochemistry. W.H. Freeman.
16. Walker J.M. and Rapley R. (2002). Molecular Biology and Biotechnology. Panima.
17. Watson J.D. et al. (2004). Molecular Biology of the gene. Pearson Education.
18. Zubay G. (1993). Biochemistry. W.C. Brown.

## **MBOC 2.22**

### **PLANT BIOCHEMISTRY AND MOLECULAR BIOLOGY**

*Practical Credit: 2*

1. Estimation of starch from plant tissues by iodine reaction.
2. Estimation of sugars from plant tissues by dinitrosalicylic acid.
3. Estimation of amino acids from plant tissues by ninhydrin reaction.
4. Estimation of soluble protein content from plant tissues by Lowry's method.
5. Separation of soluble proteins by (a) gel filtration (b) gel electrophoresis.
6. Assay of phosphatase activity in plant cells.
7. Assay of nitrate reductase activity in cells.
8. Isolation of plant DNA.
9. Agarose gel electrophoresis of DNA.
10. Spectrophotometric estimation of DNA.
11. DNA digestion by general and restriction endonucleases.

#### **Recommended Books and References:**

1. Plumer D. T. (1993). An Introduction to Practicals in Biochemistry. Tata McGraw Hill.
2. Alberts B. et al. (2002). Molecular Biology of the cell. Garland.
3. Birge, E.A. (2000). Bacterial and bacteriophage genetics. Springer.
4. Brown, T.A. (1989). Genetics a molecular approach. Van Nostrand.
5. Boyer R. (1999). Concept in Biochemistry. Brooks/Cole Publ.
6. Buchanan B.B. et al. (eds) (2004). Biochemistry and Molecular Biology of Plants. Amer. Soc. Plant Physiol.
7. Conn E.E. and Stumpf P.K. (1994). Outlines of Biochemistry. Wiley Eastern.
8. Dennis D.T. (1998). Plant metabolism. Longman.
9. Dey P.M. and Harborne J.B. (1997). Plant Biochemistry. Acad. Press.
10. Heldt H. (1997). Plant Biochemistry and Molecular Biology. Oxford Univ. Press.
11. Lea P.J. and Leagood R.C. (1999). Plant Biochemistry and Molecular Biology. Wiley.
12. Lewin B. (2002). Genes VIII. Oxford.
13. Lodish H. et al. (1996). Molecular Cell Biology. Sc. American Books.
14. Nelson D.L. and Cox M.M. (2000). Lehninger Principles of Biochemistry. Macmillan Worth.
15. Sinden P.R.R. (1994). DNA structure and function. Acad. Press.
16. Stryer L. (1993). Biochemistry. W.H. Freeman.

17. Walker J.M. and Rapley R. (2002). Molecular Biology and Biotechnology. Panima.
18. Watson J.D. et al. (2004). Molecular Biology of the gene. Pearson Education.
19. Zubay G. (1993). Biochemistry. W.C. Brown.

**MBOO 2.11**  
**BIOPROCESS DEVELOPMENT**

*Theory Credit: 2*

**UNIT I** Structure and Organization of Microbial cells; Microbial growth: growth curve of bacteria; batch, continuous and synchronous cultures; Principles and usage of Bioreactors; Microbial fermentation. Principles of bioprocess control, products with representative examples.

**UNIT II** Biosafety and Environmental Monitoring of GEMs; Bio-pesticides; Bioconversion of waste products by microbes with special reference to biogas; Intellectual Property Rights in Biotechnology.

**Recommended Books and References:**

1. Alexander N.Glazer and Hiroshi Nikaido. 1998. Microbial biotechnology. W.H.Freeman& Co., USA.
2. Behrens, D. & Kramer, P. (Eds) (1990).Bioprocess engineering: Down Stream processing & recovery of bioproducts, safety in biotechnology and regulations
3. E. M.T.E.L., Mansi and C. F. A. Bryle (2002) Fermentation Microbiology and Biotechnology Taylor & Francis Ltd, UK.
4. Edward A. Brige. 1992. Modern Microbiology – Principles and application, WMC Brown Publishers, USA.
5. Flickinger, M.C & Drew S.W (1999) Encyclopedia of Bioprocess Technology. Vol 1-5
6. Gerard J, Tortora, Berdell R, Funke, Christine, Case L. 2001.Microbiology – An introduction, Benjamin cummings, USA.
7. M. M. Young (2004). Comprehensive Biotechnology. The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4 Reed Elsevier India Private Ltd, India
8. P.F. Stanbury ,A.Whitaker and S.J.Hall (1997) Principles of Fermentation Technology
9. Pelzer MJ, Chan ECS, Kreig NR. 1993. Microbiology, Mc Graw Hill Inc., New York.
10. Prescott JP, Harley, Klein DA. 2002. Microbiology, Mc Graw Hill, Boston.
11. Stanbury PF, Whitaker. 1995. Principles of fermentation technology, Pergamon Press, Oxford.
12. Wulf Crueger and Anneliese Crueger (2000) Biotechnology: A Textbook of Industrial Microbiology Punima Publishing Corporation, India.
13. Zhou. J., Thomson D. K., Xu. Y, Tiedje JM. 2004. Microbial functional Genomics, J. Wiley & Sons.

**MBOO 2.21**  
**RIGHTS AND ISSUES IN BIOLOGY**

*Theory Credit: 2*

**UNIT I** Intellectual property and protection of intellectual property rights; International harmonization of patent laws: TRIPS, India and TRIPS; Protection of biotechnological inventions.

**UNIT II** Plant breeder's rights; Management of IPR; Benefits and problems from IPR; Geographical Indications; International convention on biological diversity (ICBD).

**Recommended Books and References:**

1. Singh B. D. (2006) Biotechnology, Expanding Horizon. Kalyani Publishers.
2. Migheli, Q. (2001). Genetically modified biocontrol agents: environmental impact and risk analysis. Jour. Plant Pathol. 83: 45-76
3. Sharma, H.C. and Ortiz, R. 2000. Transgenics, pest management and the environment. Current Sci. 79: 421-437.
4. Ghosh, P.K. (1997) Transgenic plants and biosafety concerns in India. Current Sci. 72: 172-179.
5. DBT. (1994) The Indian Recombinant DNA safety Guidelines and Regulations. DBT, New Delhi
6. Hambleton, P., Bennet, A.M., Leaver, G. and Benbough, J.E. (1992) Biosafety monitoring devices for biotechnology processes. Trends Biotechnol. 10:192-199.
7. Tolin, S.A and Vidaver, A. K. (1989). Guidelines and regulations for research with genetically modified organisms: A view from academe. Annu. Rev. Phytopath. 27: 551-581.
8. Hellman, A., Oxman, M.N and Pollack, R. (eds). 1973. Biohazards in Biological Research. Cold Spring Harbor Laboratory, N.Y
9. Steere, N.V. (ed.) 1971. Handbook of Laboratory Safety, 2nd edn. The Chemical Rubber Co., Cleveland, Ohio.

**MBOO 2.31**  
**TECHNIQUES IN MOLECULAR BIOLOGY**

*Theory Credit: 2*

**UNIT I** Microscopy; Spectrophotometry; Fluorimetry; Chromatography: Gel filtration, absorption and ion Exchange

**UNIT II** Electrophoresis; Blotting: Southern, Western, Northern, South- Western, Nucleotide sequencing and analysis; Radioisotopes in Biology.

**Recommended Books and References:**

1. Alberts B. et al. (2002). Molecular Biology of the cell. Garland.
2. Birge, E.A. (2000). Bacterial and bacteriophage genetics. Springer.
3. Brown, T.A. (1989). Genetics a molecular approach. Van Nostrand.
4. Boyer R. (1999). Concept in Biochemistry. Brooks/Cole Publ.
5. Buchanan B.B. et al. (eds) (2004). Biochemistry and Molecular Biology of Plants. Amer. Soc. Plant Physiol.
6. Conn E.E. and Stumpf P.K. (1994). Outlines of Biochemistry. Wiley Eastern.
7. Dennis D.T. (1998). Plant metabolism. Longman.

8. Dey P.M. and Harborne J.B. (1997). Plant Biochemistry. Acad. Press.
9. Heldt H. (1997). Plant Biochemistry and Molecular Biology. Oxford Univ. Press.
10. Lea P.J. and Leagood R.C. (1999). Plant Biochemistry and Molecular Biology. Wiley.
11. Lewin B. (2002). Genes VIII. Oxford.
12. Lodish H. et al. (1996). Molecular Cell Biology. Sc. American Books.
13. Nelson D.L. and Cox M.M. (2000). Lehninger Principles of Biochemistry. Macmillan Worth.
14. Sinden P.R.R. (1994). DNA structure and unction. Acad. Press.
15. Stryer L. (1993). Biochemistry. W.H. Freeman.
16. Walker J.M. and Rapley R. (2002). Molecular Biology and Biotechnology. Panima.
17. Watson J.D. et al. (2004). Molecular Biology of the gene. Pearson Education.
18. Zubay G. (1993). Biochemistry. W.C. Brown.

## SEMESTER - III

### MBOC 3.11

### GENETICS, CYTOGENETICS AND PLANT BREEDING

*Theory Credit: 4*

- UNIT I** Modern gene concept: genetic fine structure, cis-trans test; Eukaryotic gene organization, introns and exons; Organization of eukaryotic chromosomes; Linkage and genetic recombination, linkage groups; Mutations: induced and spontaneous; Physical and chemical mutagens; DNA damage and repair; Molecular mechanism of mutation and recombination.
- UNIT II** Chromosomal aberrations in plants: structural aberrations, numerical aberrations Euploidy- autopolyploidy and allopolyploidy. Aneuploidy-monosomy, trisomy and nullisomy. Interchange heterozygotes, permanent hybrids
- UNIT III** Plant breeding methods- conventional and scientific. Synthesis of tetraploid, hexaploid and octoploid triticales; Alien chromosome additions and substitutions; Chromosome fragment transfers and crop improvement; Giemsa banding of chromosomes; FISH. Application of polyploids in crop improvement.
- UNIT IV** Phenotypic variance and its components; Heritability of traits and its estimation; Gene frequency in a population, genetic equilibrium and Hardy-Weinberg law, barriers to gene flow and mechanism of speciation; Heterosis and hybrid vigour; Concept of combining ability; Male sterility and its application in hybrid seed production. QTL (Quantitative Trait Locus)

#### **Recommended Books and References:**

1. Allard R. W. (1960). Principles of Plant breeding. John Wiley.
2. Ayala F. J. and Kiger J. A. (1980). Modern Genetics. Benjamin Cummings.
3. Brown T. A. (1989). Genetics- a molecular approach. Chapman & Hall.
4. Brown T. A. (1999). Genomes. John Wiley & Sons.
5. Chopra V. L. (1989). Plant Breeding. Oxford & IBH.
6. Clark M. S. and Wall W. J. (1996). Chromosomes. Chapman & Hall.
7. Gupta P. K. (1995). Cytogenetics. Rastogi & Co.
8. Gupta P. K. (1998). Genetics and Biotechnology in Crop Improvement. Rastogi & Co.
9. Griffiths A.J. F. et al. (2000). An Introduction to Genetic Analysis. W. H. Freeman.
10. Hartl D. L. (1991). Basic Genetics. Jones & Bartlett.
11. Hartl D. L. and Jones E. W. (2001). Genetics-Analysis of Genes & Genomes. Jones and Bartlett.
12. Jain H. K. (1999). Genetics. Oxford-IBH.
13. Poehlman J. M. and Sleper D. A. (1995). Breeding Field Crops. Iowa State University Press.
14. Sharma J. R. (1994). Principles & Practices of Plant Breeding. Tata-McGraw Hill.
15. Simmonds N. W. (1979). Principles of crop improvement. Longman.
16. Snustad D. P. and Simmons M. J. (2000). Principles of Genetics. John Wiley and Sons.
17. Strickberger M. W. (1985). Genetics. Macmillan.
18. Sybenga J. (1972). General Cytogenetics. North Holland.
19. Tamarin R. H. (2002). Principles of Genetics. Tata McGraw-Hill.

**MBOC 3.12**  
**GENETICS, CYTOGENETICS AND PLANT BREEDING**

*Practical Credit: 2*

1. Preparation of materials and study of somatic chromosomes of some common plants.
2. Collection of flower buds and study of meiosis of some common plants.
3. Study of meiosis of some aberrant plants.
4. Camera lucida drawing of cytological preparations.
5. Isolation of chlorophyll mutants following irradiation treatments.
6. Numerical exercises on linkage and crossing over.
7. Numerical exercises on  $\chi^2$  for independence of attributes and goodness of fit.
8. Giemsa bonding of chromosomes.

**Recommended Books and References:**

- i. Elrod S. and Stansfield W. (2004). Genetics. Tata McGraw-Hill.
- ii. Fukui K. and Nakayam S. (1996). Plant Chromosomes: Laboratory Methods. CRC Press.
- iii. Sharma A. K. and Sharma A. (1999). Plant Chromosomes: Analysis, Manipulation and Engineering. Harwood Academic Publishers.
- iv. Stansfield W. D. (1969). Theory and Problems of Genetics. McGraw-Hill.

**MBOC 3.21**  
**PLANT PHYSIOLOGY**

*Theory Credit: 4*

- UNIT I** Water relation in plants: Chemical potential of water, water potential in plants, soil-plant-atmosphere continuum; Movement of water in Plants; Passive and active transport; Membrane transport proteins.
- UNIT II** Bioenergetics: Laws of thermodynamics and their significance in free energy changes in biological systems; Organization of the light absorbing pigment systems; Mechanisms of photoexcitation of chlorophyll and electron transport chain; Regulation of photosynthetic activity and mechanisms of repair of photosynthetic apparatus; Carbon fixations in photosynthesis; Glycolysis and its regulation; Fatty acid oxidation, mechanisms of oxidative decarboxylation of pyruvic acid; Mitochondrial electron transport and oxidative phosphorylation; Assimilation of mineral nutrients: Uptake and assimilation of nitrate and sulphate ions; Biological nitrogen fixation and assimilation of ammonia.
- UNIT III** Plant Growth Regulators: Auxins, gibberellins, cytokinins, abscisic acid, ethylene-physiological effects and mechanism of action; Hormone receptors; Steroids as plant growth regulators; Brassinosteroids- types, physiological effects and mechanism of action.
- UNIT IV** Dormancy: types and mechanism of regulation; Flowering: photoperiodism and vernalization; Biochemical mechanisms involved in flowering; Partitioning of assimilates during different phases of plant growth; Senescence and ageing, molecular aspects of senescence and ageing.

### **MBOC 3.22**

#### **PLANT PHYSIOLOGY**

*Practical Credit: 2*

1. Study of the effect of organic compounds on membrane permeability
2. Determination of water potential in plant tissues
3. Estimation of chlorophyll a, b and total chlorophyll content of plant tissues
4. Isolation of plant pigments and determination of their absorption spectra
5. Measurement of Hill reaction activity by Winkler's method; Effect of light wavelength and light intensity
6. Assay of auxin activity by Avena hypocotyl elongation
7. Assay of amylase induction by GA in plant tissues
8. Assay of effect of cytokinin on chlorophyll degradation by leaf disc method.

#### **Recommended Books and References:**

1. Aducci P. (1997). Signal Transduction in Plants. Birkhauser Verlag.
2. Annual Reviews of Plant Physiology and Molecular Biology. Academic Press (Annual Series)
3. Bernle J. D. and Black M. (1992). Seed Physiology and Biochemistry. Springer-Verlag.
4. Buchanan B.B., Wilhelm G. and Russel J. (2003). Biochemistry and Molecular Biology of Plants. ASPB. US.
5. Dennis D. T. (1997). Plant Metabolism. John Wiley.
6. Dey P. M. and Harborne, J. B. (2000) Plant Biochemistry. Academic Press.
7. Encyclopedia of Plant Physiology. Springer-Verlag. (Annual Series).
8. Gresshoff P. M. (2000). Plant Biochemistry. John Wiley.
9. Goodwin T. W. and Mercer E. I. (1983). Introduction to Plant Biochemistry. Pergamon Press.
10. Hopkins W.G. and Hunter N.P. (2003). Introduction to Plant Physiology. John Wiley & Sons.
11. Krauss G. (1999) Biochemistry of Signal Transduction & Regulation. John Wiley.
12. Lender D. W. (2001). Photosynthesis. MerceLDecker.
13. Lincoln T. and Zeiger E. (2002). Plant Physiology. Palgrave Macmillian.
14. Lehniger A. L. (1993). Principle of Biochemistry. CBS.
15. Leopold A. C. and Kreidman P. E. (1980). Plant growth and development. Tata MacGraw Hill.
16. Mattoo A. K. and Shuttle, J. C. (1995). The Plant hormone Ethylene. CRC. Press.
17. Mukherji S. and Ghosh A. K. (1996). Plant Physiology. Tata- McGraw Hill.
18. Noggle G. R. and Fritz C. J (1989). Introductory Plant Physiology. Prentice Hall
19. Seigler D. S. (1994). Plant secondary metabolism. Narosa
20. Srivastava H. S. (1994). Plant Physiology. Rastogi and Co.
21. Thomas B. and Vince-Prue D. (1997). Photoperiodism in plants. Academic Press.

### **MBOO 3.11**

#### **BIODIVERSITY AND PHYTOGEOGRAPHY**

*Theory Credit: 2*

- UNIT I** Biological diversity: Distribution and global patterns; Biodiversity hotspots; Speciation and extinction; IUCN categories of threatened species; Sustainable utilization of biodiversity; Plant diversity conservation in India.
- UNIT II** Phytogeography: Static and interpretive plant geography; phytogeographic regions of India; Altitudinal zonation of vegetation on the eastern and western Himalayas; Plant migration and barrier of plant distribution, Endemism.



**Recommended Books and References:**

1. Barnes, R.S.K. (Eds.). 1998. Diversity of living organisms. Blackwell Sciences Ltd., U.K. pp 345.
2. Barthlott, W. and Winiger, W. (Eds.). 2001. Biodiversity. Springer-Verlag, New York. pp 429.
3. Eldredge, N. (Eds.) 1992. Systematics, Ecology and Biodiversity Crisis. Cambridge University Press, New York. pp. 220.
4. Frankel, O.H., Anthony, H.D. and Burdo, J.J. 1995. Conservation of Plant Biodiversity. Cambridge University Press, Cambridge. pp 299.
5. Groombridge, B. (Eds.) 1992. Global biodiversity: status of the earth's living resources, a report compiled by the World Conservation Monitoring Centre. Chapman and Hall, London. pp. 585.
6. Heywood, V.H. and Watson, R.T. (Eds.). 1995. Global biodiversity: Assessment. Cambridge University Press, Cambridge. pp 1140.
7. Reaka-Kulda, L.M., Wilson, D.E. and Wilson, E.O. (Eds.). 1997. Biodiversity II. Understanding and protecting our biological resources. Joseph Henry Press, Washington. pp 551.
8. World Resources Institute 1992. Global Biodiversity Study: Guidelines for action to save, study and use earth's biotic wealth sustainably and equitably. pp 344.

**MBOO 3.21****ENVIRONMENTAL POLLUTION AND CONSERVATION THEORY**

*Theory Credit: 2*

**UNIT I** Environmental pollution: Kinds of sources of air, soil and water pollution, parameters to assess the pollution level, effects of pollution on plants and ecosystems and pollution abatement; Climate change: greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CFCs: sources, trends and role), ozone depletion and consequences of climate change.

**UNIT II** Human impacts on natural ecosystems - forest, grassland and mountain ecosystems; Soil erosion and its control; Shifting cultivation and its ecological implications; Coal mining and other environmental problems of northeast India; ecorestoration of degraded ecosystems; environmental impact assessment (EIA).

**Recommended Books and References:**

1. Cunningham, W.P. and Saigo, B.W. 1999. Environmental Science. WCB, McGraw Hill. pp 650.
2. Hunter, M.L. 1996. Fundamentals of Conservation Biology. Blackwell Science, Oxford. pp 482.
3. Jones, A.M. 1997. Environmental Biology. Routledge Publications, London and New York. pp. 197.
4. Mooney, H.A. and Gordon, M. 1983. Disturbance and Ecosystems components of Response. Springer Verlag. Berlin Heidelberg, New York, Tokyo. 1PP-292.

**MBOO 3.31**  
**BIOSTATISTICS**

*Theory Credit: 2*

**UNIT I** Biostatistics: Measures of variation; standard deviation, standard error, coefficient of variation; Degrees of freedom; Test of significance: Students' 't' test, Z test, Frequency distribution.

**UNIT II** Analysis of variance and 'F' test, correlation and regression; Design of Experiments: randomization; Completely randomized block and split-plot design.

***Recommended Books and References:***

1. Zar, J.H. (1984). Biostatistical analysis. Prentic-Hall International
2. Bizhop, O.N. (1980). Statistics of Biology. Longman press.
3. Panse, V.G. and Sukhatme, P.V. 2000. Statistical methods for agricultural workers. ICAR, New Delhi
4. Hoshmand, A.R. (1998). Statistical methods for environmental and agricultural sciences. CRC press, New york.
5. Gomez K. A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research. John Wiley & Sons.
6. Parker R. E. (1979). Introductory statistics for Biology. Edward Arnold.
7. Silvertown J. W. (1982). Introductory statistics for Biology. Edward Arnold

## SEMESTER - IV

### MBOC 4.11

#### PLANT REPRODUCTIVE BIOLOGY AND BIOTECHNOLOGY

*Theory Credit: 4*

- UNIT I** Microsporogenesis; Ultrastructural changes in tapetum, role of tapetum in pollen development, cytoplasmic male sterility; Development of generative cells. Megasporogenesis; Subcellular profiles of archesporial and megaspore mother cells, megaspore dyad, tetrad and coenomegaspore, polarity and ultrastructure of embryo sac.
- UNIT II** Pollen-pistil interaction; Methods of overcoming incompatibility; Differential behaviour of male gamete, heterogeneity in sperms. Endosperm types, endosperm haustoria and their function. Embryonic types, histo& organogenesis of monocot & dicot embryos; structure and function of suspensor, polyembryony and apomixes.
- UNIT III** Tissue culture: Role of in vitro tissue culture in plant biotechnology, anther culture, ovary culture, somatic hybridization and production of cybrids, embryo culture and rescue, clonal propagation, cryopreservation and germplasm storage, somatic embryogenesis, artificial seeds, somaclonal variations, virus free plants.
- UNIT IV** Transgenic plants, Gene silencing and transgenic system, useful gene transfers, Genetic engineering of plants for insect control, herbicide resistance, resistance against viruses, quality improvement, increased shelf life.

### MBOC 4.12

#### PLANT REPRODUCTIVE BIOLOGY AND BIOTECHNOLOGY

*Practical Credit: 2*

1. Study of microsporogenesis and gametogenesis in anthers.
2. Tests for pollen viability using stains and *in vitro* pollen germination.
3. Estimating percentage of pollen germination and pollen viability *in vitro*.
4. Preparation of dissected whole mounts of endothecium, tapetum and ovule.
5. Study of nuclear and cellular endosperm and suspensor through dissections and staining.
6. Isolation of globular, heart shaped and torpedo stages of embryos from suitable seeds.
7. Induction of callus and somatic embryogenesis.
8. Preparation of artificial seeds.
9. Isolation of protoplasts.
10. Clonal propagation of forest plants.

#### **Recommended Books and References:**

1. Bewley J.D. and Black M. (1994) Seeds: Physiology of Development and Germination. Plenum Press.
2. Bhojwani S.S. and Bhatnagar S. P. (2000). The Embryology of Angiosperms. Vikas Publishing House.
3. Endress P. K. and Frus F. M. (1994). Early Evolution of Flowers. Springer-Verlag.
4. Leins P. Tucker S.C. and Endress P. K. (1988). Aspects of Flower Development. J. Cramer.
5. Meeuse AD. (1966). Fundamentals of Phytomorphology. Ronald Press Co.

6. Mashewari P. (1950). An Introduction to the Embryology of Angiosperms. McGraw Hill Book Co.
7. Raghavan V. (1966). Embryogenesis in Angiosperms. Cambridge Univ. Press.
8. Raghavan V. (1999). Development Biology of Flowering Plants. Springer-Verlag.
9. Sattler R. (1978). Theoretical Plant Morphology. Leiden University Press.
10. Shivanna K. R. and Rangaswamy N.S. (1992). Pollen Biology: A Laboratory Manual, Springer-Verlag.
11. Shivanna K. R. and Johri B. M. (1985). The Angiosperm Pollen Structure and Function. Wiley Eastern.
12. Shivanna K. R. and Sawhney V. K. (1997). Pollen Biotechnology for Crop Production and Improvement. Cambridge Univ. Press.
13. Sporne K. R. (1974). The Morphology of Angiosperms. Hutchinson University Press.
14. Swamy B.G.L. and Krishnamurthy K. V. K. (1980). From Flower to Fruit. Tata McGraw Hill Book Co.

#### **MBOC 4.21**

#### **PLANT ECOLOGY AND ECOSYSTEM ANALYSIS**

*Theory Credit: 4*

- UNIT I** Concepts relating to limiting factors; environmental factors-soil, water, light, temperature and fire; concept of population, community and ecological niche; Ecosystem concept, ecosystem organization.
- UNIT II** Population ecology: Population growth; survivorship curves and life-table analysis; population dynamics and plant population regulation; population interactions with emphasis on resource competition and allelopathy; Ecotypes.
- UNIT III** Community Ecology: Structure of plant community-life forms and biological spectrum, species diversity and dominance; Quantitative methods of studying plant communities; temporal changes in communities-primary succession, secondary succession and the concept of climax.
- UNIT IV** Ecosystem function: Primary productivity and its measurement; Primary productivity of terrestrial and aquatic ecosystems of the world; Flow of energy and ecological efficiencies; Biogeochemical cycle with particular reference to cycling of carbon, nitrogen, phosphorus, sulphur; Ecosystem dynamics: development of ecosystem; Ecosystem stability-ecosystem resistance and resilience.

#### **Recommended Books and References:**

1. Begon M., Harper J.L. and Townsend C. R. (1990). Ecology: Individual, Populations and Communities. Blackwell Scientific Publisher.
2. Daubermire R. (1974). Plants and environment. John Wiley & Sons.
3. Hanson H. C. and Churchill E. D. (1963). Plant Communities. Reinhold.
4. Kormondy E. J. (1996). Concepts of ecology. Prentice-Hall.
5. Odum E. P. (1971). Fundamentals of Ecology. W. B. Saunders.
6. Odum E. P. (1983). Basic Ecology. Holt Saunders International.
7. Underwood A. J. (1997). Experiments in ecology. Cambridge University Press.
8. White J. (1985). Studies on plant demography. Academic Press.
9. Whittaker R. H. (1975). Communities and Ecosystems. McMillan.
10. Wild A. (1994). Soils and the environment. Cambridge University Press.

**MBOC 4.22**  
**PLANT ECOLOGY AND ECOSYSTEM ANALYSIS**

*Practical Credit: 2*

1. Study of interactions between plants and environment
  - a. Study of microclimatic conditions in open and closed communities
  - b. Study of plastic response of plant species under contrasting environmental conditions
2. Study of physico-chemical properties of soil; (a) texture, (b) porosity, (c) water holding capacity (d) organic matter content
3. Study of analytical characters of plant community using plot and plot-less methods
4. Study of survivorship plant populations and life-table analysis
5. Estimation of phytomass and its distribution in different compartments in grassland communities
6. Determination of leaf-area index in the grassland community
7. Estimation of primary productivity of plant community by (a) harvest method, and (b) light and dark bottle method
8. Estimation of rate of carbon dioxide evolution from different soils by alkali absorption method.

***Recommended Books and References:***

1. Anderson J. M. and Ingram J. S. I (1993). Tropical soil biology and fertility: A handbook of methods. CAB International.
2. Misra R. (1968). Ecology Workbook. Oxford & IBH.
3. Muller-Dombois D. and Ellenberg H. (1974). Aims and Methods of vegetation ecology. John Wiley & Sons.
4. Odum, E. P. (1971). Fundamentals of Ecology. W. B. Saunders.
5. Poole R. W. (1974). An Introduction to Quantitative Ecology. Mc Graw Hill Inc.
6. Zar J. H. (1984). Biostatistical analysis. Prentice-Hall International.

**MBOC 4.31**  
**PROJECT WORKS**

*Credit: 6*

**Broad areas for specialization through Project Work:**

1. Higher Plant Ecology
2. Microbial Ecology
3. Plant Molecular Biology
4. Advanced Plant Physiology
5. Taxonomy and Biodiversity of angiosperms
6. Development and Reproduction of angiosperms
7. Plant Biotechnology
8. Plant Genetics and Cytogenetics
9. Lower plants

**Evaluation scheme for Project Work:**

For continuous evaluation, she/he will be required to select a topic and submit the synopsis latest by the end of 3<sup>rd</sup> semester. The student will be required to give a seminar on submission of the project in the 4<sup>th</sup> semester. Each seminar will be evaluated for 25 marks by the supervisor and Head's nominee. Besides, the supervisor will evaluate the student for her/his performance in the lab work by way of two practical tests during the semester. Each test will carry 12.5 marks. The marks obtained by the student in the two seminars and in the two tests will be averaged separately and added to obtain the total marks of continuous evaluation. The end semester examination will be based on the evaluation of project work (75 marks for dissertation + 25 marks for seminar + 12.5 marks for viva voce). At the time of examination, the student will submit project report and will give a brief presentation of the work done by her/him, which will be followed by viva-voce examination. The end semester evaluation will be done by a board comprising the external examiner in the concerned broad areas, supervisor and Head's nominee. The external examiners shall be called in nine broad areas to evaluate the project work as well as to conduct practical examination. In case the external examiner is not able to come, the Dean of the School, as per existing practice may constitute an internal Board.

**Attachment of students and allotment of topic for Project Work:**

Each faculty will be assigned a minimum of one or a maximum of two students. Attachment of students shall be done on the basis of their choice and marks secured by them in the last end Semester examination for which the results are available. The teacher will assign one topic to the student and communicate the same to the Head of the Department by the end of III<sup>rd</sup> Semester. Modification in the topic, if absolutely necessary may be allowed during the first month of the IV<sup>th</sup> semester and not thereafter. The Head of the Department will notify the final list of topics allotted to the students. The student will work in the M. Sc. Lab or Research lab of the concerned teacher during two days in a week as per the timetable. The teacher will provide regular necessary guidance by way of discussion, tutorials and any other method, which she or he deems fit for the successful completion of work assigned to the student and will maintain the attendance. The workload for each teacher will be equivalent to five theory and six practical hours per week per student attached.

SYLLABUS FOR  
Master of Science

**CHEMISTRY**

SEMESTER SYSTEM





**CORE STRUCTURE**

<b>SEMESTER</b>	<b>COURSE CODE</b>	<b>COURSE NAME</b>	<b>CREDITS</b>
<b>I</b>	MCHC 1.11	Inorganic Chemistry-I	4
	MCHC 1.21	Organic Chemistry-I	4
	MCHC 1.31	Physical Chemistry-I	4
	MCHC 1.12	Lab course -I (Organic Chemistry)	6
<b>II</b>	MCHC 2.11	Inorganic Chemistry-II	2
	MCHC 2.21	Organic Chemistry-II	2
	MCHC 2.31	Physical Chemistry-II	2
	MCHC 2.12	Lab Course -II (Inorganic Chemistry)	6
	MCHO 2.11	Open Choice	2
	MCHO 2.21	Open Choice	4
<b>III</b>	MCHC 3.11	Inorganic Chemistry-III	2
	MCHC 3.21	Organic Chemistry-III	2
	MCHC 3.31	Physical Chemistry-III	2
	MCHC 3.12	Lab Course -III (Physical Chemistry)	6
	MCHO 3.11	Open Choice	2
	MCHO 3.21	Open Choice	4
<b>IV</b>	MCHC 4.11	Inorganic Chemistry-IV	4
	MCHC 4.21	Organic Chemistry-IV	4
	MCHC 4.31	Physical Chemistry-IV	4
	MCHC 4.41	Project Work	6

## SEMESTER - I

### MCHC 1.11 INORGANIC CHEMISTRY - I

Credit: 4

**UNIT I** **Symmetry and Structure:** Symmetry elements and operations; equivalent symmetry elements and equivalent atoms; symmetry point groups with examples from inorganic compounds; groups of very high symmetry; molecular dissymmetry and optical activity; systematic procedure for symmetry classification of molecules and illustrative examples; molecular symmetry for compounds having co-ordination numbers 2 to 9.

**UNIT II** **(a) Stereochemistry and Bonding:** LCAO-MO theory for homonuclear and heteronuclear diatomic molecules; orbital symmetry and overlap; Walsh diagrams; electronegativity (Pauling, Mulliken and Allred-Rochow methods); and polarity of bonds; review of VSEPR model and the use of outer d-orbitals  
**(b) Metal-Ligand Equilibria in Solution:** Stepwise and overall formation constants; trends in stepwise formation constants; determination of binary formation constant by spectrophotometry; factors affecting stability of metal complexes and chelate effect.

**UNIT III** **Magnetic Properties & Electronic Structure of Transition Metal Complexes:** Brief review of different types of magnetic behavior, spin-orbit coupling, quenching of orbital angular momenta, temperature-independent paramagnetism, measurement of magnetic susceptibility using Gouy and Faraday methods, Term symbols for metal ions; Crystal field theory and its application to explain magnetic properties of coordination compounds, spin crossover; Structural effects: ionic radii and Jahn-Teller effect; octahedral vs. tetrahedral coordination, magnetic properties of Lanthanides and Actinides and splitting of f-orbitals in octahedral field.

**UNIT IV** **Electronic Structure of Transition Metal Complexes:** Electronic absorption spectra of octahedral and tetrahedral complexes, Orgel diagrams, Tanabe-Sugano diagrams, calculation of  $Dq$ ,  $B$  and  $\beta$  values, selection rules, band intensities and band widths, spectra of high-spin octahedral and tetrahedral complexes of  $d^1$  to  $d^9$  systems, Spectrochemical series; Adjusted crystal field theory, Nephelauxetic series, molecular orbital theory of complexes (qualitative principles involved in complexes with and without  $\pi$ -bonding), MO diagrams for octahedral and tetrahedral complexes and charge-transfer spectra, optical properties of Lanthanides and Actinides.

#### **Recommended Books and References:**

1. J. E. Huheey, E. A. Keiter, R. L. Keiter & O. K. Medhi. *Principles of Structure and Reactivity* (1st impression), Pearson Education (2006).
2. F. A. Cotton. *Chemical Applications of Group Theory*, (3rd edn.), John Wiley & Sons (1999).
3. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry* (5th edition), John Wiley (1988).
4. Principles of Inorganic chemistry by Puri, Sharma & Kalia. Latest edition.
5. P. Atkins, T. Overton, J. Rourke, M. Weller & F. Armstrong. *Shriver and Atkins Inorganic Chemistry*, Oxford University Press (2006).
6. N. N. Greenwood & A. Earnshaw. *Chemistry of the Elements*, Pergamon Press (1984).
7. F. Basolo & R. G. Pearson, *Mechanism of Inorganic Reactions*, Wiley Eastern (1967).

8. F. A. Cotton, G. Wilkinson, C. A. Murillo & M. Bochmann. *Advanced Inorganic Chemistry* (6<sup>th</sup> edition), John Wiley (1999).
10. S. F. A. Kettle, *Physical Inorganic Chemistry*, Spectrum (1996).
11. B. Douglas, D. McDaniel and J. Alexander. *Concepts and Models of Inorganic Chemistry* (3<sup>rd</sup> edn.), John Wiley & Sons (1994).

## MCHC 1.21

### ORGANIC CHEMISTRY – I

Credits: 4

**UNIT I Stereochemistry:** Configuration nomenclature; Axial and planar chirality and helicity; Topicity and prostereo-isomerism; Racemic modification and optical purity; Conformational analysis of acyclic, cyclic, heterocyclic and steroidal systems; Effects of conformation on reactivity. Regioselectivity, stereospecificity and stereoselectivity: Mechanistic and stereochemical aspects of Addition of halogen polar reagents to alkenes.

**UNIT II Substitution & Elimination Reactions:** Applications of acid-base concept, HSAB theory and its application in nucleophilic substitution at saturated carbon; Parameters influencing reaction rates; Hammett and Taft equations, neighboring group participation by  $\pi$  and  $\sigma$  bonds, Anchimeric assistance; Synthetic applications of nucleophilic substitution involving alcohols, thiols and amines ; Aromatic nucleophilic substitutions.

**(a) Elimination Reactions:** Mechanism and stereochemistry of different types of elimination reactions; Effects of substrate structure, attacking base, leaving group and medium; Formation of other double bonds (C=N, C=O) and triple bonds by elimination reactions.

**UNIT III Photochemistry:** Photochemistry of alkenes and carbonyl compounds; Photooxygenation; Photochemistry of aromatic compounds; Photochemical isomerisation, addition and substitution; Photo-Fries rearrangement of ethers and anilides; Barton reaction, Hoffmann-Loeffler-Freytag reaction, di- $\pi$ - methane rearrangement; Singlet molecular oxygen reactions; Photo-cleavages.

**UNIT IV Pericyclic Reactions:** Main features of pericyclic reactions; Woodward-Hoffman rules, correlation diagram and FMO approaches; Electrocyclic reactions – conrotatory and disrotatory motions for  $4n$  and  $4n+2$  systems;. Cycloadditions – antarafacial and suprafacial additions, [2+2] and [4+2] reactions ( $h\nu$  and  $\Delta$ ), 1,3-dipolar cycloadditions and chelotropic reactions; Sigmatropic  $[i,j]$  shifts of C-H and C-C bonds; Sommelet-Hauser, Claisen, thio-Claisen, Cope and aza-Cope rearrangements.

#### Recommended Books and References:

1. D. Nasipuri, *Stereochemistry of Organic Compounds*, 2<sup>nd</sup> Edn, New Age International (1994).
2. J. March. *Advanced Organic Chemistry: Reactions, Mechanisms and Structure* (4<sup>th</sup> edn.), Wiley Student Edition, John Wiley & Sons Asia Pte. Ltd. (2005).
3. P. S. Kalsi. *Stereochemistry, Conformation and Mechanism* (7<sup>th</sup> edn.), New Age (2008).
4. C. Depuy & O. L. Chapman. *Molecular Reactions and Photochemistry*, Prentice-Hall of India (1975).
5. F. A. Carey & R. J. Sanburg. *Advanced Organic Chemistry*, Part A and B, 3<sup>rd</sup> edn. (1990).
6. Wamser & Harris, *Fundamentals of Organic Reaction Mechanisms*, John Wiley (1990).

7. R. B Woodward & R. Hoffman, *Conservation of Orbital Symmetry*; Verlag-Chemie Academic Press (1970).
8. I. Fleming. *Frontier Orbital Theory and Organic Reactions*, John Wiley & Sons (1976).
9. A. P. Marchand & R. E. Lehr, *Pericyclic Reactions*, Academic Press (1977).

### MCHC 1.31

#### PHYSICAL CHEMISTRY – I

Credits: 4

**UNIT I** **General Principles of Quantum Mechanics and Application to Model Systems:** Introduction; operators and related theorems; uncertainty principle; postulates; properties of wave functions; Schrodinger equation; energy eigenvalue equation; equation of motion and constant of motion.

Exactly solvable problems: Particle in a box, harmonic oscillator, rigid rotator, step potential and tunneling, hydrogen atom.

**UNIT II** **Approximation Methods and Chemical Bonding:** Linear and non-linear variations method; applications (He atom and other simple systems); Hellmann-Feynmann theorem; antisymmetry principle and many-electron wave functions.

Born-Oppenheimer approximation; valence bond (VB) and molecular orbital (MO) theory for diatomic molecules – hydrogen molecule ion, hydrogen molecule; excited states of H<sub>2</sub> – singlet and triplet; non-crossing rule and correlation diagram; hybridization; Huckel MO treatment for simple and conjugated polyenes.

**UNIT III** **Adsorption and Aggregation:** Surface tension and surface free energy; Pressure across an interface: Laplace equation, Kelvin equation; Wetting: Young-Dupre equation; Adsorption in liquid systems: Gibbs adsorption isotherm; Adsorption on solids: Langmuir isotherm, BET isotherm.

Surfactants, classification of surfactants, hydrophobic interaction, aggregation/micellization of surfactants, critical micelle concentration (cmc), factors affecting the cmc, thermodynamics of micellization: phase separation and mass action models.

**UNIT IV** **Solid State Chemistry:** Review of the basic concepts: Bragg's law, Miller indices, Elements of symmetry (plane, axis and centre of symmetry).

Crystal Defects: Types of defects, thermodynamics of Schottky and Frenkel defect formation, Kroger-Vink notation for crystal defects.

Solid Solutions: Substitutional, interstitial and substitutional solid solutions & distortions.

Metals, insulators and semiconductors; Electronic structure of solids—band theory; intrinsic and extrinsic semiconductors, p-n junction.

#### Recommended Books and References:

1. I. N. Levine. *Quantum Chemistry*, Prentice Hall India (2001).
2. D. A. McQuarrie. *Quantum Chemistry*, Viva Books Pvt Ltd (2003)
3. A. K. Chandra. *Introductory Quantum Chemistry*, Tata McGraw Hill (1994).
4. Y. Moroi. *Micelles: Theoretical and Applied Aspects*, Plenum (1992).
5. A. R. West. *Solid State Chemistry and its Applications*, John Wiley (1998).
6. Principle of physical chemistry by B.R.Puri & L.R.Sharma & M.S.Patiana. 2013 edition.
7. P. W. Atkins. *Molecular Quantum Mechanics*, Oxford University Press (1986)
8. R. McWeeny. *Coulson's Valence*, ELBS (1979).

**MCHC 1.12****LABORATORY COURSE – I**

Credits: 6

**(ORGANIC CHEMISTRY)****PART A**

1. Purification Techniques of organic compounds and their spectroscopic identifications.
  1. Purification of binary mixtures by Thin Layer Chromatography (TLC) and Column chromatography (CC).
  2. Purification of tertiary mixtures of amino acids by Paper Chromatography.
2. Extraction of Natural Products: Any one of the following – solasodine, caffeine, nicotine, piperine, rosine, carotenoids, curcumin, Citral.
3. Organic Preparations: At least eight preparations (involving two or more than two steps) involving the following representative reactions-
  - A Esterification and saponification
  - B Oxidation (peracid, chromic acid, Mn(VII))
  - C Hydride reduction or hydrogenation
  - D Nucleophilic substitution
  - E Cycloaddition reaction
  - F Grignard reaction
  - G Condensation reaction
  - H Preparation of dyes
  - I Aromatic electrophilic substitution
  - J Heterocyclic synthesis
4. Qualitative Analysis of Binary Mixtures (only two)

**PART B:**

Principle, instrumentation, handling, precautionary measures, experiment, data collection and analysis of the following instruments:

- a. IR
- b. HPLC and GC
- c. Microwave

**Recommended Books and References:**

1. R. K. Bansal. *Laboratory Manual of Organic Chemistry* (3<sup>rd</sup> edn.), Wiley-Eastern (1994).
2. R. G. Brewster & W.E. Mcweden. *Unitized Experimental Organic Chemistry* (4<sup>th</sup> edn.), East-West Press (1977).
3. A. I. Vogel. *Practical Organic Chemistry* (3<sup>rd</sup> edn.), Longman Group Ltd. (1973).
4. A. O. Fitton & R. K. Smallery. *Practical Heterocyclic Chemistry* Academic Press (1968)
5. R.L. Shriner & R. C. Fuson. *Systematic Identification of Organic Compounds* (5<sup>th</sup> edn.), John Wiley & Sons (1964).

## SEMESTER - II

### MCHC 2.11

#### INORGANIC CHEMISTRY - II

Credits: 2

**UNIT I** **Transition Metal  $\pi$ -acid Complexes and Supramolecular Chemistry:** Bonding, synthesis and reactivity of transition metal complexes with CO, NO, O<sub>2</sub>, N<sub>2</sub> and tertiary phosphine and arsine ligands; metal carbonyl hydrides and metal carbonyl clusters: LNCC and HNCC, Wade's rule and the capping rule.

Supramolecular chemistry: Definition, supramolecular host-guest compounds, macrocyclic effect, nature of supramolecular interactions.

**UNIT II** **Kinetics and Mechanism of Inorganic Reactions:** Labile and inert complexes; mechanisms of ligand-replacement reactions; ligand displacement reactions in square planar and octahedral complexes; the *trans* effect; isomerisation and racemisation of tris-chelate complexes; electron transfer reactions; stereochemical nonrigidity and fluxional molecules.

#### Recommended Books and References:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter & O. K. Medhi, *Principles, Structure and Reactivity* (1<sup>st</sup> impression), Pearson Education (2006).
2. F. A. Cotton, G. Wilkinson, C.A. Murillo & M. Bochmann, *Advanced Inorganic Chemistry* (6<sup>th</sup> edn.), John Wiley (1999).
3. P. Atkins, T. Overton, J. Rourke, M. Weller & F. Armstrong. *Shriver and Atkins Inorganic Chemistry*, Oxford University Press (2006).
4. T. Moeller. *Inorganic Chemistry: A Modern Approach*, John Wiley (1982).
5. J. W. Steed & J. L. Atwood. *Supramolecular Chemistry*, John Wiley (2002).

### MCHC 2.21

#### ORGANIC CHEMISTRY - II

Credits: 2

#### UNIT I **Redox Reactions**

1. **Catalytic hydrogenation:** Scope and mechanisms for heterogeneous catalytic hydrogenation of alkenes and other functional groups; Homogeneous catalytic hydrogenation with Wilkinson catalyst; Dissolving metal reductions: Scope and basic mechanisms; Liquid ammonia reduction with alkali metals, Birch reduction of arenes.

2. Use of hydroboration in reduction, oxidation and carbonylation, regioselectivity, stereo-selectivity and synthetic utility of alkyl boranes; Reduction of carbonyl group with hydrazine; semicarbazide; Use of hydrazine with other reducing agents on conjugated systems.

3. Oxidation of alcohols & aldehydes with Cr & Mn oxidants; Uses of PCC, PDC and Collin's reagent, Oxidation of C=C and C-H bonds; Alkene epoxidation by peracids and metal/alkyl hydroperoxides, DMSO oxidations; Oxidative cleavage of C-C single and double bonds; periodates, LTA and SeO<sub>2</sub>.

## UNIT II **Reactive Intermediates**

(a) *Carbenes*: Stability, structure and spin states of carbenes; Cyclopropanation – spin dependence and stereochemistry; Carbene insertion to C-H bonds; Rearrangement to alkenes; Wolff rearrangement of acylcarbenes and its synthetic applications; Carbenoids.

2. *Nitrenes*: Stability, structure and spin states of nitrenes; C-H bond insertions and aziridine formation; Rearrangement of acyl nitrenes (Hoffmann, Curtius and Schmidt reactions with applications in organic synthesis).

3. *Free Radicals*: Stability and fate of organic free radicals; Metal-induced radical reactions; Radical cyclisation and coupling reactions; Addition to multiple bonds; Aromatic substitution by radicals; Allylic bromination by NBS and decarboxylative bromination.

4. *Arynes*: Generation, structure and stability of arynes; Benzyne mechanism for aromatic nucleophilic substitution; Direction of aryne bond formation and of nucleophilic addition.

### **Recommended Books and References:**

1. H. O. House. *Modern Synthetic Reactions*, W. A. Benjamin (1972).
2. J. March. *Advanced Organic Chemistry: Reactions, Mechanisms and Structure* (4<sup>th</sup> edn.), Wiley Student Edition, John Wiley & Sons Asia Pte. Ltd. (2005).
3. T. L. Gilchrist & C. W. Rees, *Carbenes, Nitrenes and Arynes*, Nelson, London (1969).
4. V. K. Ahluwalia & R. Aggarwal, *Organic Synthesis: Special Techniques*, Narosa Publishing House, New Delhi (2001).

## **MCHC 2.31**

### **PHYSICAL CHEMISTRY – II**

*Credits: 2*

**UNIT I *Microwave, Infrared and Raman Spectroscopy***: Introduction: Interaction of light with matter, mechanism of absorption & emission of radiation.

***Microwave & Vibrational spectroscopy***: Classification of molecules; rigid rotor model; rotational spectra of diatomics and polyatomics; effect of isotopic substitution and nonrigidity; selection rules and intensity distribution.

Vibrational spectra of diatomics; effect of anharmonicity; Morse potential; Vibration-rotational spectra of diatomics; P,Q,R branches, normal modes of vibration, overtones, hot bands.

*Raman spectroscopy*: Origin; rotational and vibrational Raman spectra of diatomics.

## **UNIT II *Fundamentals of Nanoscience and Nanotechnology***

(A) Solid materials and their strength, Perspective of length, Nanomaterials, Nanoscience and Nanotechnology, Nanostructures in nature, Prime materials, Carbon nanostructures viz. Carbon nanotube (Single-walled and multi-walled), Fullerenes, Surface effects of Nanomaterials, Surface plasmon resonance, Quantum size effects.

(B) **Synthesis of Nanomaterials**: Introduction, Nanomaterials synthesis, Top-Down and Bottom-Up Approaches, Solvo-thermal synthesis, Hydrothermal synthesis, Reverse micellar/Micro-emulsion method, Reverse micelles works as nano reactor, Mechanism for nanoparticle synthesis inside the reverse micelles, Co-precipitation, Sol-Gel Method, Polymeric Precursor Method and Sono-chemical Methods.

**Recommended Books and References:**

1. C. N. Banwell and E. M. McCash. *Fundamentals of Molecular Spectroscopy*, 4th edn., Tata McGraw-Hill, New Delhi (1994).
2. D. A. McQuarrie and J.D. Simon –Physical Chemistry, VIVA Students Ed. (2003).
3. Principals of Nanoscience and Nanotechnology, M. A. Shah and Tokeer Ahmad, Narosa Publications, 2010.
4. Nano Materials, B. Viswanathan, Narosa Publications, 2009.
5. Nano: The Essentials, T. Pradeep, Tata McGraw Hill, 2009.
6. J. D. Graybeat. *Molecular Spectroscopy*, McGraw-Hill International Edition (1988).
7. Solid State Chemistry and its applications, Anthony R. West, John Wiley & Sons.
8. Chemistry of Nanomaterials: Synthesis, Properties and Applications by C.N.R. Rao, A. Muller and A. K. Cheetham (eds.), Wiley-VCH, Weinheim, 2004.

**MCHC 2.12****LABORATORY COURSE – II**

Credits: 6

**(INORGANIC CHEMISTRY)****PART A:**

1. Quantitative estimation involving volumetric (redox and complexometry), gravimetric and spectrophotometric methods of constituents in three component mixtures.
2. Preparation and Characterization of the following compounds (at least 6 preparations are to be completed by turn):
  - Reinecke salt
  - Tris(oxalate) manganese(III)
  - Tetrapyridinesilver(II)peroxidisulphate
  - Tris(acetylacetonato) iron(III)
  - Bis(N,N-diethyldithiocarbamato)nitrosyliron(I)
  - Optical isomers of tris(ethylenediamine)cobalt(III)chloride
  - Linkage isomers of nitro and nitritopentamminecobalt(III) chloride
  - Ferrocene or dibenzene chromium
  - Hydridochlorocarbonyl tris(triphenylphosphine)ruthenium(II)
  - Tris(2,2'-bipyridine)ruthenium(II) perchlorate
  - [(p-cymene)RuCl<sub>2</sub>]<sub>2</sub>
  - Tri(acetylacetonato)manganese(III)
  - Prussian Blue
  - Turnbull's Blue
3. Characterization includes microanalysis, conductance measurements and UV-Visible.
4. Less common metal ions: Ti, Mo, W, Tl, V, U, Zr, Th (Qualitative Analysis).

**Recommended Books and References:**

1. J. Mendham, R. C. Denney, J. D. Barnes & M. Thomas. *Vogel's Textbook of Quantitative Chemical Analysis*, Peterson Education (2000).
2. G. Marr & B. W. Rockett. *Practical Inorganic Chemistry*, Van Nostrand (1972).
3. G. Pass & H. Sutcliffe. *Practical Inorganic Chemistry* (2<sup>nd</sup> edn.), Chapman & Hill (1974)
4. J. Basset, R. C. Denney, G.H. Jeffery & J. Mendham. *Vogel's Text Book of Quantitative Analysis* (4<sup>th</sup> edn.), English Language Book Society (1978).



5. H. H. Willard, L. L. Merrit & J. A. Dean. *Instrumental Methods of Analysis* (4<sup>th</sup> edn.), East-West Press (1974).
6. G. W. Parshall (Ed. in Chief). *Inorganic Synthesis*, Vol. 15, McGraw Hill, p. 48 (1974).

## SEMESTER - III

### MCHC 3.11 INORGANIC CHEMISTRY-III

Credits: 2

**UNIT I** **(a) Infrared and Raman Spectroscopy:** Structural studies (involving IR and Raman spectroscopy) of coordination compounds containing the following molecules/ions and ligands -  $\text{NH}_3$ ,  $\text{H}_2\text{O}$ ,  $\text{OH}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{CN}^-$ ,  $\text{SCN}^-$ ,  $\text{NO}$ .

**(b) Magnetic Resonance Spectroscopy**

**Electron spin resonance spectroscopy:** ESR of  $d^1$  to  $d^9$  transition metal ions in cubic and tetragonal ligand fields; evaluation of g values, metal hyperfine coupling constants and super hyperfine coupling constants (nitrogen/nitrogen-oxygen donor ligands).

**Nuclear magnetic resonance spectroscopy:** Applications of  $^{31}\text{P}$ ,  $^{19}\text{F}$ ,  $^{119}\text{Sn}$  and  $^{195}\text{Pt}$  NMR spectroscopy in the structural assessment of inorganic compounds.

**UNIT II** **(a) X-ray Crystallography:** Lattices, planes and indices; X-ray diffraction and Bragg's law; Crystal systems and symmetry, point groups, stereographic projection of 32 point groups and space groups; Symmetry elements: isogonal symmetry groups and reciprocal lattice. Crystal growing; Data collection, data reduction, refinement and structure solution of some compounds

**(b) Mossbauer Spectroscopy:** Principles, isomer shift, quadrupole effect of magnetic field, applications to iron and tin compounds.

#### Recommended Books and References:

1. K. Nakamoto. *Infrared and Raman Spectra of Inorganic and Coordination Compounds*, (6<sup>th</sup> edn.), John Wiley (2008).
2. R. V. Parish. *NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry*, Ellis Horwood, New York (1990).
3. B. N. Figgis. *Introduction to ligand fields*, Interscience Publishers, 1966
4. J. A. Iggo, *NMR Spectroscopy in Inorganic Chemistry*, OUP Oxford (2000)
5. G.H. Stout and L.H. Jensen, *X-ray Structure Determination: A Practical Guide*, The McMillan Company, New York (1968)
6. R. S. Drago. *Physical Methods in Chemistry*, Saunders College Publishers (1977).

### MCHC 3.21 ORGANIC CHEMISTRY - III

Credits: 2

**UNIT I** **(a) Infrared Spectroscopy:** Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines; Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acid anhydrides); Effects of H-bonding and solvent effect on vibrational frequency, extension to various organic molecules for structural assignment.

**Mass Spectroscopy:** Mass spectral fragmentation of organic compounds, common functional groups; molecular peak, McLafferty rearrangements, examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

**UNIT II (a) Nuclear Magnetic Resonance Spectroscopy:** Approximate chemical shift values of various chemically non-equivalent protons and correlation to protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic); Protons bonded to other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides, SH); Chemical exchange, effect of deuteration; complex spin-spin interaction between two, three, four and interacting nuclei (first order spectra); Complex interaction, stereochemically hindered rotation, Karplus curve, variation of coupling constant with dihedral angle, nuclear magnetic double resonance, simplification of complex spectra using shift reagents.

**(b) C-13 NMR Spectroscopy:**

Chemical shift (aliphatic, olefinic, alkynes, aromatic, hetero-aromatic, carbonyl carbon); Coupling constants, two-dimensional NMR spectroscopy, NOESY, DEPT and INEPT terminologies.

**(c) Applications of IR, NMR and Mass spectroscopy for structure elucidation of organic compounds.**

**Recommended Books and References:**

1. R. M. Silverstein, G. C. Basseler & T. C. Morill. *Spectroscopic Identification of Organic Compounds*, 7<sup>th</sup> Edn., John Wiley (2005).
2. W. Kemp. *Organic Spectroscopy* (3rd edn.), McMillan Press Ltd. (1991).
3. P.S. Kalsi, *Stereochemistry conformation and mechanism* (7th Edn), New Age International (2008).
4. D Williams & I. Fleming. *Spectroscopic Methods in Organic Chemistry*, McGraw Hill (1989).
5. C. N. Banwell & E. M. McCash. *Fundamentals of Molecular Spectroscopy*, Tata McGraw-Hill, New Delhi (2006).

**MCHC 3.31**

**PHYSICAL CHEMISTRY – III**

*Credits: 2*

**UNIT I Chemical Thermodynamics:** Chemical potential and Entropies, Partial molar quantities: Partial molar free energy, Partial molar volume and Partial molar heat content and their significances. Determinations of the partial molar quantities. Thermodynamic Functions of Mixing, Non-ideal systems: Excess functions for non-ideal solutions. Activity and activity coefficients.

**UNIT II Statistical Thermodynamics: Theory and Applications**

(a) Different types of ensembles, ensemble averaging, distribution law (Boltzmann statistics), partition function and thermodynamic parameters; relation between molecular and molar partition functions, translational partition function, rotational partition function for linear and non-linear molecules; vibrational partition function, electronic partition function, reference state of zero energy for evaluating partition function, equilibrium constant in terms of partition function.

(b) Application of statistical thermodynamics: equipartition theorem, heat capacity behaviour of crystals. Introduction to quantum statistics: Distribution law for fermions (Fermi-Dirac statistics) and for bosons (Bose-Einstein statistics), and its applications.

**Recommended Books and References:**

1. P. W. Atkins & J. de Paula. *Physical Chemistry* (8th edn.), OUP (2006).
2. D. A. McQuarrie. *Statistical Mechanics*, Viva Books Pvt. Ltd., New Delhi (2003)

**MCHC 3.12****LABORATORY COURSE – III**

Credits: 4

**(PHYSICAL CHEMISTRY)****PART A:**

Students are to perform seven/eight experiments from the following list:

1. Determination of order of reaction, rate constant and energy of activation for saponification of an ester by NaOH, conductometrically.
2. Determination of critical micellar concentration (CMC) of sodium lauryl sulphate from the measurement of conductivities at different concentrations.
3. Determination of strengths of halides in a mixture, potentiometrically.
4. Determination of pH of buffer solutions and hence to calculate the  $E_0$  of quinhydrone electrode.
5. Verification of Beer-Lambert's law and determination of pKa of an indicator, spectrophotometrically.
6. Spectrophotometric determination of pKa of an indicator in micellar and microemulsion media.
7. Determination of partial molar volume of a solute in solution.
8. Determination of the stability constant of the complex formed between Cu(II) ions and 5-sulphosalicylic acid between pH 3-5 by colorimetric method and hence to calculate the free energy of formation of the complex.
9. Determination of specific rotation of sucrose and rate constant of its hydrolysis using a polarimeter.
10. Determination of coordination number of  $\text{Cu}^{2+}$  in copper-ammonia complex by partition method.
11. To study the kinetics of iodination of acetone.
12. Determination of the acidic and basic dissociation constants of an amino acid and hence its isoelectric point.

**PART B:**

Principle, instrumentation, handling, precautionary measures, experiment, data collection and analysis of the following instruments:

1. Fluorescence spectroscopy
2. UV- spectroscopy/Dynamic Light Scattering
3. TGA-DSC

**Recommended Books and References:**

1. D. P. Shoemaker, C. W. Garland & J. W. Nibler. *Experiments in Physical Chemistry* (5th edn.), McGraw Hill (1989)
2. V. D. Athawala & P. Mathur. *Experimental Physical Chemistry*, New Age International Publishers (2001).

## SEMESTER - IV

### MCHC 4.11

### INORGANIC CHEMISTRY - IV

Credits: 4

- UNIT I *Bioinorganic Chemistry:*** Essential and trace elements in biological systems, structure and functions of biological membranes; mechanism of ion transport across membranes; sodium pump; ionophores: valinomycin and crown ether complexes of  $\text{Na}^+$  and  $\text{K}^+$ ; ATP and ADP; photosynthesis: chlorophyll, PS I and PS II. Rubredoxin and ferredoxins; Metalloporphyrins; Heme proteins: hemoglobin, myoglobin and cytochrome c; Non-heme proteins: hemerythrin and hemocyanin.
- UNIT II *Photochemistry of Metal Complexes and Metal-Metal Multiple Bonds:*** Excited states, ligand field states, charge-transfer states and Thexi states; Phosphorescence and fluorescence; Photochemical reactions: substitution and redox reactions of Cr(III), Ru(II) and Ru(III) complexes; Applications: synthesis and catalysis, chemical actinometry and photo-chromism; Metal-metal multiple bonds, major structural types, quadrupole bonds and one-dimensional solids.
- UNIT III *Nanomaterials:*** General introduction to nanomaterials and emergence of nanotechnology; Moore's law; synthesis of nanoparticles of gold, rhodium, palladium, platinum, and silver; Synthesis of nanoparticle semiconductors, nanowires and nanorods; Techniques of synthesis: electroplating and electro-phoretic deposition, conversion through chemical reactions and lithography; Thin films: Chemical vapor deposition and Atomic layer deposition techniques; Carbon fullerenes and nanotubes. Applications of nanoparticles.
- UNIT IV *Selected Topics:*** Synthesis, properties and structures of boranes, carboranes, silicones, phosphazenes and S,N compounds; non-stoichiometric oxides: zeolites and clay; polymorphism of carbon, phosphorus and sulphur.

#### **Recommended Books and References:**

1. R.C. Mehrotra & A. Singh. *Organometallic Chemistry: A Unified Approach* (2<sup>nd</sup> edn.), New Age International (2000).
2. F.A. Cotton & G. Wilkinson. *Advanced Inorganic Chemistry* (5<sup>th</sup> edn.), John Wiley (1988)
3. D.M. Roundhill. *Photochemistry and Photophysics of Metal Complexes*, Plenum Press (1990).
4. G. Zhong Cao. *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, Imperial College Press (2004).
5. S. J. Lippard & J. M. Berg. *Principles of Bio-Inorganic Chemistry*, Panima Publ. Corp. (2005).
6. C. Cutal & A.W. Adamson, . *Comprehensive Coordination Chemistry*, Vol. 1, Editor-in-Chief G. Wilkinson (1985).
7. A.W. Adamson & P.D. Fleischauer. *Concepts of Inorganic Photochemistry*, John Wiley & Sons (1975).
8. M. Ratner & D. Ratner. *Nanotechnology: A Gentle Introduction to the Next Big Idea*, Pearson Education (2003).
9. P. Atkins, T. Overton, J. Rourke, M. Weller & F. Armstrong. *Shriver and Atkins Inorganic Chemistry*, Oxford University Press (2006).

**MCHC 4.21**  
**ORGANIC CHEMISTRY – IV**

Credits: 4

**UNIT I (a)Introduction:** Aromaticity in benzenoid and non-benzenoid compounds, antiaromaticity and homoaromaticity; Huckel rule, n-annulenes, heteroannulenes, fullerenes, cryptates. Hantzsch-Widman nomenclature for monocyclic, fused and bridged hetero-cycles; General approaches to heterocyclic synthesis; Aliphatic and aromatic heterocycles; Basicity and aromaticity of heterocycles.

**(b)Small Ring Heterocycles:** Syntheses of aziranes, oxiranes & thiiranes; Ring openings and heteroatom extrusion; Synthesis & reactions of azetidines, oxetanes.

**UNIT II (a)Azoles:** Structural and chemical properties; Synthesis of pyrazole, isothiazole and isoxazole; Synthesis of imidazoles, thiazoles & oxazoles; Nucleophilic and electrophilic substitutions; Ring cleavages; Benzofused analogues.

**(b)Condensed Five-membered Rings (1 Heteroatom):** Synthesis of indole, benzofuran and benzo-thiophene; Nucleophilic, electrophilic and radical substitutions; Addition reactions; Indole rings in biology.

**UNIT III (a) Diazines:** Structural & chemical properties; Synthesis of pyridazines, pyrimidines, pyrazines; Nucleophilic and electrophilic substitutions.

**(b) Bicyclic Heterocycles:** Synthesis of quinolines, isoquinolines, benzofused diazines, phenothiazines and carbazoles; Substitution reactions.

**(c)Seven-membered Rings:** Synthesis & reactions of azepines, oxepines & thiepinines.

**UNIT IV (a)Porphyrins:** Classification and synthesis of porphyrin rings; Natural and synthetic metallo-porphyrins; importance in biology.

**(b) Nucleic acid:** Primary, secondary and tertiary structure of DNA; DNA replication and heredity; Structure and function of mRNA, tRNA and rRNA.

**Recommended Books and References:**

1. L. A. Paquette. *Modern Heterocyclic Chemistry*, W. A. Benjamin (1968).
2. I. L. Finar. *Organic Chemistry*, Vol. II, ELBS (1986).
3. J. A. Joule, K. Mills, *Heterocyclic Chemistry*, John Wiley & Sons (2010)
4. A. L. Lehninger. *Biochemistry*, Kalyani Publishers (1983).
5. Katritzky, A. R., Ramsden, C. A., Joule, J. A., and V. V. Zhdankin, *Handbook of Heterocyclic Chemistry*, 3<sup>rd</sup> edition, Pergamon Press (2010)
6. A. R. Katritzky & C. W. Rees. *Comprehensive Heterocyclic Chemistry*, Vols. 1-7, Pergamon Press (1984).
7. J. Alvarez-Builla, J. J. Vaquero (Editor), J. Barluenga, *Modern Heterocyclic Chemistry* 1st edition Wiley-VCH (2011)

**MCHC 4.31**  
**PHYSICAL CHEMISTRY – IV**

Credits: 4

- UNIT I** **Theories of Reaction Rates:** Collision theory, Potential energy surfaces (basic idea), generalized kinetic theory, rate theories based on thermodynamics, conventional transition state theory (CTST) - equilibrium hypothesis, statistical mechanics and chemical equilibrium, derivations of the rate equations, applications of CTST - reaction between atoms, thermodynamic formulation of conventional transition state theory. Factors determining reaction rates in solution, collision in solution, encounter, Franck - Rabinowitch effect, reaction between ions, single-sphere and double-sphere model for activated complex, influence of ionic strength (primary salt effects),
- UNIT II** **Acid-base Catalysis:** General catalytic mechanisms, fast pre-equilibrium: Arrhenius intermediates, Steady-state conditions: van't Hoff intermediates, activation energies of catalyzed reactions, acid-base catalysis, General and Specific acid-base catalysis, mechanisms of acid-base catalysis - reaction between acetone and iodine, catalytic activity and acid - base strength, salt effects, acidity functions.
- UNIT III** **Electrochemistry:**
1. Ion-solvent interaction: free energy change due to ion-solvent interactions; Born model; electrical double layer; Helmholtz-Perrin model; Gouy-Chapman diffuse charge model and Stern model.  
Electrodics: The basic electrodic equation: Butler-Volmer equation; overpotential; polarizable and nonpolarizable interfaces.
  2. Ion-ion Interaction: Debye-Huckel theory of ion-ion interaction; Linearized Poisson-Boltzmann equation; ion-cloud and chemical potential change; activity coefficients and mean ionic activity coefficients; expression of mean ionic activity coefficients in terms of ionic strength.
- UNIT IV** **Non-Equilibrium Thermodynamics:** Entropy of irreversible processes - Clausius inequality; entropy production (heat flow, chemical reactions, electrochemical reactions) and entropy flow; Entropy production in open systems; Rate of entropy production - generalized forces and fluxes; Phenomenological equations, Onsager reciprocity relation; Electrokinetic phenomena; Stationary non-equilibrium states - states of minimum entropy production.

**Recommended Books and References:**

1. K. J. Laidler, *Chemical Kinetics* (4th Edn.), Pearson Education (2007).
2. J. O'M Bockris and A. K. N. Reddy. *Modern Electrochemistry*, Plenum, New York (1970).
3. C. Kalidas and M. V. Sangaranarayana. *Non-Equilibrium Thermodynamics - Principles and Applications*, Macmillan India (2002).
4. M. J. Pilling and P. W. Seakins. *Reaction Kinetics*, NP (1995).
5. I. Prigogine. *Introduction to Thermodynamics of Irreversible Processes*, Interscience (1960).

## OPEN COURSE

### MCHO 2.11(a)

#### ORGANOMETALLIC REAGENTS AND HOMOGENEOUS CATALYSIS

*Credits: 2*

**UNIT I. Organometallic Reagents in Organic Synthesis:** Synthesis, structure, bonding and reactivity of Transition metal-carbon  $\sigma$ -bond: metal-alkyls, metal-carbenes. Transition metal complexes with olefins, cyclopentadienyl, arenes and  $\pi$ -allyl systems;

Hydrozirconation of alkenes and alkynes; Carbonylation of Colman's reagent;  $\eta^4$ -diene iron-tricarbonyls in organic synthesis. Arylation/vinylation of olefins (Heck reaction);

**UNIT II. Homogeneous Catalysis:** Coordinative unsaturation, oxidative addition reactions, insertion reactions; Reactions of coordinated ligand and activation of small molecules by complexation; Catalytic reactions of alkenes: isomerization, hydrogenation, hydroformylation, hydrosilylation and polymerization.

#### **Recommended Books and References:**

1. C. Elschenbroich. Organometallics (3rd edn.), Wiley-VCH Publication (2006).
2. C. Elschenbroich & A. Salzer. Organometallics – A Concise Introduction (2nd edn.), VCH Publication (1992).
3. F. Mathey & A. Sevin. Molecular Chemistry of the Transition Elements, John Wiley (1996).
4. M. Bochmann. Organometallics-I Complexes with Transition Metal-Carbon  $\sigma$ -Bonds, Oxford Chemistry Primers (1994).
5. M. Bochmann. Organometallics-2 Complexes with Transition Metal-Carbon  $\pi$ -bonds, Oxford Chemistry Primers (1994).
6. J. E. Huheey, E. A. Keiter, R. L. Keiter & O. K. Medhi, Principles, Structure and Reactivity (1st impression), Pearson Education (2006).
7. F. A. Cotton, G. Wilkinson, C.A. Murillo & M. Bochmann, Advanced Inorganic Chemistry (5th edn.), John Wiley (1999).
1. P. Atkins, T. Overton, J. Rourke, M. Weller & F. Armstrong. Shriver and Atkins, Inorganic Chemistry, Oxford University Press (2006).
2. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals (4th edn.), John Wiley (2005).
3. A. J. Pearson. Metallo-Organic Chemistry, John Wiley & Sons (1985).

### MCHO 2.11(b)

#### MEDICINAL CHEMISTRY-1

*Credits: 2*

**UNIT I Introduction:** Concept of drug, lead compound and lead modification, prodrugs and soft drugs; Structure-activity relationship (SAR), quantitative structure-activity relationship (QSAR); Factors affecting bioactivity – resonance, inductive effect, isosterism, bio-isosterism, spatial considerations; Theories of drug activity – occupancy theory, rate theory, induced fit theory, Concept of drug receptors – elementary treatment of drug-receptor interactions; Physico-chemical parameters – lipophilicity, partition coefficient, electronic ionization constants, steric, Shelton and surface activity parameters and redox potentials; Factors affecting modes of drug



administration, absorption, metabolism and elimination; Significance of drug metabolism in medicinal chemistry.

**UNIT II Antibiotics:** Cell wall biosynthesis, inhibitors of  $\beta$ -lactam rings, antibiotics inhibiting protein synthesis; Isolation, structure elucidation, synthesis, SAR and mode of action of penicillins; Synthesis of penicillin G, penicillin V, ampicillin, amoxicillin and cephalosporin. Isolation, structure elucidation, synthesis, SAR and mode of action of following antibiotics: streptomycin, tetracyclines and chloroamphenicol.

**Recommended Books and References:**

1. Burger. *Medicinal Chemistry and Drug Discovery*, Vol-1, Ed. M. E. Wolff, John Wiley (1994).
2. Goodman & Gilman. *Pharmacological Basis of Therapeutics*, McGraw-Hill (2005).
3. S. S. Pandeya & J. R. Dimmock. *Introduction to Drug Design*, New Age International.(2000).
4. Graham & Patrick. *Introduction to Medicinal Chemistry* (3<sup>rd</sup> edn.), OUP (2005).
1. D. Lednicer. *Strategies for Organic Drug Synthesis and Design*, John Wiley (1998).
2. T. Nogrady, D.F. Weaver *Medicinal Chemistry* Oxford University Press (2005).
3. D. Smith, D. Walker, H. van de Waterbeemd *Pharmacokinetics and Metabolism in Drug Design* WILEY-VCH (2001)

**MCHO 2.11(c)**

**PHOTOCHEMISTRY & ELECTROCHEMISTRY**

*Credits: 2*

**UNIT I Physical Properties of Excited Molecules:** Nature of changes on electronic excitation, Potential energy diagram, Absorption band shape and Franck-Condon Principle, Emission Spectra, Environmental effects on absorption and emission properties, Excited state dipole moment, Redox potential and acidity constants of aromatic acids.

**UNIT II Transport Phenomena:** Diffusion coefficients, Fick's first law of steady – state diffusion, Fick's second law of non – steady state diffusion, relation between diffusion coefficient and mean free path, relation between thermal conductivity / viscosity and mean free path of a perfect gas, Einstein's relation between diffusion coefficient and absolute mobility of ions, Stokes – Einstein equation, Nernst – Einstein equation, Nernst – Planck flux equation.

**Recommended Books and References:**

1. C. E. Wayne & R. P. Wayne, *Photochemistry*, OUP (1996).
2. N. J. Turro. *Modern Molecular Photochemistry*, University Science Books (1991).
3. N. J. Turro V. Ramamurthy, J.C. Scaiano, *Principles of Molecular Photochemistry AnIntroduction* University Science Books (2009).
4. J. O. M. Blockris and A. K. N. Reddy : Modern Electrochemistry, Vol. 1 : Ionics, 2<sup>nd</sup> Ed., Plenum Press, New York, 1998.
5. A. J. Bard and L. R. Faulkner, *Electrochemical Methods: Fundamentals and Applications*, 2<sup>nd</sup> Ed., John Wiley & Sons : New York, 2002.
6. J.B. Buirks. *Photophysics of Aromatic Molecules*, Wiley-Interscience (1969).
7. A. Gilbert & J.E. Baggott, *Essentials of Molecular Photochemistry*, Blackwell Scientific, Oxford (1991).
4. J. O. M. Blockris and A. K. N. Reddy and M. Gamboa – Aldeco : Modern Electrochemistry Vol. 2A, Fundamentals of Electrodeics, 2<sup>nd</sup> Ed. Plenum Press, New York, 2000.

**MCHO 2.21(a)**  
**BIOINORGANIC CHEMISTRY**

Credits: 4

**UNIT I** **Scope of Bioinorganic Chemistry:** Inorganic elements in biological systems, cells, biologically important compounds amino acids, proteins, nucleotides, carbohydrates and lipids, basic bioenergetics, classification of enzymes. Biochemistry: Distribution, biological roles, active transport of cations across membranes, the sodium pump, biology of calcium carriers, role in muscle contraction, enzyme stabilization, blood clotting and biological calcification

**UNIT II** **Metalloporphyrins:** Structure and optical spectra; heme proteins: magnetic susceptibility, epr and electronic spectra; hemoglobin and myoglobin: molecular structures, thermodynamics and kinetics of oxygenation, electronic and spatial structures, synthetic oxygen carriers, modelsystems; iron enzymes, peroxidase, catalase and cytochrome P-450

**UNIT III** **Metalloenzymes:** Copper enzymes, superoxide dismutase, cytochrome oxidase and ceruloplasmin; Coenzymes; Molybdenum enzyme: xanthine oxidase; Zinc enzymes: carbonic anhydrase, carboxy peptidase and interchangeability of zinc and cobalt in enzymes; Vitamin B12 and B12 coenzymes; Iron storage, transport, biomineralization and siderophores, ferritin and transferrins

**UNIT IV** **Metals in Medicine:** Metal deficiency and disease; toxicity of mercury, cadmium, lead, beryllium, selenium and arsenic; biological defence mechanisms; chelation therapy; metals used for diagnosis and chemo- therapy, platinum complexes as anticancer drugs, Pt-DNA binding, complexes of gold, copper, zinc, mercury, arsenic and antimony as drugs.

**Recommended Books and References:**

1. S. J. Lippard & J. M. Berg. *Principles of Bio-Inorganic Chemistry*, Panima Publ. Corpn. (2005).
2. E.-I. Ochiai. *Bioinorganic Chemistry – An Introduction*, Allyn and Bacon Inc. (1977).
3. M. N. Hughes. *The Inorganic Chemistry of Biological Processes*, Wiley (1981).
4. R.P. Hanzlik. *Inorganic Aspects of Biological and Organic Chemistry*, Academic Press (1976)
5. H. Kraatz & N. Metzler-Nolte (Eds.). *Concepts and Models in Bioinorganic Chemistry*, Wiley (2006).
6. I. Bertini, H. B. Gray, S. J. Dippard & J. S. Valentine, *Bioinorganic Chemistry*, Viva Books Pvt. Ltd. (2004).
7. A.W. Addison, W.R. Cullen, D. Dolphin & B.R. James (eds.). *Biological Aspects of Inorganic Chemistry*, John Wiley (1977).
8. R.J.P. Williams & J.R.R.F. Dasilva. *New Trends in Bioinorganic Chemistry*, Academic Press (1978).
9. S. J. Lippard. *Progress in Inorganic Chemistry: Bioinorganic Chemistry*, Vol. 38, John Wiley, (1990).
10. N. Kaim & B. Schwederski. *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life*, John Wiley (1994).

**MCHO 2.21(b)**  
**SYNTHESIS & RETROSYNTHESIS IN ORGANIC CHEMISTRY**

Credits: 4

**UNIT I** (a)*Nucleophilic C-C bond formation:*Henry reaction, Wittig reaction and Horner-Wordworth-Emmons reaction and their selectivities; Chemistry of enolates – *E*, *Z* geometry of enolates, kinetic vs thermodynamic control of enolates, stereoselective enolate reactions, alkylation, aldol condensation (Zimmerman and Evans models), Mukaiyama reaction.

(b)*Electrophilic C-C bond formation:*Prins reaction, Vilsmeier-Hack reaction, Pictet-Sprengler reaction, Heck reaction, Stille coupling, Suzuki coupling, Negishi reaction, reactions of allylsilane, Acylation of carbonyl carbon; Carbonyl cyclizations and cleavages.

**UNIT II** (a)*Miscellaneous reactions:* Biginelli reaction, Hantzsch reaction, Passerini reaction, Ugi reaction, McMurry olefination, Ring closing metathesis (RCM) - Grubb's reaction, Mitsunobu reaction, Nef reaction, Sharpless asymmetric epoxidation and asymmetric dihydroxylation. Carboxylic acids and derivatives, decarboxylation reactions, 1,3-dithiane reactivity.

(b)*Reagents in organic synthesis:* K-selectride and L-selectride, sodium cyanoborohydride, super hydrides, Dess-Martin periodinane, manganese dioxide, Fetizon reagent, dioxiranes, ceric ammonium nitrate, Gilman's reagent, lithium diisopropylamide, dicyclohexylcarbodiimide, trimethylsilyl iodide, tri-*n*-butyltin hydride, Tebbe reagent, baker's yeast, lipase, Mosher's reagent.

**UNIT III** Synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, importance of order of events in organic synthesis, one group and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions, amine synthesis.

One group C-C disconnections – alcohols and carbonyl compounds, regioselectivity, alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis. Two group C-C disconnections – Diels-Alder reaction,  $\alpha,\beta$ -unsaturated carbonyl compounds, control in carbonyl condensations and Michael addition.

**UNIT IV** (a)Principle of protection and deprotection of alcohol, amine, carbonyl and carboxyl groups; Common protecting groups.

(b)Retrosynthesis, Synthesis and characterization of the following: Quercetin, Pinene, Camphor, Prostaglandins and Taxol.

**Recommended Books and References:**

1. Stuart Warren, *Organic Synthesis The Disconnection Approach*, John Wiley & Sons (1982)
2. Nicolaou and Sorensen; *Classics in Total Synthesis*, Wiley-VCH (2003)
3. F. A. Carey & R. J. Sundberg. *Advanced Organic Chemistry Part B*, Plenum Press (2007).
4. M. B Smith. *Organic Synthesis* (2<sup>nd</sup> edn.), McGraw-Hill, Inc. (2001).
5. J. March. *Advanced Organic Chemistry: Reactions, Mechanism and Structure* (4<sup>th</sup> edn.), John Wiley & Sons (2005).
6. M. Harmata. *Strategies and Tactics in Organic Synthesis* 4 & 5, Academic Press (2004).
7. W. Carruthers. *Some Modern Methods of Organic Synthesis* (4<sup>th</sup> edn.), Cambridge University Press (2004).
8. B. M Trost & I Fleming. *Comprehensive Organic Synthesis*, Vols 1-9, Pergamon (1991).

**MCHO 2.21(c)**  
**CHEMISTRY OF SURFACTANTS**

*Credits: 4*

**UNIT I**     **Introduction**

**1. Characteristic Features of Surfactants:** General structural features & behavior of surfactants, classification of surfactants, hydrophobic/solvophobic interaction, Kraft point.

**2. Adsorption of Surfactants:** Adsorption at solid/liquid, liquid/gas and liquid/liquid interfaces, Gibbs adsorption equation, adsorption isotherms, effect of added electrolyte on the surface excess of ionic surfactants.

**UNIT II**     **Micelles:** Micelle formation by surfactants: Critical micelle concentration, cmc measurement, conductance behaviour of ionic micellar solution, micellar structure and shape, factors affecting cmc, temperature dependence of cmc, thermodynamics of micellization, counterion binding constant.

**UNIT III**    **Mixed Surfactants:** Different types of mixed micelle, cmc of mixed micelle, Clint's equation for cmc, Rubingh's treatment, Rodenas treatment, counterion binding in mixed surfactants.

**UNIT IV**    **Solubilisation and Emulsification:** Solubilization and Emulsification by Surfactants: Factors determining extent of solubilization, formation of emulsions, factors determining emulsion stability, microemulsions, conductance behaviour of microemulsions, reactions in micellar and microemulsion media.

**Recommended Books and References:**

1. M. J. Rosen. *Surfactants and Interfacial Phenomena* (3rd edn.), John Wiley (2004).
2. Y. Moroi. *Micelles*, Plenum (1992).
3. K. R. Lange. *Surfactants*, Hanser Pub. (1999).
4. R. Zana (ed.). *Dynamics of Surfactant Self-Assemblies*, CRC Press (2005).
5. M. Abe & J. F. Scamehorn. *Mixed Surfactant Systems*, CRC Press (2004).

**MCHO 3.11(a)**  
**ENVIRONMENTAL AND ANALYTICAL CHEMISTRY**

*Credits: 2*

**UNIT I**     **Chemistry of air and water pollution**

*Air pollution:* Types and sources; Atmospheric chemistry, depletion of stratospheric ozone, industrial and transport-related air pollution; Global warming and its effects.

*Water pollution:* Types and sources, physical and chemical water pollutants, waste water treatment, criteria of water quality.

**UNIT II**    **Analytical instrumentation and methods**

(a) *Electrochemical and Spectral methods:* Polarography: Principle, instrumentation and applications, Cyclic voltammetry, Anodic stripping voltammetry, Amperometry, Coulometry and Conductance methods; Potentiometry: Ion selective electrodes; Atomic absorption spectrometry; Atomic fluorescence spectrometry; Turbidimetry and Nephelometry.

(b) Experimental Techniques of Purification and Separation: Solvent extraction: principles of extraction, percentage extraction, action of ion exchange resin, ion exchange equilibria, applications.

Liquid chromatography: adsorption and partition chromatography, exclusion chromatography, HPLC (principles, equipment, choice of mobile phase and detector, column efficiency, applications). Gas chromatography: Principles, instrumentation, choice of column and detector, applications.

#### **Recommended Books and References:**

1. A. K. De. *Environmental Chemistry* (4<sup>th</sup> edn.), New Age International Limited (2006).
2. P. M. S. Monk. *Fundamentals of Electroanalytical Chemistry*, John Wiley & Sons (2001).
3. H. H. Willard, L.L. Merritt, J.A. Dean & F. A. Settle. *Instrumental Methods of Analysis* (7<sup>th</sup> edn.), Wadsworth Publishing Company, California (1988).
4. J. Mendham, R. C. Denney, J. D. Barnes and M. Thomas. *Vogel's Textbook of Quantitative Chemical Analysis*, Peterson Education (2000).
5. J. W. Moore & E. A. Moore. *Environmental Chemistry*, Academic Press, London (1976).
6. I. Pulford & H. Flowers. *Environmental Chemistry at a Glance*, Blackwell Publishing (2006).
7. S. E. Manahan. *Environmental Chemistry* (6<sup>th</sup> edn.), Lewis Publishers, London (1994).

#### **MCHO 3.11(b)**

#### **MEDICINAL CHEMISTRY-II**

Credits 2

#### **UNIT I Drug Types - I**

(a) *Antineoplastic drugs*: Cancer chemotherapy, role of alkylating agents and antimetabolites in the treatment of cancer; Carcinolytic antibiotics and mitotic inhibitors; Synthesis of mechlor-ethamine, melphalan, 5-bromouracil and 6-mercaptopurine; Anticancer action of taxol.

(b) *Cardiovascular drug*: Classification, synthesis and mode of action of quinidine, verapamil, methyldopa and buphenine.

(c) *Hypnotics and sedatives*: SAR and mode of action; Synthesis of diazepam, oxazepam, chlor-azepam, alprazolam, barbiturates, thiopental sodium.

(d) *Local anaesthetics*: Classification, SAR and mode of action; Synthesis of procaine,  $\alpha$ -eucaine and  $\beta$ -eucaine, xylocaine, cinchocaine and quinisocaine.

#### **UNIT II Drug Types - II**

c. *Antiinfective drugs*: Mode of action and synthesis of sulphonamides, furazolidone, cipro-floxacin, norfloxacin, daspone, isoniazide.

d. *Antipyretic Analgesics*: Classification and mode of action of antipyretic analgesics; Synthesis of paracetamol, chincophan, Novalgin and mefenamic acid.

e. *Antihistamines*: SAR and mode of action of H<sub>1</sub>-receptor antagonists; Synthesis of bromazine, mepyramine, methapyriline, antazoline, promethazine and phenindamine.

f. *Antimalarial drug*: Nitrogen heterocycles as antimalarial agents, their classification and mode of action, synthesis of chloroquine, pamaquine, primaquine, Mepacrine and pyrimethamine. Introductory idea on artemisinin, artemether and arteether.

#### **Recommended Books and References:**

1. Burger. *Medicinal Chemistry and Drug Discovery*, Vol-1, Ed. M. E. Wolff, John Wiley (1994).
2. Goodman & Gilman. *Pharmacological Basis of Therapeutics*, McGraw-Hill (2005).

3. S. S. Pandeya & J. R. Dimmock. *Introduction to Drug Design*, New Age International.(2000).
4. Graham & Patrick. *Introduction to Medicinal Chemistry* (3<sup>rd</sup> edn.), OUP (2005).
5. D. Lednicer. *Strategies for Organic Drug Synthesis and Design*, John Wiley (1998).
6. T. Nogrady, D.F. Weaver *Medicinal Chemistry* Oxford University Press (2005).
7. D. Smith, D. Walker, H. van de Waterbeemd *Pharmacokinetics and Metabolism in Drug Design* WILEY-VCH (2001)

### MCHO 3.11(c)

#### KINETICS OF COMPLEX REACTIONS

Credits: 2

**UNIT I** **Effect of Ions on Reaction Rates:** Theory of unimolecular reactions, Lindemann mechanism and Hinshelwood treatment. ion-dipole and dipole-dipole reactions, pressure effects and volume of activation - van't Hoff's equation, substitution and correlation effects on reactivity, Linear Free Energy Relationships(LFER) - Hammett equation, uses and limitation.

**UNIT II** **Chain Reactions:** Linear chain reactions, Autocatalysis, Reaction between hydrogen and halogen, Calculation of Energy Barriers for Elementary Steps and comparison of the Mechanisms of the Hydrogen- Halogen Reactions, pyrolysis of acetaldehyde and ethane, general considerations of free radical chain mechanism,, Explosive Reactions - Combustion between hydrogen and oxygen, kinetic aspect of polymerization reactions, molecular mechanisms, Kinetic Chain Length, free radical mechanisms, cationic and anionic polymerization.

#### Recommended Books and References:

- 1 K.J. Laidler, *Chemical kinetics*,Third Edition, (1987).
- 2 F. Wilkinson, *Chemical Kinetics and reaction mechanisms*,Van Nostrand Reinhold Company (January 1980)
- 3 Pilling, M.J. & Seakins, P.W., *Reaction Kinetics*, Oxford University Press (1995).
- 4 Santosh K. Upadhyay, *Chemical Kinetics and Reaction Dynamics* Anamaya Publishers, New Delhi, (2006).
- 5 C. Kalidas, *Chemical Kinetic Methods: Principles of Relaxation Techniques and Application*, New Age International (P) limited, Publishers, (1996).

### MCHO 3.21(a)

#### ORGANOMETALLIC CHEMISTRY

Credits: 4

**UNIT I** **Main Group Organometallics:** Synthesis and reactions of organolithium compounds; Synthesis and reactions of organo-magnesium compounds; Organometallics of zinc and mercury: preparation, structure, bonding and reactions of aluminum organyls; Thallium(I) organyls (synthesis of TlCp); Organyls of sodium, synthesis of NaCp; Silicon and tin organyls of coordination number 4.

**UNIT II** **Transition Metal–Carbon Bond:** (a) *Transition Metal–Carbon  $\sigma$ -Bond:* Brief review of metal alkyl compounds; transition metal-carbene and transition metal-carbyne compounds; transition metal vinylidene and transition metal allenylidene compounds. (b) *Transition Metal–Carbon  $\pi$ -Bond:* Cyclopropenyl cation ( $C_3R_3^+$ ) as a ligand;  $C_4R_4$  as a ligand (R= H, Me, Ph)

**UNIT III** **Syntheses of Cyclopentadienyl and Arene Metal Analogues:** Synthesis and reactions of cyclopentadienyl metal carbonyls, cyclopentadienyl metal hydrides, cyclopentadienyl metal halides, arene metal group complexes,  $\eta^6$ -arene-chromium tricarbonyl in organic synthesis.

**UNIT IV** **Applications to Organic Synthesis and Homogeneous Catalysis**  
(a) *In Organic Synthesis:* Hydrozirconation of alkenes and alkynes; Carbonylation of Colman's reagent;  $\eta^4$ -diene iron-tricarbonyls in organic synthesis  
(b) *In Catalysis:* Asymmetric hydrogenation; synthesis of acetic acid and glycol (Monsanto acetic acid process); Arylation/vinylation of olefins (Heck reaction); Wacker process (olefin oxidation); Asymmetric epoxidation.

**Recommended Books and References:**

1. C. Elschenbroich. *Organometallics* (3rd edn.), Wiley-VCH Publication (2006).
2. C. Elschenbroich & A. Salzer. *Organometallics – A Concise Introduction* (2nd edn.), VCH Publication (1992).
3. F. Mathey & A. Sevin. *Molecular Chemistry of the Transition Elements*, John Wiley (1996).
4. F. A. Cotton & G. Wilkinson. *Advanced Inorganic Chemistry* (5th edn.), John Wiley (1988).
5. R. C. Mehrotra & A. Singh. *Organometallic Chemistry: A Unified Approach* (2nd edn.), New Age International (2000).
6. Yamamoto, *Organo Transition Metal Chemistry*, Wiley (1986).
7. R. H. Crabtree, *The Organometallic Chemistry of the Transition Metals* (4th edn.), John Wiley (2005).
8. A. J. Pearson. *Metallo-Organic Chemistry*, John Wiley & Sons (1985).
9. M. Bochmann. *Organometallics-1 Complexes with Transition Metal–Carbon  $\sigma$ -Bonds*, Oxford Chemistry Primers (1994).
10. M. Bochmann. *Organometallics-2 Complexes with Transition Metal–Carbon  $\pi$ -bonds*, Oxford Chemistry Primers (1994).

**MCHO 3.21(b)**

**NATURAL PRODUCTS CHEMISTRY**

**Credits: 4**

**UNIT I** **Natural Products and their Biosynthetic Pathways:** General classification of natural products, their isolation and characterisation and biosynthesis of common plant products; Biosynthesis pathways for natural products using co-enzymes and enzymes; Synthesis of selected natural products based on genetic classification – fatty acid derivatives and related compounds, general biogenesis and synthesis of cis-jasmone, methyl jasmonate, prostaglandins, exaltone and muscone.

**UNIT II** **Terpenoids:** General biosyntheses of mono- and sesquiterpenes diterpenes, and higher terpenes, *trans*-chrysanthenic acid, cyclo-pentato monoterpene lactones, Synthesis of  $\alpha$ -vetivone and total synthesis of  $\beta$ -eudesmol; Synthesis of hirsutene, abietic acid, *cis* juvenile hormone; *trans* annular cyclisation of caryophyllene,

synthesis of caryophyllene and isocaryophyllene; Rearrangements of santonic acid and thujospene; Synthesis and rearrangement of longifolene

**UNIT III** **Alkaloids:** Structure, synthesis and biosynthesis of common alkaloids: Strychnine, lysergic acid, reserpine, nicotine, morphine, emitine.

**UNIT IV** **Steroids:** Biosynthesis of steroids; Nomenclature of steroids and synthesis of squalene; Lanosterol and caretonoids; Synthesis of equilenins; Estrogens and total synthesis of non-aromatic steroids (progesterones); Corticosteroids; Degradation of diosgenin to progesterone and its synthesis; Miscellaneous transformations of steroid molecules. (progesterones); Corticosteroids; Degradation of diosgenin to progesterone and its synthesis; Miscellaneous transformations of steroid molecules.

**Recommended Books and References:**

1. K. Nakanashi. *Natural Products Chemistry*, Vols. I and II, Academic Press, New York and London (1974).
2. S.V. Bhat, B.A. Nagasampagi, S Minakshi *Natural products*; Chemistry & Applications, Alpha Science International Ltd. (2011).
3. M. Harmata. *Strategies and Tactics in Organic Synthesis* 4 & 5, Academic Press (2004)
4. T. L. Gilchrist. *Heterocyclic Chemistry* (2nd edn.), Longman Scientific & Technical Publishers. (1992).
5. R. K. Bansal. *Heterocyclic Chemistry: Synthesis, Reactions and Mechanisms*, Wiley Eastern (1991).

**MCHO 3.21(c)**

**ADVANCED SOLID STATE CHEMISTRY**

*Credits: 4*

**UNIT I** **Concepts of Solids:** Crystalline and Amorphous Solid, Unit cell, Summary of crystal lattices, Reciprocal lattice, Bonding & packing in crystals, Lattice planes, Symmetry elements, Space lattice, Glide planes, Screw Axis, Point groups and notations of 222, mm2 and mmm point groups, space groups and elucidations of representing point groups; viz. Monoclinic  $C_2$ , Orthorhombic  $p222_1$  and Tetragonal  $I4_1$ .

**UNIT II** **Crystal Defects and Non-Stoichiometry:** Perfect and imperfect crystals, Intrinsic and extrinsic defects- point defects, line defects and plane defects, Schottky and Frenkel defects, Thermodynamics of Schottky and Frenkel defect formation, Colour centers, Non-stoichiometry and calculations.

**UNIT III** **Structures of Solids:** Perovskite structure (e.g.  $CaTiO_3$  and  $BaTiO_3$ ), Spinel structure (e.g.  $MgAl_2O_4$ ), Rutile  $TiO_2$  structure, Rock salt  $NaCl$  structure, Sphalerite and Wurtzite structures of  $ZnS$ ,  $K_2NiF_4$  (e.g.  $Sr_2TiO_4$ ) and  $\beta$ - $K_2SO_4$  (e.g.  $Ba_2TiO_4$ ) structures.

**UNIT IV** **Properties of Solids:**

**(a) Magnetic Properties:** Classification of materials, Line of forces, Effect of temperature, Magnetic moment calculations, Ferro- and antiferromagnetic ordering, Dependence of magnetic properties on size, Magnetic domains and Hysteresis.

**(b) Electrical Properties:** Dielectric materials, Dielectric properties (dielectric constant and dielectric loss), Dependence of dielectric properties on size, Polarizability, Concepts of ferroelectricity, Pyroelectricity and Piezoelectricity.



**(c) Electronic Properties:** Metals, Insulators, Semiconductors and Superconductors, Density of states, Origin of bands, E-k diagrams, Bonding in solids, Band theory, Intrinsic and extrinsic semiconductors p-n junction.

**Recommended Books and References:**

1. Anthony R. West, *Solid State Chemistry and its applications*, John Wiley & Sons.
2. M. A. Shah and Tokeer Ahmad, *Principals of Nanoscience and Nanotechnology*, Narosa Publications, 2010.
3. Lesley Smart and Elaine Moore, *Solid State Chemistry*, Chapman & Hall.
4. C. N. R. Rao and J. Gopalakrishnan, *New Directions in Solid State Chemistry*, Cambridge University Press.
5. H. V. Keer, *Principles of the Solid State*, New Age International Publishers.
6. D. K. Chakrabarty, *Solid State Chemistry*, New Age International Publishers.
7. A. K. Cheetham and Peter Day, *Solid State Chemistry Techniques*, Oxford Science Publications.



*Revised*  
SYLLABUS FOR  
Master of Science

**GEOLOGY**

SEMESTER SYSTEM



### CORE STRUCTURE

SEMESTER	COURSE CODE	COURSE NAME	CREDIT
I	MGLC 1.11	Geomorphology, Structural Geology & Tectonics	4
	MGLC 1.21	Palaeobiology & Stratigraphy	4
	MGLC 1.31	Mineralogy, Crystallography & Analytical Techniques	4
	MGLC 1.12	Geomorphology, Structural Geology & Tectonics Practical	2
	MGLC 1.22	Palaeobiology & Stratigraphy Practical	2
	MGLC 1.32	Mineralogy, Crystallography & Analytical Techniques Practical	2
II	MGLC 2.11	Igneous , Sedimentary & Metamorphic Petrology	4
	MGLC 2.21	Ore Geology, Mineral Exploration & Mining Geology	4
	MGLO 2.11	Remote Sensing in Geosciences	4
	MGLC 2.12	Igneous ,Sedimentary & Metamorphic Petrology Practical	2
	MGLC 2.22	Ore Geology, Mineral Exploration & Mining Geology Practical	2
	MGLO 2.12	Remote Sensing in Geosciences Practical	2
III	MGLC 3.11	Engineering Geology & Hydrogeology	4
	MGLC 3.21	Fuel Geology & Geochemistry	4
	MGLO 3.11	Environment Geology	4
	MGLC 3.12	Engineering Geology & Hydrogeology Practical	2
	MGLC 3.22	Fuel Geology & Geochemistry Practical	2
	MGLO 3.12	Environment Geology Practical	2
IV	MGLC 4.11	Geology, Tectonics & Mineral Resources of North East India	4
	MGLC 4.21	Special Paper (Elective) anyone from MGLC 4.21 (i) to MGLC 4.21 (v) (i)Sedimentary Environment and Sedimentary Basins (ii)Advanced Hydrogeology (iii)Petroleum Exploration (iv)Marine Geology (v)Micropalaeontology	4
	MGLC 4.31	Project Work :- Dissertation	4
	MGLC 4.41	Seminar	2
	MGLC 4.51	Geological Fieldwork Training of 3 Weeks	4

## SEMESTER - I

### MGLC 1.11

### STRUCTURAL GEOLOGY, GEOMORPHOLOGY & TECTONICS

*Theory Credit: 4*

- UNIT I** Concept of stress and strain. Two-dimensional strain and stress analysis. Types of strain ellipses and ellipsoids, their properties and geological significance. Strain markers in naturally deformed rocks. Mechanical principles and properties of rocks and their controlling factors. Planar and linear fabrics in deformed rocks, their origin and significance. Types of fabrics, fabric elements.
- UNIT II** Fractures and joints: their nomenclature, age relationship, origin and significance. Fold development and distribution of strain in folds. Causes and dynamics of faulting; strike-slip faults, normal faults, overthrust and nappe.
- UNIT III** Concepts and perception of geomorphology. Landscape development: Davisian model and its merits and demerits; Penck's and King's models. Geomorphic processes and resulting landforms. Drainage patterns and morphometric analysis. Geomorphology of shorelines and ocean floors. Slope: types and evolution.
- UNIT IV** Elementary idea about morphochronology, morphotectonics, active tectonics (neotectonics) and paleoseismicity. Terrain evaluation for mineral prospecting, civil engineering, hydrogeology and environmental studies.
- UNIT V** Development of the plate tectonics theory. Principal tectonic features of the earth. Models of ophiolite emplacement. Plate tectonics in geologic history. Metamorphism and tectonics. Anatomy of orogenic belts. Origin and tectonics of the Himalayas.

#### **Recommended Books and References:**

1. Badgley, P.C. 1965: Structure and tectonics. Harper and Row.
2. Ramsay, J.G. 1967: Folding and fracturing of rocks. McGraw Hill.
3. Hobbs, B.E., Means, W.D. and Williams, P.F. 1976: An outline of structural geology. John Wiley.
4. Davis, G.R. 1984: Structural geology of rocks and regions. John Wiley.
5. Ramsay, J.G. and Huber, M.I. 1987: Modern structural geology (vol. 1 & 2). Academic Press.
6. Price, N.J. and Cosgrove, J.W. 1990: Analysis of geological structure. Cambridge University Press.
7. Bailey, B. 1992: Mechanics in structural geology. Springer Verlag.
8. Ghosh, S.K. 1995: Structural geology - fundamentals of modern developments. Pergamon Press.
9. Summerfields, M.A. 2000: Geomorphology and global tectonics. Springer Verlag.
10. Bloom, A.L. 2003: Geomorphology - A systematic analysis of Late Cenozoic landforms. Pearson Education, New Delhi.
11. Chorley, R.J., Schumm, S.A. and Sugden, D.E. (Eds) 1985: Geomorphology. Methuen.
12. Kale, V.S. and Gupta, A. 2001: Introduction to geomorphology. Orient Longman.
13. Thorn, C.E. 1998: Introduction to theoretical geomorphology. Unwin Hyman.
14. Thornbury, W.D. 1996: Principles of geomorphology. John Wiley.
15. Summerfield, M.A. (Ed) 1999: Geomorphology and global tectonics. John Wiley.
16. Naqi, M., 2005: Encyclopaedia of geomorphology (vol. 1). Anmol Publications, New Delhi.
17. Moores, E. and Twiss, R.J. 1995: Tectonics. Freeman.

18. Keary, P. and Vine, F.J. 1990: Global tectonics. Blackwell.
19. Storetvedt, K.N. 1997: Our evolving planet: Earth's history in new perspective. Bergen (Norway), Alma Mater Forlag.
20. Valdiya, K.S. 1998: Dynamic Himalaya. University Press, Hyderabad.

### **MGLC 1.12**

#### **STRUCTURAL GEOLOGY, GEOMORPHOLOGY & TECTONICS PRACTICAL**

*Practical Credit: 2*

Preparation and interpretation of geological maps and sections. Study of map projections. Structural problems concerning economic mineral deposits. Recording and plotting of field data. Plotting and interpretation of petrofabric data and resultant diagrams. Study of large scale tectonic features of the earth. Drainage patterns and analysis.

### **MGLC 1.21**

#### **PALAEOBIOLOGY AND STRATIGRAPHY**

*Theory Credit: 4*

- UNIT I** Species concept, biometrics and phylogenetic analysis. Mechanisms of evolution. Functional morphology and evolutionary trends in Mollusks, Brachiopods, Echinoderms.
- UNIT II** Taphonomy - limiting environmental factors. Major events in the history of Precambrian and Phanerozoic life. Palaeo-biogeographic provinces. Classification and significance of vertebrate palaeontology and micropalaeontology.
- UNIT III** Controls on the development of stratigraphic records. Lithostratigraphy: correlation and stratigraphic code. Biostratigraphy: controlling factors, zonation, time significance, quantitative stratigraphy. Geochronology and Chronostratigraphy. Completeness/ incompleteness of stratigraphic records.
- UNIT IV** Event stratigraphy, Magnetostratigraphy, Cyclostratigraphy, Seismic Stratigraphy, and Sequence Stratigraphy. Geophysical and chemostratigraphic Correlation.
- UNIT V** Stable isotopes and palaeoclimates. Study of palaeogeography, palaeoclimate and igneous and mountain building activities in the Indian subcontinent.

#### **Recommended Books and References:**

1. Clarkson, E.N.K. 1998: Invertebrate palaeontology and evolution. Blackwell.
2. Stearn, C.W. and Carroll, R.L. 1989: Palaeontology - The record of life. John Wiley.
3. Smith, A.B. 1994: Systematics and the fossil record - Documenting evolutionary patterns. Blackwell.
4. Prothero, D.R. 1998: Bringing fossils to Life - An introduction to palaeobiology. McGraw Hill.
5. Pomeroy, C. 1982: The Cenozoic Era: Tertiary and Quaternary. Ellis Harwood Ltd.
6. Goodwin, A.M. 1991: Precambrian geology: The dynamic evolution of continental crust. Academic Press.
7. Boggs, S. (Jr) 1995: Principles of sedimentology and stratigraphy. Prentice Hall.

8. Doyle, P. and Bennet, M.R. 1996: Unlocking the stratigraphic record. John Wiley.
9. Brenner, R.E. and McHargue, T.R. 1988: Integrative stratigraphy: Concepts and applications. Prentice Hall.
10. Naqvi, S.M. and Rogers, J.J.W. 1987: Precambrian geology of India. Oxford University Press.
11. Pascoe, E.H. 1968. A manual of geology of India and Burma (vol. 1-4). GoI Press.

**MGLC 1.22**  
**PALAEOBIOLOGY AND STRATIGRAPHY PRACTICAL**

*Practical Credit: 2*

Recognition of fossil groups in an assorted assemblage and identification of their classes. Study of important fossils from Indian stratigraphic horizons. Measurement of dimensional parameter and preparation of elementary growth-curves and scatter-plots. Exercises on stratigraphic classification and correlation. Exercises on interpretation of seismic records of stratigraphy. Study of palaeogeographic maps of all geological periods.

**MGLC 1.31**  
**MINERALOGY, CRYSTALLOGRAPHY AND ANALYTICAL TECHNIQUES**

*Theory Credit: 4*

- UNIT I** Bonding in minerals, coordination number, solid solution, polymorphism, isomorphism and pseudomorphism. Structural classification of silicates. Gem and semi- Precious minerals.
- UNIT II** Systematic mineralogy of olivine, garnet, aluminosilicate ( $\text{Al}_2\text{SiO}_5$ ), pyroxene and amphibole, kaolinite, mica, chlorite groups.
- UNIT III** Systematic mineralogy of feldspar group, native elements (diamond and graphite), sulfides (pyrrhotite and sphalerite), sulfosalts (enargite), oxides (corundum), hydroxides (brucite) and carbonates (calcite, dolomite and aragonite).
- UNIT IV** Concept of symmetry. Space lattice and symmetry of internal structures - 14 Bravais lattices. Introduction to point group and space group. Twinning and twin laws - common types of twins and their examples in minerals. Optical crystallography of uniaxial and biaxial minerals: indicatrix, pleochroism, interference figures, 2V and 2E. Determination of optic sign.
- UNIT V** Basic principles and geological application of X-ray diffractometry, cathodoluminescence, thermo luminescence, atomic absorption spectrophotometry, inductively coupled plasma - atomic emission spectrometry, X-ray fluorescence spectrometry, scanning and transmission electron microscopy, and electron-probe microanalysis.

**Recommended Books and References:**

1. Deer, W.A., Howie, R.A. and Zussman, J. 1996: The rock forming minerals. Longman.
2. Klein, C. and Hurlbut, C.S. (Jr) 1993: Manual of mineralogy. John Wiley.
3. Putnis, A. 1992: Introduction to mineral sciences. Cambridge University Press.



4. Spear, F.S. 1993: Mineralogical phase equilibria and pressure-temperature-time paths. Mineralogical Society of America Publications.
5. Phillips, W.R. and Griffin, D.T. 1986: Optical mineralogy. CBS Publishers.
6. Hutchinson, C.S. 1974: Laboratory handbook of petrographic techniques. John Wiley.

**MGLC 1.32**

**MINERALOGY, CRYSTALLOGRAPHY AND ANALYTICAL TECHNIQUES PRACTICAL**

*Practical Credit: 2*

Study of important rock forming minerals in hand specimen and atomic structure models. Determination of extinction angle and composition of plagioclase. Microscopic study of common rock-forming minerals. Calculation of mineral formulae. Stereographic projection of crystals. Sample preparation for powder diffraction by XRD and interpretation of X-ray diffractograms of common minerals and components of bulk rocks. Preparation of thin and polished sections. Etching and staining.

## SEMESTER - II

### MGLC 2.11

### IGNEOUS, SEDIMENTARY & METAMORPHIC PETROLOGY

*Theory Credit: 4*

- UNIT I** Magma generation in the mantle, their nature. Factors affecting magma generation. Magmatism in relation to plate setting. IUGS classification of Igneous rocks.
- UNIT II** Rock suite, petrographic provinces and associations. Petrography and petrogenesis of major igneous rock types such as ultramafics/komatiites, basalt, granite, alkaline rocks and ophiolites.
- UNIT III** Liberation of flux of sediments. Processes of transport and generation of sedimentary structures. Classification of sedimentary structures. Sedimentary environments and facies. Shallow coastal clastics. Marine and continental evaporates. Shallow water carbonates. Volcanoclastics: land and marine.
- UNIT IV** Evolution of sedimentary basins: tectonics and sedimentation. Palaeoclimate and palaeoenvironment analysis. Brief idea of basin analyses. Significance of ichnofossils in depositional environments. Field and laboratory techniques in sedimentology: recording of sedimentary structures and preparation of lithologs. Diagenesis of sandstones and carbonate rocks.
- UNIT V** Metamorphic facies: description of facies of low pressure (albite-epidote-hornfels, pyroxene-hornfels), medium to high pressure (greenschist, granulite) and very high pressure (eclogite) with special reference to characteristic minerals and P/T conditions. Isoreactiongrad, Schreinmaker's rule and petrogenetic grids. Regional metamorphism and paired metamorphic belts with reference to plate tectonics. Pressure-temperature-time paths. Ocean floor metamorphism.

#### **Recommended Books and References:**

1. Allen, J.R.L. 1985: Principles of physical sedimentation. George Allen & Unwin.
2. Allen, P. 1997: Earth surface processes. Blackwell.
3. Nichols, G. 1999: Sedimentology and stratigraphy. Blackwell.
4. Reading, H.G. 1996: Sedimentary environments. Blackwell.
5. Davis, R.A. (Jr) 1992: Depositional systems. Prentice Hall.
6. Einsele, G. 1992: Sedimentary basins. Springer Verlag.
7. Reineck, H.E. and Singh, I.B. 1980: Depositional sedimentary environments. Springer Verlag.
8. Prothero, D.R. and Schwab, F. 1996: Sedimentary geology. Freeman.
9. Miall, A.D. 2000: Principles of sedimentary basin analysis. Springer Verlag.
10. Pettijohn, F.J., Potter, P.E. and Siever, R. 1990: Sand and sandstone. Springer Verlag.
11. Blatt, H., Murray, G.V., and Middleton, R.C. 1980: Origin of sedimentary rocks.
12. Bhattacharya, A. and Chakraborti, C. 2000: Analyses of sedimentary successions. Oxford-IBH.
13. Bogggs, S. (Jr) 1995: Principles of sedimentology and sStratigraphy. Prentice Hall.
14. Sengupta, S. 1997: Introduction to sedimentology. Oxford-IBH.
15. Turner, F.J. 1980: Metamorphic petrology. McGraw Hill.
16. Yardley, B.W. 1989: An Introduction of metamorphic petrology. Longman.
17. Bucher, K. and Frey, M. 1994: Petrogenesis of metamorphic rocks. Springer Verlag.
18. Philipotts, A. 1992: Igneous and metamorphic petrology. Prentice Hall.
19. Best, M.G. 1986: Igneous petrology. CBS Publishers.

20. McBirney, A.R. 1993: Igneous petrology. Jones and Bartlett Publications.
21. Kretz, R. 1994: Metamorphic crystallization. John Wiley.
22. Bose, M.K. 1997: Igneous petrology. World Press.
23. Perchuk, L.L. and Kushiro, I. (Eds) 1991: Physical chemistry of magmas. Springer Verlag.
24. Spry, A. 1976: Metamorphic textures. Pergamon Press

## **MGLC 2.12**

### **SEDIMENTARY, IGNEOUS AND METAMORPHIC PETROLOGY PRACTICAL**

*Practical Credit: 2*

Study of primary, secondary, and biogenic sedimentary structures in hand specimens, in photographic atlases, field photographs, and wherever possible on outcrops. Exercises related to palaeocurrent data from different environments. Tilt corrections of palaeocurrent data. Exercises related to analysis and interpretation of depositional sedimentary environments using actual case histories from the Indian stratigraphic records. Determination of porosity in clastic and chemical sedimentary rocks. Detailed study of diagenetic features in thin sections, Separation and study of heavy minerals. Exercises on mineralogical and geochemical data plots for environmental interpretations.

Megascopic and microscopic study of igneous rocks. Megascopic and microscopic study of metamorphic rocks of different facies. Graphic construction of ACF, AKF and AFM diagrams. Estimation of pressure and temperature from important models of geothermobarometry. Interpretation of reactions textures.

## **MGLC 2.21**

### **ORE GEOLOGY, MINERAL EXPLORATION & MINING GEOLOGY**

*Theory Credit: 4*

- UNIT I** Modern concept of ore genesis. Mode of occurrence of ore bodies - morphology and relationship of host rocks. Textures, paragenesis and zoning of ores and their significance. Concept of ore bearing fluids, their origin and migration; wall rock alteration. Organic matter in ores and their significance.
- UNIT II** Orthomagmatic ores of mafic-ultramafic association - diamonds in kimberlite, REE in carbonatites. Ores of silicic igneous rocks - Kiruna type, pegmatites. Stratiform and stratabound ore deposits, placers and palaeoplacers. Metamorphism of ores and metamorphogenic ores. Ores related to weathering and weathered surfaces .
- UNIT III** Geological models in exploration planning. Basic principles of exploration geochemistry: geochemical environment, geochemical dispersion, association of elements, geochemical distribution patterns and principles of interpretation. Application of remote sensing in mineral exploration.
- UNIT IV** Geochemical rock surveys: orientation survey, collection and processing of samples and interpretation of data. Pedogeochemical, lithogeochemical, biogeochemical and geobotanical surveys in mineral exploration. Heavy mineral prospecting. Introduction to aeromagnetic surveys and electrical well logging.
- UNIT V** Factors in the choice of mining methods. Mining terminology. Surface mining: alluvial and open cast. Underground mining: shaft sinking, stoping, room and pillaring, long-

wall mining, top-slicing, sub-level caving and block caving. Ocean bottom mining. Mining hazards: mine inundation, mine fire and rock burst.

**Recommended Books and References:**

1. Evans, A.M. 1995: Introduction to mineral exploration. Blackwell Science.
2. Rose, A.W., Hawkes, H.E. and Webb, J.A. 1979: Geochemistry in mineral exploration. Academic Press.
3. Govett, G.J.S. 1983: Handbook of exploration geochemistry. Elsevier.
4. Levenson, 1974: Introduction to exploration geochemistry.
5. Sharma, P.V. 1986: Geophysical methods in geology. Elsevier.
6. Vogelsang, D. 1995: Environmental geophysics - A practical guide. Springer Verlag.
7. Dobrin, M.B. 1976: Introduction to geophysical prospecting. McGraw Hill.
8. Stanislave, M. 1984: Introduction to applied geophysics. Reidel Publications.
9. Peters, W.C. 1978: Exploration and mining geology. John Willey and Sons.
10. McKinstry, H.E. 1962: Mining geology (2nd ed). Asia Publishing House.
11. Clark, G.B. 1967: Elements of mining (3rd ed). John Wiley.
12. Arrogyaswami, R.N.P. 1996: Courses in mining geology (4th ed). Oxford IBH.
13. Craig, J.M. and Vaughan, D.J. 1981: Ore petrography and mineralogy. John Wiley.
14. Evans, A.M. 1993: Ore geology and industrial minerals. Blackwell.
15. Sawkins, F.J. 1984: Metal deposits in relation to plate tectonics. Springer Verlag.
16. Stanton, R.L. 1972: Ore petrology. McGraw Hill.
17. Torling, D.H. 1981: Economic geology and geotectonics. Blackwell.
18. Barnes, H.L. 1979: Geochemistry of hydrothermal ore deposits. John Wiley.
19. Klemm, D.D. and Schneider, H.J. 1977: Time and strata bound ore deposits. Springer Verlag.
20. Guilbert, J.M. and Park, C.F. (Jr) 1986: The geology of ore deposits. Freeman.
21. Mookherjee, A. 2000: Ore aenesis - A holistic approach. Allied Publishers.

**MGLC 2.22**

**ORE GEOLOGY, MINERAL EXPLORATION AND MINING GEOLOGY PRACTICAL**

*Practical Credit: 2*

Megascopic study of Indian metallic ores in hand specimen. Megascopic study of structures and fabric of different ores and their associations. Mineralogical and textural studies of common ore minerals under ore-microscope and petrological study of other industrial and non-metallic minerals. Exercises in the determination of reflectivity and microhardness of common ore minerals. Preparation of maps showing distribution of important metallic and industrial minerals in India and the world.

Study of symbols for field and mine geologic mapping. Calculation of Clarke concentration. Use of flame photometer and spectrophotometer. Study of gravimeter, magnetometer and seismographs. Resistivity surveys. Interpretation of underground structures on the basis of seismic data. Diagrammatic representation of open cast and underground mining. Methods of mining survey. Exercises on mine sampling and determination of tenor, cut-off grades and ore reserves. Study of flow sheet for ore beneficiation.

**MGLO 2.11**  
**REMOTE SENSING IN GEOSCIENCES**

*Theory Credit: 4*

- UNIT I** Principles of remote sensing; general idea about electromagnetic spectrum. Aerial photographs - types and geometry.
- UNIT II** Stereopair and stereoscopes; photo mosaics. Principles and applications of photogrammetry. Vertical exaggeration.
- UNIT III** Satellite remote sensing. Satellite exploration programs and their characteristics: LANDSAT, METEOSAT, SEASAT, SPOT and IRS.
- UNIT IV** Digital image processing. Elements of image interpretation. Principles of terrain analysis.
- UNIT V** Geological interpretation of remotely sensed data for : topography, lithology, structure, mineral and groundwater potential. Principles and applications of Geographic Information Systems.

***Recommended Books and References:***

1. Drury, S.A. 1987: Image interpretation in geology. Allen and Unwin.
2. Gupta, R.P. 1990: Remote sensing geology. Springer Verlag.
3. Lillesand, M.T. 2000: Remote sensing and image interpretation. John Wiley.
4. Lillesand, T.M. and Kieffer, R.W. 1987: Remote sensing and image interpretation. John Wiley.
5. Miller, V.C. and Miller, C.F. 1961: Photogeology. McGraw Hill.
6. Moffitt, F.H. and Mikhail, E.M. 1980: Photogrammetry. Harper and Row.
7. Paine, D.P. 1981: Aerial photography and image interpretation for resource management. John Wiley.
8. Pandey, S.N. 1987: Principles and applications of photogeology. Wiley Eastern, New Delhi.
9. Ray, R.G. 1969: Aerial photographs in geologic interpretations. USGS Prof. Paper.
10. Rampal, K.K. 1999: Handbook of aerial photography and interpretation. Concept Publishing Co., New Delhi.
11. Sabbins, F.F. 1985: Remote sensing - Principles and applications. Freeman.
12. Siegal, B.S. and Gillespie, A.R. 1980: Remote sensing in geology. John Wiley.
13. Nag, P. and Sengupta, S. 2007: Geographical information system: Concepts and business opportunities. Concept Publishing Co., New Delhi.

**MGLO 2.12**  
**REMOTE SENSING PRACTICAL**

*Practical Credit: 2*

Study of nature of aerial photographs: resolution, mosaic and image parallax. Determination of scale, height, dip, slope, vertical exaggeration and image distortion. Exercises on MSS, TM, FCC, IR, Thermal IR, Radar and SPOT images for geological and geomorphological mapping and in vegetation, water and mineral resource evaluation. Making false color composites and study of multi-spectral scans and spectral patterns. Exercises on digital image processing.

## SEMESTER - III

### MGLC 3.11

#### ENGINEERING GEOLOGY AND HYDROGEOLOGY

*Theory Credit: 4*

- UNIT I** Role of geology in engineering. Soil mechanics. Engineering properties of rocks. Physical characters of building stones. Metal and concrete aggregates. Mass movements with special emphasis on landslides and causes of hill slope instability.
- UNIT II** Geological considerations for evaluation of dam and reservoir sites. Geotechnical evaluation of transportation routes and bridge. Influence of geological conditions on foundation and design of buildings. Aseismic designs of buildings.
- UNIT III** Origin and types of surface and subsurface water. Hydrologic cycle. Hydrological properties of rocks: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity and storage coefficient. Types of aquifers. Geological formations as aquifers: unconsolidated and consolidated rocks.
- UNIT IV** Well hydraulics: confined, unconfined, steady and radial flow. Chemical characteristics of groundwater in relation to various uses: domestic, industrial and irrigation. Water contamination and pollution.
- UNIT V** Pumping test analysis. Artificial recharge of groundwater. Consumptive and conjunctive uses of water. Resistivity method of groundwater exploration. Groundwater provinces of India.

#### **Recommended Books and References:**

1. Alley, W.M. 1993: Regional groundwater quality. VNR, New York.
2. Davies, S.N. and Dewiest, R.J.M. 1966: Hydrogeology. John Wiley.
3. Krynine, D.H. and Judd, W.R. 1998: Principles of engineering geology. CBS Publishers.
4. Sharma, P.V. 1997: Environmental and engineering geophysics. Cambridge University Press.
5. Todd, D.K. 1980: Groundwater hydrology. John Wiley.
6. Fetter, C.W. 1990: Applied hydrogeology. Merrill Publishing.
7. Freeze, R.A. and Cherry, J.A., 1979: Groundwater. Prentice Hall.
8. Karanth, K.R. 1987: Groundwater assessment - Development and management. Tata-McGraw Hill.
9. Raghunath, N.M. 1982: Groundwater. Wiley Eastern.
10. Subramaniam. V. 2000: Water. Kingston Publications.

### MGLC 3.12

#### ENGINEERING GEOLOGY AND HYDROGEOLOGY PRACTICAL

*Practical Credit: 2*

Study of properties of common rocks with reference to their utility in engineering projects. Study of maps and models of important engineering structures such as dam sites and tunnels. Interpretation of geological maps for landslide problems.

Delineation of hydrological boundaries of water table contour maps. Chemical analysis of water and their graphical representation. Preparation of hydrogeomorphic maps using toposheets, aerial photos and satellite imagery. Determination of porosity, hydraulic conductivity, etc. from mechanical analysis data of aquifer material. Evaluation of aquifer parameters from pumping tests. Analysis and interpretation of geophysical well logs. Estimation of TDS using resistivity and SP logs.

### **MGLC 3.21**

#### **FUEL GEOLOGY &GEOCHEMISTRY**

*Theory Credit: 4*

**UNIT I** Indian and international classifications. Chemical characterization: proximate and ultimate analysis. Macroscopic ingredients and microscopic constituents - concept of maceral and microlithotypes. Maturation of coal and generation of methane in coal beds. Fundamentals of coal-bed methane exploration and production. Geological and geographical distribution of coal deposits in India.

**UNIT II** Petroleum: composition and different fractions. Transformation of organic matter into kerogen, organic maturation and thermal cracking of kerogen. Oilfield fluids - water, oil and gas occurrences. Major oil bearing basins of India. Geology of the following oilfields of India: Bombay High and Digboi.

**UNIT III** Atomic fuels: mode of occurrence and association of atomic minerals in nature. Productive geological horizons in India.

**UNIT IV** Definition and scope of geochemistry. Abundance of elements in the earth and its constituents in the solar system. Goldschmidt's geochemical classification of elements. Radiogenic isotopes. Radiometric dating of single mineral and whole-rock. Stable isotopes: nature, abundance and fractionation.

**UNIT V** Principles of ionic substitution in minerals; element partitioning in mineral/rock formation. Concept of geochemical cycle.

#### **Recommended Books and References:**

1. Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert, P. 1998: Organic petrology. Gebruder Borntraeger, Stuttgart.
2. Chandra, D., Singh, R.M. and Singh, M.P. 2000: Textbook of coal (Indian context). Tara Book Agency, Varanasi.
3. Singh, M.P. (Ed) 1998: Coal and organic petrology. Hindustan Publishing Co., New Delhi.
4. Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D. and Teichmuller, M.R. 1982: Stach's text book of coal petrology. Gebruder Borntraeger, Stuttgart.
5. Holson, G.D. and Tiratsoo, E.N. 1982: Introduction to petroleum geology. Gulf Publishers, Houston.
6. Tissor, B.P. and Welte, D.H. 1984: Petroleum formation and occurrence. Springer Verlag.
7. Selley, R.C. 1998: Elements of petroleum geology. Academic Press.
8. Durrance, E.M. 1986: Radioactivity in geology - Principles and application. Ellis Hoorwool.
9. Dahlkamp, F.J. 1993: Uranium ore deposits. Springer Verlag.
10. Boyle, R.W. 1982: Geochemical prospecting for thorium and uranium deposits. Elsevier.
11. Mason, B. and Moore, C.B. 1991: Introduction to geochemistry. Wiley Eastern.
12. Krauskopf, K.B. 1967: Introduction to geochemistry. McGraw Hill.

13. Faure, G. 1986: Principles of isotope geology. John Wiley.
14. Hoefs, J.M. 1980: Stable isotope geology. John Wiley.
15. Marshal, C.P. and Fairbridge, R.W. 1999: Encyclopaedia of geochemistry. Kluwer Academic.
16. Govett, G.J.S. (Ed) 1983: Handbook of Exploration Geochemistry. Elsevier.
17. Nordstrom, D.K. and Munoz, J.L. 1986: Geochemical thermodynamics. Blackwell.
18. Henderson, P. 1987: Inorganic geochemistry. Pergamon Press.
19. Rastogi, R.P. and Mishra R.R. 1993: An introduction to chemical thermodynamics. Vikash Publishing House.
20. Spear, F.S. 1993: Mineralogical phase equilibria and P-T-t Paths. Mineralogical Society of America.

### **MGLC 3.22**

#### **FUEL GEOLOGY & GEOCHEMISTRY PRACTICAL**

*Practical Credit: 2*

Megascopeic characterization of banded coals. Proximate analysis of coal. Completion of outcrops in the given maps and calculation of coal reserves. Preparation of polished particulate mounts of coal. Microscopic examination of polished coal pellets. Identification of macerals in coal. Megascopeic and microscopic study of cores and well cuttings. Study of geological maps and sections of important oilfields of India and world. Calculation of oil reserves. Study of geological sections of U-Th bearing rocks of India. Megascopeic study of some uranium and thorium bearing minerals and rocks.

Geochemistry

Calculation of structural formulae of pyroxenes, amphibole and garnet. Calculation of CIPW and Niggli values from different rock compositions; plotting of variation diagrams - binary and ternary. Calculation of weathering indices in soil and sediments. Presentation of analytical data.

### **MGLO 3.11**

#### **ENVIRONMENTAL GEOLOGY**

*Theory Credit: 4*

**UNIT I** Time scales of global changes in the ecosystems and climate. Carbon dioxide in the atmosphere; carbon sequestration; calcite compensation depth; records of palaeotemperatures in ice cores of glaciers.

**UNIT II** Global climate change and its impact on the environment; major climate forcings. Geological record of climatic change; causes of climatic change. Cenozoic climate extreme evolution of life, especially impact on human evolution.

**UNIT III** Impact assessment of degradation and contamination of surface water and groundwater quality due to industrialization and urbanization. Water logging problems due to indiscrete construction of canals and dams.

**UNIT IV** Soil quality degradation due to irrigation, use of fertilizers and pesticides. Energy crises: alternative energy resources. Waste management: solid, liquid and radioactive. Geologic aspects of environmental health.



**UNIT V** Influence of neotectonics in seismic hazards assessment. Preparation of seismic hazard maps. Distribution, magnitude and intensity of earthquakes. Man made hazards: Deforestation, its causes, impact and remedial measures.

***Recommended Books and References:***

1. Bell, F.G. 1999: Geological hazards. Routledge.
2. Bryant, E. 1985: Natural hazards. Cambridge University Press.
3. Keller, E.A. 1978: Environmental geology. Bell and Howell.
4. Patwardhan, A.M. 1999: The dynamic earth system. Prentice Hall.
5. Smith, K. 1992: Environmental hazards. Routledge.
6. Subramaniam, V. 2001: Textbook in environmental science. Narosa International.
7. Valdiya, K.S. 1987: Environmental geology - Indian context. Tata McGraw Hill.

**MGLO 3.12**

**ENVIRONMENT GEOLOGY PRACTICAL**

*Practical Credit: 2*

Study of seismic and flood-prone areas India. Analyses for alkalinity, acidity, pH and electrical conductivity of water samples. Classification of groundwater for use in drinking, irrigation and industrial purposes. Evaluation of environmental impact of air pollution, groundwater, landslides, deforestation. Study of environmental hazard maps.

## SEMESTER - IV

### MGLC 4.11

### GEOLOGY, TECTONICS AND MINERAL RESOURCES OF NORTHEAST INDIA

*Theory Credit: 4*

- UNIT I** Stratigraphic succession, lithology, structure, tectonics and mineral resources of Nagaland and Manipur.
- UNIT II** Stratigraphic succession, lithology, structure, tectonics and mineral resources of Assam.
- UNIT III** Stratigraphic succession, lithology, structure, tectonics and mineral resources of Meghalaya.
- UNIT IV** Stratigraphic succession, lithology, structure, tectonics and mineral resources of Arunachal Himalaya.
- UNIT V** Stratigraphic succession, lithology, structure, tectonics and mineral resources of Mizoram and Tripura.

#### ***Recommended Books and References:***

1. Nandy, D.R. 2001: Geodynamics of Northeastern India and the adjoining region. ACB Publications.
2. Kumar. G. 1997: Geology of Arunachal Pradesh. Geol. Soc. India Publication.
3. Karunakaran, C. 1972: Geology and Mineral Resources of the states of India. Misc. Publ., GSI, vol. 30.
4. Dasgupta, A.B. and Biswas, A.K. 2000: Geology of Assam. Geol Soc. India Publication.
5. Naqvi, S.M. 2005: Geology and evolution of the Indian Plate (4 Ga to 4 Ka). Capital Publishing Co.
6. Krishnan, M.S. 1982: Geology of India and Burma (6th ed). CBS Publishers and Distributors, Delhi.
7. Kumar, R. 1985: Fundamental of historical geology and stratigraphy of India (3rd ed) Wiley Eastern.
8. Wadia, D.N. 1957: Geology of India (3rd ed).

## **SPECIAL PAPER (ELECTIVE)**

### **MGLC 4.21(i)**

#### **SEDIMENTARY ENVIRONMENT AND SEDIMENTARY BASINS**

*Theory Credit: 4*

- UNIT I** Modern laboratory techniques in sedimentological studies. Detailed study of volcanoclastics, chemical precipitates. Clay deposits: mineralogy, physical properties, chemistry and genesis. Processes of dolomitization and phosphatization. Origin of various types of cements.
- UNIT II** Use of trace fossils, stromatolites, thrombolites, and related structures in palaeoenvironmental analysis. Methods of palaeocurrent determination and basin analysis. Tectonics and evolution of the sedimentary basins. Sedimentary cycles, rhythms and cyclothems.
- UNIT III** Analysis of sedimentary facies and preparation of facies maps. Lithofacies, biofacies, dynamics and primary structures associated with the following environments: Deserts, Alluvial Fans, River Plains, Glaciers, Deltas, Estuaries, Clastic Shorelines, Clastic Shelves, Marine Evaporite Basins, Carbonate Platforms, Deep Sea and Ocean Bottom, Deep Sea Trench and Rise.
- UNIT IV** Sedimentation pattern and depositional environment of selected undeformed and deformed sedimentary basins of India representing Precambrian, Phanerozoic and Contemporary basins.

#### **Recommended Books and References:**

1. Reading, J.G. 1986: Sedimentary Environment & Facies. Blackwell.
2. Reineck, H.E. and Singh, I.B. 1975: Depositional Sedimentary Environment. Springer Verlag.
3. Carver, R.E. 1971: Procedures of Sedimentary Petrology. John Wiley.
4. Tucker, M. 1988: Techniques in Sedimentology. Blackwell.
5. Friedman, G.M. and Sanders, J.E. 1978: Principles of Sedimentology. John Wiley.
6. Guy Plint, A. 1995: Sedimentary Facies Analysis. Spl. Publ. IAS No.22. Blackwell.
7. Miall, A.D. 1996: The Geology of Fluvial Deposits. Springer Verlag.
8. Miall, A.D. 1997: The Geology of Stratigraphic Sequences. Springer Verlag.

### **MGLC 4.21(ii)**

#### **ADVANCED HYDROGEOLOGY**

*Theory Credit: 4*

- UNIT I** Groundwater and the hydrologic cycle. Precipitation: types and causes. Factors affecting evaporation and transpiration. Runoff characteristics: the hydrograph; hydrographic analyses. Water balance studies. Distribution of water in the earth's crust. Origin of springs (including thermal). Geologic structures favouring groundwater occurrence.
- UNIT II** Forces and laws of groundwater movement. Factors affecting groundwater movement and occurrence: geomorphology, lithology, and structure. Movement of groundwater:

Darcy's law of fluid flow. Water table contour maps and flow net analysis. Well hydraulics: confined, unconfined, steady, unsteady and radial flow. Pumping tests and analysis of test data; evaluation of formation characteristics; Thiem's equilibrium method; Theis' method.

**UNIT III** Groundwater in arid, semiarid, coastal and alluvial regions. Groundwater in hard-rock and limestone terrain of India. Groundwater recharge: artificial and natural; factors controlling recharge. Conjunctive use of water resources in basin management. Groundwater legislation. Problems of over-drafting of groundwater. Water logging. Sources of salinity of groundwater. Seawater intrusion in coastal aquifers and remedial measures. Fluctuations of groundwater level: causes and their measurement.

**UNIT IV** Environmental impact of groundwater extraction. Groundwater quality: major chemical constituents, sources, concentrations and effects on usability; physical and chemical criteria. Water pollution and contamination; its treatment; problems of arsenic and fluoride. Wells: their types, construction and design. Types of drilling: cable tool, hydraulic rotary, reverse rotary and DTH. Geological and geophysical (gravity, magnetic, resistivity and seismic refraction methods) methods of groundwater exploration. Radiation / geophysical logging. Application of remote sensing in groundwater exploration. Stable isotopes in hydrogeological studies.

**Recommended Books and References:**

1. Alley, W.M. 1993: Regional groundwater quality. VNR, New York.
2. Davies, S.N. and Dewiest, R.J.M. 1966: Hydrogeology. John Wiley.
3. Fetter, C.W. 1990: Applied hydrogeology. Merrill Publishing.
4. Freeze, R.A. and Cherry, J.A. 1979: Groundwater. Prentice Hall.
5. Garg, S.P. 1982: Groundwater and tube wells. Oxford and IBH Publishing Co.
6. Hudak, P.F. 2000: Principles of hydrogeology. Lewis Publishers.
7. Karanth, K.R. 1987: Groundwater assessment - Development and management. Tata-McGraw Hill.
8. Mahajan, G. 1990: Evaluation and development of groundwater. D.K. Publishers.
9. Mahajan, G. 1995: Groundwater. D.K. Publishers.
10. Pitchaiah, P.S. (Ed) 1995: Groundwater. Ashish Publishing House, New Delhi.
11. Raghunath, N.M. 1982: Groundwater. Wiley Eastern.
12. Singhal, B.B.S. 1986: Engineering geosciences. Savita Prakashan.
13. Subramaniam, V. 2000: Water. Kingston Publications, London.
14. Todd, D.K. 1980: Groundwater hydrology. John Wiley.
15. USDI, 1993: Groundwater manual. Scientific Publishers, Jodhpur.
16. Viessman, W., Knapp, J.W., Lewis, G.L. and Harbaugh, T.E. 1977: Introduction to hydrology. Harper and Row.
17. Walton, W.C. 1988: Groundwater resource evaluation. McGraw Hill.

**MGLC 4.21(iii)**

**PETROLEUM EXPLORATION**

*Theory Credit: 4*

**UNIT I** Identification and characterization of petroleum source rocks. Amount, type and maturation of organic matter. Oil and source correlation. Locating petroleum

prospects based on principles of petroleum generation and migration (Geological modeling).

**UNIT II** Quantitative evaluation of oil and gas prospects through geochemical modeling, Reconstruction of the ancient geothermal gradient. Migration Modeling, Inputs for the assessment of accumulation of petroleum.

**UNIT III** Elements of geophysical methods of exploration. Magnetic, gravity and seismic methods. Interpretation of seismic data in basin modeling and preparation of subsurface geological maps. Application of Remote Sensing techniques in basin analysis.

**UNIT IV** Elements of well drilling. Cable-tool drilling, rotary drilling, various types of drilling units. Elements of logging. Electric, radioactivity and the sonic logs. Nuclear magnetic resonance and dielectric logging. Application of logs in petro-physical analysis and facies analysis.

***Recommended Books and References:***

1. North, F.K. 1985: Petroleum geology. Allen & Unwin.
2. Tissot, B.P. and Welte, D.H. 1984: Petroleum formation and occurrence. Springer Verlag.
3. Selley, R.C. 1998: Elements of petroleum geology. Academic Press.

**MGLC 4.21(IV)  
MARINE GEOLOGY**

*Theory Credit: 4*

**UNIT I** Ocean morphology, deep ocean floor and various topographic features: ridges, sea mounts, coral reefs, continental shelf, continental slope, trenches and canyons.

**UNIT II** Oceanic circulation, waves and currents.

**UNIT III** Oceanic sediments and distribution of marine microfossils; stratigraphy and geochronometry of deep-sea deposits.

**UNIT IV** Tectonic history and chemistry of oceanic rocks.

**UNIT V** Mineral resources of the oceans.

***Recommended Books and References:***

1. Kennett, J.P. 1982: Marine geology. Prentice Hall.
2. Seibold, E. and Berger, W.H. 1982: The sea floor. Springer Verlag.
3. Pipkin, B.W., Gorsline, D.S., Casey, R.E. and Hammond, D.E. 1972: Laboratory exercises in oceanography. Freeman.

**MGLC 4.21(v)**  
**MICROPALAEONTOLOGY**

*Theory Credit: 4*

**UNIT I** Surface and sub-surface sampling methods, processing of samples. Morphology, classification and evolution of foraminifera.

**UNIT II** Detailed study of major morphologic groups, morphology and biometrics of important larger foraminifera; stratigraphy of foraminifera with special reference to India; palaeoenvironmental interpretation using microfossils.

**UNIT III** Morphology and geological distribution of ostracoda. Calcareous nannofossils, radiolaria, conodonts and bryozoa.

**UNIT IV** Role of micropalaeontology in hydrocarbon exploration. Deep-sea records with reference to Indian Ocean. Stable isotopic study of foraminifera and interpretation of palaeoecology.

***Recommended Books and References:***

1. Haq, B.V. and Boersma, A. 1998: Introduction to marine micropalaeontology. Elsevier.
2. Haynes, J.R. 1981: Foraminifera. John Wiley.
3. Bignot, G. 1985: Elements of micropalaeontology. Graham and Trotman.

**MGLC 4.31**  
**DISSERTATION**

*Credit: 4*

**MGLC 4.41**  
**SEMINAR**

*Credit: 2*

**MGLC 4.51**  
**GEOLOGICAL FIELD WORK**

*Credit: 4*

Training of 3 Weeks

*Revised*  
SYLLABUS FOR  
Master of Science  
**MATHEMATICS**  
SEMESTER SYSTEM





### CORE STRUCTURE

SEMESTER	COURSE CODE	COURSE NAME	CREDIT
<b>I</b>	MMAC 1.11	Analysis I	4
	MMAC 1.21	Linear Algebra	4
	MMAC 1.31	Ordinary Differential Equations	4
	MMAC 1.41	Classical Mechanics	4
	MMAC 1.51	FORTTRAN Programming	2
<b>II</b>	MMAC 2.11	Algebra	4
	MMAC 2.21	Analysis II	4
	MMAC 2.31	Partial Differential Equations	4
	MMAO 2.41	Programming in C & Applications	4
	MMAO 2.42	Computer Programming Practical	2
<b>III</b>	MMAC 3.11	Topology	4
	MMAC 3.21	Complex Function Theory	4
	MMAO 3.31	Numerical Analysis	4
	MMAO 3.32	Computer Oriented Numerical Methods Practical	2
	MMAC 3.51	OPTIONAL	4
<b>IV</b>	MMAC 4.11	Elementary Number Theory	4
	MMAC 4.21	Application of Mathematics in Environmental Studies	2
	MMAC 4.31	OPTIONAL	4
	MMAC 4.41	OPTIONAL	4
	MMAC 4.51	OPTIONAL	4

*Note: MMAC 3.51 will correspond to the course code of the optional papers being offered in the 3<sup>rd</sup> semester.*

*MMAC 4.31, MMAC 4.41, MMAC 4.51 will correspond to the course code of the optional papers being offered in the 4<sup>th</sup> semester.*

**OPTIONAL COURSES**

<b>THIRD SEMESTER (any one)</b>	
<b>COURSE NAME</b>	<b>CREDITS</b>
Differential Geometry	4
Theory of Field Extensions	4
Fluid Mechanics	4
Tensor Analysis & Riemannian Geometry	4

<b>FOURTH SEMESTER (any three)</b>	
<b>COURSE NAME</b>	<b>CREDITS</b>
Theory of Relativity	4
Functional Analysis	4
Mathematical Methods	4
Ring Theory	4
$p$ -adic Analysis	4
Relativistic Cosmology	4
Algebraic Topology	4
Algebraic Geometry	4
Dynamical Oceanography	4
Commutative Algebra	4
Non-linear Dynamical Systems	4
Discrete Mathematics	4
Operations Research	4

## SEMESTER - I

### MMAC 1.11 ANALYSIS I

*Theory Credits: 4*

- UNIT I** Brief review of sets, relations and functions. Finite and infinite sets, countable and uncountable sets, Schröder-Bernstein theorem, Ordered fields, least upper bound property, the field of real numbers, Archimedean property, density of rational numbers, existence of  $n^{\text{th}}$  root of positive real numbers, exponential and logarithm, the extended real number system, the complex field.
- UNIT II** Numerical sequences and their convergence, bounded sequences, Cauchy sequences, construction of real numbers using Cauchy sequences; series of complex numbers, convergence of series, series of nonnegative terms, the number  $e$ , the root and ratio tests, limit supremum and limit infimum, power series, summation by parts, absolute convergence, addition and multiplication of series, rearrangements (statement only).
- UNIT III** Euclidean spaces, metric spaces, open and closed sets, limit points, interior points, compact spaces; statements only of the following: nested interval theorem, Heine-Borel theorem, and Bolzano-Weierstrass' theorem.
- UNIT IV** Limits of functions, continuous functions, continuity and compactness, uniform continuity, connected sets, connected subsets of real numbers, continuity and connectedness, intermediate value theorem; discontinuities and their classifications, monotonic functions, infinite limits and limits at infinity.
- UNIT-V** Differentiation of real-valued functions and its elementary properties; mean value theorem; Taylor's theorem; differentiation of vector-valued functions; elementary properties of Riemann integral (brief review); integration of vector-valued functions.

#### **Recommended Books and References:**

1. Naïve Set Theory (3<sup>rd</sup> edition) – P. R. Halmos, D. Van Nostrand Co., Inc, Princeton, New Jersey, 2002.
2. Principles of Mathematical Analysis (5<sup>th</sup> edition) – W. Rudin, McGraw Hill Kogakusha Ltd., 2004.
3. An Introduction To The Theory of Groups (4<sup>th</sup> edition) – J. J. Rotman, Allyn and Bacon, Inc., Boston, 2002.
4. Mathematical Analysis (5<sup>th</sup> edition) – T. Apostol, Addison-Wesley; Publishing Company, 2001.
5. Introduction to Real Analysis (3<sup>rd</sup> edition) – R. G. Bartle and D. R. Sherbert, John Wiley & Sons, Inc., New York, 2000.
6. A First Course in Abstract Algebra (4<sup>th</sup> edition) – J. B. Fraleigh, Narosa Publishing House, New Delhi, 2002.
7. Contemporary Abstract Algebra (4<sup>th</sup> edition) – J. A. Gallian, Narosa Publishing House, New Delhi, 1999.
8. Basic Real Analysis – H.H. Sohrab, Birkhäuser ( 2003).

**MMAC 1.21**  
**LINEAR ALGEBRA**

*Theory Credits: 4*

- UNIT I** Vector spaces, linear independence; linear transformations, matrix representation of a linear transformation; isomorphism between the algebra of linear transformations and that of matrices;
- UNIT II** Similarity of matrices and linear transformations; trace of matrices and linear transformations, characteristic roots and characteristic vectors, characteristic polynomials, relation between characteristic polynomial and minimal polynomial; Cayley-Hamilton theorem (statement and illustrations only); diagonalizability, necessary and sufficient condition for diagonalizability;
- UNIT III** Projections and their relation with direct sum decomposition of vector spaces; invariant subspaces; primary decomposition theorem, cyclic subspaces; companion matrices; a proof of Cayley-Hamilton theorem; triangulability; canonical forms of nilpotent transformations; Jordan canonical forms; rational canonical forms.
- UNIT IV** Inner product spaces, properties of inner products and norms, Cauchy-Schwarz inequality; orthogonality and orthogonal complements, orthonormal basis, Gram-Schmidt process; adjoint of a linear transformation; Hermitian, unitary and normal transformations and their diagonalizations.
- UNIT V** Forms on inner product spaces and their matrix representations; bilinear forms; Hermitian forms; symmetric bilinear forms; orthogonal diagonalization of real quadratic forms.

**Recommended Books and References:**

1. Linear Algebra (2<sup>nd</sup> edition) – K. Hoffman and R. Kunze, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. First Course in Linear Algebra – P. B. Bhattacharya , S. K. Jain and S. R. Nagpal, Wiley Eastern Ltd., New Delhi, 2000.
3. Topics in Algebra (4<sup>th</sup> edition) – I. N. Herstein, Wiley Eastern Limited, New Delhi, 2003.
4. Linear Algebra – G. E. Shilov, Prentice Hall, 1998.
5. Finite Dimensional Vector Spaces – P. R. Halmos, Van Nostrand Inc., 1965.
6. Introduction to Matrices and Linear Transformations (3<sup>rd</sup> edition) – D. T. Finkbeiner, D.B. Taraporevala, Bombay, 1990.
7. Linear Algebra, A Geometric Approach – S. Kumaresan , Prentice-Hall of India Pvt. Ltd., New Delhi, 2001.

**MMAC 1.31**  
**ORDINARY DIFFERENTIAL EQUATIONS**

*Theory Credits: 4*

- UNIT I** Linear equations with constant coefficients; the second and higher order homogeneous equation; initial value problems for second order equations; existence theorem; uniqueness theorem; linear dependence and independence of solutions; the

Wronskian and linear independence; a formula for the Wronskian; the non-homogeneous equation of order two.

**UNIT II** Linear equations with variable coefficients, initial value problems for the homogeneous equations; existence theorem; uniqueness theorem; solutions of homogeneous equations; the theorem on  $n$  linearly independent solutions; the Wronskian and linear independence;

**UNIT III** Existence and uniqueness of solutions – introduction; equations with variable separated; exact equations, Lipschitz condition; non-local existence of solutions; uniqueness of solutions; existence and uniqueness theorem for first order equations; statement of existence and uniqueness theorem for the solutions of ordinary differential equation of order  $n$ .

**UNIT IV** Initial value problems for the homogeneous equations; solutions of homogeneous equations; Wronskian and linear independence; non-homogeneous equations; homogeneous equations with analytic coefficients; Legendre equation, justification of power series method; Legendre polynomials and Rodrigues' formulae.

**UNIT V** Linear equations with regular singular points – introduction; Euler equation; second order equations with regular singular points – example and the general case, convergence proof, exceptional cases; Bessel equation; regular singular points at infinity.

**Recommended Books and References:**

1. An Introduction to Ordinary Differential Equations – E. A. Coddington, Prentice-Hall of India Private Ltd., New Delhi, 2001 .
2. Spherical Harmonics – T. M. Mac Robert, Pergamon Press, 1967.
3. Elementary Differential Equations (3<sup>rd</sup> Edition) – W. T. Martin and E. Reissner, Addison Wesley Publishing Company, inc., 1995.
4. Theory of Ordinary Differential Equations – E. A. Coddington and N. Levinson, Tata McGraw hill Publishing co. Ltd. New Delhi, 1999.
5. Differential Equations, Dynamical Systems and an Introduction to Chaos – M.W. Hirsch, S. Smale, and R.L. Devaney, Elsevier (2004).

**MMAC 1.41**

**CLASSICAL MECHANICS**

*Theory Credits: 4*

**UNIT I** Generalized coordinates; holonomic & non-holonomic systems; D'Alembert's principle; Lagrange's equations; calculus of variations.

**UNIT II** Hamilton's principle, Lagrange's equations from Hamilton's principle, extension of Hamilton's principle to non-conservative and non-holonomic systems, conservation theorems and symmetry properties.

**UNIT III** Eulerian angles; Euler's theorem on the motion of a rigid body; infinitesimal rotations; rate of change of a vector; coriolis force; Euler's equations of motion; force free motion of a rigid body; heavy symmetrical top with one point fixed.

**UNIT IV** Hamilton's equations of motion, conservation theorems and physical significance of Hamiltonian, Hamilton's equations from variational principle, principle of least action.

**UNIT V** Equations of canonical transformation; integral invariants of Poincare'; Lagrange and Poisson brackets as canonical invariants, equations of motion in Poisson bracket notation; infinitesimal contact transformations; constants of motion and symmetry properties.

**Recommended Books and References:**

1. Classical Mechanics (3<sup>rd</sup> edition) – H. Goldstein, Addison Wesley Publications, Massachusetts, 2002.
2. Classical Mechanics – C. R. Mondal, Prentice-Hall of India, 2001.
3. Classical Mechanics – T. W. B. Kibble, Orient Longman, London, 1985.
4. Mechanics – L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1976.
5. Lectures on Mechanics – J. E. Marsden, Cambridge University Press, 1992.

**MMAC 1.51**

**FORTRAN PROGRAMMING**

*Theory Credit: 2*

**UNIT I** Working of a digital computer; machine language on a small hypothetical computer; decimal, binary, octal and hexadecimal representation of numbers and mutual conversions; remarks about logic gates and machine language in binary system; high level language, character sets for FORTRAN; constants and variables (including complex and double precision) in FORTRAN; arithmetic expressions in FORTRAN; arithmetic statements in FORTRAN; built-in functions and libraries in FORTRAN; input and output statements in FORTRAN; comment statements; data types; TYPE declarations; statement labels; elementary programs in FORTRAN. Logical IF statements in FORTRAN; GOTO, nested logical IF, arithmetic IF, computed GOTO and assigned GOTO statements in FORTRAN; DO loops, nested DO loops.

**UNIT II** Subscripted variables and arrays in FORTRAN; single and multiple subscripts, dimension statements, assigned DO type notations for input/output of arrays, DO loops with subscripts in FORTRAN; format specifications in FORTRAN. Statement functions, functions subprogram, subroutine subprogram, COMMON statements, use of procedure names and arguments in FORTRAN; character manipulation, execution time format declaration, EQUIVALENCE declarations in FORTRAN. File processing commands.

**Recommended Books and References:**

1. Computer Programming in FORTRAN 77 – V. Rajaraman, Prentice-Hall of India Pvt. Ltd., 2005.
2. Computer Applications of Mathematics and Statistics – A. K. Chattopadhyay and T. Chattopadhyay, Asian Books Pvt. Ltd., New Delhi, 2005.
3. Computer Programming in FORTRAN IV – V. K. Gupta, Pragati Prakashan, 2004.
4. Computer Programming for FORTRAN 77 – Ramkumar, Tata McGraw Hill, 2002.
5. Primes and Programming – An Introduction to Number Theory with Programming – P. Goblin, Cambridge University Press, 1993.

## SEMESTER - II

### MMAC 2.11 ALGEBRA

*Theory Credit: 4*

- UNIT I** A brief review of groups, their elementary properties and examples, subgroups, cyclic groups, homomorphism of groups and Lagrange's theorem; permutation groups, permutations as products of cycles, even and odd permutations, normal subgroups, quotient groups; isomorphism theorems, correspondence theorem;
- UNIT II** Group action; Cayley's theorem, group of symmetries, dihedral groups and their elementary properties; orbit decomposition; counting formula; class equation, consequences for p-groups; Sylow's theorems (proofs using group actions)
- UNIT III** Applications of Sylow's theorems, conjugacy classes in  $S_n$  and  $A_n$ , simplicity of  $A_n$ . Direct product; structure theorem for finite abelian groups; invariants of a finite abelian group (Statements only)
- UNIT IV** Basic properties and examples of ring, domain, division ring and field; direct products of rings; characteristic of a domain; field of fractions of an integral domain; ring homomorphisms (always unitary); ideals; factor rings; prime and maximal ideals, principal ideal domain; Euclidean domain; unique factorization domain.
- UNIT V** A brief review of polynomial rings over a field; reducible and irreducible polynomials, Gauss' theorem for reducibility of  $f(x) \in \mathbf{Z}[x]$ ; Eisenstein's criterion for irreducibility of  $f(x) \in \mathbf{Z}[x]$  over  $\mathbf{Q}$ , roots of polynomials; finite fields of orders 4, 8, 9 and 27 using irreducible polynomials over  $\mathbf{Z}_2$  and  $\mathbf{Z}_3$ .

#### **Recommended Books and References:**

1. Basic Abstract Algebra (3<sup>rd</sup> edition) – P.B. Bhattacharya, S. K. Jain and S. R. Nagpal, Cambridge University Press, 2000
2. Basic Algebra I (3<sup>rd</sup> edition) – N. Jacobson, Hindustan Publishing corporation, New Delhi, 2002.
3. Contemporary Abstract Algebra (4<sup>th</sup> edition) – J. A. Gallian, Narosa Publishing House, New Delhi, 1999.
4. Topics in Algebra (4<sup>th</sup> edition) – I. N. Herstein, Wiley Eastern Limited, New Delhi, 2003.
5. A First Course in Abstract Algebra (4<sup>th</sup> edition) – J. B. Fraleigh, Narosa Publishing House, New Delhi, 2002.
6. Abstract Algebra – D.S. Dummit, R.M. Foote, John Wiley & Sons (2003)

### MMAC 2.21 ANALYSIS II

*Theory Credit: 4*

- UNIT I** Sequences of functions, pointwise and uniform convergence; uniform convergence and continuity; uniform convergence and integration; uniform convergence and

differentiation; nowhere differentiable functions; Statement of Stone-Weierstrass' theorem for a real and complex-valued functions on an interval.

**UNIT II** Directional derivatives; derivatives of functions of several variables and their interrelationship; chain rule; mean value theorem; higher order partial derivatives; equality of mixed partial derivatives, Schwarz lemma; Taylor's theorem.

**UNIT III** Injective mapping theorem, surjective mapping theorem, inverse function theorem and implicit function theorem of functions of two and three (for analogy) variables; extremum problems with and without constraints of functions of two and three (for analogy) variables.

**UNIT IV**  $\sigma$  rings of sets, additive, countably additive, regular set functions, outer measures on power set of reals, measurable spaces, Lebesgue measure, measurable functions and their properties.

**UNIT V** Lebesgue integral, Lebesgue integrable functions, properties of integrals, Lebesgue's monotone convergence theorem, Fatou's lemma, Lebesgue's dominated convergence theorem, integration of complex valued functions, functions of class  $L^2$ , Fourier series, Riesz-Fischer theorem.

**Recommended Books and References:**

1. Principles of Mathematical Analysis (5<sup>th</sup> edition) – W. Rudin, McGraw Hill Kogakusha Ltd., 2004.
2. Mathematical Analysis (5<sup>th</sup> edition) – T. Apostol, Addison-Wesley; Publishing Company, 2001.
3. The Elements of Real Analysis (3<sup>rd</sup> edition) – R. G. Bartle, Wiley International Edition, 1994.
4. Advanced Calculus (4<sup>th</sup> Edition) – R.C. Buck & E.F. Buck, McGraw Hill Book Company, 1999.
5. Introduction to Topology and Modern Analysis (4<sup>th</sup> edition) – G. F. Simmons, McGraw Hill Kogakusha Ltd., 2000.
6. Introduction to Real Analysis (3<sup>rd</sup> edition) – R. G. Bartle and D. R. Sherbert, John Wiley & Sons, Inc., New York, 2000.

**MMAC 2.31**

**PARTIAL DIFFERENTIAL EQUATIONS**

*Theory Credit: 4*

**UNIT I** Definition of PDE, origin of first-order PDE; determination of integral surfaces of linear first order partial differential equations passing through a given curve; surfaces orthogonal to given system of surfaces; non-linear PDE of first order, Cauchy's method of characteristic; compatible system of first order PDE; Charpit's method of solution, solutions satisfying given conditions, Jacobi's method of solution.

**UNIT II** Origin of second order PDE, linear second order PDE with constant coefficients, linear second order PDE with variable coefficients; characteristic curves of the second order PDE; Monge's method of solution of non-linear PDE of second order.

**UNIT III** Separation of variables in a PDE; Laplace's equation, elementary solutions of Laplace's equations; families of equipotential surfaces.



- UNIT IV** Wave equation, the occurrence of wave equations, elementary solutions of one-dimensional wave equation; vibrating membranes, three dimensional problems.
- UNIT V** Diffusion equation, resolution of boundary value problems for diffusion equation, elementary solutions of diffusion equation, separation of variables.

**Recommended Books and References:**

1. Elements of Partial Differential Equation (3<sup>rd</sup> edition) – I. N. Sneddon, McGraw Hill Book Company, 1998.
2. Partial Differential Equations (2<sup>nd</sup> edition) – E. T. Copson, Cambridge University Press, 1995.

**MMAO 2.41**

**PROGRAMMING IN C AND APPLICATIONS**

*Theory Credit: 4*

- UNIT I** Character sets for C; constants and variables in C; arithmetic expressions in C; assignment and multiple assignments and mode of statements in C; built-in functions and libraries in C; input and output statements in C; comment statements; data types; TYPE declarations; statement labels; elementary programs in C.
- UNIT II** Logical IF statements in C; switch, break, continue GOTO statements in C; WHILE, FOR, DO WHILE loops in C.
- UNIT III** Subscripted variables and arrays in C; array variables, syntax rules, use of multiple subscripts in arrays, reading and writing multi-dimensional arrays, for loops, for arrays in C; format specifications in C.
- UNIT IV** Some algorithms and programs on theory of matrices and numbers like Sieve method for primality test, generation of twin primes, solution of congruence using complete residue system, addition, subtraction and multiplication of matrices. transpose, determinant .
- UNIT V** Function definition, function prototypes, arguments, call by value, call by reference, pointers, character arrays, automatic variables in C; external variables and scopes in C; some applications of C; operations with strings and sorting; file processing commands.

**Recommended Books and References:**

1. Computer Programming in C – V. Rajaraman, Prentice- Hall of India Pvt. Ltd., 2005.
2. Computer Applications of Mathematics and Statistics – A. K. Chattapadhyay and T. Chattapadhyay, Asian Books Pvt. Ltd., New Delhi, 2005.
3. The C Programming Language – B. W. Kernighan and D. M. Ritchie, Prentice Hall, India, 1995.
4. Primes and Programming – An Introduction to Number Theory with Programming – P. Goblin, Cambridge University Press, 1993.

**MMAO 2.42**  
**COMPUTER PROGRAMING (PRACTICAL)**

*Practical Credit: 2*

The following programs are to be practised:

1. Determination of roots of quadratic equations,  $Ax^2+Bx+C=0$ ,
2. Arranging given set of numbers in increasing/decreasing order, calculation of Mean,
3. Evaluation of sum of power series eg.  $e^x$ ,  $\sin x$ ,  $\cos x$ ,  $\log(1+x)$ .
4. Calculation of GCD/LCM of two integers.
5. Evaluation of factorial of a positive integer and evaluation of binomial coefficients.
6. Evaluation of factorial of binomial coefficients mod 2.
7. Sieve method for primality test.
8. Generation of twin primes.
9. Solution of congruence using complete residue system.
10. Evaluation Legendre polynomial from recurrence relation.
11. Addition, subtraction and multiplication of matrices.
12. Transpose, determinant.
13. Inversion of real or complex matrices.
14. Searching a pattern in a given text and replacing every occurrence of it with another given string.
15. Writing a given number in words using function.
16. Arranging a set of names in alphabetical order.
17. Operations with strings and sorting.

## SEMESTER - III

### MMAC 3.11 TOPOLOGY

*Theory Credit: 4*

- UNIT I** Definition and examples of topological spaces; basis and sub basis; order relations, dictionary order, order topology; subspace topology; Kuratowski's closure axioms.
- UNIT II** Continuity and related concepts; product topology; quotient topology; a brief introduction to minimal uncountable well ordered set  $S_\omega$ ; countability axioms; Lindelof spaces and separable spaces.
- UNIT III** Connected spaces, generation of connected sets; component, path component; local connectedness, local path-connectedness.
- UNIT IV** Compact spaces; limit point compact and sequentially compact spaces; locally compact spaces; one point compactification; finite product of compact spaces, statement of Tychonoff's theorem.
- UNIT V** Separation axioms; Urysohn's lemma; Tietze's extension theorem; statement of Urysohn's metrization theorem.

#### **Recommended Books and References:**

1. Topology, a first course – J. R. Munkres, Prentice- Hall of India Ltd., New Delhi, 2000.
2. General Topology – J. L. Kelley, Springer Verlag, New York, 1990.
3. An introduction to general topology (2<sup>nd</sup> edition) – K. D. Joshi, Wiley Eastern Ltd., New Delhi, 2002.
4. General Topology – J. Dugundji, Universal Book Stall, New Delhi, 1990.
5. Foundations of General Topology – W. J. Pervin, Academic Press, New York, 1964.
6. General Topology – S. Willard, Addison-Wesley Publishing Company, Massachusetts, 1970.
7. Basic Topology – M.A. Armstrong, Springer International Ed. 2005.

### MMAC 3.21 COMPLEX FUNCTION THEORY

*Theory Credit: 4*

- UNIT I** Brief survey of formal power series, radius of convergence of power series, exponential, cosine and sine, logarithm functions introduced as power series, their elementary properties.
- UNIT II** Integration of complex-valued functions and differential 1-forms along a piecewise differentiable path, primitive, local primitive and primitive along a path of a differential 1-form, homotopic paths, simply connected domains, index of a closed path, holomorphic functions, Cauchy's theorem and its corollaries.

**UNIT III** Cauchy's integral formula, Taylor's expansion of holomorphic functions, Cauchy's estimate; Liouville's theorem; fundamental theorem of algebra; zeros of an analytic function and related results; maximum modulus theorem; Schwarz' lemma.

**UNIT IV** Laurent's expansion of a holomorphic function in an annulus, singularities of a function, removable singularities, poles and essential singularities; extended plane and stereographic projection, residues, calculus of residues; evaluation of definite integrals; argument principle; Rouché's Theorem.

**UNIT V** Complex form of equations of straight lines, half planes, circles, etc., analytic (holomorphic) function as mappings; conformal maps; Möbius transformation; cross ratio; symmetry and orientation principle; examples of images of regions under elementary analytic function.

**Recommended Books and References:**

1. Functions of one complex variable – J. B. Conway, Springer International Student edition, Narosa Publishing House, New Delhi, 2000.
2. Elementary Theory of Analytic Functions of one or several complex variables – H. Cartan, Courier Dover Publications, New York, 1995.
3. Complex Analysis (2<sup>nd</sup> Edition) – L. V. Ahlfors, McGraw-Hill International Student Edition, 1990.
4. Complex Variables and applications – R. V. Churchill, McGraw-Hill, 1996.
5. An Introduction to the Theory of functions of a complex Variable – E. T. Copson, Oxford university press, 1995.
6. An Introduction To Complex Analysis – A. R. Shastri, Macmillan India Ltd., 2003.
7. Complex Variables and Applications – S. Ponnusamy, and H. Silverman, Birkhäuser, 2006.

**MMAO 3.31**

**NUMERICAL ANALYSIS**

*Theory Credit: 4*

**UNIT I** A brief introduction to algebraic and transcendental equations and their roots; direct and iterative methods for determination of roots of these equations; initial approximations; bisection method, secant method, Regula-Falsi method, Newton-Raphson method for determination of roots of algebraic and transcendental equations; error analysis, rate of convergence and algorithm for each of these methods.

**UNIT II** A brief introduction to systems of linear algebraic equations and their solutions, eigenvalue problem and its solution; direct and iterative methods; forward and backward substitution method; Cramer's rule; Gauss elimination method; Gauss-Jordan elimination method; Gauss-Jacobi iteration method; Gauss-Seidel iteration method; power method for eigenvalue problem; iterative method for matrix inversion; error analysis, rate of convergence and algorithm for each of these methods.

**UNIT III** Lagrange and Newton interpolation; Lagrange interpolating polynomial and Newton divided differences interpolating polynomial; linear interpolation; Newton's divided difference interpolation and its generalizations; finite difference operators; relation between differences and derivatives; Gregory-Newton forward and backward difference interpolation; truncation error bounds and algorithm for each of these interpolations.

**UNIT IV** Differentiation and integration; numerical differentiation; methods based on linear and quadratic interpolation with error of approximation; methods based on finite differences; optimum choice of step length; numerical integration; methods based on interpolation; determination of the error term; trapezoidal rule; Simpson's rule; error of integration; algorithms for numerical differentiation and integration.

**UNIT V** Ordinary differential equations and their numerical solutions; initial value problems; error estimates; Euler-Richardson method, Runge-Kutta methods and Predictor-Corrector method; error analysis and algorithm for each of these methods; partial differential equations; finite-difference method with error analysis and algorithm.

**Recommended Books and References:**

1. Numerical Methods for scientific and Engineering computation – M. K. Jain, S. R. K. Iyenger and R. K. Jain, New Age international publishers, New Delhi, 2003.
2. Fundamental of Computer Numerical Analysis – M. Fri edman and A. Kandel, CRC Press, Boca Raton, 1993.
3. Applied Numerical Analysis (5<sup>th</sup> edition) – C. F. Gerald and P. O. Wheatley, Addison-Wesley, New York, 1998.
4. Introduction to Numerical Analysis (2<sup>nd</sup> edition) – K. E. Atkinson, John Wiley, 1989.
5. Elementary Numerical Analysis: An Algorithmic Approach (3<sup>rd</sup> edition) – S. D. Conte and C. de Boor, McGraw Hill, New York, 1980.
6. Numerical Mathematical Analysis – J. B. Scarborough h, Oxford & IBH Publishing Co., 2001.
7. Computer Oriented Numerical Analysis – V. Rajaraman , Prentice-Hall of India Pvt. Ltd., 2002.

**MMAO 3.32**

**COMPUTER ORIENTED NUMERICAL ANALYSIS (PRACTICAL)**

*Practical Credit: 2*

The following programs are to be practised:

1. Solving simple/algebraic/transcendental equations; Newton's method (real roots only),
2. Solutions of system of linear equations, using Gauss' elimination method.
3. Solutions of system of linear equations, using Gauss-Siedel Iterative method.
4. Matrix inversion using Gauss' elimination method.
5. Matrix inversion using Gauss-Jordan method.
6. Power method for finding largest Eigen value.
7. Interpolation using Lagrange's formula.
8. Interpolation using Newton's divided difference formula.
9. Numerical differentiation using Newton's formula.
10. Numerical differentiation using Lagrange's formula.
11. Numerical integration using trapezoidal rule.
12. Numerical integration using Simpson's rules.
13. Improving the numerical integral using Richardson's Extrapolation.
14. Numerical solutions of ordinary differential equations (initial value problems) using Euler-Richardson method.
15. Numerical solutions of ordinary differential equations (initial value problems) using Runge-Kutta methods.

16. Numerical solutions of ordinary differential equations (initial value problems) using Predictor-Corrector method.

## SEMESTER - IV

### MMAC 4.11

#### ELEMENTARY NUMBER THEORY

*Theory Credit: 4*

- UNIT I** Divisibility; Euclidean algorithm; primes; congruences; Fermat's theorem, Euler's theorem and Wilson's theorem; Fermat's quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem; Euler's phi-function.
- UNIT II** Congruence modulo powers of prime; power residues; primitive roots and their existence; quadratic residues; Legendre symbol, Gauss' lemma about Legendre symbol; quadratic reciprocity law; proofs of various formulations; Jacobi symbol.
- UNIT III** Greatest integer function; arithmetic functions, multiplicative arithmetic functions (elementary ones); Mobius inversion formula; convolution of arithmetic functions, group properties of arithmetic functions; recurrence functions; Fibonacci numbers and their elementary properties.
- UNIT IV** Diophantine equations – solutions of  $ax + by = c$ ,  $x^2 + y^2 = z^2$ ,  $x^4 + y^4 = z^2$ ; properties of Pythagorean triples; sums of two, four and five squares; assorted examples of diophantine equations.
- UNIT V** Simple continued fractions, finite and infinite continued fractions, uniqueness, representation of rational and irrational numbers as simple continued fractions, rational approximation to irrational numbers, Hurwitz theorem, basic facts of periodic continued fractions and their illustrations (without proofs); Pell's equation.

#### **Recommended Books and References:**

1. Elementary Number Theory (4<sup>th</sup> edition) – D. M. Burton, Universal Book Stall, New Delhi, 2002.
2. An Introduction to the Theory of Numbers (6<sup>th</sup> edition) – I. Niven, H. S. Zuckerman and H. L. Montgomery, John Wiley and sons, Inc., New York, 2003.
3. History of the Theory of Numbers (Vol. II, Diophantine Analysis) – L. E. Dickson, Chelsea Publishing Company, New York, 1971.
4. An Introduction to the Theory of Numbers (6<sup>th</sup> edition) – G. H. Hardy and E. M. Wright, The English Language Society and Oxford University Press, 1998.
5. An Introduction to the Theory of Numbers (3<sup>rd</sup> edition) – I. Niven and H. S. Zuckerman, Wiley Eastern Ltd., New Delhi, 1993.

### MMAC 4.21

#### APPLICATION OF MATHEMATICS IN ENVIRONMENTAL STUDIES

*Theory Credit: 2*

- UNIT I** Linear Equations, matrix form, row reduction; row rank and column rank, row equivalence, row reduced echelon matrices, various methods to find solutions of a system of linear equations, linear inequalities.

**UNIT II** Introduction to ecology and environment; linear programming problem – introduction, graphical solution method, some exceptional cases; general linear programming problem, duality, simplex method; problems related to ecology and environment.

***Recommended Books and References:***

1. Linear Algebra (2<sup>nd</sup> edition) – K. Hoffman and R. Kunze, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. Introduction to Matrices and Linear Transformations (3<sup>rd</sup> edition) – D. T. Finkbeiner, D.B. Taraporevala, Bombay, 1990.
3. Operations Research (for Group B) – K. Swarup, P. K . Gupt and Man Mohan, Sultan Chand & Sons, New Delhi, 2000.
4. Applied Operation Research: A Survey (for Group B) – G. E. Whitehouse and B. L. Wechsler, John Wiley & Sons, 1975.
5. Ecology: The Experimental Analysis of Distribution and Abundance (2<sup>nd</sup> edition) (for Group B) – C. J. Krebs, Harper and Row Publish ers, 1978.



## OPTIONAL PAPERS

### MMAC 3.51

#### DIFFERENTIAL GEOMETRY

*Theory Credit: 2*

- UNIT I** Vectors; tangent vectors; tangent spaces; tangent vector fields; derivative mappings; translations; affine transformations and rigid motions (isometries); exterior derivatives.
- UNIT II** Space curves; arc length; tangent vectors and vector fields on a curve; curvature and torsion; Serret-Frenet formulas; osculating plane; osculating circle; osculating sphere; fundamental theorem of local theory of space curves (existence and uniqueness theorems).
- UNIT III** Surfaces and their (local) parametrization on coordinate systems; change of parameters; parametrized surfaces; curves on surfaces; tangent and normal vectors; tangent and normal vector fields on a surface; first, second and third fundamental forms of a surface at a point; Gauss mapping.
- UNIT IV** Normal sections and normal curvature of a surface at a point; Meusnier's theorem; elliptic, hyperbolic, parabolic and planar points; Dupin indicatrix; principal directions; principal curvatures of a surface at a point; Mean curvature and Gaussian curvature of a surface at a point.
- UNIT V** Line of curvature; asymptotic curves; conjugate directions; fundamental equations of the local theory of surfaces; statement of Bonnet's fundamental theorem of local theory of surfaces.

#### **Recommended Books and References:**

1. A first course in Differential Geometry – Chun-Chin Hsiung, Willey-Interscience Publications, John Wiley & Sons, 1981.
2. A treatise on the differential geometry of curves and surfaces – P. Eissenhart, Dover Publications, Inc., New York, 1960.
3. Differential Geometry of three dimensions – C. R. Weatherburn, The English Language Book Society and Cambridge University Press, 1964.
4. An Introduction to differential geometry – T. S. Willmore, Oxford, Clarendon Press, 1979.
5. A course in differential geometry – W. Klingenberg, Graduate Texts in Mathematics 51, Springer-Verlag, 1978.
6. Elementary differential Geometry – A. Pressley, Springer International Edition, 2005.

#### THEORY OF FIELD EXTENSIONS

*Theory Credit: 4*

- UNIT I** Extension fields, finite extensions; algebraic and transcendental elements, adjunction of algebraic elements, Kronecker theorem, algebraic extensions, splitting fields – existence and uniqueness; extension of base field isomorphism to splitting fields;

- UNIT II** Simple and multiple roots of polynomials, criterion for simple roots, separable and inseparable polynomials; perfect fields; separable and inseparable extensions, finite fields; prime fields and their relation to splitting fields; Frobenius endomorphisms; roots of unity and cyclotomic polynomials.
- UNIT III** Algebraically closed fields and algebraic closures, primitive element theorem; normal extensions; automorphism groups and fixed fields; Galois pairing; determination of Galois groups, fundamental theorem of Galois theory, abelian and cyclic extensions.
- UNIT IV** Normal and subnormal series, composition series, Jordan-Holder theorem (statement only); solvable groups; nilpotent groups.
- UNIT V** Solvability by radicals; solvability of algebraic equations; symmetric functions; ruler and compass constructions, fundamental theorem of algebra.

**Recommended Books and References:**

1. Basic Abstract Algebra (3<sup>rd</sup> edition) – P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Cambridge University Press, 2000.
2. Basic Algebra I (3<sup>rd</sup> edition) – N. Jacobson, Hindustan Publishing corporation, New Delhi, 2002.
3. Galois Theory – T. I. F. R. Mathematical pamphlets, No. 3, 1965
4. Topics in Algebra (4<sup>th</sup> edition) – I. N. Herstein, Wiley Eastern Limited, New Delhi, 2003.
5. A First Course in Abstract Algebra (4<sup>th</sup> edition) – J. B. Fraleigh, Narosa Publishing House, New Delhi, 2002.
6. Contemporary Abstract Algebra (5<sup>th</sup> edition) – J. A. Gallian, University of Minnesota, Duluth, 2004.

**FLUID MECHANICS**

*Theory Credit: 4*

- UNIT I** Lagrangian and Eulerian methods of description; Governing equations of fluid motion; stream line; velocity potential, path line, velocity and circulation; equations of continuity in Lagrangian and Eulerian methods; equivalence of the two forms of equations of continuity; Boundary surface; acceleration; Euler's equations of motion; integrals of Euler's equations of motion, Lagrange's equations of motion; Cauchy's integrals; equation of energy.
- UNIT II** Motion in two dimensions; stream function; complex potential; source; sink and doublet; image, images in two dimensions, images of a source with regard to a plane, a circle and a sphere; image of a doublet; circle theorem; theorem of Blasius.
- UNIT III** Vortex Motion, Helmholtz properties of vortices, velocity in a vortex field, motion of a circular vortex, infinite rows of vortices, Kármán vortex street.
- UNIT IV** Viscous fluid, Stokes-Navier equations; diffusion of vorticity, dissipation of energy; steady motion of a viscous fluid between two parallel planes; steady flow through cylindrical pipes; Reynolds' number.

**UNIT V** Waves motion in a gas; speed of sound; equation of motion of a gas; subsonic, sonic and supersonic flows of a gas; isentropic gas flow; flow through a nozzle; shock formation; elementary analysis of normal and oblique shock waves.

**Recommended Books and References:**

1. A treatise of Hydromechanics (3<sup>rd</sup> edition) – W. H. Besant, A. S. Ramsey and G. Bell, 1997.
2. Ideal and Incompressible Fluid Dynamics – M. E. O'Neill and F. Chorlton, John Wiley publications, 1986.
3. Theoretical Hydrodynamics – L. M. Milne-Thomson, Macmillan Publishing co., 1985.
4. Text Book of Fluid Dynamics – F. Chorlton, Van Nostrand Reinhold Co., London, 1990.

**TENSOR ANALYSIS AND RIEMANNIAN GEOMETRY**

*Theory Credit: 4*

**UNIT I** Idea of differentiable manifolds with  $n$  dimensions; space of  $n$  dimensions, subspaces; transformation of coordinates; scalar; contravariant (tangent) and covariant (cotangent) vectors; scalar product of two vectors; tensor space of rank more than one contravariant and covariant tensors; symmetric and skew-symmetric tensors; addition and multiplication of tensors; contraction; composition of tensors; quotient law; reciprocal symmetric tensors of the second order.

**UNIT II** Riemannian space; fundamental tensor; length of a curve; magnitude of a vector; associated covariant and contravariant vectors; inclination of two vectors, orthogonal vectors; coordinate hypersurfaces; coordinate curves; field of normals to a hypersurface; principal directions for a symmetric covariant tensor of the second order; Euclidean space of  $n$  dimensions.

**UNIT III** Levi-Civita tensors; Christoffel symbols and second derivatives; need for covariant derivative; parallel transformations; covariant derivative of a contravariant and covariant vector; curl of a vector and its derivative; covariant differentiation of a tensor; divergence of a vector.

**UNIT IV** Gaussian curvature; Riemann curvature tensor; geodesics; differential equations of geodesics; geodesic coordinates; geodesic deviation; Riemannian coordinates; geodesic in Euclidean space; straight lines.

**UNIT V** Parallel transport along an extended curve; curvature tensor; Bianchi identities; Ricci tensor; scalar curvature; Killing vector field; space-time symmetries (homogeneity and isotropy); space time of constant curvature; conformal transformations.

**Recommended Books and References:**

- 1 An Introduction to Riemannian Geometry and Tensor Calculus – C. E. Weatherburn, Cambridge university Press, 1986.
- 2 General Relativity and Cosmology – J. V. Narlikar, The Mac-Millan Company of India Ltd., 1978.
- 3 Aspects of Gravitational Interactions – S. K. Srivastava & K. P. Sinha, Nova Science publications Inc., Commack, NY, 1998.
- 4 Tensor Analysis – I. S. Sokolnikoff, John Wiley & Sons, Inc., 1964.

**OPTIONAL PAPERS**  
**MMAC 4.31, MMAC 4.41, MMAC 4.51**

**THEORY OF RELATIVITY**

*Theory Credit: 4*

- UNIT-I** The special theory of relativity: inertial frames of reference; postulates of the special theory of relativity; Lorentz transformations; length contraction; time dilation; variation of mass; composition of velocities; relativistic mechanics; world events, world regions and light cone; Minkowski space-time; equivalence of mass and energy.
- UNIT II** Energy-momentum tensors: the action principle; the electromagnetic theory; energy-momentum tensors (general); energy-momentum tensors (special cases); conservation laws.
- UNIT III** General Theory of Relativity: introduction; principle of covariance; principle of equivalence; derivation of Einstein's equation; Newtonian approximation of Einstein's equations.
- UNIT IV** Solution of Einstein's equation and tests of general relativity: Schwarzschild solution; particle and photon orbits in Schwarzschild space-time; gravitational red shift; planetary motion; bending of light; radar echo delay.
- UNIT V** Brans-Dicke theory: scalar tensor theory and higher derivative gravity; Kaluza-Klein theory.

***Recommended Books and References:***

1. The Theory of Relativity (2<sup>nd</sup> edition) – R.K. Pathria, Hindustan Publishing co. Delhi, 1994.
2. General Relativity & Cosmology (2<sup>nd</sup> edition) – J.V. Narlikar, Macmillan co. of India Limited, 1988.
3. Aspects of Gravitational Interactions – S. K. Srivastava and K. P. Sinha, Nova Science Publishers Inc. Commack, New York, 1998.
4. Essential Relativity – W. Rindler, Springer-Verlag, 1977.
5. General Relativity – R.M. Wald, University of Chicago Press, 1984.

**FUNCTIONAL ANALYSIS**

*Theory Credit: 4*

- UNIT I** Classical Banach spaces,  $L^p$  spaces; Holder's inequality, Minkowski's inequality; convergence and completeness; Riesz-Fischer theorem, bounded linear functional on  $L^p$  spaces, Riesz representation theorem.
- UNIT II** General Banach spaces – definition and examples; continuous linear transformations between normed linear spaces; Hahn-Banach theorem and its consequences.
- UNIT III** Embedding of a normed linear space in its second conjugate space; strong and weak topologies; open mapping theorem; closed graph theorem; uniform boundedness theorem; conjugate of an operator.

**UNIT IV** Hilbert's space, examples and simple properties, orthogonal complements, orthonormal set, Bessel's inequalities, complete orthonormal sets, Gram-Schmidt orthogonalization process, self adjoint operators.

**UNIT V** Normal and unitary operators, projections, spectrum of an operator, spectral theorem for a normal operator on a finite dimensional Hilbert space.

**Recommended Books and References:**

1. Real Analysis (4<sup>th</sup> edition) – H. L. Royden, Macmillan Publishing co. inc, New York, 1999.
2. Introduction to Topology and Modern Analysis (4<sup>th</sup> edition) – G. F. Simmons, Tata McGraw - Hill Ltd., 2004.
3. Functional Analysis – W. Rudin, Tata McGraw hill Bo ok Company, 1974
4. Functional Analysis – B. V. Limaye, Willy Eastern L td., 1991.
5. First course in Functional Analysis – C.Goffman and G. Pedrick, Prentice-Hall of India Pvt. Ltd, New Delhi, 1974.

**MATHEMATICAL METHODS**

*Theory Credit: 4*

**UNIT I** Laplace transforms, properties of Laplace transform, inversion formula convolution, application to ordinary and partial differential equations; Fourier transform, properties of Fourier transform, inversion formula, convolution, Parseval's equality; Fourier transform of generalized functions, application of transforms to heat wave and Laplace equation.

**UNIT II** Formulation of integral equations, integral equations of Fredholm and Volterra type, solution by successive substitution and successive approximation; integral equations with degenerate kernels.

**UNIT III** Integral equations of convolution type and their solutions by Laplace transform, Fredholm's theorems; integral equations with symmetric kernel; eigenvalues and eigenfunctions of integral equations and their simple properties.

**UNIT IV** Generalized functions; Minusinski's operational calculus of one variable (algebra of addition and convolution of functions, ordered pairs of functions, convolution quotients of a function with a nonzero function), Dirac delta function.

**UNIT V** Eigenvalue problem; ordinary differential equations of the Sturm-Liouville type; eigenvalues and eigenfunctions; expansion theorem; extrema properties of the eigenvalues of linear differential operators, formulation of the eigenvalue problem of a differential operator as a problem of integral equation.

**Recommended Books and References:**

1. Laplace Transform Theory – M. G. Smith, Van Nostran d Inc., 2000.
2. Generalized Functions and Partial Differential Equations – G. E. Shilov, Bernard Seckler, Gordon and Breach, 1999.
3. Integral Equations – David Porter and David S. G. S tirling, Cambridge University Press, 1993.

4. The Use of Integral Transforms – I. N. Sneddon, Tata McGraw Hill, New Delhi, 1974.
5. Fourier Transforms – R. R. Goldberg, Cambridge University Press, 1970.
6. Lectures on integral equations – H. Widom, Van Nostrand, 1969.

## RING THEORY

*Theory Credit: 4*

- UNIT I** Basic concepts of rings, modules, operations on ideals and sub-modules; matrix rings, polynomial rings; direct products of rings; fields and division rings; idempotent and nilpotent elements in a ring.
- UNIT II** Isomorphism theorems; exact sequences; the group of homomorphisms and its properties relative to exact sequences.
- UNIT III** Direct sums and direct products of modules, external and internal direct sums, direct summands; Zorn's lemma, every vector space has a basis; free modules and projective modules; torsion free and torsion modules over commutative domains; exact sequences and projectivity.
- UNIT IV** Injective modules, injectivity and divisibility over domains; exact sequences and injectivity; Baer's theorem and its elementary applications; simple modules, semisimple modules (as per Bourbaki); Schur's lemma.
- UNIT V** Equivalent conditions for semisimple modules; Wedderburn structure theorem (only statement); characterization of semisimple rings via projective and injective modules.

### **Recommended Books and References:**

1. Elementary Rings and Modules – I. T. Adamson, Oliver and Boyd, Edinburgh, 1995.
2. Notes on Homological Algebra – J. J. Rotman, Van Nostrand, 1990.
3. Basic Algebra II (3<sup>rd</sup> edition) – N. Jacobson, Hindustan Publishing Corporation, New Delhi, 2002.
4. Algebra, Second Edition – S. Lang, Addison-Wesley, Massachusetts, 1984.
5. Algebra, Vol. 2: Rings – I. S. Luthar and I.B.S. Passi, Narosa Publishing House, New Delhi, 1999.

## **p-ADIC ANALYSIS**

*Theory Credit: 4*

- UNIT I** Norm on a field; Archimedean and non-Archimedean norm;  $p$ -adic norm on rationals; metric induced by a norm; isosceles triangle principle; equivalent norm; Ostrowski's theorem.
- UNIT II** Completion  $\mathbb{Q}_p$  of  $\mathbb{Q}$  with respect to the  $p$ -adic norm;  $p$ -adic numbers and  $p$ -adic integers; standard expansion of  $p$ -adic numbers; arithmetic in  $\mathbb{Q}_p$ ; Hensel's lemma; sequence and series in  $\mathbb{Q}_p$ , exponential and logarithmic series in  $\mathbb{Q}_p$ .

- UNIT III** Topology on  $\mathbb{Q}_p$ ; existence of nontrivial locally constant functions; Teichmüller functions and expansions; compactness and sequential compactness of  $\mathbb{Z}_p$ ; continuous functions from  $\mathbb{Z}_p$  to  $\mathbb{Q}_p$ .
- UNIT IV** A brief introduction to Mahler expansion and Mahler coefficients of a continuous function from  $\mathbb{Z}_p$  to  $\mathbb{Q}_p$ ;  $p$ -adic interpolation;  $p$ -adic gamma function and its elementary properties; Gauss multiplication formula; Mahler's expansion of gamma function; the 2-adic gamma function.
- UNIT V** Vector space norm and their equivalence; extension of  $p$ -adic norm from  $\mathbb{Q}_p$  to its algebraic closure  $\overline{\mathbb{Q}_p}$ ; incompleteness of  $\overline{\mathbb{Q}_p}$ ; completion  $\hat{\mathbb{Q}_p}$  of  $\overline{\mathbb{Q}_p}$ ; Krasner's lemma; proof of  $\hat{\mathbb{Q}_p}$  being algebraically closed.

**Recommended Books and References:**

1.  $p$ -adic Number,  $p$ -adic Analysis, and Zeta-Functions – Neal Koblitz, Graduate Text in Mathematics, vol 58, Springer-Verlag.
2. An Introduction to  $p$ -adic Number and  $p$ -adic Analysis – A. J. Baker, Lecture Notes, University of Glasgow.
3. A Course in  $p$ -adic Analysis – A. M. Robert, Graduate Text in Mathematics, vol. 1998, Springer.
4. Introduction to  $p$ -adic analytic Number Theory – M. Ram Murty, Lecture notes, Harishchandra Research Institute, Allahabad, 2001.

**RELATIVISTIC COSMOLOGY**

*Theory Credit: 4*

- UNIT I** Gravitational collapse of a homogeneous dust ball; observational background for cosmology; Weyl's postulates; cosmological principle; Hubble's law; angular size; flux of radiation; surface brightness.
- UNIT II** Cosmological field equations for Friedmann models (dust and radiation models); cosmologies with nonzero cosmological constant; cosmic microwave radiation background; Newtonian cosmology.
- UNIT III** Perfect cosmological principle; creation of matter; creation field; C-field cosmology; observable parameters of the steady state theory; event horizon.
- UNIT IV** Mach's principle, Brans-Dicke theory, Hoyle-Narlikar theory, variation of gravitational constant, Dirac cosmology, white holes.
- UNIT V** Big-bang nucleosynthesis; horizon and flatness problems of the early universe; inflation as remedy to these problems, dark energy; dark matter and present cosmic acceleration.

**Recommended Books and References:**

1. General Relativity and Cosmology – J. V. Narlikar, Macmillan Co of India Ltd., 1978.
2. Gravitation and Cosmology: Principles and Applications – S. Weinberg, John Wiley and sons, 1972.
3. Cosmology and Particle Physics – R. D. Teureiro and M. Quiros, World Scientific, 1988.

4. An Introduction to Cosmology – J. V. Narlikar, Macmillan Co of India Ltd., 1983.
5. General Relativity – R.M. Wald, University of Chicago Press, 1984.

## ALGEBRAIC TOPOLOGY

*Theory Credit: 4*

- UNIT I** Homotopy of paths, fundamental group of a topological space, fundamental group functor, homotopy of maps of topological spaces; homotopy equivalence; contractible and simply connected spaces; fundamental group of  $\mathbb{S}^1$ ,  $\mathbb{S}^1 \times \mathbb{S}^1$  etc.; degree of maps of  $\mathbb{S}^1$ .
- UNIT II** Calculation of fundamental groups of  $\mathbb{S}^n$  ( $n > 1$ ) using Van Kampen's theorem (special case); fundamental group of a topological group; Brouwer's fixed point theorem; fundamental theorem of algebra; vector fields, Frobenius theorem on eigenvalues of  $3 \times 3$  matrices.
- UNIT III** Covering spaces, unique lifting theorem, path-lifting theorem, covering homotopy theorem, applications; criterion of lifting of maps in terms of fundamental groups; universal coverings and its existence; special cases of manifolds and topological groups.
- UNIT IV** Simplicial and singular homology, reduced homology, Eilenberg-Steenrod axioms (without proof), relation between  $\Pi_1$  and  $H_1$ ; relative homology.
- UNIT V** Calculations of homology of  $\mathbb{S}^n$ ; Brouwer's fixed point theorem for  $f : \mathbb{E}^n \rightarrow \mathbb{E}^n$  ( $n > 2$ ) and its applications to spheres and vector fields; Meyer-Vietoris sequence and its application.

### **Recommended Books and References:**

1. Topology, a first course – J. R. Munkres, Prentice- Hall of India Ltd., New Delhi, 2000.
2. Algebraic topology, a first course (2<sup>nd</sup> edition) – M. J. Greenberg and J. R. Harper, Addison-Wesley Publishing co., 1997.
3. Algebraic Topology – A. Hatcher, Cambridge University Press, 2002.
4. Algebraic Topology (2<sup>nd</sup> edition) – E. H. Spanier, Springer-Verlag, New York, 2000.
2. An Introduction to Algebraic Topology – J. J. Rotman, Graduate Text in Mathematics, No. 119, Springer, New York, 2004.
3. Algebraic topology, a first course (2<sup>nd</sup> edition) – W. Fulton, Graduate Text in Mathematics, No. 153, Springer, New York, 1995.
4. Foundations of Algebraic Topology (2<sup>nd</sup> edition) – S. Eilenberg and N. E. Steenrod, Princeton University Press, 1995.



## ALGEBRAIC GEOMETRY

*Theory Credit: 4*

- UNIT I** Introduction; affine varieties, Hilbert's Nullstellensatz, polynomial function and maps; rational functions and maps.
- UNIT II** Projective space; projective varieties; rational functions and morphisms; smooth points and dimension, smooth and singular points, algebraic characterizations of the dimension of a variety.
- UNIT III** Plane cubic curves, plane curves, intersection multiplicity, classification of smooth cubics, the group structure of an elliptic curve.
- UNIT IV** Cubic surfaces, the existence of lines on a cubic, configuration of the 27 lines, rationality of cubics.
- UNIT V** Introduction to the theory of curves, divisors on curves, the degree of a principal divisor, Bezout's theorem, linear system on curves, projective embeddings of curves.

### **Recommended Books and References:**

1. Elementary Algebraic Geometry – K. Hulek (translated by H. Verrill), Student Mathematical Library, vol 20, American Mathematical Society, 2003.
2. Algebraic Geometry – R. Hartshorne, Springer-Verlag, 1977.
3. Algebraic Geometry: A First Course – J. Harris, Springer-Verlag, 1992.
4. Elliptic Curves – Notes on NBHM Instructional conference held at TIFR, Mumbai, 1991.

## DYNAMICAL OCEANOGRAPHY

*Theory Credit: 4*

- UNIT I** Thermodynamics of equilibrium state; Gibbs' relation; Gibbs-Duhem relation; sea water as a two-component solution; conditions of equilibrium of sea-water; conditions for the absence of convection – Vaisala frequency.
- UNIT II** Thermodynamics of irreversible processes; equations of conservation of mass; equations of motion; equations of conservation of energy.
- UNIT III** Wave motion in the ocean, basic equations; separation of variables; analysis of the simplest cases.
- UNIT IV** Equations of the theory of ocean currents and their properties; equations of evolution of potential vorticity; Boussinesq's approximations; averaging of basis equations; the basis equations in spherical coordinates; coefficients of turbulent exchange; boundary conditions; quasi-static approximation; geostrophic motion.
- UNIT V** Ekman theory; wind driven currents in a homogeneous ocean; pure drift current, the basis equations of Ekman theory; vertical structure of the flow-Ekman boundary layers; certain very simple solutions; western boundary current.

**Recommended Books and References:**

1. Fundamentals of Ocean Dynamics – V. M. Kamenkovich, Elsevier, 1997.
2. Waves in the Ocean – P. H. Leblond and B. A. Mysak, Elsevier, 1987.
3. Thermodynamics and Introduction to Thermo statistics (Second Edition) – Herbert B. Callen, John Willey, 1985.
4. The Theory of Rotating Fluids – H. P. Greenspan, Cambridge University Press, First Edition, 1968.
5. Geo-physical Fluid Dynamics – J. Pedlosky, first edition, Springer-Verlag, 1979.

**COMMUTATIVE ALGEBRA**

*Theory Credit: 4*

- UNIT I** Preliminaries on rings and ideals; local and semilocal rings; nilradical and Jacobson radical; operations on ideals; extension and contraction ideals; modules and module homomorphisms; submodules and quotient modules; operations on submodules; annihilator of a module; generators for a module, finitely generated modules; Nakayama's lemma; exact sequences.
- UNIT II** Existence and uniqueness of tensor product of two modules; tensor product of  $n$  modules; restriction and extension of scalars; exactness properties of tensor products; flat modules.
- UNIT III** Multiplicatively closed subsets; saturated subsets; ring of fractions of a ring; localization of a ring; module of fractions and its properties; extended and contracted ideals in a ring of fractions; total ring of fractions of a ring.
- UNIT IV** Primary ideals;  $p$ -primary ideals; primary decomposition, minimal primary decomposition, uniqueness theorems; primary submodules of a module.
- UNIT V** Chain conditions, ascending chain conditions on modules; maximal condition; Noetherian modules; descending chain condition; minimal condition; Artinian modules, their properties; Noetherian rings; Hilbert basis theorem; Artinian rings; structure theorem for Artinian rings.

**Recommended Books and References:**

1. Introduction to Commutative Algebra – M. F. Atiyah and I. G. Macdonald, AddisonWesley, 2000.
1. Undergraduate Commutative Algebra – M. Reid, London Math. Soc. Student Texts, No. 29, 1995.
2. Algebra (Volume 2: Rings) – I. S. Luther and I. B. S. Passi, Narosa Publishing House, New Delhi, 1999.
3. Algebra (Volume 3: Modules) – I. S. Luther and I. B. S. Passi, Narosa Publishing House, New Delhi, 1999.
4. Algebra – S. Lang, Addison-Wesley Publishing Company, London, 2000.

## **NON-LINEAR DYNAMICAL SYSTEMS**

*Theory Credit: 4*

- UNIT I** First order continuous autonomous systems – some terminology, classification of fixed points of autonomous systems, attractors and repellers, natural boundaries, case study: population growth.
- UNIT II** Second order continuous autonomous systems – autonomous second order systems, constant coefficient equations, phase curves and fixed points, classification of fixed points of linear systems, analyzing non-linear systems, case studies: lead absorption in the body, interacting species.
- UNIT III** Discrete Systems – examples of discrete systems, some terminology, linear discrete systems, non-linear discrete systems, quadratic maps.
- UNIT IV** Bifurcations in one-dimensional flows – introduction, saddle-node bifurcation, transcritical bifurcation, Pitchfork bifurcation.
- UNIT V** Bifurcation in two-dimensional flows – saddle-node, transcritical, and Pitchfork bifurcations, Hopf bifurcations.

### ***Recommended Books and References:***

1. Introduction to Non-Linear Systems – J. Berry and Arnold, Great Britain 1996.
2. Non Linear Dynamics and Chaos – S. H. Strogatz, Addison-Wesley Publishing Company, USA, 1994.
3. Introduction to Applied Non-Linear Dynamical systems and Chaos (Vol-2) – S. Wiggins, TAM, Springer-Verlag, New York, 1990.
4. Differential Equations, Dynamical Systems and an Introduction to Chaos – M.W. Hirsch, S. Smale, and R.L. Devaney, Elsevier (2004).

## **DISCRETE MATHEMATICS**

*Theory Credit: 4*

- UNIT I** Sets and classes, Relations and functions, Equivalence relations and equivalence classes, Principle of mathematics induction, Recursive definitions, Posets, Chains and well-ordered sets, Axiom of choice, Cardinal and ordinal numbers, Cantor's lemma, Set theoretic paradoxes.
- UNIT II** Propositional Calculus: Well-formed formulas, Tautologies, Equivalence, Normal forms, Truth of algebraic systems, Calculus of predicates.
- UNIT III** Principles of addition and multiplication, Arrangements, Permutation and combinations, Multinomial theorem, Partitions and allocations, Pigeonhole principle, Inclusion-exclusion principle, Generating functions, Recurrent relations.
- UNIT IV** Graphs and digraphs, Eulerian cycle and Hamiltonian cycle, adjacency and incidence matrices, vertex colouring, planarity and duality, trees, spanning trees, minimum spanning trees.

**UNIT V** Applications of graph theory to transport networks, matching theory and graphical algorithms, spectra of graphs, graph colorings, Ramsey theory.

**Recommended Books and References:**

1. J.P. Tremblay and R.P. Manohar , *Discrete Mathematics with Applications to Computer Science*, McGraw Hill , 1989.
2. V. K. Balakrishnan, *Introductory Discrete Mathematics*, Dover, 1996
3. F. Harary, *Graph Theory*, Narosa, 1995
4. Bela Bollobas, *Graph Theory: An Introductory Course*, GTM, Springer Verlag, 1990

**OPERATIONS RESEARCH**

*Theory Credit: 4*

**UNIT I Linear Programming Problem:** Introduction- Nature and Features of Operations Research (O.R)- Convex set-Polyhedral Convex Set-Linear Programming (L.P)- Mathematical Formulation of the Problem- Graphical Solution Method-Some Exceptional Cases-General Linear Programming Problem (General L.P.P) – Slack and Sur plus Variables-Reformulation of the General L.P.P.- Simplex Method- Matrix Notation-Duality (Statement only of Property without Proof)- Initial Simplex Tableau-Pivot-Calculating the new Simplex Tableau-Terminal Simplex Tableau- Algorithm of the Simplex Method.

**UNIT II Markov Analysis:** Introduction- Probability Vectors-Stochastic Matrices – Regular Stochastic Matrices- Fixed Points of Square Matrices- Relationships between Fixed Points and Regular Stochastic Matrices- Markov Processes- State Transition Matrix-Transition Diagram-Brand Switching Analysis-Construction of State Transition Matrices—n-step Transition Probabilities- Stationary Distribution of Regular Markov Changes- Steady State (Equilibrium) Conditions- Markov Analysis Algorithm.

**UNIT III Games and Strategies:** Introduction- Two- person Zero-sum games-Pay-off Matrix – some basic terms-the Maximum –Minimal Principle-Theorem on Maximum and Minimal Values of the Game-Saddle Point and Value of the Game-Rule for determining a Saddle Point-Games without Saddle Points-Mixed Strategies-Graphic solution of 2 x n and m x 2 games- Dominance Property- General rule for Dominance-Modified Dominance Property.

**UNIT IV Inventory Control:** Introduction- The Inventory Decisions- Costs Associated with Inventories-Factors affecting Inventory Control- Economic Order Quantity (EOQ) – Deterministic Inventory Problems with no Shortages- Case 1: The fundamental EOQ problem; Characteristics and Corollary. Case 2: EOQ Problem with Several Production Runs of Unequal Length. Case 3: EOQ Problem with Finite Replenishment (Production); Characteristics- Deterministic Inventory Problems with Shortages Case 1: EOQ Problem with Instantaneous Production and Variable Order Cycle Time; Characteristics. Case 2: EOQ Problem with Instantaneous Production of Fixed Order Cycle. Case 3: EOQ Problem with Finite Replenishment (Production); Characteristics.

**UNIT V Replacement Problem and System Reliability:** Introduction- Replacement of Equipment/Asset that deteriorates gradually-Replacement Policy when value of money does not change with time. Case 1: when t is a continuous variable. Case 2: when t is a discrete variable- Replacement Policy when value of money changes with

time and its Corollary- Selection of the best equipment amongst two- Replacement of equipment that fails suddenly- Reliability and System Failure Rates- Definition of Reliability- Failure Rates- Bath-tub-shaped Failure Rate-Instantaneous Failure Rate- Mean Time Between Failure (MTBF)- Estimation of Reliability-Reliability Improvement.

***Recommended Books and References:***

1. Operations Research by Kanti Swarup, P.K. Gupta and Man Mohan, Published by Sultan Chand & Sons, New Delhi-110002, Ninth Edition (2002).
2. Operations Research- by Friderick S. Hillier and Gerald J. Lieberman, Published by Holden-Day Inc, San Fransisco, USA. Second Edition (1974)
3. Operation Research – An Introduction by Hamdy A. Ta ha. Published by Prentice-Hall of India Pvt. Ltd., New Delhi- 110001, Sixth Edition (2002).



*Revised*  
SYLLABUS FOR  
Master of Science

**PHYSICS**

SEMESTER SYSTEM





### CORE STRUCTURE

<b>SEMESTER</b>	<b>COURSE CODE</b>	<b>COURSE NAME</b>	<b>CREDIT</b>
<b>I</b>	MPHC 1.11	Classical Mechanics	4
	MPHC 1.21	Quantum Mechanics - 1	4
	MPHC 1.31	Electromagnetic Theory	3
	MPHC 1.41	Mathematical Methods - I	3
	MPHC 1.12	General Laboratory 1	4
<b>II</b>	MPHC 2.11	Quantum Mechanics – II	3
	MPHC 2.21	Mathematical Methods – II	3
	MPHO 2.11	Astronomy and Remote Sensing Applications	6
	MPHC 2.31	Statistical Mechanics	3
	MPHC 2.12	Computational Methods Laboratory	3
<b>III</b>	MPHO 3.11	Analog and Digital Electronics (O)	6
	MPHC 3.11	Solid State Physics – I	3
	MPHC 3.21	Spectroscopy	3
	MPHC 3.31	Nuclear and Particle Physics	3
	MPHC 3.12	Electronics Laboratory – I	3
<b>IV</b>	MPHC 4.11(a)	Advanced Quantum Mechanics OR	4
	MPHC 4.11(b)	Astrophysics	
	MPHC 4.21(a)	Solid State Physics – II OR	3
	MPHC 4.21(b)	Advanced Electronics	
	MPHC 4.31(a)	Modern Optics OR	4
	MPHC 4.31(b)	Atmospheric Physics	
	MPHC 4.41	Project	3
	MPHC 4.12	General Physics Laboratory – II	4

## SEMESTER - I

### MPHC 1.11 CLASSICAL MECHANICS

*Theory Credit: 4*

- UNIT I** Conservation principles of a single and system of particles, Constraints, Degrees of freedom, Generalized coordinates, Hamilton's variational principle, D'Alembert's principle, Deduction of Lagrange's equation and Hamilton's principle, Rayleigh's dissipation function, Lagrange's equation of motion, Lagrangian for a charged particle in an electromagnetic field, and other applications, Non-holonomic system and applications, Superiority of Lagrangian approach over Newtonian mechanics.
- UNIT II** Hamilton's equations of motion, Significance of Hamiltonian, Applications of Hamiltonian formulation, Charged particle in an Electromagnetic field, Ideal spring, Mass system, Cyclic coordinates, Routh's procedure, Principle of Least action, Canonical transformations, Conditions for a transformation to be canonical, Hamilton-Jacobi method, Harmonic oscillator.
- UNIT III** Poisson brackets and properties – Invariance of Poisson's brackets under canonical transformation – Hamilton's equation in Poisson bracket notation. Generalized coordinates of a rigid body – body and space reference systems, Euler's Angles, Angular momentum and Inertia tensor, Euler's equations of motion for a rigid body – Force free motion of a symmetrical top – Motion of a heavy symmetrical top – notation – precession.
- UNIT IV** Motion under a Central force, General features, Motion under inverse square law – Kepler problem, Virial theorem, Unbound motion in Rutherford scattering, Transformation of scattering problem to laboratory co-ordinates.
- UNIT V** Introduction to small oscillations, Two coupled oscillators, Lagrange's formulation, Eigen vectors and Eigen frequencies, Normal coordinates, Systems with few degrees of freedom, Small oscillations of particles on string, Transition from discrete to continuous system.

#### **Recommended Books and References:**

1. Classical Mechanics – J.C.Upadhyaya, Himalaya Publishing House, India (2010).
2. Introduction to Classical Mechanics – R.G. Takwale & P.S. Puranik, Tata McGraw - Hill Education, New Delhi.
3. Classical Mechanics – H.Goldstein, 2<sup>nd</sup> Edition, Addison-Wesley Pub. Co.
4. Classical Mechanics of particles and Rigid bodies – Kiran C. Gupta, New Age International (p) Ltd (2008).
5. Classical Dynamics – J. B. Marion, Saunders College Publishing.
6. Classical Mechanics – A. K. Raichaudhuri Oxford University Press.
7. Classical Mechanics – S.L. Gupta, V. Kumar and H.V. Sharma, Pragati Prakashan Publishers, Meerut, India (2010).
8. Classical mechanics – P.S. Joag and N.C. Rana, Tata McGraw - Hill Education (2001).

**MPHC 1.21**  
**QUANTUM MECHANICS – I**

*Theory Credit: 4*

- UNIT I    **Linear spaces:**** Groups, fields, Vector spaces and subspaces, Linear dependence and independence, Basis and Dimensions, linear operators, Inverses, Inverse and rank of an operator, Matrix representation, Similarity transformations, Eigenvalues and eigenvectors, Norm and Inner product. Cauchy-Schwarz Inequality, Orthogonality, Introduction only to Gram-Schmidt orthogonalization procedure, Self adjoint and Unitary transformations, Eigenvalues & eigenvectors of Hermitian & Unitary transformations, Diagonalization.
- UNIT II    **Operators:**** Review of linear algebra and introduction to Hilbert space. Dirac Bra-Ket notations, dynamical variables and linear operators, projection operators, unit operator, unitary operator, matrix representation of an operator, change of basis, unitary transformation.
- UNIT III    **Introduction to Quantum Mechanics:**** Black body radiation, Planck's hypothesis, Specific heat of solids, Photoelectric effect, Compton Effect, Classical atomic structure models, Bohr's theory of Hydrogen spectrum, Heisenberg's uncertainty principle, Wave – Particle duality, Inadequacy of classical physics, the formulation of Quantum mechanics
- UNIT IV    The Schrödinger wave equations, Time Dependent, Time Independent, Ehrenfest theorem, stationary states and their properties. Postulates of Quantum Mechanics, particle in one dimension and three dimensions,**
- UNIT V    Applications to potential well in three dimensions, square well potential, delta function potential, harmonic oscillator, hydrogen atom and rigid rotator, Problems**

***Recommended Books and References:***

1. Quantum Mechanics – Leonard I. Schiff, 3<sup>rd</sup> Edition, Tata McGraw-Hill Education Private Limited, New Delhi. (2010).
2. Quantum Mechanics – Eugene Merzbacher, 3<sup>rd</sup> Edition, John Wiley & Sons, New York (1998).
3. Practical Quantum Mechanics – S. Flugge, 1<sup>st</sup> Edition, Springer-Verlag New York (1998)
4. A text book of Quantum Mechanics – Mathews and Venkatesan 2<sup>nd</sup> Edition, McGraw-Hill Education Private Limited, New Delhi (2010).
5. Quantum Mechanics – M. P. Khanna, Har-Anand Publications Pvt. Limited
6. Principles of Quantum Mechanics – P. A. M. Dirac, 4<sup>th</sup> Edition, Oxford University Press, London (1967).
7. Introduction to Quantum mechanics – David J. Griffiths, Prentice Hall, Inc. USA (1995).
8. Quantum mechanics – A. Ghatak and S. Lokanathan, McMillan publishers India Limited, New Delhi (2010)
9. Quantum physics of atoms, molecules, solids, nuclei, and particles – R. Eisberg and R. Resnick, 2<sup>nd</sup> Edition, John Wiley & Sons, Inc. (1985)
10. Linear Vector Spaces – R. R. Halmos.

### MPHC 1.31 ELECTRODYNAMICS

*Theory Credit: 3*

#### **Recommended Books and References:**

1. Introduction to Electrodynamics – Griffiths
2. Electrodynamics of continuous media – Landau & Lifshitz
3. Classical Fields – Landau & Lifshitz
4. Classical Electrodynamics – J.D. Jackson
5. Classical Electrodynamics – J. B. Marion

### MPHC 1.41 MATHEMATICAL METHODS – I

*Theory Credit: 3*

**UNIT I Vector Analysis:** Definitions, Dot and cross product, Scalar and vector triple product, Gradient, Divergence, Curl, Vector integration, Gauss and Stokes' theorem, Gauss's law, Poisson's equation, Delta function, Helmholtz's theorem.

**Complex Variables:** Geometrical representation of complex numbers, Functions of complex variables, Properties of elementary trigonometric and hyperbolic functions of a complex variable, Differentiation, Cauchy-Riemann equations, Properties of analytical functions, Contours in complex plane, Integration in complex plane,

**UNIT II** Cauchy theorem, Deformation of contours, Cauchy integral representation, Taylor series representation, Isolated and essential singular points, Laurent expansion theorem, Poles, Residues at an isolated singular point, Cauchy residue theorem, Applications of the residue theorem.

**UNIT IV Group Theory:** Definitions and examples of physically important finite groups. Point groups, multiplication table, Subgroups, Cyclic groups, Center, Classes, Cosets, Lagrange Theorem. Representations of finite groups, Irreducible representation characters, Great Orthogonality theorem and its consequences, Character table.

**UNIT V** Symmetry elements, Operations, Planes, Reflections, Inversion Center, Proper and Improper axes and rotations, Equivalence, Symmetry and Optical Isomerism, Symmetry point groups, Classes of Symmetry operations, Systematic procedure for symmetry classification of molecules and applications.

#### **Recommended Books and References:**

1. Applied Mathematics for Engineers and Physicists – Liou A Pipes and Lawrence R. Rivill.
2. Mathematical Physics – By Ghatak, A K and Goyal, I
3. Mathematical Physics – By Satya Prakash
4. Mathematics for Physicists – Dennery & Kryzywicki
5. Complex Variables & Applications – R. V. Churchill
6. Mathematical Methods for Physics – G. Arfken
7. Mathematical Physics – B. D. Gupta. Vikas Publishing House, New Delhi
8. Complex Variables – Schaum Series

9. Vector and Tensor Analysis – Schaum Series
10. Chemical Applications of Group Theory – F.A. Cotton, John-Wiley and Sons.

**MPHC 1.12**  
**GENERAL PHYSICS LABORATORY - I**

*Practical Credit: 4*

*This course aims at the providing exposure to computer programming. Each student is expected to do at least 70% of the listed experiments. The teacher in charge has the flexibility to add/ delete any experiments as per the need of the course.*

1. Experiments with Michelson's Interferometer: Determination of wavelength, small difference in wavelength etc.
2. Experiments with the Fabry – Parot Interferometer: Determination of wavelength, small difference in wavelength etc.
3. Study of the Zeeman Effect and determination of  $e/m$  of an electron.
4. Determination of wavelengths of spectral lines using constant deviation spectrometers.
5. Analysis of elliptically polarized light using the Babinet's Compensator.
6. Determination of the refractive index or thickness of thin films using the Jamin's Interferometer.
7. Study of Hall Effect. (general model)
8. Determination of velocity of ultrasonic waves in liquid by using Ultrasonic Interferometer.
9. Determination of velocity of ultrasonic waves in liquid by study of diffraction of light by the wave.
10. Determination of the Stefan's Constant.
11. Determination of the Planck's Constant using photo cell.
12. Determination of  $\epsilon_0$  – electrical constant. (General model)
13. Study of plateau of a Geiger – Muller counter and carry out statistical analysis of the data.

## SEMESTER - II

### MPHC 2.11

### QUANTUM MECHANICS – II

*Theory Credit: 4*

- UNIT I** **Approximation methods:** Time-independent Perturbation theory: Non degenerate and degenerate cases (upto second order). Applications: Zeeman effect, Stark effect, anharmonic oscillator.
- UNIT II** Time-dependent Perturbation theory: Transition amplitude 1st and 2nd order, selection rules, constant perturbation (1st order). Fermi's golden rule, Harmonic perturbation, Interaction of atom with electromagnetic radiation, dipole approx. Einstein coefficient for spontaneous emission.
- UNIT III** Variational method: Basic principles and applications to particle in box, Harmonic oscillator, hydrogen atom, helium atom. (Qualitative approach)  
WKB approximation: Qualitative development and condition for validity of this approx., Bohr's quantization condition, applications to tunneling such as alpha-particle, field emission. Einstein's coefficients
- UNIT IV** **Angular momentum:** Commutation relations, eigen-functions of the angular momentum operators, matrix representation of angular momentum operators.
- UNIT V** **Spin:** Stern Gerlach experiment, Pauli's two component equation, addition of angular momenta. Identical particles, symmetrization postulate, Bose and Fermi-statistics, Pauli exclusion principle. Helium atom, Spin in a time dependent magnetic field, Hartree-Fock method. Symmetry in quantum mechanics, space and time displacements, rotations, space inversion, time reversal, Spin-orbit coupling, j-j coupling, Zeeman effect.

#### **Recommended Books and References:**

1. Quantum Mechanics – Leonard I. Schiff, 3<sup>rd</sup> Edition, Tata McGraw-Hill Education Private Limited, New Delhi. (2010).
2. Quantum Mechanics – Eugene Merzbacher, 3<sup>rd</sup> Edition, John Wiley & Sons, New York (1998).
3. Practical Quantum Mechanics – S. Flugge, 1<sup>st</sup> Edition, Springer-Verlag New York (1998)
4. A text book of Quantum Mechanics – Mathews and Venkatesan 2<sup>nd</sup> Edition, McGraw-Hill Education Private Limited, New Delhi (2010).
5. Quantum Mechanics – M. P. Khanna, Har-Anand Publications Pvt. Limited
6. Principles of Quantum Mechanics – P. A. M. Dirac, 4<sup>th</sup> Edition, Oxford University Press, London (1967).
7. Introduction to Quantum mechanics – David J. Griffiths, Prentice Hall, Inc. USA (1995).
8. Quantum mechanics – A.Ghatak and S.Lokanathan, McMillan publishers India Limited, New Delhi (2010)
9. Quantum physics of atoms, molecules, solids, nuclei, and particles – R. Eisberg and R.Resnick, 2<sup>nd</sup> Edition, John Wiley & Sons, Inc. (1985)

**MPHC 2.21**  
**MATHEMATICAL METHODS – II**

*Theory Credit: 3*

- UNIT I    Differential equations & Special functions** Power series solution for a differential equation, Legendre's differential Equation and its solution, Legendre's polynomials and Associated Polynomials Generating function, Rodrigue's formula – Orthogonal property, Recurrence Relations,
- UNIT II**    Beta and Gamma functions, Properties-Relation between them, Bessel's differential equation and solution, Bessel's functions of 1<sup>st</sup> and 2<sup>nd</sup> kind, Generating function, Orthogonal property, Recurrence relations.  
Hermite differential equation and solution, Hermite polynomials, Generating functions, Orthogonal property, Recurrence relations, Rodrigue formula,
- UNIT III**    Hyper geometric equation and its solution, Laplace equation and its solution in Cartesian and spherical coordinates, Wave equation and its application to (i) Rectangular and (ii) Circular membranes.
- UNIT IV    Fourier and Laplace transforms:** Fourier transforms and its properties, Fourier transform of a derivative, Finite Fourier transforms, Application of Fourier transform, Dirac delta function and its Fourier transform Auto correlation, Cross correlation and Convolution operations. Laplace transform and properties, Laplace transform of i) Derivative of a function (ii) Periodic function and (iii) Special functions like gamma, Bessel and error functions, Inverse Laplace transform and its properties, Convolution theorem and its use in evaluation of Inverse Laplace transform.
- UNIT V    Tensors:** Transformation laws, Kronecker delta symbol, Contravariant and Covariant tensors, Rank of a Tensor, Tensors of higher rank, Pseudo and dual Tensor, Addition and subtraction of tensors, Outer product, Contraction of tensors, Inner product, Quotient Law, Extension of rank of a tensor, Symmetric and anti symmetric tensors, Invariant tensors, Metric tensor, Christoffel's symbols of first and second kind and transformation laws, Application of tensor to elasticity (simple stress and strain tensors only).

***Recommended Books and References:***

1. Mathematics for Physicists – Dennery&Kryzywicki
2. Mathematical Methods for Physics – G.Arffen
3. Laplace and Fourier Transforms – Goyal and Gupta. Pragati Prakashan Meerut
4. Matrices and Tensors for Physicists – A W.Joshi
5. Mathematical Physics – B.D.Gupta, Vikas Publishing House, New Delhi
6. Applied Mathematics for Engineers and Physicists – By Liou A Pipes and Lawrance R. Rarvill.
7. Mathematical Physics – A.K. Ghatak, and I. Goyal,
8. Mathematical Physics – Satya Prakash
9. Tensor Analysis –Schaum series
10. Ordinary differential equations – R. L. Rabenstein
11. Partial Differential Equation for Scientists – G. Stephenson

## MPHO2.11

### ASTRONOMY AND REMOTE SENSING APPLICATIONS

*Theory Credit: 6*

**UNIT I Time and Co-ordinate Systems:** Spherical trigonometry, the celestial sphere, the cardinal points and circles on the celestial sphere. Equatorial ecliptic and galactic system of coordinates. Constellations and nomenclature of stars. Aspects of the sky from different places of the earth. Twilight, Seasons, Sidereal, Apparent and mean solar time and their relations. Equations of time. Ephemeris and Atomic Times, Calendar, Julian date and heliocentric corrections, precession, nutation, and proper motion on the coordinates of the stars.

**Astronomical Measurements and Telescopes:** Magnitude systems, apparent and absolute magnitudes, distance modulus, color index, Atmospheric extinction, seeing and scintillation. Distance of stars from the trigonometric and moving cluster, parallaxes, Stellar motions, Variable stars as distance indicators. Basic optics and optical telescopes, detectors, photographic plates, Photo multiplier tubes (PMT), Charge coupled Devices (CCD).

**UNIT II Solar System:** Origin and the evolution of the solar system: Physical characteristics of the sun rotation, magnetic field, granulation, sunspots, other chromospheric activities, Inner planets. Jovian planets, dwarf planets, asteroids, classification and origin of asteroids.

Comets: Discovery and designation, physical nature, classification and origin, Meteors, meteorites.

**UNIT III Stars and Galaxy:** Colour - Magnitude relation, H R Diagrams, Different spectral type of stars, Star formation in molecular clouds, Stellar evolution, End state of stars: Supernova, Neutron star and Black hole. Normal Galaxies, Classification schemes for external galaxies, Hubble's law.

Our Galaxy: Milky way, structure and morphology of our galaxy, Galactic rotation.

**UNIT IV Remote Sensing and its Applications:** Remote Sensing Principles and basic concepts of remote sensing, physics of remote sensing. Effects of Atmosphere, Rainfall estimation techniques, cyclone analysis techniques & synoptic weather analysis using visible, Near Infrared.

Principles and basic concepts of microwave remote sensing – Doppler weather Radar, Principles of Image interpretation – Types of Imagery, their formation and characteristics, elements of interpretation techniques of visual interpretation.

**UNIT V Digital Image Processing Digital Image, Digital Image data formats, Band sequential; Band Interleaved and its characteristics. Image processing systems considerations and characteristics – Image enhancements techniques – Image reduction and magnification, contrast enhancements, rationing, spatial filtering, edge enhancements.**

#### **Recommended Books and References:**

1. Physical Universe – Frank Shu,
2. Text Book of Spherical Astronomy – W.M. Smart
3. Astronomy: From the Earth to the Universe (Sixth Edition)
4. Orbital Motion – A.E. Roy
5. Introduction to Celestial Mechanics – Mc Cusky.



6. Astrophysics: Stars and Galaxies, Tata McGraw Hill Publication.
7. Exploration of the Universe – G. Abell
8. Introduction to Astrophysics – B. Basu, T Chatterjee and S.N. Biswas.
9. New Cosmos – A. Unsold.
10. Text Book of Photogrammetry, Rampal, K.K. Oxford & IBM, 1982.
11. Remote Sensing: Methods and Applications, Hard R. Michael, John Wiley, 1987

## MPHC 2.31

### STATISTICAL MECHANICS

*Theory Credit: 3*

**UNIT I Statistical Description of System of Particles:** Specification of the state of the system, Macroscopic and Microscopic states, Phase space, Statistical ensemble, Postulate of equal a priori probability, Probability calculations, Behaviour of density of states, Liouville's theorem (Classical), Quasi-static processes.

**Statistical Thermodynamics:** Equilibrium conditions and constraints, Distribution of energy between systems in equilibrium, Approach to thermal equilibrium, Temperature, Heat reservoir, Sharpness of the probability distribution, Dependence of the density of states on the external parameters, Equilibrium between interacting systems.

**UNIT II Classical Statistical Mechanics:** Micro-canonical ensemble, System in contact with heat reservoir, Canonical ensemble, Applications of canonical ensembles (Paramagnetism, Molecule in an ideal gas, Law of atmosphere), System with specified mean energy, Calculation of mean values and fluctuations in a canonical ensemble, Connection with thermodynamics, Grand-canonical ensemble, Physical interpretation, Chemical potential in the equilibrium state, Mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand partition function.

**UNIT III Applications of Statistical Mechanics:** Classical partition functions and their properties, Calculations of thermodynamic quantities, Ideal monoatomic gas, Gibbs paradox, Equipartition theorem and its Simple applications. i) Mean kinetic energy of a molecule in a gas ii) Brownian motion iii) Harmonic Oscillator iv) Specific heat of solid. Maxwell velocity distribution, related distributions and mean values.

**UNIT IV Quantum Statistics of Ideal Gases:** Symmetry of wave functions, Quantum distribution functions, Boltzmann limit of Boson and Fermion gases, Evaluation of the partition function, Partition function for diatomic molecules, Equation of state for an ideal gas, the quantum mechanical paramagnetic susceptibility.

**Ideal Bose System:** Photon gas – i) Radiation pressure ii) Radiation density iii) Emissivity iv) Equilibrium number of photons in the cavity.

**UNIT V** Einstein derivation of Planck's law, Bose-Einstein Condensation, Specific heat, Photon gas – Einstein and Debye's model of solids.

**Ideal Fermi System:** Fermi energy, Mean energy of fermions at absolute zero, Fermi energy as a function of temperature, Electronic specific heat, White – Dwarfs, Compressibility of Fermi gas, Pauli's paramagnetism, A relativistic degenerate electron gas.

**Recommended Books and References:**

1. Fundamentals of Statistical and Thermal Physics – F.Reif, McGraw – Hill, International Edition.
2. Fundamentals of Statistical Mechanics – B.B.Laud, New Age International Publication (2003).
3. Statistical Mechanics – R.K.Pathria, Butterworth Heinemann (2nd Edition).
4. Statistical Mechanics – K.Huang, John Wiley & Sons (2nd Edition).
5. Statistical Mechanics – Satya Prakash, Kedar Nath Ram Nath Publication (2008).
6. Statistical Mechanics – Loknathan and Gambhir.
7. Thermal Physics – C. Kittel.
8. Statistical Physics – L. D. Landau and E. M. Lifshitz.
9. Statistical mechanics – Gupta, Kumar and Sharma
10. Statistical Mechanics – Eisner and Agarwal.
11. Problems in Thermodynamics and Statistical Physics – P. T. Landsberg (Ed.).

**MPHC 2.12****COMPUTATIONAL METHODS LABORATORY**

*Practical Credit: 3*

*This course aims at the providing exposure to computer programming. Each student is expected to do at least 70% of the listed experiments. The teacher in charge has the flexibility to add/ delete any experiments as per the need of the course.*

1. Roots of algebraic and transcendental equations: One point and two-point iterative methods, such as bisection method, inverse interpolation and Newton Raphson methods.
2. Matrix operations and simultaneous linear equations: Matrix addition, multiplication and inversion. Solution of simultaneous linear equations by matrix inversion methods.
3. Interpolation: Linear interpolation, Lagrangian interpolation, Newton's interpolation (different forms).
4. Integration: Newton-Cotes formulae, Gauss quadrature.
5. Ordinary Differential equations: Initial value problem Taylor's algorithm, Euler's methods, Runge-Kutta, and Predictor-corrector methods.

*To execute the above mentioned course, the course instructor may choose any one of the programming coding FORTRAN, C, MATLAB or MATHEMATICA, at his/ her discretion.*

**Recommended Books and References:**

1. Introduction to Numerical Methods – T. R. McCalla,
2. Numerical Methods that work – F. S. Acton
3. An Introduction to Numerical Analysis – K. E. Atkinson
4. Numerical Recipes – W. H. Press

## SEMESTER - III

### MPHO3.11

### ANALOG AND DIGITAL ELECTRONICS

*Theory Credit: 6*

- UNIT I** Network theorems. A. C. Equivalent Circuits of networks with active devices. Power Supplies: Half-Wave, Full-Wave and Bridge rectifiers with Capacitive input, Inductance input and PI filters. Regulated power supplies: Shunt regulated power supplies using zener diodes, Series regulated power supply. I. C. Voltage regulators. Transistor amplifiers: The CE, CB and CC configurations. Class A, Class B and Class C amplifiers. Low-frequency amplifiers. The transistor hybrid model and the h-parameters for a transistor. Conversion formulae for the h-parameters of the different transistor configurations.
- UNIT II** Analysis of a transistor CE amplifier at low frequencies using h-parameters. The CE amplifier with unbypassed emitter resistor. The emitter follower at low frequencies. The emitter-coupled differential amplifier and its characteristics. Low frequency power amplifiers. The push-pull and the complementary - symmetry power amplifiers. Transistor biasing, Self-bias and thermal stability. The BJT at high frequencies – the hybrid – model. Analysis of CE amplifier at high frequencies. Single stage CE amplifier and the gain-bandwidth product. Cascaded amplifiers. The emitter follower at high frequencies. The field effect transistor and its small signal model. The CS and CD amplifiers at low frequencies. Biasing the FET. The CS and CD amplifiers at high frequencies.
- UNIT III** Feedback: The Gain of an amplifier with feedback. General characteristics of negative feedback amplifiers. Stability of feedback amplifiers, The Barkhausen Criteria. Gain and Phase margins. Compensation. Sinusoidal oscillators: RC oscillators – The Phase shift and the Wien's bridge oscillators. LC oscillators. Frequency stability and the crystal oscillators. Operational amplifiers: Characteristics of an ideal operational amplifier. Applications of operational amplifiers – Inverting and Non-inverting amplifiers. Summing circuits, integration and Differentiation. Waveform generators.
- UNIT IV** **Digital Electronics** Digital computers, number systems, Arithmetic operations, decimal codes, Gray codes, alphanumeric codes Combinational logic circuits, binary logic and gates, Boolean algebra, Standard forms, Two-level circuit optimization, functions of two variables, exclusive-OR operator. Combinational logic design: design concepts, Design procedure, Combinational functions and circuits, Binary adders (half and full adder), Binary subtraction (half and full subtraction), binary adder-subtractions, decoder, encoder, multiplexers, demultiplexer.
- UNIT V** Sequential circuits: latches, Flip-flops: R-S, J-K, Master slave J-K, Flip Flop. Sequential circuit design, Registers, Shift registers, Synchronous Counters, Asynchronous Counters, Arbitrary sequence counter design and construction. Data Converters: Analog to Digital data converters, Digital to analog data converters.

#### **Recommended Books and References:**

1. Integrated Electronics – Maillman and Halkias

2. Introduction to Operational Amplifiers –
3. Electronic devices and circuit theory – Robert Boylested and Louis Nashlsky PHI 1991
4. Op-Amps & Linear integrated circuits – RamakanthA.Gayakwad PHI 1991
5. SemiConductor Electronics – A.K.Sharma New Age International Publishers.
6. Electronics-anlog and digital – Nagarath PHI
7. Digital Logic and Computer Design – M. Morris Mano, Prentice-Hall India Pvt. Ltd.
8. Digital Electronics: Fundamental Concepts and Applications – C. E. Strangio, PHI.
9. Semi Conductor Electronics – A.K.Sharma New Age International Publishers.
10. Fundamentals of Digital Circuits – A. Ananda Kumar, PHI, New Delhi.
11. Digital principles and applications – A.P. Malvino and Donald P. Leech TMH 1993

### **MPHC 3.11**

#### **SOLID STATE PHYSICS – 1**

*Theory Credit: 3*

- UNIT I** Crystalline and amorphous solids, Classification of crystal structures, Miller indices, Reciprocal lattice, X-ray diffraction, Bragg's law, Experimental methods, Atomic scattering factor, Electron and neutron diffraction. Classical picture of specific heat, Einstein's theory, Debye's approximation, Phonons, Lattice vibrational modes and specific heat of finite 1-D identical atoms and 3-D lattice, Diatomic linear lattice, Thermal properties.
- UNIT II** Free Electron model, Fermi-Dirac distribution, Electronic specific heat, Thermionic emission, Photoelectric effect, Block theorem, Kronig-Penny model, 1-D and 3-D electron motion, Band theory of solids, Metals, Semiconductors and insulators, Concept of Hole, Brillouin zones, Density of states.
- UNIT III** Electrical conductivity of metals, Boltzmann equation, Sommerfield theory, mean free path, Electron-phonon collisions, Electrical conductivity at low temperature, Thermal conductivity of metals and insulators, Hall Effect.
- UNIT IV** Lattice defects in metals, Configurational entropy, Vacancies and interstitials, Self and chemical diffusion, Kirkendall effect, Elastic constants, Edge and Screw Dislocations, Dislocation density, Uniform shear stress, Stress fields, Colour centers, Schottky and Frankel defects.
- UNIT V** Intrinsic and Extrinsic Semiconductors, Chemical binding in Semiconductors, Typical Examples of Energy Band Calculations, Kinetic phenomena/transport properties, Diffusion of electrons and holes and recombination effects, Characteristic Properties of Semiconductors and their determination.

#### **Recommended Books and References:**

1. Introduction to Solid State Physics – C. Kittel, 7<sup>th</sup> Edition, John-Wiley & Sons, New York.
2. Solid State Physics – N.W. Ashcroft and N.D. Mermin, Harcourt college publishers, New York.
3. Solid State Physics – A.J. Dekker, Prentice-Hall, Inc., New Jersey.
4. Solid State Physics – J. S. Blakemore, 2<sup>nd</sup> Edition, Cambridge University press, W.B. Saunders Company, Cambridge, United Kingdom (1998).
5. Principles of Solid State Physics – R. A. Levy, Academic press, New York.
6. Principles of the Theory of Solids – J. Ziman, 2<sup>nd</sup> Edition, Cambridge University Press, Cambridge, United Kingdom (1995).
7. Solid State Electronics – S. Wang, McGraw-Hill Inc., USA (1996).

## MPHC 3.21 SPECTROSCOPY

Theory Credit: 3

- UNIT I** Electromagnetic Spectrum, Bohr's atomic model, Hydrogen-like spectra, Spin-orbit coupling, Many-electron atoms: selection rules and spectra, Born Oppenheimer approximation, LCAO-MO wave functions, Electronic spectra, Valence bond (VB) and molecular orbital (MO) theories for diatomic molecules, Comparison of MO and VB method.
- UNIT II** Hydrogen molecules ion ( $H_2^+$ ), Hydrogen molecule; resonance, Symmetry and nature of bonding, Microwave spectrum of a diatomic molecule, Rigid and Non-rigid rotator approximation, Moment of inertia and bond lengths of diatomic and linear triatomic molecule, Quantum theory of Raman Effect, Experimental setup and applications,
- UNIT III** Rotational Raman spectra. Rotational and vibrational spectra of Diatomic molecule, Harmonic and Anharmonic oscillator, Rotational constants from Infrared and Raman vibration-rotation spectra. Fourier transform of IR spectroscopy – Theory, Experimental setup and applications.
- UNIT IV** **Electron Spin Resonance:** Basic Principle and theory, ESR spectrometer, experimental methods, thermal equilibrium and Relaxation methods, characteristics of g and A values, Unpaired electron, fine structure and Hyperfine structure.  
**Nuclear magnetic resonance:** Basic Principle and theory, Nuclear spin and Magnetic moment, Relaxation mechanism, spin-lattice and spin-spin relaxation, Pulse method, Bloch's equations and solution, Experimental methods, CW NMR Spectrometer.
- UNIT V** **Nuclear quadrupole resonance:** Fundamental requirements of NQR spectroscopy, General principles, Integral spins and Half Integral Spin., experimental detection of NQR frequencies, block diagram of NQR spectrometer, Experimental methods of SR oscillator, CW oscillator, pulse methods.  
**Mössbauer spectroscopy:** Mössbauer Effect, Recoil less Emission and Absorption, Mössbauer spectrometer, Experimental Methods, Chemical shift, Magnetic Hyperfine interactions. Basics of Auger spectroscopy, Terahertz, Circular Dichroism spectroscopy, Inelastic neutron scattering, Neutron spin echo, Scanning tunneling spectroscopy, X-ray photoelectron spectroscopy.

### **Recommended Books and References:**

1. Fundamentals of Molecular spectroscopy – Colin N. Banwell and E.M. McCash, 4<sup>th</sup> Edition, Tata McGraw-Hill Publishing company limited, New Delhi (1995).
2. Fundamentals of Molecular spectroscopy – Walter S. Struve, John-Wiley & Sons, Inc. (1989).
3. Mössbauer spectroscopy – N.N. Greenwood and T.C. Gibb, Chapman and Hall Ltd., UK.
4. Spectroscopy – B.P. Stranghon and S.Walker, Volume 1, John Wiley and Sons Inc., New York.
5. Elements of Spectroscopy, R.C. Sharma, S.I. Gupta, V. Kumar V, Pragati Prakashan, Meerut, India (2013).
6. Nuclear Magnetic Resonance– E.R. Andrew, Cambridge University Press, UK.
7. Molecular spectra and Molecular Structure (van Nostrand) – G.Herzberg, Prentice-Hall
8. Introduction to atomic spectra – H.E. White, McGraw-Hill Book Company.
9. Pulse and Fourier transform NMR – T.C. Farrar and E.D. Becker, Academic Press 1971

**MPHC 3.31**  
**NUCLEAR AND PARTICLE PHYSICS**

*Theory Credit: 3*

**UNIT I Introduction:** Objective of studying Nuclear Physics, Nomenclature, nuclear radius, mass & Binding energy, angular momentum, magnetic dipole moment, Electric quadrupole moment, parity and symmetry, domains of instability, Energy levels, mirror nuclei.

**Nuclear Forces:** Characteristics of Nuclear Forces- Ground state of deuteron, scattering cross-sections, qualitative discussion of neutron-proton and proton-proton scattering at low energies- charge independence, spin dependence and charge symmetry of nuclear forces - exchange forces and tensor forces- Meson theory of nuclear forces (Yukawa's Potential).

**UNIT II Nuclear Models:** Weisazacker's semi-empirical mass formula- mass parabolas- Liquid drop model -Bohr -Wheeler theory of nuclear fission - Nuclear shell model: magic numbers, spin orbit interaction, prediction of angular momenta and parities for ground states, Collective model, and More-realistic models

**UNIT III Nuclear Decay:** Alpha decay process, Energy release in Beta-decay, Fermi's theory of  $\beta$  - decay, selection rules, parity violation in  $\beta$  -decay, Detection and properties of neutrino, energetics of gamma decay, selection rules, angular correlation, Mössbauer effect.

**UNIT IV Nuclear Reactions:** Types of reactions and conservation laws, Nuclear kinematics - the Q - equation, threshold energy- Nuclear cross section, Nuclear fission- energy release in fission- Stability limit against spontaneous fission, Characteristics of fission, delayed neutrons, Nuclear fusion, prospects of continued fusion energy. Four factor formula for controlled fission (nuclear chain reaction)-nuclear reactor- types of reactors.

**Applications of Nuclear Physics:** Trace Element Analysis, Rutherford Back-scattering, Mass spectrometry with accelerators, Diagnostic Nuclear Medicine, Therapeutic Nuclear Medicine.

**UNIT V Elementary Particle Physics:** Classification, Particle interactions and families, symmetries and conservation laws for energy and momentum, angular momentum, parity, Baryon number, Lepton number, isospin, strangeness quantum number, Discovery of K-mesons and hyperons, Gellmann and Nishijima formula, and Charm, Elementary ideas of CP and CPT invariance, SU(2), SU(3) multiplets, Quark model.

**Accelerators:** Electrostatic accelerators, Cyclotron, Synchrotron, Linear accelerators, Colliding beam accelerators, Intersecting Storage rings and stochastic cooling, Detectors for photons, leptons and hadrons.

**Recommended Books and References:**

1. Nuclear Physics – D.C.Tayal, Himalaya publishing Co.,
2. Introduction to Nuclear Physics – Harald A.Enge
3. Concepts of Nuclear Physics – Bernard L.Cohen.
4. Introduction to High Energy physics – D.H. Perkins
5. Introduction to Elementary Particles – D. Griffiths
6. Nuclear Physics – S.B.Patel, Wiley Eastern Ltd.,
7. Introductory Nuclear Physics – Kenneth S. Krane, John Wiley (1988)
8. Physics of Nuclei and Particles – E. Segre

9. Elements of Nuclear Physics – W. E. Burcham, Longman (1986)
10. An Introduction to Nuclear Physics – W. N. Cottingham and D. A. Greenwood

**MPHC 3.12**  
**ELECTRONICS LABORATORY**

*Practical Credit: 3*

*This course aims at the providing exposure to experiments in electronics. Each student is expected to do at least 70% of the listed experiments. The teacher in charge has the flexibility to add/ delete any experiments as per the need of the course.*

1. Diode Applications – I: Power supplies – Bridge rectifiers with capacitive input filters. Shunt Voltage regulator using zener diode.
2. Diode Applications – II: Clipping and Clamping circuits.
3. BJT characteristics. Determination of h-parameters in the CE configuration using the measured input and output characteristics of a BJT (e.g. 2N 2218)
4. Common Emitter Amplifier with and without feedback.
5. Common Source and Common Drain Amplifiers using JFET.
6. RC Oscillators: Phase shift oscillator using RC ladder network as the phase shifting network; Wien's Bridge Oscillator.
7. Emitter Coupled Differential Amplifier using BJT's.
8. Multivibrators – Bistable, Monostable and Free Running multivibrators using BJT's (e.g. 2N 2218).
9. Op-Amp (741) characteristics:  $V_{io}$ ,  $I_b$ ,  $V_{ol}$ , CMRR, Slew Rate. Applications of Op-amps: inverting Amplifier, Unity Gain Buffer, Summing Amplifier.
10. 555 IC timer. Free Running and Monostable Multivibrators, Sawtooth wave generator.
11. Series Dissipative Voltage Regulator using 723 IC.
12. Series Switching Voltage Regulator using 494 IC.
13. Tuned High Frequency Amplifiers: RF and IF amplifiers.
14. High Frequency Oscillators: Colpitts and Hartley Oscillators.

## SEMESTER - IV

### MPHC 4.11(a)

### ADVANCED QUANTUM MECHANICS (OPTIONAL)

*Theory Credit: 4*

- UNIT I Relativistic Quantum Mechanics:** Klein-Gordon equation, Non-relativistic limit, Dirac equation, properties of Dirac Matrices, positive and negative energy states. Spin of the Dirac particle, Significance of negative energy states, Free Dirac particle in an external electro-magnetic field, relativistic electron in a central potential.
- UNIT II Theory of Scattering:** Differential and total cross sections, scattering amplitudes using Green's function, scattering by symmetric potential, mutual scattering of two particles,
- UNIT III** Centre of Mass frame, Laboratory frame. Born approximation, Validity of Born Approx., Application to square well potential and Yukawa potential.
- UNIT IV** Partial wave analysis, phase shift, scattering amplitudes in terms of phase shift, optical theorem, scattering by square well potential and perfectly rigid sphere. Scattering Theory, Central force problem, partial wave analysis Born's approximation, optical theorem bound states and resonances. Schrodinger and Heisenberg pictures.
- UNIT V Quantization of fields:** Introduction, Concept of field Hamiltonian formulation of classical field, Real scalar field Schrodinger field, Dirac field, Maxwell's field, Quantum equation of the field, Quantization of real scalar field and second quantization, Quantization of complex scalar field, Quantization of Schrödinger field, Quantization of Dirac field.

#### **Recommended Books and References:**

1. Quantum Mechanics – Leonard I. Schiff, 3<sup>rd</sup> Edition, Tata McGraw-Hill Education Private Limited, New Delhi. (2010).
2. Practical Quantum Mechanics – S. Flugge, 1<sup>st</sup> Edition, Springer-Verlag New York (1998)
3. A text book of Quantum Mechanics – Mathews and Venkatesan 2<sup>nd</sup> Edition, McGraw-Hill Education Private Limited, New Delhi (2010).
4. Quantum Mechanics – M. P. Khanna, Har-Anand Publications Pvt. Limited
5. Introduction to Quantum mechanics – David J. Griffiths, Prentice Hall, Inc. USA (1995).
6. Quantum mechanics –A.Ghatak and S.Lokanathan, McMillan publishers India Limited, New Delhi (2010)
7. Advanced Quantum Mechanics – J. Sakurai
8. Relativistic Quantum Fields. Vols. I & II – Bjorken and Drell
9. Quantum Field Theory – Mandl
10. Particles and Fields – Lurie
11. Quantum Theory of Fields. Vols. I & II – Weinberg



**MPHC 4.11(b)**  
**ASTROPHYSICS**

*Theory Credit: 4*

- UNIT I Star formation in Interstellar medium:** Interstellar medium(ISM)-various nebula- Jeans condition for collapse-Protostars –star formation. Stellar Clusters : open and Globular- IMF.Variable stars-period luminosity relations and distance determination- Binary stars-types of binaries.
- UNIT II Stellar structure and Evolution:** Spectral classification of stars- Saha's equation- CNO cycles –HR Diagram--radiative transfer- structure of spectral line-hydrostatic equilibrium equation of state-main sequence. Evolution of main sequence-late stages-supernovae degenerate remnants: white dwarf-Chandrasekhar limit-Neutron star- pulsars-Black Holes- $\gamma$ -ray burst.
- UNIT III Radiative Processes in Astronomy:** Synchrotron emission for a single particle and an ensemble of particles, Energy loss and electron scattering-Compton scattering-Bremstrahlung radiation
- UNIT IV Large scale Structure and Cosmology:** Hubble's law, Friedman-Robertson-Walker Model, Cosmological constant.Theories of origin and evolution of Universe.Standard Cosmological model, thermodynamics of early universe, nucleo-synthesis, MicrowaveBackground radiation, Elementary ideas on structure formations, age of Universe.
- UNIT V General Theory of Relativity:** Principle of Equivalence. Gravity and Geometry. Metric Tensor and its properties. Curved space time. Tensor calculus: co-variant differentiation, parallel transport, Bianchi Identities. Particle trajectories in Gravitational field. Einstein's Field equations and Stress-energy tensor, Schwarzschild metric.

***Recommended Books and References:***

1. K.S Krishnaswamy , Astrophysics, CUP.
2. BaidyanathBasu, Astrophysics, Prentical Hall.
3. KD Abhankar, Astrophysics, Orient Longman.
4. Mclean,Electronic Imaging in Astronomy, Willey.
5. V.B.Bhatia, Text Book on Astronomy and Astrophysics with elements of cosmology, Narosa.
6. Smith, Observational, Astrophysics.CUP.
7. F Shu, Physical Universe. CUP.
8. Allen,Astrophysical Quantities. Willey.
9. KR Lang, Astrophysical Quantities, Springer Verlag.

**MPHC 4.21(a)**  
**SOLID STATE PHYSICS - II (OPTIONAL)**

*Theory Credit: 3*

- UNIT I** Dielectric materials, Macroscopic description of static dielectric constant, static and ionic polarizabilities, Orientational polarization, Static dielectric constant of solids

and gases, Complex dielectric constant, Dielectric losses, Relaxation time, Classical theory of electronic polarization.

**UNIT II** Ferroelectric materials, Classification, Dipole theory and limitations, Spontaneous polarization, Thermodynamics of ferroelectric transitions, Ferroelectric domains, Behaviour of BaTiO<sub>3</sub>,

**UNIT III** Magnetic materials, Dia-, para-, ferro-, antiferro and ferrimagnetism, origin of permanent magnetic dipoles, Larmor precession, Static paramagnetic susceptibility, Hamilton for an electron in magnetic field, Weiss theory of ferromagnetism and interpretation, Domains, Anisotropy energy, Heisenberg exchange interaction, Thickness and energy of the Bloch wall, Coercive force and Hysteresis, Two-sublattice model of antiferromagnetism, Superexchange interaction, Structure of ferrites, Elements of Néel's theory, Spin-lattice and Spin-spin relaxation.

**UNIT IV** Highlights of Ginzburg-Landau theory, variation of the order parameter, energy gap with magnetic field, isotope effect, Cooper Cooper pairs electron-phonon interaction, brief discussion of the B.C.S. theory and highlights of BCS theory results.

**UNIT IV** Basic properties of superconductors, Experimental survey, Phenomenological thermodynamic treatment, Two fluid model, Magnetic behaviour of superconductors, intermediate state, London's equations and penetration depth, quantized flux. Type I and II superconductors, magnetization of type-II superconductors, mixed state, surface energy, specific heat, critical currents of type-II superconductors flux lattice, flux flow (creep).

**Recommended Books and References:**

1. Introduction to Solid State Physics – C. Kittel, 7<sup>th</sup> Edition, John-Wiley & Sons, New York.
2. Solid State Physics – N.W. Ashcroft and N.D. Mermin, Harcourt college publishers, New York.
3. Solid State Physics – A.J. Dekker, Prentice-Hall, Inc., New Jersey.
4. Solid State Physics – J. S. Blakemore, 2<sup>nd</sup> Edition, Cambridge University press, W.B. Saunders Company, Cambridge, United Kingdom (1998).
5. Principles of Solid State Physics – R. A. Levy, Academic press, New York.
6. Principles of the Theory of Solids – J. Ziman, 2<sup>nd</sup> Edition, Cambridge University Press, Cambridge, United Kingdom (1995).
7. Introduction to Superconductivity – M. Tinkham, 2<sup>nd</sup> Edition, McGraw-Hill, New York (1996).
8. The Physical Principles of Magnetism – A. H. Morrish, 1<sup>st</sup> Edition, Wiley-IEEE Press, New York (2001).
9. Introduction to Magnetic materials – B.D. Cullity and C.D. Graham, 2<sup>nd</sup> Edition, Wiley-IEEE Press, New York (2009).

**MPHC 4.21(b)**

**ADVANCE ELECTRONICS(Optional)**

*Theory Credit: 3*

**UNIT I Embedded system introduction:** Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges & design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers.

- UNIT II** Review of microprocessors: Organization of Microprocessor based system, 8085µp pin diagram and architecture, concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts.
- UNIT III** 8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions. 8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description & their functions,
- UNIT IV** I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation.  
Programming: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions.
- UNIT V** **Programming Embedded Systems:** Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging.  
Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry.

**Recommended Books and References:**

1. Embedded Systems: Architecture, Programming & Design, R.Kamal, 2008, Tata McGraw Hill
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A.Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
3. Embedded microcomputer system: Real time interfacing, J.W.Valvano, 2000, Brooks/Cole
4. Microcontrollers in practice, I. Susnea and M. Mitescu, 2005, Springer.
5. Embedded Systems: Design & applications, S.F. Barrett, 2008, Pearson Education India
6. Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

**MPHC 4.31(a)**

**MODERN OPTICS(Optional)**

*Theory Credit: 4*

- UNIT I** **Quantum Optics:** Quantum theory of Radiation, Second quantization, Quantum statistical description of the radiation fields, Coherent states, Photon correlations, Squeezed states and applications. **Non linear Optics:** Basic Principles, Harmonic generation, Second harmonic generation, Phase matching, Third Harmonic generation, Optical mixing, Parametric generation of light, Parametric light oscillator, Frequency up conversion, Self focusing of light.

**UNIT II Holography:** Introduction, Basic theory of Holography, Recording and reconstruction of Hologram, Diffuse object illumination, Speckle pattern, Fourier transform Holography, Applications.

**Lasers:** Introduction, Directionality, Brightness, Monochromaticity, Coherence, Relation between the coherence of the field and the size of the source, Absorption and emission processes, Einstein coefficients, Amplification in a medium, Laser pumping, Boltzmann's principle and the population of energy levels, Attainment of population inversion, Two level, three level and four level pumping.

**UNIT III Optical feedback:** Optical resonator, Laser power and threshold condition, Confinement of beam within the resonator, Stability condition. **Laser output:** Absorption and emission, Shape and width of broadening lines, Line broadening mechanisms, Natural, Collision and Doppler broadening, Ruby laser, He-Ne Laser, CO<sub>2</sub> laser, Semiconductor Ga-As laser, Applications.

**UNIT IV Fiber Optics:** Introduction, Total internal reflection, Optical fiber modes and configurations, Fiber types, Rays and modes, Step index fiber structures, Ray optics representation, Wave representation, Mode theory for circular wave guides, Wave guide equations, Wave equations for step indexed fibers, Modal equation, Modes in step indexed fibers, Power flow in step indexed fibers, Graded indexed fiber structure, Numerical aperture and modes in graded index fibers,

**UNIT V** Signal degradation in optical fibers, Attenuation, Losses, Absorptive and radiative scattering, Core cladding, Signal distortion in optical wave guides, Information capacity determination, Group delay, Material dispersion, Wave guide dispersion, Inter modal dispersion, Pulse broadening, Preparation of different techniques of optical fibers.

**Recommended Books and References:**

1. Introduction to Electrodynamics – D.J.Griffiths, Prentice-Hall, India
2. Electromagnetics – B.B.Laud, Wiley –Eastern, New Delhi.
3. Modern Optics – Fowels
4. Laser and their applications – M.J.Beesly, Taylor and Francis, 1976.
5. Laser and Non-Linear Optics – B.B.Laud, Wiley Eastern Ltd., 1983.
6. Optics – E.Hecht, Addison Wiley, 1974.
7. Optical fibers communications – Gerel Keiser, McGraw Hill Book, 2000.
8. Introduction to Quantum Optics – Baldwin

**MPHC 4.31(B)**

**ATMOSPHERIC PHYSICS(Optional)**

*Theory Credit: 4*

**UNIT I Physical Meteorology:** Thermal structure of the atmosphere and its composition. Radiation: basic Laws - Rayleigh and Mie scattering, multiple scattering, radiation from the sun, solar constant, effect of clouds, surface and planetary albedo. Emission and absorption of terrestrial radiation, radiation windows, radiative transfer, Greenhouse effect, net radiation budget; Thermodynamics of dry and moist air: specific gas constant, Adiabatic and iso – entropic processes, entropy and enthalpy, Moisture variables, virtual temperature; Clausius – Clapeyron equation, adiabatic process of moist air; thermodynamic diagrams: Hydrostatic equilibrium: Hydrostatic

equation, variation of pressure with height, geo - potential, standard atmosphere, altimetry. Vertical stability of the atmosphere: Dry and moist air parcel and slice methods. Tropical convection.

**UNIT II Atmospheric Electricity and Cloud Physics:** Fair weather electric field in the atmosphere and potential gradients, ionization in the atmosphere. Electrical fields in thunderstorms, theories of thunderstorm electrification. Cloud classification, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron, Findeisen process, coalescence process – Precipitation of warm and mixed clouds, artificial precipitation, hail suppression, fog and cloud – dissipation, radar observation of clouds and precipitation, radar equation, rain drop spectra, radar echoes of hail storm and tornadoes, radar observation of hurricanes, measurements of rainfall by radar.

**UNIT III Dynamic Meteorology:** Basic equations and fundamental forces: Pressure, gravity, centripetal and Coriolis forces, continuity equation in Cartesian and isobaric coordinates. Momentum equation Cartesian and spherical coordinates; scale analysis, inertial flow, geostrophic and gradient winds, thermal wind. Divergence and vertical motion Rossby, Richardson, Reynolds and Froude numbers. Circulation, vorticity and divergence; Bjerknes circulation theorem and applications, vorticity and divergence equations, scale analysis, potential vorticity, stream function and velocity potential.

**UNIT IV Atmospheric turbulence:** Mixing length theory, planetary boundary layer equations, surface layer, Ekman layer, eddy transport of heat, moisture and momentum, Richardson criterion; Linear Perturbation Theory: Internal and external gravity waves, inertia waves, gravity waves, Rossby waves, wave motion in the tropics, barotropic and baroclinic instabilities. Atmospheric Energetics: Kinetic, potential and internal energies – conversion of potential and internal energies into kinetic energy, available potential energy.

**UNIT V General Circulation and Climate Modelling:** Observed zonally symmetric circulations, meridional circulation models, mean meridional and eddy transport of momentum and energy, angular momentum and energy budgets; zonally asymmetric features of general circulation; standing eddies; east-west circulations in tropics: climate variability and forcings; feedback processes, low frequency variability, MJO (Madden-Julian oscillation), ENSO, QBO (quasi-biennial oscillation) and sunspot cycles. Basic principles of general circulation modelling; grid-point and spectral GCMs; role of the ocean in climate modeling; interannual variability of ocean fields (SST, winds, circulation, etc.) and its relationship with monsoon, concepts of ocean – atmosphere coupled models.

**Recommended Books and References:**

1. Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rd edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and KHamazu, Springer Japan, 2014.

**MPHC 4.41**  
**PROJECT WORK**

**Total Credit: 4**

**The Student will complete the project under supervision of the project guide. The topic of the project will be decided by the Faculty in charge of that student. A proper project report / dissertation will be graded by the faculty members on completion of the project.**

**PHC 4.12**  
**NUCLEAR, ASTROPHYSICS AND ATMOSPHERIC PHYSICS**

*Practical Credit: 4*

*This course aims at experiments in Basic Nuclear, astrophysics and Atmospheric Physics. Each student is expected to do at least 70% of the listed experiments. The teacher in charge has the flexibility to add/ delete any experiments as per the needs of the course.*

1. Study of the characteristics of a GM tube and determination of its operating voltage, plateau length/slope etc
2. Verification of inverse square law for gamma rays.
3. Estimation of efficiency of the GM detector for gamma source/ Beta source.
4. To study Beta particle range and Maximum Energy (Feather analysis)
5. Backscattering of Beta particles
6. Production and attenuation of Bremsstrahlung.
7. Study of Energy resolution characteristics of a scintillation spectrometer as a function of applied high voltage and to determine the best operating voltage.
8. Study of Cs-137 spectrum and calculation of FWHM & resolution for given scintillation detector.
9. To install astronomy software heasoft/ds9/IRAF/AIPS
10. To plot the light curve using the astronomy software of an astronomical object using archived data.
11. To find the different parameters (Magnification, resolving power, f-number) of an optical telescope and balancing/ aligning the equatorial mount/ Dobsonian telescope
12. To study the radar reflectivity factor with the help of rain drop size distribution.
13. To study the spectral characteristics of a given time series data.
14. To study the characteristic of electric field during thunder storm.

**Recommended Books and References:**

- |  |                                       |
|--|---------------------------------------|
| 1. Radiation Detection and Measurement | G. F. Knoll, John Wiley (1988)        |
| 2. Nuclear Electronics                 | P. W. Nicholson, Wiley, London (1974) |

*Revised*  
SYLLABUS FOR  
Master of Science

**ZOOLOGY**

SEMESTER SYSTEM





### CORE STRUCTURE

SEMESTER	COURSE CODE	COURSE NAME	CREDIT
<b>I</b>	MZOC 1.11	Cell Biology and Immunology	4
	MZOC 1.12	Cell Biology and Immunology (Practical)	2
	MZOC 1.21	Biological Chemistry & Molecular Biology	4
	MZOC 1.22	Biological Chemistry & Molecular Biology (Practical)	2
	MZOC 1.31	Animal Physiology	4
	MZOC 1.32	Animal Physiology (Practical)	2
<b>II</b>	MZOC 2.11	Genetics & Developmental Biology	4
	MZOC 2.12	Genetics & Developmental Biology (Practical)	2
	MZOC 2.21	Parasitology and Insect Physiology	4
	MZOC 2.22	Parasitology and Insect Physiology (Practical)	2
	MZOO 2.11	Techniques in Biology	4
	MZOO 2.12	Techniques in Biology (Practical)	2
<b>III</b>	MZOC 3.11	Endocrinology & Reproductive Biology	4
	MZOC 3.12	Endocrinology & Reproductive Biology(Practical)	2
	MZOC 3.21	Aquatic Biology and Fisheries	4
	MZOC 3.22	Aquatic Biology and Fisheries(Practical)	2
	MZOO 3.11	Animal Diversity	4
	MZOO 3.12	Animal Diversity(Practical)	2
<b>IV</b>	MZOC 4.11	Biosystematics, Evolution & Ecology	4
	MZOC 4.12	Biosystematics, Evolution & Ecology(Practical)	2
	MZOC 4.21(a)	Biochemical Adaptation and Metabolic Regulation	4
	MZOC 4.22(a)	Biochemical Adaptation and Metabolic Regulation (Practical)	2
	MZOC 4.21(b)	Fish Biology	4
	MZOC 4.22(b)	Fish Biology(Practical)	2
	MZOC 4.21(c)	Entomology	4
	MZOC 4.22(c)	Entomology(Practical)	2
	MZOC 4.21(d)	Limnology	4
	MZOC 4.22(d)	Limnology(Practical)	2
MZOC 4.31	Dissertation	4	
MZOC 4.32	Dissertation(Practical)	2	

## SEMESTER - I

### MZOC 1.11

#### CELL BIOLOGY AND IMMUNOLOGY

*Theory Credit: 4*

- UNIT I** Cell-chemical complexity and organisation.  
Plasma membrane: Fluid mosaic Model: Chemical constituents (Membrane lipids, proteins and carbohydrates) and their organization and functional features.  
Cytoskeleton – general features: microtubules, microfilaments and intermediate filaments-structural and functional dynamics. Mitochondria, endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes and nucleus-ultrastructure and functional characteristics; protein sorting and transport to these cell organelles.
- UNIT II** Chromatin: Chemical composition, histones, molecular organization of nucleosomes, nucleoplasmin, chromatin to chromosomes, histone modifications, Chromatin remodelling complex.  
Cell cycle-features and phases; cyclins and cyclin dependent kinases, regulation of CDK- cyclinactivity, cell cycle check points. Benign and malignant tumours; characteristic features of malignant cells.  
Cell death: Type's significance, salient features; mechanism: extrinsic and intrinsic pathways.
- UNIT III** Innate and acquired immunity-component and characteristic features organization and structure of lymphoid organs; humoral and cell mediated immune response and cytotoxins.  
Antigens- antigenicity and immunogenicity; factors affecting immunogenicity, epitopes and haptens.  
Immunoglobulin: B cell receptor –basic molecular structure, classes and functions; antibody mediated effector functions; antigen-antibody interactions.
- UNIT IV** Major histocompatibility complex (MHC) – in mouse and human, MHC genes arrangements.  
Class-I & II molecules: T cell receptors-structure and function.  
Complement system –characteristic features: classical and alternate pathways of complement activation.  
Introduction to cytokines and interferon.  
Hypersensitivity –types and features and mechanism of immediate hypersensitive reactions.

### MZOC 1.12

#### CELL BIOLOGY AND IMMUNOLOGY

*Practical Credit: 2*

1. Study of metaphase plate in red corneal cell/root tip.
2. Study of meiosis in grasshopper testis.
3. Study of sex-chromatin in human buccal cavity cells.
4. Isolation and staining of mitochondria from mice/rat.

5. Dissection and histology of lymphoid organs in laboratory bred animals.
6. Determination of blood group in human.
7. Study of different cell in blood smears from laboratory bred animals.
8. Antigen-antibody interaction *in vitro*-Double immunodiffusion.

**Recommended Books and References:**

1. Alberts B. Johnson A. Lewis J., Raff M. Roberts K. And Walter P. (2008) Molecular Biology of the cell, 5<sup>th</sup>Edn, Garland publishing, Inc., New York.
2. Cooper G.N and Hausman R.E (2007) the cell: A Molecular Approach, 4<sup>th</sup>edn. ASM Press, Washington D.C, USA.
3. Male D., Brostoff J., Roth D.B and Roitt, I (2006) Immunology, 7<sup>th</sup>edn, Mosby Elsevier.
4. Lodish H. Berk A., Kaiser C.A. Kaiser C.A. Krieger M. Scott M.P Bretcher A., ploegh H. And Matsudaira P. (2008) Molecular Cell Biology, W.H Freeman and Co., England.
5. Murphy K., Travers P. And Walport M. (2008) Janeway's immunobiology, 7<sup>th</sup>edn. Garland Science, New York.
6. Kindt T.J., Goldsby R.A. and Osborne B.A (2007) Kuby Immunology, 6<sup>th</sup>edn. W.H. Freeman and Co. New York.
7. Roitt I.M and delves P.I, (2001) Roitt's Essential Immunology, 10<sup>th</sup>edn. Blackwell Science Lrd. London.
8. Kleinsmith L.J and Kish V.M (1995) Principles of Cell & Molecular Biology. Harper Collins Publishers, New York.
9. Elgert K.D. (2009) immunology-Understanding the Immune System, 2<sup>nd</sup>edn., Wiley-Blackwell, a John Wiley & Sons, Inc., Publication, New York.
10. Owen A.O., Punt, J., Stranford, S.A. and Jones , P. (2013) Kuby Immunology, 7<sup>th</sup>edn., W.H. Freeman & Company, New York.
11. Murphy K. (2012) Janeway's Immunobiology, 8<sup>th</sup>edn. Garland Science Publ.
12. Karp G. (2007) Cell Bioloy, 7<sup>th</sup>edn. Wiley Publ., New York.
13. DeRobertis E.D.P. and Derobertris E.M.F. (2008) 8<sup>th</sup>edn., Wolters Kluwer Publ. New York.

**MZOC 1.21**

**BIOLOGICAL CHEMISTRY & MOLECULAR BIOLOGY**

*Theory Credit: 4*

**UNIT I** Acids, bases, pH and buffer; derivation of Henderson and Hasselbach equation and simple calculations on pH and buffer. Bioenergetics: Standard reduction potential; Gibbs free energy changes: mitochondrial electron transport chain complexes: oxidative and photophosphorylation.

**UNIT II** Enzymes: An introduction to enzyme properties, active sites, specificity and enzyme classification; cofactors and coenzyme energetic of enzyme-catalyzed reaction, transition state, binding energy.  
Effect kinetic-Michaelis-Menten equation and its derivation, Lineweaver-Burk Plot; significant of Km: calculations on enzymes kinetics. Inhibition of enzyme activity:allosteric;isoenzymes.

- UNIT III** Structure and properties of DNA and RNA  
 DNA replication: Mechanism of DNA replication in prokaryotes and eukaryotes; structure and properties of DNA polymerases; enzymes and factors involved in DNA replication.  
 Transcription –Mechanism of transcription-initiation, elongation and termination steps, sense and antisense strand, structure and properties of RNA polymerases in prokaryotes and eukaryotes: RNA processing.
- UNIT IV** Protein synthesis: initiation, elongation and termination of protein synthesis.  
 Prokaryotic gene expression; positive and negative control of gene expression, lac operon in *E. coli*, tryptophan operon in *E. Coli*. Repression and attenuation.  
 Recombination DNA technology: Restriction enzymes: cloning, cloning vectors.

## **MZOC 1.22**

### **BIOLOGICAL CHEMISTRY & MOLECULAR BIOLOGY**

*Practical Credit: 2*

1. Preparation of phosphate and acetate buffers with different pH.
2. Determination of pka for glycine and glutamic acid.
3. Estimation of protein using Bradford method.
4. Estimation of amino acids using Ninhydrin reagent.
5. Estimation of inorganic phosphate by Fiske-Subharao's method.
6. To study the effect of time on urease activity.
7. To study the effect of enzyme concentration on urease activity.
8. To study the effect of substrate concentration on urease activity, and determination of  $K_m$  and  $V_{max}$  by Michaelis-Menten and Lineweaver-Burk plots.
9. Estimation of DNA by diphenylamine reagent.
10. Estimation of RNA by orcinol reagent.
11. Amplification of a target gene by PCR and determination of molecular size by agarose gel electrophoresis.

#### **Recommended Books and References:**

1. Nelson D.L Cox. M.M (2013) Lehninger Principle of Biochemistry, 6<sup>th</sup>Edn.,, Worth Publisher, New York.
2. Moran L.A et al. (2011) Principles of Biochemistry, 5<sup>th</sup>edn., Prentice, 5<sup>th</sup>Edn. ASM, USA.
3. Cooper G.M and Hausman R.E (2009). The Cell: Molecular Approach, 5<sup>th</sup>edn, ASM Press, USA.
4. Metzler D.E. (2005) Biochemistry, vol. 1 and 2, 3<sup>rd</sup>edn., Academic Press, New Delhi.
5. Rawn J.D. (2004) Biochemistry, Panima Publishing Corporation, New Delhi.
6. Berg J.M., Tymocko J.L. and Stryer L. (2010) Biochemistry, 7<sup>th</sup>Edn., H. Freeman and Company, UA.
7. Muray R.K et al. (2010) Harpers Illustrated Biochemistry, 29<sup>th</sup>Edn.,McGraw hill, London.
8. Alberts et al. (2008) Molecular Biology of the Cell, 5<sup>th</sup>Edn. Garand publishing.
9. Lewin B. (2011) Gene XI, John CI, John Wiley & Sons.
10. Weaver R.F (2005) Molecular Biology, 3<sup>rd</sup>Edn., McGraw-Hill International.
11. Watson J.D., Baker T.A., Bell S.P., Gann A., Levin M. and R. (2007) Molecular Biology of the Gene, Benjamin Cummings, San Francisco, USA Losick.
12. Plummer L. (1989) Practical Biochemistry, Tata McGraw-Hill.
13. McPherson H.J. and Moller S.G (2006) PCR, 2<sup>nd</sup>Edn., Taylor & Francis.

**MZOC 1.31**  
**ANIMAL PHYSIOLOGY**

*Theory Credit: 4*

- UNIT I** Physiology of digestion-digestive enzymes in vertebrates; secretion and regulation in mammal; mechanism of digestion and absorption of different component of food materials. Circulation system in invertebrates and vertebrates; physiological types of hearts. Cardiac cycle and its regulation in mammals. Composition and functions of blood volume; haemopoiesis; blood pressure; blood groups; blood coagulation.
- UNIT II** Neuron: Ultrastructure, types and functions: resting and action potential: Nernst equations: neural conduction through an axon; neurotransmitters and synaptic transmission.  
Musculature in vertebrates: smooth, skeletal and cardiac; ultra-structure and chemical composition of skeletal muscle; neuromuscular junction, molecular mechanism and regulation of muscle contraction; energetics of muscle contraction; muscle fatigue; tetanus and rigor mortis.
- UNIT III** Respiratory organs in vertebrates. Mechanism of respiration through gills in fishes. Mechanism of breathing and its regulation in mammals. Respiratory pigments-brief chemistry and functions. Transport of oxygen and carbon dioxide; oxygen dissociation curve; Bohr effect and Root effect; acid-base disturbances of respiratory origin.
- UNIT IV** Nitrogen excretion in animals; modification of nitrogen excretion among different animal groups. Structure of vertebrate kidney and nephron; formation of urine; counter current mechanism in higher vertebrates; renal control mechanism; acid-base balance; homeostasis; Osmoregulation in aquatic and terrestrial animals – mechanism and regulation.

**MZOC 1.32**  
**ANIMAL PHYSIOLOGY**

*Practical Credit: 2*

1. RBC count in blood.
2. WBC count in blood.
3. Hb concentration in the blood.
4. Measurement of blood pressure under different physiological conditions.
5. Estimation of casein in milk.
6. Estimation of glycogen content in liver of fish/goat.
7. Estimation of ascorbic acid in tomato, lemon and milk.
8. Determination of the rates of oxygen consumption by an aquatic animal
9. Determination of respiratory quotient of an air breathing animal.
10. Absorption of glucose by the gut in laboratory bred animal.

**Recommended Books and References:**

1. Hill R.W., Wyse G.A and Anderson M. (2008) Animal Physiology, 2<sup>nd</sup>Edn. Sinauer Associates, Inc USA.
2. William B., M.D. (2008) Carpenter Animal Physiology, New Rev Edn. Kessinger Pub. Co.

3. Moyes C.D., Schulte P.M. (2006) principles of Animal Physiology, Pearson Benjamin Cummings (USA)
4. Willmer P. Stone G. and Johnston I. (2000) Environmental Physiology of Animals, Blackwell Science Ltd. USA.
5. Prosser, C.L. (1991) Comparative Animal physiology, Saunders, Philadelphia, USA.
6. Eckert, R and Randall, d. (2005) Anima Physiology, Mechanism & Adaptations, 2<sup>nd</sup>Edn., CBS publishers & Distributors, New Delhi.
7. Schmidt-Nielsen K. (2005) Animal Physiology, Harper & Row, NY.
8. Witherspoon J.D. (2001) Human Physiology: Adaptation and Environment, Cambridge Press.
9. Hoar W.S. (1993) General and Comparative Physiology, Pentice Hall of India Pvt. Ltd.
10. Hainsworth F.R (1999) Animal Physiology: Adaptations' in function, Addison Wesley Longman Publishing Co., USA.

## SEMESTER - II

### MZOC 2.11

### GENETICS AND DEVELOPMENT BIOLOGY

Theory Credit: 4

#### (A) GENETICS

- UNIT I** Genome size and evolutionary complexity: C-value paradox.  
Organization of chromosomes: Unique and repetitive sequences in eukaryotic genome.  
Sex determination and dosage compensation: in *Caenorhabditiselegans*, *Drosophila* and human. Mendelian principles and extensions: Dominance, segregation, independent assortment, deviation from Mendelian inheritance, sex linkage, sex limited and sex influenced traits.  
Human genetics: Mendelian pedigree analyses, organization and distribution of human genes. Population and Quantitative Genetics: Hardy-Weinberg equilibrium, polygenic/multifactorial inheritance.  
Somatic Cell Genetics: Concept and applications, transfection of cells-principles and method, cell fusion, hybridoma, applications of embryonic stem cells.
- UNIT II** Mutation: Molecular basis, different types of DNA damages, physical and chemical mutagens, DNA repair mechanism-Base excision repair system, Nucleotide excision repair system, mismatch repair system, recombination repair system, SOS repair, Structural and numerical alterations of chromosomes: Deletion, duplication, inversion,. Translocation, polyploidy and their genetic implications.  
Microbial Genetics: methods of gene transfer: transposition, transduction, conjugation, and sexduction. Transposable genetic elements in prokaryotes and eukaryotes: IS element, Composite transposons, Tn3 element, mechanism of transposition, P element and hybrid dysgenesis in *Drosophila*, retrotransposons.

#### (B) DEVELOPMENT BIOLOGY

- UNIT I** Gametogenesis: Spermatogenesis –formation of spermatids and spermiogenesis, sperm function, composition of semen, oogenesis-oocyte growth, maturation and vitellogenesis, types of egg.  
Fertilization: Fertilization in sea urchin, recognition of egg and sperm, prevention of polyspermy, activation of egg metabolism and fusion of genetic material.  
Cleavage: characteristics, plane and patterns cleavage: mechanism and products of cleavage: types of blastulae; axis pattern in *Drosophila*. Gastrulation and formation of germinal layers; gastrulation in Amphibia, concept of organizer, induction and competence. Nuclear transplantation experiments and genomic equivalence.
- UNIT II** Neurogenesis in zebra fish or vulva formation in *Caenorhabditiselegans*.  
Organogenesis-development of vertebrate brain and the dynamics of optic development-the vertebrate eye. Regeneration in invertebrates and vertebrates.  
Metamorphosis-metamorphosis in Amphibia and insects; Hormonal control of amphibian and insect metamorphosis. Teratogenesis: Teratogenic agents-malformations and disruptions. *In-vitro* fertilization. Theories of aging. Stem cells-concepts, types and significance.

## **MZOC 2.12**

### **GENETICS AND DEVELOPMENTAL BIOLOGY**

*Practical Credit: 2*

#### **(A) GENETICS**

1. Meiosis from grasshopper testes and calculations of chiasma frequency and co-efficient of terminalisation.
2. Preparation and mapping of polytene chromosomes: from salivary gland of *chironomous/Drosophila* larvae.
3. Preparation of human karyotypes: normal male and female; analysis of some common human chromosomal aberrations.
4. Demonstration of monohybrid and dihybrid crosses of *Drosophila*.

#### **(B) DEVELOPMENTAL BIOLOGY**

1. Study of developmental stages of frog permanent slides/models/charts.
2. Study of different types of invertebrate and vertebrate eggs from permanent slides/models/charts.
3. Study of regeneration in *Planaria/ Hydra*.
4. Study of regeneration in the tail of tadpoles.
5. Study of developmental stages of chick from permanent slides/models/charts
6. Preparation of whole mount of chick embryo of 13-18, 24-33 , 36-48 and 48-72 hours and identification of the developmental stages

#### **Recommended Books and References:**

1. Snustad P. and Simmons M.J (2011) Principles of Genetics, 8<sup>th</sup>Edn. John Willey & Sons Inc., USA.
2. Russels P. (2006) Fundamentals of Genetics, Addison Wesley Longman Inc.
3. Brooker R.J (2009) Genetics: Analyses and Principles, McGraw Hill.
4. Griffiths A.J.F, Wesslers S.R., Lewontin R.C and Carroll S.B (2007) introduction to Genetic Analysis, 9<sup>th</sup>Edn.
5. Gilbert S.F (2004) Developmental Biology 10<sup>th</sup>Edn.Sinauer Association Inc. Publishers.
6. Ericson B.L.W., Carl A. And Jeffery W.R. (1997) Developmental Biology, Saunders Publ.
7. Shi. Y.B., (2005) Amphibian metamorphosis of Molecular Biology, John Wiley & Sons, inc., Publ.
8. Balinsky B.I (1981): An introduction to Embryology, 5<sup>th</sup>Edn. Holt-Saunders and International Editions.
9. Wolpert L. And Tickle C. (2011) Principles of Development, 4<sup>th</sup>Edn,Oxford University Press.

## **MZOC 2.21**

### **PARASITOLOGY AND INSECT PHYSIOLOGY**

*Theory Credit: 4*

#### **(A) PARASITOLOGY**

**UNIT I** Introduction to parasitism, basic principles and concepts, various symbiotic associations. Protozoa-Introduction and biology of parasitic amoebae, intestinal flagellates, haemoflagellates (*Leishmania, Trypanosomes*). *Plasmodium, Toxoplasma*, piroplasms. Newly emerging infections in humans –soil amoebae, *Cryptosporidium, Pneumocystis*. Platyhelminthes: General organization and classification, Biology and economic importance of Monogenea (*Polystoma*), Digenetic trematodes: Liver flukes-



*Fasciola*; Lung fluke-*Paragonium*; Blood flukes-*Schistosoma* spp.; Cestodes; Pseudophyllidea-*Diphyllobothrium*; Cyclophyllidea-*Taenia* spp.

**UNIT II** Nematoda : General organisation and classification : biology and economic importance of; Adenophorea –*Trichuris*; Secernentea –*Ascaris*, hookworms, *Dracunculus*, filarial worms; Acanthocephala – *Macracanthorhynchus hirudinaceus*. Host specificity – concepts and definition, kinds of specificity, determining factors. Immunity against parasites: Protozoa (*Plasmodium*), trematoda (Schistosomes), intestinal nematodes (*Ascaris* and hookworm spp); Immuno-evasive strategies.

### **(B) INSECT PHYSIOLOGY**

**UNIT I** Insect alimentary tract and its development; midgut cell types; process of digestion and absorption; water and electrolyte absorption. Tracheal system; Structure, ventilation and diffusion of gases; mechanism of respiration in terrestrial, aquatic and parasitic insects.

Malpighian tubules: Structure and function; cryptonephridial system; biosynthesis of ammonia and uric acid; excretion of nitrogenous waste with special reference to uric acid excretion. Structure of insect eye; mechanism of vision.

**UNIT II** Basic components of nervous system; generation of electrical potential and nervous transmission. Endocrine centres; Neurosecretory cells; corpora cardiac; corpora allata; prothoracic glands. Neuropeptides in insects: Juvenile hormones : Major types: biosynthesis and degradation : mode of action. Male and female reproductive systems; types of ovarioles; vitellogenesis; hormonal control of reproduction; juvenile hormones as gonadotropins.

## **MZOC 2.22**

### **PARASITOLOGY AND INSECT PHYSIOLOGY**

*Practical Credit: 2*

#### **(A) PARASITOLOGY**

1. Preparation and study of enteric and parenteric protozoans from earthworm and insects.
2. Preparation of thin and thick blood smears of albino mice/fish for detection of blood protozoans.
3. Study of permanent blood films depicting haemoflagellates, Haemosporidia, microfilariae.
4. Exploration and study of helminthic infections in locally slaughtered vertebrate hosts.
5. Study of helminthic infections in locally slaughter vertebrate hosts.
6. Study of helminth parasites of medico-veterinary importance from permanent preparations.
7. Dissection of *Ascaris suum* to observe the reproductive and digestive systems.
8. Microscopic examination of faecal samples for diagnosis of helminth egg/larvae.

#### **(B) INSECT PHYSIOLOGY**

1. Dissection of alimental canal of honeybee.
2. Study of male and female reproductive systems in cockroach.
3. Dissection of nervous system of adult grasshopper and cockroach, and larvae of silkworm.
4. Dissection of brain; corpora allata and prothoracic gland of silkworm larvae.
5. Dissection of silk gland from silkworm larvae; developing wing and ovary from pupae.
6. Assay of amylase from salivary gland of cockroach.
7. Estimation of total proteins in hemolymph.

### **Recommended Books and References:**

#### **(A) PARASITOLOGY**

1. Chatterjee, K. (2009). Parasitology (Protozoology and Helminthology) in Relation to Clinical Medicine, 13<sup>th</sup>Edn, CRC publisher New Delhi.
2. Cox F.E.G (1993) Modern Parasitology: A Text Book of Parasitology, 2<sup>nd</sup>Edn. Blackwell Science Limited, Oxford.
3. Cheng T.C (1999). General Parasitology, 2<sup>nd</sup>Edn. Harcourt Brace, Singapore.
4. Smyth J.D and Wakelin, D. (2001) Introduction to Animal parasitology, 3<sup>rd</sup>Edn., Cambridge University Press, London.
5. Roberts L.S Nadler, S. Schmidt G.D. and Janovy J. (2013) Foundations of Parasitology, 9<sup>th</sup>Edn., McGraw-Hill Higher Education New York
6. Soulsby E.J.L. (1983) Helminths, Arthropods and Protozoa of Domesticated Animals, 7<sup>th</sup>Edn., Lea &Febiger, Philadelphia.

#### **(B) INSECT PHYSIOLOGY**

1. Klowden M.J (2013) Physiological systems in insects, 3<sup>rd</sup>Edn., Academic Press.
2. Gilbert L.I (2011) Insect Endocrinology, 1<sup>st</sup>Edn. Academic Press.
3. Nation J.L (2008) insect Physiology and Biocemistry, 2<sup>nd</sup>Edn., CRC Press
4. Latou, K. Gil,S.S. and Gilbert L.I (2005) Comprehensive molecular insect Science, Vol. 1-7, Pergamon Press.
5. Chapman R.F. (2000) The Insects: Structure and Function, 4<sup>th</sup>Edn. Cambridge univ. Press.
6. Gullan P.J and Cranston P.S (1994) The insects, an outline of Entomology, Chapman & Hall.
7. Kerkut G.A and Gilbert L.I (1985) Comprehensive insect Physiology, Biochemistry and Pharmacology, Vols. 1-12 Ed. Pergamon Press, oxford.
8. Blum M.S (1985) Fundamentals of insects Physiology, Biochemistry and Pharmacology, (1970)The Physiology of insect Physiology. John Willey Sons, New York, Chicester, Brisbane, Toronto and Singapore.
9. Englemann F. (1970) The Physiology of Insect Reproduction, academic Press, New York.
10. Imms. A.D. (1964) The Text book of Entomoloy. Methuen Co., London.
11. Wiggleswoth, V.B. (1984) The Principles of Insect Physiology, 8<sup>th</sup>Edn. Chapman and Hall.

### **MZOO 2.11**

#### **TECHNIQUES IN BIOLOGY**

*Theory Credit: 4*

- UNIT I** Microscopy: Light, phase-contrast, fluorescent and electron microscopy.  
Methods in Cell Biology: Cell and tissue culture.  
Principle and application of tracer techniques: Autoradiography, radioimmunoassay.  
Immunological techniques: Immunodiffussion, immunoelectrophoresis, enzyme linked Immunosorbant assay (ELISA)  
Spectrophotometry: Spectrofluorometry; spectroscopy  
Tissue processing and separation of various sub-cellular organelles by centrifugation.
- UNIT II** Chromatography: Adsorption, ion-exchange, gel filtration, affinity and high performance liquid chromatography (HPLC).  
Electrophoresis: Isoelectrophoresis and pulse field electrophoresis.  
Blotting Technique: Southern, Northern and Western blotting.  
Sequencing of nucleic acids.  
Polymerase Chain Reaction (PCR).
- UNIT III** Statistics and its applications in biology.  
Measure of central tendency: mean, median and mode

Statistics of dispersion: Standard deviation and coefficient of variation.  
Distribution: Normal, Binomial and Poisson distribution.  
Tests of statistical significance: t-test, Chi-square test, ANOVA.  
Simple correlation using statistical software.  
Protein motifs; Microarray analysis.

**UNIT IV** Introduction to bioinformatics: Database concepts and biological databases (NCB, EBI and DDBJ).  
Information retrieval and sequence alignment (BLAST and FASTA).  
Database submission.

## **MZOO 2.12**

### **TECHNIQUES IN BIOLOGY**

*Practical Credit: 2*

1. Use of different types of microscope: phase contrast, fluorescent and electron microscope.
2. Demonstration of ELISA/radioimmunoassay techniques.
3. Estimation of certain biomolecules using spectrophotometry
4. Computation of average, variances, standard deviation.
5. Regression analysis and fitting straight line for a bivariate data.
6. Students't test, chi-square test and computation of ANOVA for one-way.
7. Retrieval of DNA sequences and alignment.

#### **Recommended Books and References:**

1. Norman G. R and Striner D.L (2014) Biostatistics: The bare essentials, 4<sup>th</sup>Edn., PMPH-USA Limited.
2. Wilson K. and Walker J. (2010) Principles and Techniques of Practical Biochemistry, Cambridge University Press.
3. Nelson and Cox (2013) Lehninger Principles of Biochemistry, 6<sup>th</sup>Edn.
4. Marc M. Triola M.D and Tiola (2009) Biostatistics for the biological and health sciences: Books a La Carte Edn. Prentice Hall College Div.
5. Plummer D.T. (2008) Introduction to Practical Biochemistry, 3<sup>rd</sup>Edn., Tata McGraw Hill.
6. Baxevanis A.D. and Ovellette B.F.F (2002) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Willey-Interscience.
7. Hayat M.A (2000) Principal and Techniques of Electron Microscopy: Biological Application, 4<sup>th</sup>Edn. Maniatis T. et al. (1982) Molecular Cloning. A Laboratory Manual. Cold Spring.
8. Rodney F. Boyer (2000) Modern Experimental Biochemistry 3<sup>rd</sup>Edn., Prentice Hall.
9. Elston R.C. and Johnson W.D. (1994) Essential Biostatistics 3<sup>rd</sup>Edn., Prentice Hall.
10. Elston R.C and Johnson W.D. (1994) Essential Biostatistics, 2<sup>nd</sup>Edn. F.A Davis Company, USA.
11. Switzer R.L. and Garrity L.F (1999) Experimental Biochemistry. 3<sup>rd</sup>Edn.
12. Stiles et al. (1991) basic and clinical Immunolgy, Prentice- Hall international inc.
13. Murad H. and Antique M.V.A.(1991). Biological Techniques in electron Microscopy, CBS publication.
14. Rao C.D.R., Mitra S.K., Mathai A. and Ramamurthy, K. G. (1985) Formulae and Tables for statistical Work, Statistical Publishing Society, Calcutta.
15. Fisher R.A (1970) Statistical Methods for Research Workers. Hafner Press, new York.

## SEMESTER – III

### MZOC 3.11

#### ENDOCRINOLOGY AND REPRODUCTIVE BIOLOGY

*Theory Credit: 4*

- UNIT I** Hormones as chemical messengers: endocrine, paracrine and autocrine hormones; Neuroendocrine system in vertebrates; structure and function of the hypothalamus; hypothalamic hormones; Hormonal feedback mechanism; chemistry and biosynthesis of hormones; steroid hormones, Thyroid hormones and melatonin; Metabolism of hormones.
- UNIT II** Hormone receptors: Characteristics and types of receptors: Membrane-bound receptors and intracellular receptor recycling; Hormone-receptor complex and signal transduction mechanism ; Mechanism of action of peptide/protein and steroid hormones
- UNIT III** Structure and functions: Renin-Angiotensin system (RAS); Erythropoietin; Atrial natriuretic peptides: ANF; Thymosins; Growth factors; Insulin & glucagon in glucose homeostasis; Hormonal regulation of oxidative metabolism in vertebrates; Hormonal regulation of calcium homeostasis in blood.
- UNIT IV** Hormones and reproduction : Seasonal and continuous breeders; Estrous and Menstrual cycle and their regulation by hormones ; Hypothalamo-hypophyseal-gonadal axis; Photoperiodic regulation of breeding cycle of vertebrates; Hormonal regulation of reproductive behaviour in vertebrates ; Contraceptive methods for male and females.

### MZOC 3.12

#### ENDOCRINOLOGY AND REPRODUCTIVE BIOLOGY

*Practical Credit: 2*

1. Study of endocrine glands in albino rat/mouse using charts/models/computer software (s).
2. Histological study of endocrine glands (thyroid, adrenal, testis and ovary) using charts/models/computer software(s).
3. Castration in albino rat/mouse.
4. Study of estrous cycle in albino rat/mouse.
5. Comparative study of male and female reproductive organs of vertebrates using charts/models/computer software(s).

#### **Recommended Books and References:**

1. Bentley P.J. (1998) Comparative Vertebrate Endocrinology, Cambridge University Press.
2. Charles G.D and Marshall N.J. (2001) Essential Endocrinology, 4<sup>th</sup>Edn., Blackwell Science, London.
3. Covacs W.J and Odeja S.R. (2011) Textbook of Endocrine Physiology, 6<sup>th</sup>Edn., Oxford University Press, New York.
4. Gorbman A., Dickoff W.W., Vigna S.R., Clark N.B and Ralph C.L (1983) Comparative Vertebrate Endocrinology, Wiley International.

5. Hadley M.E. (2000) Endocrinology (5<sup>th</sup>Edn, Prentice Hall Internal, Inc.
6. Hadley M.E and Levine J.E. (2007) Endocrinology, Pearson Prentice Hall.
7. Jones R.E (1997) Human Reproductive Biology, Academic Press, London.
8. Larsen P.R., Kronenberg H.M, Melmed S. and Polonsky K.S (2011) Williams Textbook of Endocrinology, 12<sup>th</sup>Edn., W.I Saunders Company.
9. Martine C.R (1985) Endocrine Physiology, Oxford University Press, London.
10. Norris D.O. and Carr J.A (2013) Vertebrate Endocrinology, 5<sup>th</sup>Edn., Academic Press.
11. Norman W.A and Litwack G. (1997) Hormones, 2<sup>nd</sup>Edn., Academic Press.
12. Turner C.D and Bangnara J.T. (1976) General Endocrinology, W.B. Saunders Company.
13. Nelson R.J. (2011) An Introduction to behavioral Endocrinology, Sinauer Associates, inc, Publishers.

### **MZOC 3.21**

#### **AQUATIC BIOLOGY AND FISHERIES**

*Theory Credit: 4*

**UNIT I** Aquatic resources: Water as an environment for aquatic communities; environmental stress and global water balance; conservation management and recharge of aquatic resources and harvesting of rain-water.

Aquatic ecosystems: Classification and diversity; characteristics of lentic, lotic and ground water ecosystems; lake basins and their origin.

Abiotic factors: Light, temperature and thermal stratification; ionic concentrations and meromixis; pH and carbonate system; dissolved oxygen and nutrients.

Aquatic Biocoenosis: Composition of aquatic communities, Functional components – plankton, nekton, neuston, periphyton and benthos and their role. Different systems of classification of planktons

**UNIT II** The river continuum concept: Stream orders and biotic community structure, structural adaptations to fast-flowing waters; river-lake continuum concept.

Cyclomorphosis: Theories and adaptive significance; visible and invisible predation, predation avoidance, costs of cyclomorphosis.

Aquatic productivity: Biomass and production; primary production and its assessment secondary production and its assessment.

Eutrophication; Process, Causes and impacts on aquatic biota point source and non-point source pollution; restoration of lacustrine and riverine systems.

National river action plan.

Bio-monitoring: Assessment criteria; biological water quality evaluation; bio-indicator species and biotic inducers.

**UNIT III** Aquaculture: Principles and types of aquaculture production of fish, crustaceans, molluscs and seaweeds in India.

Aquaculture potential: Scope of freshwater, brackish water and marine aquaculture in India. Commercially important freshwater, brackish water and marine fishes of India.

Fish –farm management: Construction and management of nursery, rearing and stocking ponds, and their economic viability.

### **MZOC 3.22**

#### **AQUATIC BIOLOGY AND FISHERIES**

*Practical Credit: 2*

1. Determination of percentage saturation of dissolved oxygen.
2. Estimation of free carbon dioxide of water samples.
3. Estimation of total alkalinity.
4. Estimation of total hardness of water samples.
5. Estimation of calcium and magnesium hardness.
6. Estimate of chloride content of water samples.
7. Study of penetration of light in an aquatic ecosystem.
8. Estimation of total solids and dissolved solids of water samples.
9. Estimation of primary production (light and dark bottle method) in an aquatic ecosystem.
10. Qualitative analysis of planktonic communities in a water body.
11. Quantitative analysis of planktonic communities in a water body.
12. Analysis of aquatic communities in a Hill-stream.
13. Analysis of morphometric variations in commonly available fish species.
14. Analysis of meristic variations in commonly available fish species.
15. Analysis of length-weight relationships in a commonly available fish.
16. Analysis of gut content of commonly available fish.
17. Analysis of condition factor or Ponderal Index of a commonly available fish.
18. Qualitative and quantitative analysis of plankton of nursery, rearing and stocking ponds.

#### **Recommended Books and References:**

1. Jeffries M. and Mill D.F. (1992) Freshwater Ecology, CBS Publishers and Distributer (P) Ltd.
2. Moss B. (1998) Ecology of Freshwaters: Main and Medium, past to future, 3<sup>rd</sup> edition. Blackwell Science Publications.
3. Wetzel R.G. (2001) Limnology: Lakes and River Ecosystems, 3<sup>rd</sup> edition. Academic press.
4. Goldman, C.R and Horne, A.J. (1983) Limnology, McGraw-Hill International Book Company.
5. Sugunam V.V, and Bhaumik, U. (1990) Technologies for Inland Fisheries Development, Central Inland Capture Fisheries Research Institute.
6. Kumar S. and Tembhire M. (2011) Fish and Fisheries, New Central Book Agency (P) Ltd. (NCBA).
7. Ahmad S.H. and Singh A.K. (2011) Freshwater Aquaculture, Daya Publishing House, New Delhi, India.
8. Jhingran V.G. (2007) Fish and Fisheries of India, 3<sup>rd</sup>edn., Hindustan Publishing Corporation, India.
9. Talwar P.K. and Jhingran V.G. (1991) Inland Fisheries of India and Adjacent Countries, Oxford and IBH Publishing Co. Pvt. Ltd.

### **MZOO 3.11**

#### **ANIMAL DIVERSITY**

*Theory Credit: 4*

**UNIT I** Biodiversity: Concepts of Biological diversity, mega-diversity centers; global biodiversity hot-spots; biodiversity convention; Ramsar convention and Ramsar sites. Animal diversity: Global perspective; diversity in time and space; zoogeography and zoogeographical realms.

- UNIT II** Conventional and recent systems of classification.  
 Animal diversity in India: General profile of faunal resources; endemic and threatened species.  
 Wild-life in India: important features and distribution.  
 Protected areas net-works: Biosphere reserves; national parks and sanctuaries.
- UNIT III** Animal diversity: Salient features and composition of life forms in terrestrial, desert and Caverniculous ecosystem.  
 Animal diversity: salient features and composition of like forms in freshwater, estuarine and marine ecosystems.  
 Adaptations in animal diversity: adaptations in desert, caverniculous and deep-sea life forms.  
 Animal diversity and human health: Important pathogenic life forms.  
 Animal diversity and human society: Ethnozoology and Zootheurpetics.
- UNIT IV** Conservation and management of wildlife: Principles of conservation; managing landscapes for wildlife.  
 Wildlife Health and diseases: Surveillance, investigation and management.  
 Human-wildlife conflicts; people's participation in managing protected areas.  
 Wildlife trade and laws: wildlife protection Act of India, CITES, RED Data Book, measure to control poaching and wildlife trade.

### **MZOO 3.12**

#### **ANIMAL DIVERSITY**

*Practical Credit: 2*

1. Study of invertebrates museum specimens (two examples from each phyla).
2. Study of vertebrates museum specimens (two examples from each class).
3. Mounting of mouthparts of common insects.
4. Mounting of Fish scaled.
5. Studies on the characteristic features of different social casts/types in honey bee/ants/termites using diagram/photographs.
6. Identify venomous snakes (Cobra,viper) using diagram/photographs/painting.
7. Isolation of DNA, amplification of specific region having taxonomic value (e.g., ITS-II) using PCR.

#### **Recommended Books and References:**

1. Krishnamurthy V.K (2003) Text Book of Biodiversity, Science Publisher, Chennai.
2. Rana S.V.S (2005) Essentials of Ecology and animal Science, Pretntice Hall of India Pvt. Ltd.
3. BotkinD. And Keller E. (2014) Environment science, John Willey and Sons. Inc., New York.
4. Handbook on convention on Biodiversity (2006). UNEP, Viva Books Pvt.Ltd, Kolkata.
5. Hill D., Fasham M., Grahm T., Shewary M. and Saw P. (2005) Handbook of Biodiversity Methods: survey, Evaluation and monitoring, Cambridge University Press.
6. Handbook on convention on Biodiversity (2006), UNEP, Viva Books Pvt. Ltd. Kolkata.
7. Silvy N.J (2012) the wildlife Technique Manual, vol.2: Management, 7<sup>th</sup> edition. Edn. John Hopkins Univ. Press.
8. Sharma B.D. (1999) Indian Wildlife Resources, Ecology and Development, Daya Publishing house, Delhi.
9. Hudson P.J., Rizzoli A., Grenfell B.T., Heestrbeek H. and Dobson A.P (2002) The Ecology of Wildlife Disease, Oxford Uni. Press, Oxford.

10. Sanderson J. and Moulton M. (1998) Wildlife issues in a changing world, CR Press.
11. Kotwal P.C., Banerjee S. (1998) Biodiversity Conservation in Managed and Protected Areas, Agro-bios India.
12. Singh K. (1998) Handbook of Environment, Forest and Wildlife Protection Laws in India, Natraj Publishers, Dehradun.
13. Arora B.M (2007) Rehabilitation in wildlife Mamalia and Conservation, AIZ and WV, Bareilly.
14. Jim C. (2007) The Temple Tiger, Oxford Univ. Press, New delhi.



## SEMESTER - IV

### MZOC 4.11

#### BIOSYSTEMATICS, EVOLUTION AND ECOLOGY

*Theory Credit: 4*

- UNIT I** Zoological classification: Theories of classification, merits and limitations; Linnean hierarchy, status and ranking of categories.  
Typification: Concepts of type and typification: zoological types, primary and secondary types.  
Zoological nomenclature: Objectives, basic and operative principles of nomenclature.  
International code of Zoological nomenclature (ICZN): salient features of different articles. Interpretation and application of important rules; formulation of scientific names of taxa of different species, intraspecific and higher category ranks.  
Species concepts: Species category, apomictic and panmictic species; Species concepts and their merits and limitations; subspecies other infra-specific categories and their validity.
- UNIT II** Theory of Natural Selection; synthetic theory.  
Genetic variations, genetic polymorphism; Kimura hypothesis-Neutral mutation.  
Evolution by duplication; Concept of molecular evolution: Molecular clock and molecular drive.  
Isolation mechanism and their role in evolution; implication of geographical distribution for mode of speciation.  
Ecological laws and rules; Shelford's law of Tolerance. Liebig's law of minimum and limiting factors.
- UNIT III** Biotic community: Species richness; frequency, density, relative abundance, species diversity, dominance, equitability and carrying capacity.  
Ecological niche: Concept, different niches, niche diversity and ecosystem heterogeneity.  
Population ecology: Concept and characteristics, natality and mortality, growth patterns, density dependent and density independent factors, population dispersal, distribution and aggregation; population interactions; Pauli's principles of competitive exclusion; predator-prey relationships, competition and population regulation; mutualism, commensalism, symbiosis and parasitism.  
Life history strategies-'K'; and 'r' selection; age and sex ratios.
- UNIT IV** Ecological succession: process, models and examples of ecological succession in terrestrial and aquatic ecosystems: types of community changes; concept of climax and ecosystem stability.  
Trophic dynamics: Elton's Principle of food size; energy flow and Lindemann's trophic dynamics concept;  
Productivity: concepts of production: assessment of primary productivity.

### MZOC 4.12

#### BIOSYSTEMATICS, EVOLUTION AND ECOLOGY

*Practical Credit: 2*

1. Identification and classification of aquatic microorganisms.
2. Extraction, identification and classification of soil micro-invertebrates.

3. Identification and classification of amphibian.
4. Analysis of morphometric variations in selected natural populations.
5. Preparation of taxonomic keys for identification of the studied organisms.
6. Analysis of pH and specific conductivity of soil samples
7. Analysis of moisture content of different types of soil.
8. Study of temperature profile of soil layers.
9. Estimation of the organic carbon of soil samples.
10. Estimation of the nitrate content of soil.
11. Estimation of the phosphate content of soil.
12. Estimation of population size of a known sample.
13. Estimation of population size of an unknown samples.
14. Estimation of biomass in a terrestrial ecosystem.
15. Analysis of species diversity in a natural community.

**Recommended Books and References:**

1. Ridley M (2004) Evolution, Blackwell Science Ltd. USA.
2. Randall T.S (2000) Biological Systematics: Principles and Applications, Cornell University press, USA.
3. Minelli A. (1993) Biological Systematics, Chapman & Hall.
4. Quicke D.L.J (1993) Principles and Techniques of contemporary Taxonomy, Blackie Academic & Professional.
5. Cian M.L bowman W.D and Hacker S.D. (2008) Ecology, sinauer Associates, Inc., Sunderland, Massachusetts.
6. Smith T.M and Smith R.L (2006) Elements of Ecology, 6<sup>th</sup>Edn, Pearson education Inc.
7. Odum .E.P. (1996) Fundamentals of Ecology 3<sup>rd</sup>Edn., W.B. Saunders Company.
8. Kormondy.E.J. (200). Concepts of Ecology 4<sup>th</sup>Edn. Prentice Hall of India Pvt. Ltd.
9. Smith .R.L (1974). Ecology and Field Biology 2<sup>nd</sup>edn..Harper & Row Publishers.
10. Jeffery C. (1980) biological Nomenclature, Oxford & IBH Publishing Company.
11. Mayer E. (1980) Principles of Systematic, Addison Wasley Publishing Company, Inc.
12. Vole E.P (1989) Understanding evolution, universal book Stall, NewDelhi.

**MZOC 4.21(a)**

**BIOCHEMICAL ADAPTATION AND METABOLIC REGULATION**

*Theory Credit: 4*

- UNIT I** Concept of stress resistance, stress avoidance, and stress tolerance; elastic and plastic train.  
 Biochemical adaptation: Basic mechanisms, adaptive changes in enzyme machinery, time courses of biochemical adaptation compensatory and exploitative adaptation; acclimation and acclimatization.  
 Biochemical adaptation to heat and cold (structural and rate effects), endothermy, ectothermy and metabolic regulation of body temperature.  
 Biochemical adaptation to oxygen deficient stress, oxygen sensing and signal transduction in metabolic defense against hypoxia.
- UNIT II** Mechanism of enzyme catalysis: Proximity and orientation effect, acid-base, covalent and metal ion catalysis; catalytic action of chymotrypsin.  
 Enzyme activity regulation by non-covalent modification; phosphorylation and dephosphorylation; proteolysis; calmadulin; multiple regulatory mechanisms of enzyme activity. Folding and unfolding of enzymes, enzyme denaturation.

Enzyme turnover, kinetics and calculations related to enzyme kinetics; measurement of rates of enzyme turnover; determination of  $K_s$  and  $K_d$ .

**UNIT III** Amino acid synthesis and regulation.

Nitrogen metabolism : ammonia production, utilization, ammonia toxicity and detoxification; ornithine-urea cycle and its regulation; different isoforms of carbamyl phosphate synthases; genetic defects in ornithine-urea cycle; urea cycle; uric acid synthetic pathway ; uricolytic pathway.

Evolutionary significance of nitrogen metabolism in animals.

**UNIT IV** Metabolic regulation of; Glycolytic pathway; TCA cycle; oxidative phosphorylation; Glycogenesis and glycogenolysis ; gluconeogenesis; HMP shunt pathway; Akt and MAP Kinase pathways with reference to regulation of carbohydrate metabolism.

**MZOC 4.21(A)**

**BIOCHEMICAL ADAPTATION AND METABOLIC REGULATION**

*Practical Credit: 2*

1. Estimation of proteins in fish tissue.
2. Estimation of amino acids in fish tissue.
3. Estimation of sugars in fish tissue.
4. Estimation of ammonia in fish tissue.
5. Estimation of urea in fish tissue.
6. Assay of arginase enzyme and determination of tissue and specific activity.
7. Determination of  $K_m$ ,  $K_i$  and  $V_{max}$  for arginase enzyme.
8. Study the effect of pH on arginase activity.
9. Study the effect of temperature on arginase activity.
10. SDS-gel electrophoresis of proteins.
11. Western blot analysis of a specific protein.
12. Extraction of RNA from an animal tissue and RT-PCR analysis of a specific gene.

**Recommended Books and References:**

1. Nelson D.L., Cox, M.M (2013). Lehninger Principle of Biochemistry, 6<sup>th</sup>edn., Woth Publishers, New York.
2. Moran L.A. et al. (2011). Principles of Biochemistry, 5<sup>th</sup>edn., Prentice Hall, USA.
3. Cooper G.M and Hausman R.E. (2009). The Cell: Molecular Approach, 5<sup>th</sup>edn., ASM Press, USA.
4. Metzler D.E. (2005). Biochemistry, vol. 1 and 2, 3<sup>rd</sup>edn. Academic Press, New York.
5. Rawn J.D. (2004) Biochemistry, Panima Publishing Corporation, new Delhi.
6. Berg J.M., Tymoczko J.L. and Stryer L. (2010) 7<sup>th</sup>edn., H. Freeman and Company, USA.
7. Muray R.K. et al. (2012) Harpers Illustrated Biochemistry 29<sup>th</sup>edn. McGraw Hill, London.
8. Hochachka P.W., Somero, G.N. (1985) biochemical adaptation, princiton University Press, new Jersey.
9. Prosser C.L. (11986) Adaptational Biology: Molecules to organisms, John Wiley & Sons, New York.
10. Plummer L. (1989) Practical Biochemistry, Tata McGraw-Hill, New Delhi.
11. Wilson K., Walker, J. (1994) Practical Biochemistry, Cambridge.
12. Switzer R.L. Garry L.F. (1999) Experimental Biochemistry, 3<sup>rd</sup>Edn.
13. McPherson H.J., Moller S.G (2006) PCR, 2<sup>nd</sup>edn., Taylor & Francis.
14. Sadasivam S., Manickam, A. (1996) Biochemical Methods, New Age international, New Delhi.

**MZOC 4.21(b)**  
**FISH BIOLOGY**

*Theory Credit: 4*

- UNIT I** Taxonomy and biodiversity: Classification of living fishes (up to order); fish diversity in India; status of indigenous and exotic species; conservation of fish germplasm.  
Body forms and locomotion: Morphological adaptations to deep sea, riverine, hill stream and caverniculus environments; fins and muscles: types and mechanisms of locomotion.  
Feeding and digestion: Food and feeding habits; modification of alimentary canal and associated organs; process of digestion.  
Circulation: Heart and circulatory system; composition of blood.
- UNIT II** Respiration: Mechanism of gaseous exchange, transport of oxygen and carbon dioxide; accessory organs; structure and function of air bladder; physiological adaptations in air-breathing fishes.  
Excretion and osmoregulation: Types of excretion and regulation; osmotic regulation: Salt and water balance in freshwater, marine and brackish water fishes; acid-base balance.  
Nervous system: Structure and major function of brain; cranial nerves and their function; sense organs; chemoreceptors, electroreceptors and acoustic-lateralis system.  
Endocrine gland and hormones: Hypothalamo-hypophyseal complex; gonadal steroidogenesis and its control; environment control of gonadal maturation.
- UNIT III** Reproduction and gametogenesis: Reproductive system in teleosts; sexual maturation and breeding cycle; spermatogenesis, oogenesis and vitellogenesis; fecundity, growth and development.  
Nutrition: Nutritional requirements; nutrient bioenergetics.  
Methods of fish preservation and fish by-products.  
Diseases: Fungal, bacterial, protozoan and metazoan diseases; nutritional disorders.  
Immune defense: Types of antibodies in fishes.
- UNIT IV** Genetics: Polyploidy, hybridization, gynogenesis, androgenesis, inbreeding, gene transfer; Sex reversal.  
Biotechnology: Transgenic species; cryopreservation.  
Ethology: Foraging, reproductive behaviour and parental care.  
Toxicology: Pollutants and their effects.

**MZOC 4.22(b)**  
**FISH BIOLOGY**

*Practical Credit: 2*

1. Identification of freshwater fish species representing major orders.
2. Analysis of morphometric variations in teleosts.
3. Analysis of meristic variations in teleosts.
4. Length-weight relationship and K-factor.
5. Gonadosomatic index, absolute and relative fecundity.
6. Gastrosomatic index and gut content analysis.
7. Estimation of glycogen in fish tissues.
8. Estimation of protein in fish tissues.
9. Estimation of phospholipid in fish tissues.
10. Analysis of LDH isoenzymes using PAGE
11. Histology of gut, liver and kidney.

**Recommended Books and References:**

1. Kumar S. and Tembhire M. (2011) fish and Fisheries, New Central book Agency (P) Ltd. (NCBA).
2. Ahmad S.H and Singh A.K (2011) freshwater Aquaculture, Days Publishing, House, New Delhi India.
3. Jhingran V.G (2007) Fish and fisheries of India, 3<sup>rd</sup>edn. Hindustan Publishing Corporation, India.
4. Evan D. H. (2006) The Physiology of Fishes, CRC Press, Boca Raton, U.S.A.
5. Dhalakia A.D. (2004) Fisheries and Aquatic Resources of India, Daya Publishing House, Delhi.
6. Arratia G., Kapoor B.G., Chardon M. And Diago R. (2003) Catfishes (Vol.1 & II), Science Pub. Inc., USA.
7. Hart P. and Reynold J.D. (2002) Handbook of Fish Biology and Fisheries (Volumn I & II) Blackwell Publishing.USA.
8. Wright P. and Anderson P. (200) Nitrogen Excretion (In Fish Physiology, Vol. 21) Academic Press, USA.
9. Wootton R.J. (1994) Ecology of Teleost Fishes, Chaman and Hall. London.
10. Moyle P. B. And Cech J.J. Jr. (1988) Fishes: An Introduction of Ichthyology, Prentice Hall, New Jersey, USA.
11. Datta-Munshi J.S. and Hughes G.M) (1992) Air-breathing Fishes of India, Oxford and IBH Publ. Co., New Delhi.
12. Matty A.J. (1995) Fish Endocrinology, Croom Helm Ltd. Australia.
13. Lagler K.F., Bardach J.E., Miller R.R and passion D.M (1977) Ichthyology, John Wiley and Sons.

**MZOC: 4.21(c)**  
**ENTOMOLOGY**

*Theory Credit: 4*

- UNIT I**      Origin and evolution of insects; Theories; classification of insects (up to orders with characters and examples). Insect biodiversity and biogeography. Insect life history patterns; voltinism; diapause; polymorphism and polyphenism; environmental effect on development.

Wings: Structural variations and venation: mouthparts –structure and variations; genitalia-structure and variations.

Eusocial insects from Hymenoptera and Isoptera; life cycle and development; polyethism in bees and mechanism of caste differentiation.

**UNIT II** Structure of insect integument; chemistry and functions of various components of cuticle: Sclerotization in cuticle.

Types and functions of hemocytes; chemistry and function of hemolymph.

Innate immunity in insects: role of hemocytes; antimicrobial peptides in insects.

Glycerol-3-phosphate shuttle in flight muscles; proline metabolism; trehalose metabolism.

**UNIT III** Ecdysteroids: Biosynthesis and mode of action.

Embryonic development; three patterns of insect development; types of insect metamorphosis; molting process and the formation of new cuticle; hormonal control of moltings and metamorphosis. Diapause and its hormonal control.

**UNIT IV** Useful insects: silkworm –*bombyx* sp., *Antheraea* spp., *Philosamia* sp., honey bees – *Apis* spp., *trigona* sp. and lac insect –*kerria* laca; insects as pollinators.

Insect pest management: Concepts of Insect pest; chemical control – use of parasites, predators and pathogens; concept of IPM, pheromones and insect attractants; major insect pests of crops- *Helicoverpa armigera*, *Scirpophaga incertulas*, *Dicladispa armigera*, *Sesamia inferens*, *Leucinodes orbonalis*, *Plutella xylostella*, *Spodoptera litura*-their control measures

Medical entomology- Venoms and allergens; insects as causes and vectors of diseases.

#### **MZOC 4.22 (c) ENTOMOLOGY**

*Practical Credit: 2*

1. Study of morphology of grasshopper to show various organs.
2. Study of human body louse, dog's louse and cat flea from permanent slides.
3. Study of museum specimens representing major insect's orders.
4. Preparation of external genitalia of grasshopper, cockroach and housefly.
5. Study of different mouth parts, legs, antennae and wings in household, agricultural and medically important insects like aphids, housefly, honey bees, cockroach, mosquito.
6. Techniques of insect collection, data recording; preservation and display of insects.

#### **Recommended Books and References:**

1. Chapman R.F. (2012). The Insect Structure and Function, ELBS 5<sup>th</sup>Edn. The English Univ. Press, London.
2. Blum M.S (1985) Fundamental of Insect Physiology, John Wiley and Sons.
3. Imms A.D. (1977). A General textbook of entomology, 10<sup>th</sup>Edn. Methuen & Co. London.
4. Gullan P.J and Cranston P.S (2010) The Insects : An Outline of Entomology. Wiley-Blackwell.
5. Hermes, W.B. (1995) Medical and Veterinary Entomology. CAB International U.K.
6. Hermes, W.B. (1950) Medical Entomology, Macmillan and Co. NY.
7. Hill D.S (1994) Agricultural Entomology, Oregon Timber Press.
8. Ramakrishnan, T.V. (1984). Handbook of Economic Entomology of South India, International Books and Periodicals Service India.
9. Lamb. K.P (1974). Economic entomology in the tropics, London, Academic Press.
10. Abhrol D.P (2009) Bees and Bee Keepings in India, Kalyani Publishers, New Delhi.

**MZOC 4.21 (d)**  
**LIMNOLOGY**

*Theory Credit: 4*

- UNIT I** Limnology: Objectives, status and scope; concepts of applied limnology and palaeo-limnology; developments in limnology in India.  
Inland aquatic environs: Diversity of ecosystems, salient features of wetlands, lentic and lotic ecosystems; groundwater.  
Limnological methods: Techniques for qualitative and quantitative sampling of aquatic communities in ground water, running water and lacustrine systems.
- UNIT II** Water movement : Surface and internal water movements in standing water, wind action and surface waves; role of water movements in cycling of nutrients.  
Light: Significance and nature of light; colour of natural water; turbidity; factors effecting light penetration; temporal variations in transparency.  
Temperature: Thermal stratification-significance, stability and process of mixing ; lake typology. Meromixis and its causes.  
Ionic spectrum: Specific conductance and salinity; distribution of conservative and dynamic ions in inland water; cation-anion ratio in natural water.
- UNIT III** Dissolved oxygen: Factors influencing solubility of oxygen: distribution of dissolved oxygen and lake typology; metalimnetic oxygen maxima and minima; hypolimnetic oxygen deficit. Carbonate system: Fate and distribution of inorganic carbon in freshwater, hypolimnetic accumulation of carbon dioxide.  
Fate of major nutrients: Importance, occurrence, distribution and utilization of phosphorus, nitrogen and silica; micronutrients as limiting factors.  
Water and human health: Water-borne diseases, their general impact and control.
- UNIT IV** Biomonitoring of inland water: Concepts of biomonitoring, bio-indicators and biotic indices. The Ganga action plan.  
Eutrophication: Causes, consequences and management (guidelines for choosing alternatives and management plan; point-source and non-point source management).  
Waste water:Limnological characteristics; waste stabilization ponds and their role in waste stabilization.  
Treatment of wastewaters; Mechanical, biological and chemical treatment alternative systems of treating raw sewage; reclamation and harvesting of water from sludge.

**MZOC 4.22(d)**  
**LIMNOLOGY**

*Practical Credit: 2*

1. Analysis of dissolved oxygen, BOD, free  $\text{CO}_2$ , dissolved organic matter.
2. Analysis of pH, conductivity, alkalinity, hardness
3. Estimation of calcium and magnesium.
4. Estimation of chloride and sulphate contents.
5. Estimation of phosphate, nitrate and silicate contents.
6. Analysis of aquatic communities of a pond ecosystem.
7. Analysis of aquatic communities of a lacustrine ecosystem.

8. Analysis of aquatic communities of a lotic ecosystem
9. Determination of biomass of algae and zooplankton species.
10. Determination of species richness and similarities of communities.
11. Determination of species diversity, equitability and dominance of selected communities.

***Recommended Books and References:***

1. Allan J.A. (1995) Stream Ecology; Structure and function of running waters. Chapman & Hall.
2. Jefferies M. And Mills D. (1992) Freshwater-ecology, CBS Publishers.
3. Kalff (2002). Limnology, Prentice-Hall.
4. Goldman C.R. and Horne A.J (1983). Limnology, McGraw-Hill International
5. Moss B. (1988) Ecology of Freshwaters, Blackwell Scientific Publications.
6. Payne A.I (1986) The Ecology of Tropical Lakes and Rivers, John Wiley & Sons.
7. Wetzel R.G (2001). Limnology: Lakes and River ecosystems, Academic Press.
8. Wetzel R.G and Likens, G.E (2000) Limnological Analysis, Springer-Verlag.
9. Wetzel R.G (1983) Limnology, Saunders College Publishing.