KOHIMA SCIENCE COLLEGE

(An Autonomous Government P.G. College)

JOTSOMA, NAGALAND

Revised

SYLLABI OF M.SC. PROGRAMMES

Under UGC CBCS Guidelines

2019

CONTENT

M.Sc.		
SL.	**DEPARTMENT**	**PAGE**
1.	Anthropology	MAN - 1
2.	Botany	MBO - 1
3.	Chemistry	MCH - 1
4.	Geology	MGL - 1
5.	Mathematics	MMA - 1
6.	Physics	MPH - 1
7.	Zoology	MZO - 1

SCHEME FOR CHOICE BASED CREDIT SYSTEM

M.Sc. (All Departments)

SEMESTER	CORE COURSE	CREDITS	DISCIPLINE SPECIFIC ELECTIVE (DSE)	CREDITS
I	Core 1	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	---	---
	Core 2	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	---	---
	Core 3	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	---	---
	Core 4	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	---	---
II	Core 5	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	---	---
	Core 6	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	---	---
	Core 7	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	---	---
	Core 8	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	---	---
III	Core 9	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	DSE 1	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)
	Core 10	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	DSE 2 / Field Work	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial) *OR* 6 (Field Work)
IV	Core 11	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	DSE 3	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)
	Core 12	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial)	DSE 4 / Dissertation	4 (Theory) + 2 (Practical) *OR* 5 (Theory) + 1 (Tutorial) *OR* 6 (Dissertation)

a) Total Credits – 96 (24 credits per semester)
b) Each theory paper has 5 (five) units.
c) Contact Hours – 75 (15 per unit) per theory paper.
d) DSE – Discipline Specific Elective / Specialization

M.Sc.

SYLLABUS FOR
Master of Science

ANTHROPOLOGY

Under CBCS guidelines

COURSE STRUCTURE

SEMESTER	COURSE CODE	COURSE TITLE	CREDITS
I	MANC 1.11	Fundamental issues in Physical Anthropology	4
	MANC 1.21	Society and Culture; Foundation course	5+1
	MANC 1.31	Fundamentals of Archaeological Anthropology	4
	MANC 1.41	Anthropology of NE India	5+1
	MANC 1.12	Physical Anthropology I (Practical)	2
	MANC 1.32	Fundamentals of Archaeological Anthropology (Practical)	2
II	MANC 2.11	Formal Genetics	4
	MANC 2.21	Museology and Cultural resource management	4
	MANC 2.31	Prehistoric and Early Human Cultures	5+1
	MANC 2.41	Research Method	4
	MANC 2.12	Physical Anthropology II (Practical)	2
	MANC 2.22	Ethnographic Museum Studies (Practical)	2
	MANC 2.42	Bio-statistical Practical (Practical)	2
		SPECIALIZATION	
III		**Specialization Physical/Biological**	
	MANC 3.11	Human Genetics and Variation	5+1
	MANC 3.21	Human Growth, Development & Nutrition	4
	MANC 3.22	Physical Anthropology III (Practical)	2
	MAND 3.11(a)	Medical Genetics	5+1
	MAND 3.11(b)	Physiological Anthropology	5+1
	MAND 3.11(c)	Palaeoanthropology	5+1
	MAND 3.21(a)	Kinantropometry & Ergonomics	5+1
	MAND 3.21(b)	Forensic Anthropology & Criminology	5+1
	MAND 3.21(c)	Environmental Archaeology (Bio-archaeology)	5+1
		Specialization Social/Cultural	
	MANC 3.31	Urban Anthropology	4
	MANC 3.41	Ethnography: Theory & Methods	5+1
	MANC 3.32	Urban Anthropology (Practical)	2
	MAND 3.31(a)	Development Anthropology	5+1
	MAND 3.31(b)	Study of Monograph	5+1
	MAND 3.31(c)	Visual Anthropology	5+1
	MAND 3.41(a)	Gender Studies	5+1
	MAND 3.41(b)	Anthropological Theories	5+1
	MAND 3.41(c)	Medical Anthropology	5+1
IV		**Specialization Physical/Biological**	
	MANC 4.11	Human Population Genetics	5+1
	MANC 4.21	Anthropological Demography	5+1
	MAND 4.11	Fieldwork	5+1
	MAND 4.21	*Dissertation and Viva Voce	5+1
		Specialization Social/Cultural	
	MANC 4.41	Demographic Studies	5+1
	MANC 4.51	Anthropology of India	5+1
	MAND 4.11	Fieldwork	5+1
	MAND 4.21	*Dissertation and Viva Voce	5+1

*Theoretical & methodological preparation for this paper begins in the 3rd semester. Supervisors for this paper are allotted in the beginning of the 3rd semester, & the students leave for fieldwork training soon after the 3rd semester examination.

SEMESTER - I

MANC 1.11
FUNDAMENTAL ISSUES IN PHYSICAL ANTHROPOLOGY

Theory Credit: 4

This paper aims to impart knowledge on the fundamental issues of biological anthropology. 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 History and development of physical anthropology. Current trends of Physical anthropology with reference to India.

UNIT II Evolution: a) theories of evolution (Larmarckism, Neo-Larmarckism, Darwinism, Neo-Darwinism, Synthethic theory), microevolution and macroevolution, evidences for human evolution.
b) Processes and principles of human evolution: Parallelism and convergence, morphology and speciation, irreversibility, adaptive radiation in primates, orthogenesis, cladogenesis.

UNIT III Distribution, classification and characteristics of living primates. Comparative anatomy of man and non-human primates with special reference to skull, pelvis, dentition and long bones. Evolution of brain and senses, Non human primate behavior.

UNIT IV Human evolution with respect to hominoid fossil.

UNIT V Concept of Race, historical development, formation and criteria of racial classification. Racial classification of Hooton's, Deniker's, Coon, Garn and Birdsell's and Boyd's. UNESCO statement.

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*, 4th 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: Palaka Prakashan.
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.

MANC 1.21
SOCIETY AND CULTURE: FOUNDATION

Theory Credit: 5
Tutorial Credit: 1

UNIT I Emergence and formation of social-cultural anthropology; Basic orientations: Holism, Empiricism, Comparative method and Relativism

UNIT II Emerging area of study in socio-cultural anthropology:
Basic concepts - Applied anthropology, medical anthropology, ecological anthropology, communication anthropology, urban anthropology, development anthropology, business anthropology, feminist anthropology.

UNIT III Anthropological approaches to Religion and Magic: Evolutionary, psychological and functional with reference to the works of E.B Tylor, James Frazer, Emile Durkheim, Sigmund Freud, Karl Jung, Malinowski and E.E Evans Pritchard

UNIT IV 1.Political Organization: types of political organization: bands, tribe, state, kingship, chiefdom. Concept of authority and leadership, justice and redressal
2. Social stratification: slavery, estate, caste, class, rank and power.

UNIT V Assignments, quiz, oral tests/presentation, book readings based on the above UNITs as prescribed by the concerned teacher.

MANC 1.31
FUNDAMENTALS OF ARCHEOLOGICAL ANTHROPOLOGY

Theory Credit: 4

This paper deals with some core issues in archaeological anthropology, to establish the relationship of archaeological anthropology with earth sciences, physical and life sciences. It also focuses on locating archaeological sites, excavations, analysis, relevance of palaeo-environment and a practical component on lithic and bone tools to understand cultural processes and typo-technologies.

UNIT I Archaeology as anthropology, Branches of archaeology, Historical development of archaeology.

UNIT II Kinds of Archaeology: Basic concepts and relevance - Pre-historic archaeology, Proto-historic archaeology, Historic archaeology, Ethno-archaeology, experimental archaeology, salvage archaeology.

UNIT III Location and identification of archaeological sites, Method of excavations, Methods of recording. Interpreting archaeological materials - Subsistence pattern, settlement pattern and environment.

UNIT IV Dating methods: Chronometric dating – radio carbon, potassium-argon, thermoluminiscence, archaeomagnetic, dendrochronology, fission tract, obsidian hydration. Relative dating – stratigraphy, seriation, fluorine analysis and zonal concept.

UNIT V Palaeo-environment**:** Geological and archaeological time scales: Tertiary, Quaternary, Pleistocene (Glacial, Interglacial, Pluvial, Inter-pluvial) and Holocene

Recommended Books and References:

1. Andrefsky, Jr., W. *Lithic: Macroscopic Approaches to Analysis*. Cambridge University Press.
2. Binford, L. R. *An Archaeological Perspective*. Seminar Press
3. Brix, H. J. (Ed.). 21st Century Anthropology: A Reference Handbook. Sage Publications.
4. Brothwell, D., and E. Higgs. *Science in Archaeology*.
5. Butzer, K. W. *Environment and Archaeology*. Methuen and Co. Ltd.
6. Coles, J. M. & Higgs, E. S. *The Archaeology of Early Man*. Faber & Faber.
7. Cornwall, I. W. *Soils for Archaeologist*. Phoenix.
8. Daniel, G. *A Short History of Archaeology*. Thames and Hudson Ltd.
9. Gamble, C. *Archaeology: The Basics*. Routledge.
10. Hester, J. J. *Introduction to Archaeology*. Holt, Rinehart and Winston.
11. Hodder, I. & S. Hutson. *Reading the Past*. Cambridge University Press.
12. Jim, G., Gorin, S. and Flemin, N. *The Archaeology Course Book: An Introduction to Themes, Sites, Methods and Skills*. Routledge
13. Roskam, S. *Excavation*. Cambridge: University Press
14. Roy, I. B. *Anthropology the Study of Man*. S. Chand and Company Pvt. Ltd.
15. Sankalia, H. D. *Stone Age Tools: Their Techniques, Names and Probable Functions*. Pune: DCPRI.

MANC 1.41
ANTHROPOLOGY OF NE INDIA

Theory Credit: 5
Tutorial Credit: 1

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 Origin and growth of Physical, socio-cultural anthropology and Archeology in Northeast India: Pre-independence and post-independence scenario.

UNIT II ***Social/Cultural Anthropology:*** Orality and ethnic history of the Northeast; Kinship studies; Christianity and change; Ethnicity and identity; Social values, change and continuity. (With special reference to the state Nagaland)

UNIT III ***Physical Anthropology:*** Growth and development studies, Physical characteristics and variations, population genetics, demography and studies in the field of nutrition and health of NE India. (With special reference to the state Nagaland)

UNIT IV ***Archeology:*** Emerging trends of Archaeological anthropological studies in North east India. (With special reference to the state Nagaland)

UNIT V Assignments, Quiz, Oral test/presentation, Book readings based on the above UNITs as prescribed by the concern teacher.

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. *Garo and Khasi: 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. Jamir Moasangla, R. 2014. *Physical characteristics of the Nagas of Nagaland (Vol I): An Anthropometric & Anthroscopic study of the Angami, Ao, Chakhesang and Rengma tribes.* Heritage Publishing House, Dimapur.
18. Jamir Moasangla, R. 2014. *Physical characteristics of the Nagas of Nagaland (Vol II): An Anthropometric & Anthroscopic study of the Sumi, Lotha, Pochury, Konyak, Sangtam, Chang, Phom, Yimchunger, Khiamniungan and Zeliang tribes*. Heritage publishing house, Dimapur.
19. Aier Anungla.2018. *Studies on Oral Tradition (Vol I): Memories and telling of origin myth and migration.* Heritage Publishing House, Dimapur.
20. Jamir Tiatoshi, Vasa Ditamulu, Tetso David. 2014. *Archaeology of Naga ancestral sites: Recent Archaeological investigation at Chungliyimti and adjoining sites (Vol I).* Heritage Publishing House, Dimapur.
21. Jamir Tiatoshi, Tetso David, Venuh Zokho, Tripathy Mushrif Veena, Pokharia Anil K. 2014. *Archaeology of Naga ancestral sites: Recent Archaeological investigation in Phek and Kiphire districts of Nagaland (Vol II).* Heritage publishing house, Dimapur.
22. Nagi Kevilhuninuo.2018. *Traditional festivals of Nagaland (Vol-I).* Heritage Publishing House, Dimapur.

SEMESTER - II

MANC 2.11
FORMAL GENETICS

Theory Credit: 4

UNIT I History and development of human genetics, scope and its branches, relationship with other sciences

UNIT II Chemical aspects of genetics: Watson and Crick model, DNA, RNA, protein synthesis, Genetic code, Sex determination, Sex-abnormality, Lethal and sublethal genes.

UNIT III Human cytogenetic: Identification of human chromosomes, Chromosomal structure, Chromosomal polymorphism, karyotyping, nomenclature, autoradiography, banding techniques.

UNIT IV Chromosomal aberrations: Tunner's syndrome, Klinfelter's syndrome, Triple-x, Tetra-x, Down's syndrome, Patau's syndrome, Edward's syndrome, Structural-Cri-du-chat syndrome, Philadelphia chromosome.

UNIT V Translocations – Aerocentric, Ring chromosome, Isochromosome, Inversion, Mosaicism, Triploid and tetraploidy. Abnormal traits and diseases: syndactyly, polydactyly, achondroplasia, phenylketonuria, Disease association with blood groups (erythroblastosis fetalis, small pox, malaria, cancer, ulcer).

Recommended Books and References:

1. Curt Stern, Principles of Human Genetics
2. Niyogi and Srivastava, Human Genetics
3. E.A. Carlson, Human Genetics
4. N.V. Rothwell, Human Genetics
5. Mange and Mange, Basic Human Genetics

MANC 2.12
PHYSICAL ANTHROPOLOGY II (PRACTICAL)

Practical Credit: 2

UNIT I A) Genetic markers: ABO, Rh blood system, total haemoglobin estimation, Color blindness.
B) Pulse rate, body temperature, blood glucose test, blood pressure.

UNIT II Dermatoglyphics: Study and analysis finger ball pattern types, ridge counts, palmar main line and pattern indices.

Recommended Books and References:

1) Mukherji, D., D. Mukherjee and P. Bharti. 2009. *Laboratory Manual for Biological*
2) *Anthropology*. Asian Books Pvt. Ltd., New Delhi.
3) Das, B.M. and R. Deka. 1998. *Physical Anthropology Practical*. Kitab Mahal, Allahabad.
4) Singh I.P. and M.K. Bhasin. 1989. *A Laboratory Manual on Biological Anthropology:*
5) *Anthropometry*. Kamal-Raj Enterprises, Delhi
6) Cummins, H and C. Middlo. 1943. *Finger Prints, Palms and Soles: An Introduction to*
7) *Dermatoglyphics*. Blackistone Co., Philadelphia, USA.

MANC 2.21
MUSEOLOGY AND CULTURAL RESOURCE MANAGEMENT

Theory Credit: 4

UNIT I Museum – Definition, Historical background, Types of museum, Scope of Anthropological Museum

UNIT II Anthropological Theories on museum, Anthropological museums in India and in the North East India

UNIT III Systematic documentation of data – from field case to show case; preparation of index card; methods of arrangement and display.

UNIT IV Preservation – preventive and curative measure, brief ideas of the factors and agencies causing deterioration to the museum exhibits.

UNIT V Cultural Resource Management (CRM) AND Heritage Management:

a. Definition, meaning, concept and relevance of CRM, History and origin of CRM
b. Laws and Policy on CRM (important legislations, Rules and Acts) and Guidelines for preservation and Conservation of Monuments, Sites and Remains with special reference to India. Distribution of monuments in different geographical zones and their conservation problems.

Recommended Books and References:

1) Alkawali, Rosa Cabrera, Jeniffer Anderson. Last revised 6th May 2016; Last modified 11th January 2012. Museum Anthropology.
2) Anita Herle. University of Cambridge. 6th October 2016. Anthropology Museums and Museum Anthropology.
3) Ames, M. 1986. Museums, the Public and Anthropology: A Study in the Anthropology of Anthropology. Vancouver and New Delhi: University of British Colombia. Press and concept publishing company.
4) Clifford, J. 1988. On collecting art and culture. The predicament of culture: twentieth century ethnography, literature and art. Cambridge, press: Harvard University press.
5) Clifford, J. 1997. Museums as contact zones, four Northwest Coast Museums: travel reflections, routes: travel and translations in the late twentieth century. 188 – 219, 212 – 54. Cambridge, press: Harvard University press.
6) Agarwal, O.P. 1997. Care and Preservationof Museum objects. New Delhi: National Research Laboratory for conservations of cultural property.
7) Clure, Henry ed al. Archaeological Heritage Management in the modern world. London unwind – Hymen 1989.
8) Fowler, Don. Cultural Resources Management, "Advances in Archaeological methods and Theory." 5 (1982): 1 – 50.
9) Ambrose, Timothy& Paine, Crispin: Museum Basics (Heritage: Care-Preservation-Management)
10) Bedakar,V.H : New Museology
11) Folk, John. H, Lynn, D D: Learning from Museums
12) Ghosh,D: Studies in Museum and Museology
13) Gawel, Lukasz & Kocój, Ewa (Ed): Cultural Heritage (Management, Identity and Potential)
14) Greenhills,Eileen H: Museums and interpretation of Visual culture
15) Harrison, Richard & Butterworth: Heinemann (Manual of Heritage Management)
16) Lord, Barry: The Manual of Museum Exhibition
17) Messenger, Phyllis M &G. S. Smith (ed):Cultural Heritage Management-A Global Perspective (Cultural Heritage Studies)
18) Nigam,M : Fundamentals of Museology
19) Tilley,Chris, Keane,Webb, S.Küchler, M.Rowlands & S,Patricia: Handbook of Material Culture

MANC 2.22
ETHNOGRAPHIC MUSEUM STUDIES (PRACTICAL)

Practical Credit: 2

At the beginning of the Semester, the Supervisor in consultation with the Department may select/identify Museum objects for study. Students will be made to do a thorough study on the cultural implication/history/background of the selected Museum exhibits and prepare a full inventory along with photographs, life drawing/sketch. The student will write their report within a minimum of 3000 words under the guidance of the Supervisor and submit the same for evaluation.

MANC 2.31
PREHISTORIC AND EARLY HUMAN CULTURES

Theory Credit: 5
Tutorial Credit: 1

The main focus of this paper is to highlight the anthropological perspectives of archaeological materials in order to throw light on the emergence and evolution of human cultures.

UNIT I Lower Palaeolithic (Important sites and associated fossils) - Oldowan, Abbevillian, Clactonian, Acheulean and allied development in India.

UNIT II Middle Palaeolithic (Important sites) – Mousterian and Levalloisean development in Europe and India. Upper Palaeolithic art and cultures in Europe.

UNIT III Mesolithic cultures: Salient features – Europe and India and Early Holocene Cultures of South East Asia – (Ecological background, Hoabinhian culture).

UNIT IV Early farming cultures in – West Asia and India subcontinent (evidence from important excavated sites). Chalcolithic cultures in India (Ahar, Malwa, Jorwe). Harappan Civilization – (settlement pattern, trade and economy).

UNIT V Iron Age in India: Megalithic cultures in South India (distribution and typology), PGW and NBPW in North India (Hastinapur, Atranjikhere)
*****Assignment/ Presentation

Recommended Books and References:

1) Allchin, B. & F. R. Allchin. *Rise of Civilization in Indian in Indian and Pakistan*. Cambridge University Press.
2) Agarwal, D. P. *The Archaeology of India*. Curzon Press.
3) Banerjee. *Iron Age in India*. Munshiram Manoharlal.
4) Bhattacharya, D. K. *Outline of Indian Prehistory*. Palaka Prakashan.
5) Bhattacharya, D. K. *Prehistoric Archaeology*. Hindustan Publishing Corporation.
6) Bhattacharya, D. K. *Emergence of Cultures in Europe*. B. R. Publishing Corporation.
7) Bhattacharya, D. K. *Palaeolithic Europe*. Netherlands Humanities Press.
8) Clark, J. G. D. *Mesolithic Settlement of Northern Europe*. Cambridge University Press.
9) Cole, S. *The Neolithic Revolution*. British Museum.
10) Ember, C. R., M. Ember & P. N. Peregrine. *Anthropology*. Pearson Prentice Hall of India Pvt. Ltd., New Delhi
11) Fagan, B. M. and N. Durrani. *People of the Earth: An Introduction to World Prehistory*. Routledge.
12) Phillipson, D. W. *African Archaeology*. Cambridge University Press.
13) Reddy, R. *Elements of Prehistory*. South Asia Books.
14) Reddy, R. *Neolithic and Post-Neolithic Cultures*. Mittal Publication.

15) Roy, I. B. *Anthropology the Study of Man*. S. Chand and Company Pvt. Ltd.
16) Sankalia, H. D. *Pre and Proto-history of India and Pakistan*. Pune: DCPGRI.
17) Scupin, R. and C. R. DeCorse. *Anthropology: A Global Perspective*. Pearson.

MANC 2.41
RESEARCH METHODS

Theory Credit: 4

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
A) Data Collection: Observation, interview, questionnaire, Survey methods and Sampling techniques; Case studies; Focus group discussion; Oral narratives; Literature review and Bibliography.
B) 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 IV Ethics and politics in Research:
1. Ethical importance of consent, privacy and confidentiality in research
2. Issues of academic fraud and plagiarism, conflicts of interest, authorship and Publication.

UNIT V 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 Khiamniungan 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.

MANC 2.42
BIO STATISTICAL PRACTICAL (PRACTICAL)

Practical Credits: 2

Measures of central tendency and dispersion, test of significance, analysis of variance and correlation based on hypothetical data.

1. Odds ratios and confidence intervals.
2. The use of various statistical software like SPSS, Stata, Statistica, etc. for data entry and analysis of biological epidemiological and clinical data.

Recommended Books and References:

1) Altman, D. G. 1991. *Practical Statistics for Medical Research*. London: Chapman and Hall.
2) Brown, B.W. and M. Hollander. 1977. *Statistics: A Biomedical Introduction*. New York: John Wiley & Sons.
3) Cochran, W.G. 1977. *Sampling Techniques. New York:* John Wiley & Sons.
4) Daniel, W.W. 1999. *Biostatistics.* New York: John Wiley& Sons.
5) Fisher, R.A. 1991. *Statistical Methods for Research Workers*. Oxford: Oxford University Press.
6) Hosmer, D. W. and S. Lemeshow. 1989. *Applied Logistic Regression,* 2nd ed. New York: Wiley.
7) Kleinbaum, D. G. and M. Klein. 2002. *Logistic Regression — A Self Learning Text*. New York: Springer.
8) Madrigal, L. 1998. *Statistics for Anthropology*. Cambridge: Cambridge University Press.
9) Montgomery, D.C. 2001. *Design and Analysis of Experiments*, 5th ed. New York: John Wiley & Sons.
10) Polkinghorne, D. 1983. *Methodology for the Human Sciences*. New York: State University of Albany, New York Press.
11) Rao K. Vivweswara. 1996. *Biostatistics: A Manual of Statistical Methods for Use in Health, Nutrition and Anthropology*. New Delhi: Jaypee Brothers Medical Publishers (P) Ltd.
12) Snedecor, G. W. and W.G. Cochran. 1967. *Statistical Methods*. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.
13) Zar, J.H. 1999. *Biostatistical Analysis*, 4th ed. Upper Saddle River: New Jersey: Prentice-Hall.

SEMSTER - III

SPECIALIZATION PHYSICAL/BIOLOGICAL

MANC 3.11
HUMAN GENETICS AND VARIATION

Theory Credit: 5
Tutorial Credit: 1

UNIT I Introduction: historical views of human variation; the concept of race, racism, intelligence. 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.

UNIT II The adaptive significance of human variation: solar radiation, vitamin D and skin colour; the thermal environment; high altitudes; infectious diseases.

UNIT III Human DNA polymorphism, evidence of human evolution from mtDNA and Y chromosomal DNA haplogroups, neutral theory and its reconciliation to synthetic theory.

UNIT IV 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 V 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.

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) Gisli Palson 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*, 7th edition. New York: W H Freeman & Co
9) Harrison, G.A.& 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*, 2nd 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*. Kokata: ISI
14) Maxson, L.R. and C.H. Daugherty. 1992. *Genetics: A Human Perspective*, 3rd 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.

MANC 3.21
HUMAN GROWTH, DEVELOPMENT & NUTRITION

Theory Credit: 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.

UNIT V **Nutritional Anthropology:** The students are to be taught on the following aspects of Nutritional Anthropology.
Determination of Nutritional Status: Each Student is to record dietary intake of household members belonging to three households and calculate intake of different nutrients consumed.

Recommended Books and References:

1) Bogin, B. 1999. *Patterns of Human Growth*. Cambridge: Cambridge University Press.
2) Carter, J.E. L. 1980. *The Heat-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.

MANC 3.22
PHYSICAL ANTHROPOLOGY III (PRACTICAL)

Practical Credit:2

1. A. Size and Shape measurements: Standing Height Vertex, Sitting Height Vertex,. Body weight, Total Right Upper Extremity Length (Direct & Indirect), Total Right Lower Extremity Length (K-quotient method), Right Upper Arm Length (Direct & Indirect),. Right Fore Arm Length (Direct & Indirect), Right Hand Breadth, Right Hand Length, Right Foot Length,, Right Foot Breadth, Biacromial Breadth, Bicristal Breadth, Chest Breadth (Transverse), Chest Depth (Sagittal), Chest Girth (Inspiration, Expiration, Normal), Minimum Waist Girth, Head Circumference, Mid. Upper Arm Girth, Maximum Calf Girth, Skinfold at Triceps, Skinfold at Biceps,

B. Shape Growth Ratios, Relative Sitting Height vertex, Relative Right Total Upper Extremity Length, Relative Right Total Lower Extremity Length, Relative Right Fore Arm Length, Relative Right Hand Length, Relative Biacromial Breadth, Relative Bicristal Breadth, Relative Head and Face Segment, Relative Head and Neck Segment, Relative Height Gnathion, Relative Height Cervicale, Relative Right Upper arm length, Cephalic Index, Nasal Index

2. Nutritional Anthropometry (For assessment of Grades of Malnutrition)
(i) Wt for age (ii) Ht for age (iii) Wt /Ht (iv) Mid Arm Circumference
a. Calculation of Body Mass Index and Conicity Index
b. Calculation of Total Body Fat
c. Measurement of Sub-Cutaneous fat: Tricep. Bicep. Sub-scapula

SPECIALIZATION SOCIAL/CULTURAL

MANC 3.31
URBAN ANTHROPOLOGY

Theory Credit: 4

UNIT I Urban anthropology: Aim, scope and methodology; processes of urbanization (urbanism, urban ecology and urban structures)

UNIT II Basic features of urban society (heterogeneity, neighbourhood, slums, ethnic, cultural, linguistic affiliation of an Indian city); folk-urban continuum,

UNIT III Classification of city cultures: Administrative, industrial, mercantile, colonial and city states. (R.G. Fox).

UNIT IV Urbanization in India: rise of city and civilization in India (pre-industrial, post industrial)

UNIT V Urban poverty: Culture of poverty (Oscar Lewis); Multiculturalism in the urban setting. Community studies in complex societies (Indian case studies):
a. A.C. Mayer's study in Central India.
b. S.C. Sinha and B.N. Saraswati's study on Kashi

Recommended Books and References:

1. Fox, R: Urban Anthropology: (Cities in their Cultural Settings)
2. Redfield, R: Folk Culture of Yucatan
3. Redfield, R: Peasant Society and Culture.
4. Southall, A: Urban Anthropology.
5. Redfield, R: Tepoztlan : A Mexican Village
6. Eames,E & Good, J.G. : Anthropology of the City
7. Rivke, jaffe: Introducing Urban Anthropology
8. Gmelch, George & zenner, walter.p.: Urban Life; Reading in Urban Anthropology
9. Kaul, Shonaleeka.: Imagining the Urban.
10. Pardo, Italo : Anthropology in the City: Methodology and Theory.
11. Dicky, Sara.: Living Class in Urban India.
12. Krase, Jerom : Seeing Cities Change: Local Culture and Class.
13. Prato, giuliana. B : Beyond Multiculturalism; views from
14. Anthropology (Urban Anthropology)
15. Mayer, AC: Caste and Kin and Central India
16. Sinha, s.c.& Saraswati, B.N: Ascetics of Kashi

MANC 3.32
URBAN ANTHROPOLOGY (PRACTICAL)

Practical Credit: 2

Project:

The students will undertake minor research project comprising of an urban setting.

1. Identify a problem in an urban area
2. Write a report on the problem selected

MANC 3.41
ETHNOGRAPHIC: THEORY AND METHODS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Concept and Definition of ethnography; nature of ethnographic studies. History and development of ethnographic studies: Boas and Malinowski's anthropological tradition; The Chicago School of ethnography

UNIT II A brief overview of different approaches to ethnography: Ethnography and symbolic interactionism; Community studies; Orientalism; Semiotics and semantics.

UNIT III Tools of ethnography: Participant observation; field notes; Life stories; ethnographic interviewing; autobiography; narrative analysis; Photography and film; computer applications in qualitative research.

UNIT IV Writing cultures and ethics of ethnography; ethnography after post-modernism.

UNIT V Assignments, quiz, oral tests/presentation, book readings based on the above UNITs as prescribed by the concerned teacher.

Recommended Books and References:

1) Atkinson P, Delamont, Coffey, Lofland and Lofland: Handbook of Ethnography
2) Brewer, JD: Ethnography
3) Bryman, Alan: Social Research Methods
4) Burawoy M. et al.: Ethnography Unbound: Power and Resistance in the modern Metropolis
5) Clifford J and G.E Marcus: Writing Cultures: The poetics and Politics of Ethnography
6) Malinowski B: Argonauts of Western Pacific
7) Mead: Coming of Age in Samoa
8) O'reilly, K: Ethnographic methods
9) Said, E: Orientalism

SEMESTER - IV

SPECIALIZATION PHYSICAL/BIOLOGICAL

MANC 4.11
HUMAN POPULATION GENETICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I History of Human Population Genetics, aim and scope of population genetics and its significance in anthropology, Mendelian populations

UNIT II Hardy-Weinberg Equilibrium (HWE), Measuring Departure from HWE. Application of Hardy-Weinberg law in human population genetics.

UNIT III A) Genetic polymorphism: Transient and balanced polymorphism. Haemoglobin polymorphisms and their distribution, Thalassaemia, G6PD Deficiency and its distribution.
B) Dermatoglyphics in relation to population variation.

UNIT IV Concept of genetic drift, Effective Population size, genetic isolates, Dynamics of genetic drift, mutation, gene flow, migration. Natural selection**:** Concept of fitness, Models explaining the maintenance of genetic polymorphism and selection relaxation.

UNIT V Breeding population—mating patterns: random mating, non-random mating; Consanguinity and inbreeding - Definitions and concept, Genetic consequences of inbreeding in human population, inbreeding coefficient and genetic load, genetic isolates; Miscegenation; Eugenics and Genetic Counseling.

Recommended Books and References:

1. Rothwell, N.V. Human Genetics
2. Stern, Curt. Principles of Human Genetics
3. Janusch, J, Buetner. Principles of Human Genetics
4. Cumins and Midlo. Finger prints, palm, and soles: An introduction to Dermatoglyphics
5. Watson, E.H and G.H.Lowrey. Growth and Development of Children
6. Livingstone, Frank.B. Abnormal Haemoglobin in Human populations
7. Principles of Population Genetics Daniel Hartl& A.G. Clark (1997) Sinaver Associates, Inc.
8. Principles of Genetics Peter Snustad and M. J. Simmons (2006). John Wiley and Sons, Honboken, NJ.
9. Genetics: A Conceptual Approach Benjamien Pierce (2003). W. H. Freeman & Company.
10. A Primer of Population Genetics Daniel Hartl (1999) Sinaver Associates, Inc.
11. The genetics of Human Population Cavalli - S. Ferza and Bodmer (1976) Freeman, San Francisco.

MANC 4.21
ANTHROPOLOGIGAL DEMOGRAPHY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Nature of population studies, population concepts, history of population studies; sources of population data: population census, registration of vital statistics; sample survey, population registers; international publications; history of census; census in India.

UNIT II Population composition: population size, population structure, population characteristics; factors affecting age and sex structure. Population explosion in India; National Population policy.

UNIT III Fertility and fecundity: factors associated with change in fertility—physiological factors and sociocultural factors; differential fertility.

UNIT IV Mortality and morbidity: basic measures of mortality; age and sex patterns in mortality; infant mortality and factors affecting it; causes of death; differential mortality.

UNIT V

1. Migration: nature and theories of migration; rural-urban migration, seasonal migration and transhumance; causes and consequences of migration.
2. Demographic transition: stages of demographic transition; demographic transition in India.
3. Demographic theories: Malthus, Sadler, Doubleday, Arsene-Dumont, Spencer, Carr-Saunders.

Recommended Books and References:

1) Agarwala, S.N. India's Population Problems
2) Bhende, A & T.Khanitkar. Principles of population studies
3) Misra, B.D. An Introduction to the study of Population
4) Ram Kumar, R. Technical Demography
5) Roy,S.Basu, S.Tindal, Bogue, D.J. Principles of Demography
6) Sharma A.N Trends in Anthropological Demography
7) Rawat, D.S Fundamentals of Demography: Concepts and Theories
8) Bose , Ashish India's Basic Demographic Statistics
9) Agarwala, S.N: India's Population Problem
10) Bhende, Asha A & Kanitkar, Tara: Principles of population studies

SPECIALIZATION PHYSICAL/BIOLOGICAL

MANC 4.41
DEMOGRAPHIC STUDIES

Theory Credit: 5
Tutorial Credit: 1

UNIT I Nature and definition of population studies. Population concepts. History of population studies. Interrelation between population studies and other disciplines. Population Theories: Malthusian theory (Thomas Malthus) and Theory of demographic transition (warren Thompson)

UNIT II Anthropology and determinants of population growth: Migration, Marriage, Fertility, Mortality, Morbidity and Fecundity. Population composition and population Pyramid.

UNIT III Role of Culture in population control, Importance of population education. Ageing population – Culture and care for the aged, issues and problems in developed and developing countries, policies for the aged people in developed and developing countries.

UNIT IV Population planning activities in India: pre-independence and post- independence scenario and activities, National Population Policy. Evaluation and management of Family welfare Programmes.

UNIT V Assignments, quiz, oral tests/presentation, book readings based on the above UNITs as prescribed by the concerned teacher.

Recommended Books and References:

1) Agarwala, S.N: India's Population Problem
2) Bhende, Asha A & Kanitkar, Tara: Principles of population studies
3) Bose, Ashish: India's Basic Demographic Statistics
4) Dyson, Tim: Population and Development: The demographic transition
5) Misra, B.D: An Introduction to the study of Population
6) Preston, Samuel H, Heuveline, Patrick & Juillot, Michel Demography: Measuring and Modeling Population processes
7) Patha K, Lalit: Population studies Ram Kumar, R: Technical Demography
8) Roy, S.Basu, S.Tindal, Bogue, D.J: Principles of Demography
9) Rawat, D.S: Fundamentals of Demography: Concepts and Theories
10) Sharma, A.N: Trends in Anthropological Demography

MANC 4.51
ANTHROPLOGY OF INDIA

Theory Credit: 5
Tutorial Credit: 1

UNIT I Indian Society: Features, Linguistic and Cultural divisions; Cultural unity and diversity and National Integration.

UNIT II Basis of Indian Social life: Theories of origin of Caste and sub-caste, Caste and Class, Caste and Tribe, Dominant castes, Denotified tribes, Tribe -Caste continuum.

UNIT III Approaches to the study of Indian society:

1. Indological Approach - G. S. Ghurye, Louis Dumount
2. Structural Functional Approach - M.N. Srinivas, S. C. Dube.
3. Marxian Approach - D.P. Mukherjee, A.R. Desai
4. Civilization and Subaltern Approach - Surajit Sinha, Dr. B.R. Ambedkar
5. Conflict Approach - Kathleen Gough, Daniel Thorner

UNIT IV Contemporary Challenges in the Indian society: Tradition versus Modernity, Secularism, Regionalism, Pluralism, Terrorism, Caste Conflict, Ethnic conflict, Communalism and Religious Revivalism.

UNIT V Assignments, quiz, oral tests/presentation, book readings based on the above UNITs as prescribed by the concerned teacher.

Recommended Books and References:

1) Bose, NK : The Structure of Hindu Society
2) Basham, AL : The Wonder that was India
3) Das Veena. 2004. : Oxford India Encyclopedia of Sociology and Social Anthropology. New Delhi: OUP.
4) Dumont Louis 1970 : Homo Hierachicus: The Caste System and its Implications.
5) Dube, S.C. 1973 : Social Sciences in a Changing Society Lucknow University Press
6) Dube, S.C. 1967 : The Indian Village London: Routledge, 1955
7) Ghurye, GS : Caste, Class and Occupation
8) Karve, Irawati 1961 : Hindu Society: An Interpretation Poona: Deccan College
9) Majumdar, DN : Races and Cultures of India
10) Mandelbaum, DG : Society in India: Changes and Continuities
11) Rajni, K : Caste in Indian Politics
12) Singh, Y. 1973 : Modernisation of Indian Tradition, Delhi, Thomson Press.
13) Srinivas, M.N. 1960 : India's Villages Asia Publishing House, Bombay.
14) Srinivas, M.N. 1960 : Social Change in India
15) Srinivas, M.N. 1960 : Caste in Modern India and other essays
16) Tylor, Stephen : India: An Anthropological Perspective
17) Karve, I : Hindu Society: AN Interpretation
18) Singer, M : Traditional Indian Structure and Change.

DISCIPLINE SPECIFIC ELECTIVE 1
SPECIALIZATION PHYSICAL/BIOLOGICAL

MAND 3.11(a)
MEDICAL GENETICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Medical Genetics: Meaning and Scope; History and impact of genetics in medicine; Genetic factors in Common Diseases: Gene- Disease-Environment interaction; Genetic susceptibility to Common Diseases: Diabetes, Hypertension, Coronary Heart Diseases. Single Gene Disorder and Chromosomal Disorders in Man.

UNIT II Biochemical Genetics: Inborn Error Metabolism; Disorder of Amino Acid Metabolism. Disorder of Carbohydrate Metabolism, Disorder of Lipid Metabolism. Haemoglobin & Haemoglobinopathies: Structure of Haemoglobin, Development and expression of haemoglobin, Disorder of haemoglobin: Sickle Cell Anaemia, Thalassemia; Clinical variation of the haemoglobinopathies. Pharmacogenetics: Definition, evolutionary origin of variation in drug responses, pharmacogenomics, ecogenetics

UNIT III Immunogenetics: Immunity, Innate and acquired immunity, Inherited immune deficiency disorder: HLA and Disease; Blood groups. The genetics of Cancer: Differentiating between genetic and environmental factors in cancer; Oncogens, Tumour suppressor genes, genetics of familial cancer.

UNIT IV Application of Medical Genetics: Prenatal diagnosis & Genetic Counselling, Gene Therapy; Stem cell therapy and Bone marrow transplantation. Population Screening and community genetics. Ethical, Legal & Social (ELSI) issues in Medical Genetics.

UNIT V Assignments, Quiz, Oral test/presentation, Book readings based on the above UNITs as prescribed by the concern teacher.

Recommended Books and References:

1) Crawford, M. (Ed). 2006 *Anthropological Genetics*. Cambridge University Press.
2) Brown, T. A. 2002. *Genomes 2 Edition*. Wiley-Liss, UK.
3) Jobling M. A., M. E. Hurles and C. Tyler-Smith. 2004. *Human Evolutionary Genetics: Origins, Peoples & Disease*. Garland Science. New York.
4) Sudbery, P. 2009. *Human molecular genetics*, 2nd Edition. Pearson (LPE).
5) Cummings, M. R. 2009. *Human Genetics*. Cengage Learning.
6) Vogel, F and Motulsky, G. 1998. *Human genetics: Problems & Approaches*. Springller, Berlin.
7) Tamarin, R. H. 2002. *Principles of Genetics*. Tata Mc Graw-Hill Edition.
8) Gelehort, T.D., F. S. Collins and D. Gineburg. 1998. *Principles of Medical Genetics*. Williams & Wilkins, USA
9) Li, Wen-Hsiung. 1997. *Molecular Evolution*. Sinauer Associates, Inc., Publishers, USA.
10) Page, R. D. M. and E. C. Holmes. 1998. *Molecular Evolution: A Phylogenetic Approach*. Blackwell Science, London.
11) Cavalli-Sforza, L., P. Menozzi, and A. Piazza. 1996. *The History and Geography of Human Genes*. Princeton University Press.
12) Klung S. W, M. R. Cummings and C. A. Spencer.2007. *Essentials of Genetics*, Sixth Edition. Pearson Education International.
13) Muller R. F. and I. D. Young. 2001. Emery's Elements of Medical Genetics. Churchill Livingstone, London.

MAND 3.11(b)
PHYSIOLOGICAL ANTHROPOLOGY

Theory Credit: 5
Tutorial Credit: 1

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: effect of environmental hazards, lifestyle and occupational factors in physical functions. Evaluation of response and adaptation of the body to stress of exercise. Aging and health related aspects of exercise.

UNIT III Body composition and physique: methods of assessment; environmental and genetic contribution to obesity; treatment and prevention and management; Global prevalence and secular trends in obesity.

UNIT IV Impact of smoking, alcohol, air pollution and occupation on cardio-respiratory function. Variations in respiratory functions with age, sex and environment.

UNIT V Physical performance and environmental stress: heat stress, cold stress and high altitude, chronic diseases**,** 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. Huge, Eggleton, M Grace. Lea & Febiger 1968. Principle of human physiology
4) Function Vander, Arthur J; Sherman, James H; Luciano, Dorothys, 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

MAND 3.11(c)
PALEOANTHROPOLOGY

Theory Credit: 5
Tutorial Credit: 1

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,

UNIT II Geological time scale, Introduction to Palaeo-demography and Palaeo-pathology

UNIT III Homonid evolution: Characteristics and phylogenetic position of *Ramaphithecus*, *Australophithecines*, *Homo habilis, Homo erectus* and *Neanderthals*.

UNIT IV Emergence of modern man: Anatomical features and geographical distribution of Cro-Magnon, Grimaldi, Chancelade, Brunn, Offnet and Premost.

UNIT V Modern theories of human evolution: punctuated equilibrium theory, out of Africa hypothesis and multi regional continuity theories

Recommended Books and References:

1) Aufderheide, A.C. and C. Rodriguez-Martin. 1998. *The Cambridge Encyclopedia 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: Palaka Prakashan.
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.

DISCIPLINE SPECIFIC ELECTIVE 2
SPECIALIZATION PHYSICAL/BIOLOGICAL

MAND 3.21(a)
KINANTHROPOMETRY & ERGONOMICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Kinanthropometry: concept and historical background, Anthropology of sports: Physical conditioning, Training-Techniques and Physiological effects, Athletes and Body composition, Athletes and Nutrition, doping and performance.

UNIT II Ergonomics: Concept, evolution and scope, Theories and concepts (Posture, Concept of safety, efficiency and comfort, Clearance and Reach), Man-Machine relationship and operational designing and its relationship with human factors

UNIT III Anthropometry in Designing: Use of Percentiles in designing products, Design of workplace and work environment, Design of Clothing, personal equipment, component and devices, designing for PWD

UNIT IV Environmental effects on physical performance of athletes: Effect of heat stress, cold stress and high altitude on their physiological response and performance.

UNIT V Physical Activity and Health, Physical performance tests

Recommended Books and References:

1) Applied Bio-mechanics concepts & connections (2008) John Mclester; Peter St. Pierre. Wadsworth Publishing Co.
2) Ergonomics man in his working environment by Murrell, KFH (1965) London; Chapman & Hall.
3) Ergonomics Glossary: Terms Commonly used in Ergonomics by North, K; Stepheton, C; Vogt, Chantal(1982). Published for the Bureau of information and co-ordination of community ergonomics action of the European Coal and Steel Community by Bohn, Scheltema & Holkema (Utrecht).

MAND 3.21(b)
FORENSIC ANTHROPOLOGY AND CRIMINOLOGY

Theory Credit: 5
Tutorial Credit: 1

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, Scope and methods of Forensic Anthropology. Criminology: Concept and meaning. Theories of crime, types and definitions of crime, causes and correlates of crime. Anthropological criminology.

UNIT II Basics of Human Osteology and Odontology Study of Skeletal Material: Human and animal remains. The study of bone fragments. Attributes of sex, estimation of age and reconstruction of stature from the skeletal remains and their medico-legal implication. Forensic Odontology: tooth structure and growth, estimation of age in young and adult. Population difference in size and morphology. Bite marks. Individualization of tooth pulp.

UNIT III Establishment of partial and complete identity of skeletal material and dead bodies morphometric techniques. Personal identification of living persons: Identification through somatometric and somatoscopic observations, nails, occupation marks, scars, tattoo marks and deformities; handwriting and mannerism. Finger prints: Identification of living and dead through partial and complete prints. Classification of fingerprints for criminal record purposes. Chance Prints. Various methods of latent print development. Sole prints.

UNIT IV Forensic Haemogenetics: Pattern of blood splashes. Identification of blood stains and determination of species of origin. Individualization of blood stains: Determination of blood group, sex, age and racial origin from dried bloodstains. Identification and individualization of body fluids like semen, saliva and urine. DNA profiling and individualization. Disputed parentage: role of Anthropological traits in solving such cases. Forensic Anthropologist's as an expert witness under section 45 of the Indian Evidence Act. Ethical responsibilities in Forensic Science.

UNIT V Assignments, Quiz, Oral test/presentation, Book readings based on the above UNITs as prescribed by the concern teacher.

Recommended Books and References:

1) Sharma B.R. *Forensic Science in Criminal Investigation & Trials* (4th Edition) universal Law publishing Co. Pvt. Ltd 2003.
2) Byere S.N. *Anthropology to Forensic Anthropology- A Text Book* (2nd Edition) Pearson Newyork.2005.
3) Chatterjee S.K. *Finger, Palm and Sole Print.* Calcutta,17. Lake Avenue.1967.
4) Nath S*; An Introduction to Forensic Anthropology* Gain Publishing House, New Delhi, 1989.
5) Bask R. *Fundamentals of Forensic Medicine and Toxicology* (2nd Edition) Books and Allied Pvt. Ltd. Kolkata.2009.
6) Treadwell, James. *Criminology*. Sage Publication Ltd. London. 2006.
7) Freell J, Hayward K, Morrison W, Presee, M. C. *Cultural Criminology*. The Glass House Press, London. 2004.
8) Klepinger L. L. *Fundamentals in Forensic Anthropology*. Wiley –Liss. 2006.
9) Buikstra E. J and D. J. Ubelaker. 1994. *STANDARDS: For Data Collection From Human Skeletal Remains.* Arkansas Archaeological Survey Research Series No.44.
10) Weiner J.S. and J.A. Louri. 1981. *Practical Human Biology*. Academic Press, New York

MAND 3.21(c)
ENVIROMENTAL ARCHAEOLOGY (BIO ARCHAEOLOGY)

Theory Credit:5
Tutorial Credit: 1

This course aims to impart a better understanding of the bioarchaeological approaches, domestication process and how it can be used for archaeological interpretation. It will also help the students to know the scope of archaeozoology, fossil studies and human remains from archaeological sites.

UNIT I Environmental archaeology - Definition and scope, Branches related to Environmental Archaeology.

UNIT II Theories of Plant Domestication and Origin of Agriculture, Early Agriculture in Old and New World.

UNIT III Palaeontology and Past Environmental Interpretation, Fossils and Process of Fossilisation. Pleistocene Vertebrate Fauna of India.

UNIT IV Archaeozoology – Definition and Scope, Archaeozoology Techniques – Quantification (NISP, MNI, Weight, Metrical Studies), Aeging and Sexing Methods; Holocene Faunal Record from Archaeological Sites in India.

UNIT V Dental and Bone Histology, Nature of Archaeological Human Bone Assemblage, Bone Diseases, Dental Disease, Traces of injury on Skeleton, Chemical Analysis of Bone.

Recommended Books and References:

1) Badam, G. L. *Pleistocene Fauna of India.* Pune: DCPRI.
2) Badam, G. L., and V. Sathe. 1995. Palaeontological Research in India: Retrospect and Prospect. Memoir 32. *Geological Survey of India,* pp. 473 – 495.
3) Behrensmeyer, A. K. And A. Hill (eds.). Fossils in the Making: *Taphonomy and Paleoecology*, Chicago: University of Chicago Press.
4) Brothwell, D. and E. Higgs (eds.). *Sciences in Archaeology*, London: Thames and Hudson.
5) Bruce, S. *Origins of Agriculture*, New York: Plenum Publications.
6) Clason, A. T. *Archaeozoological Studies*. Amsterdam: Elsevier.

7) Clutton-Brock, J. *Domesticated Animals from Early Times*, London: British Museum Natural History.
8) Dina, F. D. *Environmental Archaeology: Principles and Practice*, Cambridge: Cambridge University Press.
9) Elizabeth, J. R. and E. S. Wing. *Zooarchaeology*, Cambridge: Cambridge University Press.
10) Thomas, P. K. and P. P. Joglekar. 1994. Holocene Faunal Studies in India, *Man and Environment* Vol. 19 (1&2): 179 – 204.
11) Thomas, K. D. 1993. Molecular Biology and Archaeology: a Prospectus for Interdisciplinary Research, *World Archaeology* 25 (1): 1 – 7.

DISCIPLINE SPECIFIC ELECTIVE 1
SPECIALIZATION SOCIAL/CULTURAL

MAND 3.31(a)
DEVELOPMENT ANTHROPOLOGY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Concept of Development in Anthropology, Role of development in anthropological studies. Development from below.

UNIT II Application of Anthropological knowledge in Planning and Development, Tribal Development, Tribal sub-plans and programmes – ITDPs, TRYSEM, LAMPS

UNIT III Sustainable Development: Concept, Salient features and components of Sustainable Development, Strategies for Sustainable Development, Sustainable Human Development

UNIT IV Emerging issues of Development in North East India- Ethnicity, Inequality, Insurgency, Look East Policy, Act East Policy and Regionalism

UNIT V Assignments, quiz, oral tests/presentation, book readings based on the above UNITs as prescribed by the concerned teacher.

Recommended Books and References:

1) Arce, Alberto and N.Long: Anthropology, Development and Modernities
2) Bardhan, PK: Development and Change
3) Cochrane, G: Development Anthropology
4) Desai, AR: India's Path to Development
5) Dube, SC: Tradition and Development
6) Kumar, Hagira: Social work, Social Development and Sustainable Development
7) Eriksen, TH: Ethnicity and Nationalism
8) Kedia and Willgen: Applied Anthropology: Domains of Application
9) Mair, L: Anthropology and Development
10) Malhotra, R: Anthropology of Development
11) Malhotra, R: Human Rights Approaches to Sustainable Development
12) Mathur, HM: Anthropology in Development Process
13) Mathur, HM: Human Dimension of Development
14) Hasnain, N: Tribal India
15) Pitt-David, C: Development from Below: Anthropologists and Development Situation
16) Subba, TB: Ethnicity, State and Develoopment
17) Vidhyarthi, V and Sahay: Applied Anthropology and Development in India

18) Vidhyarthi, V: Applied Anthropology in India
19) Vidhyarthi, V: Tribal Development and its Administration.

MAND 3.31(b)
STUDY OF MONOGRAPHS

Theory Credit: 5
Tutorial Credit: 1

The paper will have two components- a. a monograph and b. a book review.

a. The study of monograph should emphasize on: Methodology, Structure and Organization of data, Analysis and Interpretation. The contribution of the monograph in furthering the existing knowledge in the concerned field of study should also be taken into consideration. The monographs will be recommended from the list of 'Recommended Books' of this paper.

b. The book review should be of a book as prescribed from time to time.
c. Presentations and book readings.

Recommended Books and References:

1) E.E Evans-Pritchard : Nuer
2) Malinowski : Argonauts of the Western Pacific
3) Srinivas M.N : The Remembered Village
4) Majumdar : Culture Change in Two Garo Villages
5) McKim Marriot : Village India
6) James Frazer : The Golden Bough
7) Hutton : The Angami Nagas
8) JP Mills : The Sema Nagas
9) JP Mills : The Rengma Nagas
10) JP Mills : The Ao Nagas
11) Hutton : The Lotha Nagas
12) S.R. Maitra : Ethnographic Study of the Chakma Of Tripura
13) N.K. Das : Kinship, Politics and Law of the Angami Nagas
14) Cariappa and Cariappa : The Coorgs and their origins

MAND 3.31(c)
VISUAL ANTHROPOLOGY

Theory Credit: 5
Tutorial Credit: 1

This paper aims to introduce students to the world of communication, its various channels and the relation it shares with culture. It will also discuss the meaning and scope of visual anthropology, ethnographic films in India and audio-visual documentation. The paper attempts to throw some light on the development of visual anthropology in India also.

UNIT I History of Visual Anthropology, Nature and Scope, relevance of visual anthropology and use of visual aids in studying culture.

UNIT II Ethical Concerns – Theoretical issues concerning ethnographic films; ethical dimensions of ethnographic films - Privacy, Informed Consent, Telling the truth, Distribution.

UNIT III Impact of mass media on youth, children, women and disadvantaged group

UNIT IV Visual Anthropology as ethnographic film. Interdependency of technology and culture.

UNIT V (a) Focus on an issue relating to the subject of the lecture and
(b) Students to develop their own research proposal through presentation to the group.

Recommended Books and References:

1. Roger, E.M Communication of Innovation
2. Agrawal, B.C Anthropological Applications in Communication Research and Evaluation of SITE in India, in Media Asia vol.8, pp 136-146
3. Fisher, Andy. B. Perspectives in Human Communication
4. Herskovits Cultural Anthropology
5. Hymes, Dell The Anthropology of Communication in Human Communication Theory
6. Rai Samir An introduction to Visual Anthropology
7. Sahay, K.N Visual Anthropology in India and its Development

DISCIPLINE SPECIFIC ELECTIVE 2
SPECIALIZATION SOCIAL/CULTURAL

MAND 3.41(a)
GENDER STUDIES

Theory Credit: 5
Tutorial Credit: 1

UNIT I Concept of gender: Biological, psychological and social concepts of gender; socialization and construction of gender; cross cultural concept of gender.

UNIT II Rights of women; violence against women (rape, domestic violence, sati, bride torture, natality violence); women deprivations (food, medical, economic and educational facilities). Gender and religion.

UNIT III Gender and development- gender equity, gender and employment, SHG, entrepreneurship. Role of NGO's and government in developing awareness among women. Gender sensitive planning and development policies.

UNIT IV An overview of feminist anthropology; critique of Malinowski's fieldwork by A. Weiner; women as muted groups in society (Edwin Ardner). Anthropology as a male dominated discipline (Edwin Ardner); women, men and ethnography; issues relating to the development of gender free anthropology.

UNIT V Assignments, quiz, oral tests/presentation, book readings based on the above UNITs as prescribed by the concerned teacher.

Recommended Books and References:

1) Ardner, E. 1989 : The Voice of Prophecy and Other Essays
2) Dube, L. 1997 : Comparative Perspectives on Gender in South and Southeast Asia New Delhi Vistar.
3) Dube, L E. Leacock and S. Ardner 1989 : Visibility and Power: Essays on Women in Society and Development. Delhi: Oxford University Press.
4) Moore, H. 1988 - : Feminism and Anthropology. Cambridge: Cambridge Polity Press.

5) Moore, H. 1994 - : A Passion for Difference Essays in Anthropology and Gender. Cambridge: Cambridge Polity Press.
6) Bell. D.P, Caplan W.J. Karin (eds) 1993 : Gendered Fields : Women, Men and Ethnography. London: Routledge.
7) Poonia, M and Poonia VS : Women and Human Rights in India
8) Sergeant, C. and C. Brettell 199 : Gender and Health. N.J. Prentice -Hall.
9) Rajani, KR and Sujatha KM : Women Development and Empowerment
10) World Bank Report 1991 : Gender and Poverty in India.
11) Weinder, A. 1976 : Women of Value, Men of Renown: New Perspectives on Trobriand exchange. Ausutin: University of Texas Press.

MAND 3.41(b)
ANTHROPOLOGICAL THEORIES

Theory Credit: 5
Tutorial Credit: 1

UNIT I Emergence of Anthropological theory, Concepts of Structure and Function: Contribution of Emile Durkheim, Bronislaw Malinowski, A.R. Radcliffe Brown, M. Fortes, E.E Pritchard, E R Leach, C. Levis Strauss

UNIT II Cognitive Anthropology:
New Ethnography: Emicism and Eticism; Sementic Analysis

UNIT III Interpretative Approach – Clifford Geertz, Victor Turner, Mary Douglas

UNIT IV Cultural Ecology –Contributions of Julian Steward, Leslie White, Marvin Harris; Post- Modern developments and Globalisation

UNIT V Assignments, quiz, oral tests/presentation, book readings based on the above UNITs as prescribed by the concerned teacher.

Recommended Books and References:

1) Bernard, Alan : History and Theory in Anthropology
2) Bidney, David : Theoretical Anthropology
3) Douglas, Mary : Cultural Bias
4) Ericksen, Paul : Anthropological lives: Biographies of Eminent Anthropologists
5) Geertz, Clifford : The Interpretation of Culture
6) Harris, Marvin : Rise of Anthropological Theory
7) Hastrup : A Passage to Anthropology
8) Ingham, John : Psychological Anthropology Reconsidered
9) Donat,L and Erickson : A History of Anthropological Theory
10) Levi-Strauss : Structural Anthropology
11) Malinowski : Scientific Theory of Culture and Other Essays
12) Manganaro, Marc : Modernist Anthropology: From Fieldwork to Text
13) Manners, R. A. : Theory in Anthropology
14) McGee and Warms : Anthropological Theory: An Introductory History
15) Moore, JD : An Introduction to Anthropological Theories and Theorists
16) Moore, JD : The Future of Anthropological Knowledge
17) Nadel, S.P. : The Foundation of Social Anthropology
18) Sahlins & Service : Evolution and Culture
19) Tyler, Stephen (Ed.) : Cognitive Anthropology

MAND 3.41(c)
MEDICAL ANTHROPOLOGY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Historical development of Medical Anthropology. Scopes of Medical Anthropology. Concept of health, disease and illness. Occupational and life style ailments.

UNIT II Development of Theories in Medical Anthropology.

UNIT III Medical pluralism in India- Ayurveda, Siddha, Unani, Naturopathy, Homeopathy and Allopathic medical practices.

UNIT IV Ethnomedicine- Meaning and Scope, Ethnomedical practices in India, Traditional /Folk healers- their status and role. Ethnopsychiatry.

UNIT V Assignments, quiz, oral tests/presentation, book readings based on the above UNITs as prescribed by the concerned teacher.

Recommended Books and References:

1) Alland, A : Adaptation in Cultural Evolution: An Approach to Medical Anthropology
2) Brown, Barrett, and Padilla : Understanding and Applying
3) Boban : Tribal Ethnomedicine: Continuity and Change
4) Caudill, *W* : *Applied Anthropology in Medicine*
5) Helman, C. and Heinman, B : Culture, Health and Illness
6) Hassan, K : The Cultural Frontiers of Health
7) Foster, GM and Anderson, PG : Medical Anthropology
8) Landy,D : Culture, Disease and Healing: Studies in Medical Anthropology
9) Morsy : Handbook of Medical Anthropology
10) Simons, RC and Hughes : Culture Bound Syndrome
11) Kalla, AK and Joshi PC : Tribal Health and Medicines
12) Kakar, S : Shamans, Mystics and Doctors
13) Joshi, PC and Mahajan, A : Studies in Medical Anthropology
14) Read, M : Culture, Health and Disease
15) Worsley, P : Non-Western Medical Systems and Annual Review of Anthropology Vol, 11
16) Jalota, R and Banerjee : Folk Illness and Ethnomedicine
17) Rivers, WHR : Medicine, Magic and Religion
18) Scotch, A, Norman : Medical Anthropology: Biannual Review of Anthropology
19) Paul, BD : Health, Culture and Community
20) Fritzerald, T(Ed) : Nutrition and Anthropology in Action
21) Loudon, JB : Social Anthropology and Medicine

DISCIPLINE SPECIFIC ELECTIVE 3

MAND 4.11
FIELDWORK

Credits: 6

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.

DISCIPLINE SPECIFIC ELECTIVE 4

MAND 4.21
DISSERTATION AND 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.

SYLLABUS FOR
Master of Science

BOTANY

Under CBCS guidelines

COURSE STRUCTURE

SEMESTER	COURSE CODE	COURSE TITLE	CREDITS
I	MBOC 1.11	Microbiology &Algae	4
	MBOC 1.21	Bryophytes & Pteridophytes	4
	MBOC 1.31	Gymnosperms & Paleobotany	4
	MBOC 1.41	Plant Morphology & Anatomy	4
	MBOC 1.12	Microbiology & Algae (Practical)	2
	MBOC 1.22	Bryophytes & Pteridophytes (Practical)	2
	MBOC 1.32	Gymnosperms & Paleobotany (Practical)	2
	MBOC 1.42	Plant Morphology & Anatomy (Practical)	2
II	MBOC 2.11	Angiosperm Taxonomy	4
	MBOC 2.21	Mycology & Plant Pathology	4
	MBOC 2.31	Biochemistry & Biotechnology	4
	MBOC 2.41	Cell & Molecular Biology	4
	MBOC 2.12	Angiosperm Taxonomy (Practical)	2
	MBOC 2.22	Mycology & Plant Pathology (Practical)	2
	MBOC 2.32	Biochemistry & Biotechnology (Practical)	2
	MBOC 2.42	Cell & Molecular Biology (Practical)	2
III	MBOC 3.11	Genetics, Cytogenetics & Plant Breeding	4
	MBOC 3.21	Plant Physiology	4
	MBOC 3.12	Genetics, Cytogenetics & Plant Breeding (Practical)	2
	MBOC 3.22	Plant Physiology (Practical)	2
	MBOD 3.11(a)	Plant Systematics	4
	MBOD 3.11(b)	Medicinal Plants	4
	MBOD 3.11(c)	Biodiversity and Conservation	4
	MBOD 3.12(a)	Plant Systematics (Practical)	2
	MBOD 3.12(b)	Medicinal Plants (Practical)	2
	MBOD 3.12(c)	Biodiversity and Conservation (Practical)	2
	MBOD 3.21(a)	Research Methodology & Biostatistics	4
	MBOD 3.21(b)	Methods in Plant Sciences	4
	MBOD 3.21(c)	Agroecosystems – Principles and Applications	4
	MBOD 3.22(a)	Research Methodology & Biostatistics (Practical)	2
	MBOD 3.22(b)	Methods in Plant Sciences (Practical)	2
	MBOD 3.22(c)	Agroecosystems – Principles and Applications (Practical)	2
IV	MBOC 4.11	Plant Development & Reproductive Biology	4
	MBOC 4.21	Ecology and Ecosystem Analysis	4
	MBOC 4.12	Plant Development & Reproductive Biology (Practical)	2
	MBOC 4.22	Ecology and Ecosystem Analysis (Practical)	2
	MBOD 4.11(a)	Plant Resource Utilization	4
	MBOD 4.11(b)	Phytogeography and Evolution	4
	MBOD 4.11(c)	Biofertilizers and Biopesticides	4
	MBOD 4.12(a)	Plant Resource Utilization (Practical)	2
	MBOD 4.12(b)	Phytogeography and Evolution (Practical)	2
	MBOD 4.12(c)	Biofertilizers and Biopesticides (Practical)	2
	MBOD 4.21	Dissertation Work	6

SEMESTER – I

MBOC 1.11
ALGAE & MICROBIOLOGY

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).

UNIT II Types of pigments. Diversity of light harvesting pigments, food reserves; Extracellular products and flagellar structures in algae.

UNIT III Algal ecology: Distribution of algae in diversified habitats, algae as biological monitor of water pollution; Lichen as pollution indicators. Symbiotic algal associations; Economic importance of algae. Technique of culturing algae

UNIT IV Microorganisms found in food; food spoilage and food poisoning; Fermentation and food preservation; Industrial microbiology: production of alcohol, organic acid &Antibiotics. Bacterial Genetics Organization and replication of genetic material in bacteria: chromosome and plasmid: gene transfer mechanisms: conjugation, transformation and transduction. Medical Microbiology: A brief account of major human disease and their bacterial and viral pathogens. General account of chemotherapeutic agents. Fundamentals of Immunology: innate and acquired immunity, humoral and cell mediated immunity, organ and cells involved in immunity, T cells and B cells; antigens: characteristics and types, adjuvants. Immunoglobins: types, structure and properties.

UNIT V Effect of environmental factors on microbial growth; various nutritional forms of microorganisms; microbial colonization, succession and climax, Role of microbes in phosphorous and Sulphur cycles. Nitrogen fixation: ammonification, nitrification, denitrification. Interaction between microbes and roots of higher plants; rhizosphere; Bioremediation, Bio-fertilizers: 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. Aneja K. R. (1996). Experiments in Microbiology, Plant Pathology and Tissue Culture. Wishwa Prakashan.
3. Atlas R. M. and Bartha R (1997) (4th Edition) Microbial Ecology: Fundamental Applications. Benjamin/Cummings Science Pub.
4. Barnett H. L. and Hunter, B. B. (1972). Illustrated genera of imperfect fungi. Burges Publ.
5. Benson H.J. (1990). Microbiological Applications - A Laboratory Manual in General Microbiology. Wm. C. Brown Publishers.
6. Cappuccino J. G. and Sherman N. (1999). Microbiology- A Laboratory Manual (Fourth Edition). Addison Wesley.
7. Creager, J. G., Black, G and Davidson, V. E (1990). Microbiology: Principles and Applications, Prentice Hall.
8. Domsch K. H., Gams W. and Anderson T. H. (1980). Compendium of soil fungi. Academic Press
9. George, N. A (1988) Plant Pathology (third edition) Academic Press.
10. Gilman J. C. (1967). A Manual of Soil fungi. Oxford and IBH Publishing Co.
11. Harley, H. L and Smith, S. E (1983). Mycorrhizal symbiosis. Academic Press.
12. Johnson L. F. and Curl E. A. (1972). Methods for Research on the Ecology of soil borne plant pathogens. Burgess Publishing Co.
13. Lee F. R. (1980). Phycology. Cambridge Univ, Press.
14. Madigan, M. T., Martinko, J. M and Parker, J (2000). Brock Biology of Microorganisms. Prentice Hall International, Inc
15. Mishra, R.R. (1996). Soil Microbiology. CBS Publ.
16. Morris I. (1986). An Introduction to the Algae. Cambridge Univ. Press
17. Nester E. W., Roberts C. e. and Nester M. T. (1995). Microbiology: A Human Perspective. Wm. C. Brown Publisher.
18. Round F. E. (1986). The Biology of Algae. Cambridge Univ. Press.
19. Stevens F. L. (1985). The fungi which cause plant diseases. IBS. Intl.

20. Stewart W. D. P. (1974). Biochemistry and Physiology of algae. Blackwell Scientific Publ.
21. Tate, R. L (1995). Soil Microbiology, John Wiley and Sons Inc.
22. Tortora, G., Berdell, R. R and Case. C. L (1995). Microbiology – An Introduction. The Benjamin/Cumming Publishing Company.
23. Trainer F. R. (1978). Introductory Phycology. John Wiley & Sons
24. Van Elsas J. D., Trevors, J. T., Wellington, e. M. H. (1997). Modern Soil Microbiology, Marcel Dekker Inc.

MBOC 1.21
BRYOPHYTES & PTERIDOPHYTES

Theory Credit: 4

Bryophytes:

UNIT I Origin of Bryophytes; classification of Bryophytes; range of thallus structure; Structure, reproduction and life cycle of *Riccia*, *Pellia*; *Anthoceros*; *Funaria*, *Polytrichum*.

UNIT II Evolution of sporophyte; Ecological significance: colonization, succession and role of bryophytes in ecosystem; Bryophyte as site-specific bio-indicator and phytoremediator for environmental pollution; Economic Importance of Bryophytes.

Pteridophytes:

UNIT III Distinguishing Characters; classification of pteridophytes; Origin of Pteridophytes – Algal origin, Bryophyte Origin; heterospory, Telome Theory, Stelar Evolution; affinities with gymnosperms.

UNIT IV Structure, reproduction and life cycle of *Rhynia, Lycopodium, Calamites, Ophioglossum, Azolla*.

UNIT V Diversity of ferns in an ecological perspective; insect, microorganism- pteridophyte interactions; endangered and endemic pteridophytes and their conservation; Cytogenetics and reproductive biology of ferns; economic importance of Pteridophytes.

Recommended Books and References:

Bryophytes

1. Cavers F. (1976). The interrelationships of the Bryophytes. S.R. Technic, Ashok Rajpath, Patana.
2. Chopra R.N. and Kumar P.K. (1988). Biology of Bryophytes. John Wiley & Sons, New York, NY.
3. Kashyap S.R. (1929). Liverworts of the Western Himalayas and the Punjab Plain. Part 1, Chronica Botanica, New Delhi.
4. Kashyap S.R. (1932). Liverworts of the Western Himalayas and the Punjab Plain (illustrated): Part 2. Chronica Botanica, New Delhi.
5. Parihar N.S. (1980). Bryophytes: An Introduction to Embryophyta. Vol I. Central Book Depot, Allahabad.
6. Prem Puri (1981). Bryophytes: Morphology, Growth and Differentiation. Atma Ram and Sons, New Delhi.
7. Udar R. (1975). Bryology in India. Chronica Botanica, New Delhi.
8. Udar R. (1970). Introduction to Bryophytes. Shashidhar Malaviya Prakashan. Lucknow.
9. Watson E.V. (1971). Structure and Life of Bryophytes. 3rd Edn. Hutchinson University Library, London.
10. Vashista B.R., Sinha A.K., Kumar A. (2008). Botany for degree students – Bryophyta, S.Chands Publication.

Pteridophytes:

1. Agashe S.N. (1995). Paleobotany. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
2. Arnold A.C. (2005). An Introduction to Paleobotany. Agrobios (India). Jodhpur.

3. Eames E.J. (1983). Morphology of Vascular Plants. Standard University Press.
4. Rashid A. (1999). An Introduction to Pteridophyta. Vikas Publishing House Pvt. Ltd. New Delhi.
5. Sharma O.P. (1990). Textbook of Pteridophyta. MacMillan India Ltd. Dehi.
6. Smith G.M. (1955). Cryptogamic Botany Vol II. McGraw Hill.
7. Sporne K.R. (1986). The morphology of Pteridophytes. Hutchinson University Library, London.
8. Stewart W.N. and Rothwell G.W. (2005). Paleobotany and the Evolution of Plants. 2nd Edn. Cambridge University Press.
9. Vashista B.R., Sinha A.K., Kumar A. (2008). Botany for degree students – Pteridophyta, S.Chands Publication.
10. Gangulee and Kar (2006). College Botany. New Central Book Agency.
11. Sundar Rajan S. (1999). Introduction to Pteridophyta. New Age International Publishers, New Delhi.
12. Surange K.R. (1966). Indian Fossil Pteridophytes. CSIR., New Delhi.
13. Parihar N.S. (1976). Biology and Morphology of Pteridophytes. Central Book Depot.

MBOC 1.31
GYMNOSPERMS AND PALEOBOTANY

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

UNIT II Diversity, morphology, anatomy, reproduction and affinities of living gymnosperms: Cycadales, Ginkgoales, Taxales, Coniferales, Ephedrales, Gnetales, Welwitschiales.

UNIT III Palaeobotany; Geological timescale, Continental drift/ plate tectonics. Types of fossil, fossilization process.

UNIT IV Salient structural features and affinities of fossil gymnosperms; Pro-gymnosperms; Pteridospermales; Cycadeoidales (Bennettitales); Pentoxylales; Cordaitales.

UNIT V Study of Fossil Pteridophytes. Applied aspects of palaeobotany.

Recommended Books and References:

1. Andrews H. N. (1961). Studies in palaeobotany. McGraw Hill.
2. Arnold C. A. (1947). An Introduction to Palaeobotany. McGraw Hill.
3. Beck B.(ed.) (1988). Origin and evolution of gymnosperms. Columbia University Press.
4. Bhatnagar and Moitra (1996) Gymnosperms. New Age International Press.
5. Bhatnagar, S.P. and Moitra A. (1996), Gymnosperms, New Age International Pvt. Ltd.,
6. Bierhorst D.W. (1971): Morphology of vascular plants McMillan, New York.
7. Biswas, C. and B. M. Johri (2004) The Gymnosperms, Narosa Publishing House, New Delhi
8. Chamberlain C.J. (1934). Gymnosperms, structure and evolution. Univ. of Chicago Press.
9. Chamberlain C.J. (1986); Gymnosperms, structure and Evolution, CBS publishers
10. Coulter J. M. and C. J. Chamberlain (1978) Morphology of Gymnosperms, Central Book Depot, Allahabad
11. Discordies Press, Fortland, USA.
12. Gebryder, Bortragear, Berlin.
13. Johansen D. A. (1940). Plant Microtechnique, 2nd Ed. Tata McGraw-Hill.
14. Kakkar, R. K. and B. R. Kakkar (1995) The Gymnosperms (Fossils and Living) Central Publishing House, Allahabad New Delhi.
15. Palaeobotany. Systematic Association Special Volume.
16. Pant, D.D. (2003): Cycas and allied Cycadophytes, BSIP, Publications.

17. Sambamurty A. V. S. S., (2005) A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany, Today & Tomorrow's Printers and Publishers
18. Sharma O. P. (2002) Gymnosperms, PragatiPrakashan, Meerut.
19. Sharma P. N. and Sahni K. C. (2005) Gymnosperms of India and Adjacent Countries Publisher- Bhishan Singh Mahendra Pal Singh, Dehradun
20. Siddiqui, K.A. (2002) Elements of Palaeobotany, Kitab Mahal, Allahabad.
21. Singh, H. (1978), Embryology of Gymnosperms, Encyclopedia of Plant Anatomy X,
22. Spicer, R.A. & Thomas, B.A. (1986) Systematic and taxonomic approaches in
23. Sporne K. R. (1965). The morphology of Gymnosperms. Hutchinson & Co.
24. Thomas, B.A. & Spicer R.A. (1987): The Evolution and Palaeobiology of land plants.
25. Trivedi B. S and Singh D. K. (1965). Structure and reproduction of Gymnosperms.

MBOC 1.41
PLANT MORPHOLOGY & ANATOMY

Theory Credit: 4

UNIT I Introduction to morphological features of root, stem, leaves and flower; Shoot development: - Organization of shoots apical meristem (SAM) cytological and molecular aspects of SAM; Control of cell division and cell to cell communication; Control of tissue differentiation especially xylem and phloem. Cytological zonation – Anneaun initial and Meristem. Recent views on organization of shoot Apical Meristem and types of vegetative shoot apex in Gymnosperms and Angiosperms.

UNIT II Leaf growth and Differentiation: - Determination, control and leaf forms: Differentiation of epidermis (with special Recommended Books and References:- to stomata and trichomes) and mesophylls. Leaf Structure with reference to C3 and C4 plants – Kranz and CAM Syndrome.

UNIT III Root development: Organization of root apical meristem (RAM), Vesscular tissue differentiation, Lateral roots, root hairs, root- microbe's interaction. Application: - Utility in systematics, archaeology climatic studies. Organization of root apex and significance of Quiscent center.

UNIT IV Epidermology: Structural composition of Epidermal cells, stomata and trichomes. Epidermal cell complex – Structure, orientation and arrangement. Stomatal complex–Basic structure with reference to subsidiaries and ultrastructure of guard cells. Ontogeny of Paracyctic, diacytic, and anisocytic stomata. Trichome complex-Basic structure with reference to foot and body. Classification of trichomes. Transfer cells: Structure, distribution, ontogeny and function.

UNIT V Secondary growth with reference to Dicot stem. Significance of Dicot wood anatomy. Morphology and arrangement of Vessels, Axial Parenchyma Fibres and Ray parenchyma and their value in wood identification. Salient features of the following woods; *Tectona grandis, Terminalia tomentosa, Shorea robustAA Pongamia pinnata.*

Recommended Books and References:

1. Barnova, M A. 1987: Historical developments of the present classification of morphological • types of stomata. Bot.Res.53:53-79.
2. Carliquist. S. (1988). Comparative wood anatomy, Springer – Berlag, Berlin
3. Cutter, E G 1971 Plant Anatomy
4. Cutter, E.G. Plant Anatomy, Part I and II Edward Arnold; London, 1971 and 1978
5. Dilcher, D D 1974: Approaches to the identification of angiosperms leaf remains. Bot.Rev. 40:2-157
6. Easau, K. 1962: Plant anatomy –anatomy of seed plants.

7. Easu, K. Anatomy of Seed Plants.
8. Easu, K. Plant Anatomy, 2nd Ed. Wiley N.Y. 1965.
9. Emmes, E J. and M C Danials, 1947: An introduction to plant anatomy.
10. Fahn, A. Plant Anatomy (4th Ed.), 1990.
11. Fahn, A.1969: Secretary Tissue system
12. Foster, A S 1942: Practical plant anatomy
13. Haberland, G.1965: Physiological
14. Jeffrey, E.C. The Anatomy of woody plants.
15. Lyndon R.F. 1990. Plant development – The cellular basis. Unnin. Hyman, London.
16. Masueth, J D. 1936: Plant anatomy
17. Metcalf (1982-87) Anatomy of Dicots Vol. I to III
18. Metcalf and Chalk. Anatomy of dicots (2nd Edition) (1983). Clarendon Press, Oxford
19. Metcalfe, C R and L Chalk, 1950: Anatomy of the dicotyledons
20. meureth, J.D. 1988. Plant Anatomy. The Benjamin/Cummings Pub1. Inc., Menlo Park California.
21. Pearspm & Brown – Commercial Timbers
22. Rao, K.R. & K.B.S. Juneja (1971) A Hand book for identification of fifty important Timbers of India.
23. Solender, H. 1908: Systematics anatomy of the dicots
24. Steeves T.A. & Sussex 1. M, 1989, Pattersacin plant development 92nd Edition) Cambridge UNIT y Press, Cambridge.
25. Tomlinson, P S 1961: Anatomy of the monocotyledons.

SEMESTER – II

MBOC 2.11
ANGIOSPERM TAXONOMY

Theory Credit: 4

UNIT I **Principles in Plant Taxonomy**: Definitions and concepts: Systematic and Plant taxonomy, Scope and importance of taxonomy and need for classification; conceptual basis of classification: essentialism, nominalism, empiricism, Phenetics and Cladistics, Phylogenetic and alternative; Alpha and Omega taxonomy, taxonomy as synthetic discipline; Concept of species, genus, family and other categories; Taxonomic hierarchy- Ranks and categories of taxa; Herbarium and botanical gardens, their role in teaching, research and conservation

UNIT II A Brief History of Pre-Darwinian Classifications: Systems based on habit: Theophrastus, Albert Magnus; The sexual system: Carolus Linnaeus and his students; Systems based on form-relationships: Michel Adanson, Bentham and Hooker.
A Brief History of Post Darwinian Classifications: The evolutionary theory by Darwin and Wallace; Systems based on phylogeny- The Englarian School of thoughts-August Wilhelm Eichler, Adoph Engler; The Ranalian School of thoughts-Charles E. Bessey, John Hutchinson.
Recent Systems of Classifications: Broad outline of classification by Armen L. Takhtajan and R. M. T. Dahlgren, revised and updated classification of flowering plants by APG-III-Basal angiosperms, magnoliids, monocots, commelinids, eudicots, core eudicots, rosids, fabids, malvids, asterids, lamiids and campanulids.

UNIT III **Floristics and taxonomic literature:** Need and significance of floristic studies, methodology, analysis and data presentation; Taxonomic literature: General taxonomic indexes, world floras and manuals, monographs and revisions, bibliographies, catalogues, review serials, periodicals, glossaries; computer aided studies; taxonomic keys: Diagnostic, synoptic and artificial keys-Single access and multi-access keys; computerized keys, their merits and demerits

UNIT IV **International code of Nomenclature for Algae, Fungi & Plants (ICN):** Principles of the code; ranks of taxa; scientific names; Rules of Priority and limitations of principles of priority; Effective and valid publications; author citation, rejection of names and names of hybrid; nomen nudum, later homonym; Type method and typification.

UNIT V **Families of Angiosperms**: characteristic features, interrelationships, classification (APG) and economic importance of families: ANITA grade: Amborellaceae, Nymphaeaceae, Hydatellaceae; MAGNOLIIDS: Magnoliaceae, MONOCOTS: Araceae, COMMELINOIDS: Arecaceae, EUDICOTS: Papaveraceae, CORE EUDICOTS: Amaranthaceae, EUROSIDS-I:Malpighiaceae, EUROSIDII: Malvaceae, ASTERIDS:Sapotaceae, EUASTERIDS-I:Gentianaceae, Acanthaceae, EUASTERID-II: Apiaceae, Asteraceae

MBOC 2.22
ANGIOSPERM TAXONOMY (PRACTICAL)

Practical Credit: 2

Practical:

1. Herbarium technique
2. Study of the locally available plants: Description and identification at family, genus and species levels using Floras.
3. Study of different types of ovules and placentations.
4. Identification of key characters of families studied and construction of keys.
5. Identification of families studied based on flowers or essential parts of the flowers
6. Simple Nomenclatural problems.
7. Field trips within and around the College campus, compilation of field notes and preparation of herbarium sheets of such plants.

Recommended Books and References:

1. Briggs David 2009. Plant microevolution and Conservation in Human-influenced Ecosystems.Cambridge University Press.
2. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
3. Cronquist, A. 1988.The Evolution and Classification of Flowering Plants (2nded.) Allen Press, U.S.A.
4. Davis, P. H. and V. H. Heywood 1991.Principles of Angiosperm Taxonomy.Today and Tomorrow Publications, New Delhi.
5. Hutchinson, J. 1959. Families of Flowering plants. Clarendon Press, Oxford.
6. Judd Walter S., Campbell, C. S., Kellogg, E. A., Stevens, P.F. and M. J. Donoghue. 2008. Plant Systematics- A Phylogenetic Approach. Sinauer Associates, INC, Publishers. Sunderland, Massachusetts, USA.
7. Lawrence George H. M. 195.1 Taxonomy of Vascular Plants.Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.
8. Leadlay E. and S. Jury (ed.) 2006.Taxonomy and Plant conservation.Cambridge University Press.
9. Manilal, K. S. and M. S. Muktesh Kumar [ed.] 1998.A Handbook of Taxonomic Training. DST, New Delhi.
10. Naik, V. N. 1984.Taxonomy of Angiosperms. Tata McGraw-Hill Publication Com. Ltd. New Delhi
11. Quicke, Donald L. J. 1993. Principles and Techniques of Contemporary Taxonomy. Blakie Academic & Professional, London.
12. Simpson, M. G. 2010. Plant Systematics. Elsevier, Amsterdam.
13. Takhtajan, A. 1969. Flowering plants-Origin and Dispersal. Oliver and Boyd, Edinburg.
14. Taylor, D. V. and L. J. Hickey 1997. Flowering Plants: Origin, Evolution and Phylogeny.CBS Publishers & Distributers, New Delhi.

MBOC 2.21
MYCOLOGY & PLANT PATHOLOGY

Theory Credit: 4

UNIT I Historical introduction of mycology**,** General introduction of fungi, Fungal classification (Ainsworth and Alexopoulos). General accounts of Myxomycotina, Mastigomycotina, Zycomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina with representative classes and type studies. Lichens: Thallus structure, reproduction and economic importance.

UNIT II Recent trends and criteria used in the classification of fungi with reference to vegetative and reproductive structures; Parasexuality; wood decay fungi and their importance; Heterothalism, Development of Asci and Basidiocarp. Fungi in bioremediation. Economic importance of fungi in medicine, agriculture (Biopesticide, biofertilizers) and food.

UNIT III Plant disease diagnosis: Field observation, Laboratory investigation, isolation of plant pathogens and purification, Kotch's postulates and identification of plant pathogens. Methods of plant disease control.

UNIT IV Role of enzymes and toxins in pathogenesis. Effects of temperature, pH, and moisture in the development of plant diseases, Mechanism of infection and host defense mechanism.

UNIT V Symptoms, etiology and disease cycle of disease caused by: a) Mastigomycotina: Damping off of seedlings, white rust of crucifers. b) Ascomycotina: Powdery mildew of grapes and Ergot of Bajra. c) Basidiomycotina: Loss smuts of wheat and Rusts of wheat. d) Deuteriomycotina: early blight of potato and Red rot of sugarcane.

MBOC 2.22
MYCOLOGY & PLANT PATHOLOGY (PRACTICAL)

Practical Credit: 2

Practical

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. Measurement of fungal growth by linear and weight determination.
7. Effects of temperature on the growth of microbes.
8. Study of different mycorrhizal association.
9. Study of morphology and reproductive structures of soil and air fungi
10. Study of various diseased plants.
11. Experiment to test pathogenicity of fungal pathogens.

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. Aneja K. R. (1996). Experiments in Microbiology, Plant Pathology and Tissue Culture. Wishwa Prakashan.
4. Atlas R. M. and Bartha R (1997) (4th Edition) Microbial Ecology: Fundamental Applications. Benjamin/Cummings Science Pub.

5. Barnett H. L. and Hunter, B. B. (1972). Illustrated genera of imperfect fungi. Burges Publ.
6. Benson H.J. (1990). Microbiological Applications - A Laboratory Manual in General Microbiology. Wm. C. Brown Publishers.
7. Blakeman, J. P and Williamson B. (1994). Ecology of plant pathogens. CAB International.
8. Cappuccino J. G. and Sherman N. (1999). Microbiology- A Laboratory Manual (Fourth Edition). Addison Wesley.
9. Creager, J. G., Black, G and Davidson, V. E (1990). Microbiology: Principles and Applications, Prentice Hall.
10. Domsch K. H., Gams W. and Anderson T. H. (1980). Compendium of soil fungi. Academic Press
11. George, N. A (1988) Plant Pathology (third edition) Academic Press.
12. Gilman J. C. (1967). A Manual of Soil fungi. Oxford and IBH Publishing Co.
13. Harley, H. L and Smith, S. E (1983). Mycorrhizal symbiosis. Academic Press.
14. Johnson L. F. and Curl E. A. (1972). Methods for Research on the Ecology of soil borne plant pathogens. Burgess Publishing Co.
15. Madigan, M. T., Martinko, J. M and Parker, J (2000). Brock Biology of Microorganisms. Prentice Hall International, Inc
16. Mehrotra R.S. (1995). Plant Pathology. Tata Mc Graw Hill.
17. Michael J., Carlile, S., Watkinson C and Gooday, G. W. (1994). The Fungi (second edition) Academic Press.
18. Mishra, R.R. (1996). Soil Microbiology. CBS Publ.
19. Nester E. W., Roberts C. e. and Nester M. T. (1995). Microbiology: A Human Perspective. Wm. C. Brown Publisher.
20. Ravichandra, N.G. Fundamentals of plant pathology. PHI Learning Pt. Ltd Delhi.
21. Sarbhoy A. K. (2002) Text Book of Mycology, ICAR.
22. Sharma, P.D. Microbiology and plant pathology, Rastogi Publications.
23. Stevens F. L. (1985). The fungi which cause plant diseases. IBS. Intl.
24. Tate, R. L (1995). Soil Microbiology, John Wiley and Sons Inc.
25. Tortora, G., Berdell, R. R and Case. C. L (1995). Microbiology – An Introduction. The Benjamin/Cumming Publishing Company.
26. Van Elsas J. D., Trevors, J. T., Wellington, e. M. H. (1997). Modern Soil Microbiology, Marcel Dekker Inc.
27. Vashishta, B.R and Sinha, A.K. Botany for degree students (Fungi). S. Chand and Company Ltd.

MBOC 2.31
BIOCHEMISTRY & BIOTECHNOLOGY

Theory Credit: 4

UNIT I Carbohydrates, their derivatives and inter-conversions; Lipids: types and their derivatives: biosynthesis of fatty acids and their regulation, fatty acid oxidation. Amino acids: structure and function, properties of amino acids, formation of peptide bonds; Proteins: Hierarchical structure of proteins, Ramachandran plot, protein functions.

UNIT I Bioenergetics: Laws of thermodynamics and their significance in free energy changes in biological systems, bioenergetically favourable reactions; Enzymes: general classes of enzymes, significance of ribozymes; general principles governing enzyme-catalyzed reactions. Mechanism of enzyme catalysis, Michaelis-Menten steady-state kinetics. Factors affecting enzyme activity, regulatory enzymes.

UNIT III Signal Transduction: Overview, second messengers, receptors and G-proteins, phospholipid signaling, role of cyclic nucleotides, calcium-calmodulin cascade, protein kinases and phosphatases, specific signaling mechanisms and their

regulation, e.g. simple and hybrid type of two-component sensor-regulator system in bacteria and plants: chemotaxis, osmosensing, ethylene and cytokinin signaling, quorum sensing.

UNIT IV Recombinant DNA technology: restriction enzymes and construction of hybrid DNA; Gene cloning: cloning vehicles (plasmids, bacteriophages, YAC, BAC), T-DNA, Ti-plasmid *(Agrobacterium temefaciens)* mediated gene transfer. Construction and screening of genomic DNA and cDNA libraries;

UNIT V Polymerase Chain Reaction: principle, primer designing, *Taq* polymerase, introduction to RT-PCR. Brief overview of nested PCR, inverse PCR, Hot start PCR, Touch down PCR, Nested PCR, Reverse transcriptase PCR, Assymetric PCR. DNA sequencing – Chain Termination Method and Chemical Degradation Method. Blotting techniques (Southern, Western & Northern). DNA Fingerprinting (AFLP, RAPD, RFLP)

MBOC 2.32
BIOCHEMISTRY & BIOTECHNOLOGY (PRACTICAL)

Practical Credit: 2

Practical

1. Estimation of starch from plant tissues by iodine reaction
2. Estimation of sugars from plant tissues by dinitrosalycilic 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 filteration (b) gel electrophreis
6. Assay of phosphatase activity in plant cells
7. Assay of nitrate reducatase acivity in cells
8. Demonstration of of PCR technique
9. Study of blotting techniques.
10. Study of DNA fingerprinting techniques.

Recommended Books and References:

1. Nelson D.L. and Cox M.M. (2000). Lehningers Principles of Biochemistry. Macmillan Worth.
2. Stryer L. (1993). Biochemistry. W.H. Freeman.
3. Zubay G. (1993). Biochemistry. W.C. Brown.
4. Heldt H. (1997). Plant Biochemistry and Molecular Biology. Oxford Univ. Press
5. Boyer R. (1999). Concept in Biochemistry. Brooks/Cole Publ.
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. Nelson DL and Cox MM. (2004) Lehninger Principles of Biochemistry, 4th Edition, W.H., Freeman and Company, New York, USA.
10. Kuby, J. 2000. Immunology, 4th edition, W.H. Freeman and Company, New York, USA.
11. Roitt et al., 1998, Immunology 5th edition, Mosby International Ltd. London. UK.
12. Buchanan, Grissem and Jones (2000). Biochemistry and Molecular Biology of
13. Plants. American Soc. Plant Biologists, Waldorf.
14. Lewin B. (2000). Gene VII. Oxford University Pres. New York, USA
15. Sinden P.R.R. (1994). DNA structure and function. Acad. Press.
16. Walker J.M. and Rapley R. (2002). Molecular Biology and Biotechnology. Panima.
17. Brown TA. (2002) Genomes, BIOS Scientific Publishers Ltd, Oxford, UK.
18. Brown TA. (2008) Gene cloning and DNA analysis (5th Edition),Blackwell Publishing, Oxford, UK.

19. Click, B.R. and Thompson, J.E. 1998. Methods in Plant Molecular biology and biotechnology. CRCPress, BOCA RBTON Florida.
20. Hackett, P.B., Funchs, J.A. and Messing, J.W. 1998. An Introduction to recombinant DNAtechniques: Basic experiments in gene manipulation. The Benjamin Cummings PublishingCompany, Inc. Memno Park, California.
21. Glover, D.M. and Hames, B.D. (Eds.) 1995. DNA cloning I: A practical approach, Core techniques,first edition, TASIRL Press al Oxford University Press, Oxford.
22. Debata, A., Pamda, D. & Debata, A. (2014). Language of Biotechnology. New Central Book Agency (P) Ltd. London.

MBOC 2.41
CELL BIOLOGY & MOLECULAR BIOLOGY

Theory Credit: 4

UNIT I Prokaryotic and eukaryotic Cell: The ultra-structural details and comparative assessment. Plasma membrane: Molecular. organization, current models and functions. Cell wall architecture, biosynthesis, assembly, growth and cell expansion. Plasmodesmata: Structure and role in movement of molecules and macromolecules. Structure and function of Endoplasmic Reticulum & Golgi complex. Cell cycle- Phases of cell cycle, functional importance of each phase, Molecular events during cell cycle, Regulation of cell cycle.

UNIT II Cytoskeleton: Organization and role of microtubules and microfilaments. Implications in flagellate and other movements. ii. Plant vacuole: Tonoplast membrane.
Chloroplast and Mitochondria: Ultrastructure, function and biogenesis.
Nucleus: Microscopic and submicroscopic organization. Structure and function of nuclear Envelope. The ultrastructure of nucleolus and its role in rRNA biosynthesis.
Ribosomes: Structure and site of protein synthesis.
Lysosomes- Ultra structure of lysosomes, Membrane integrity and role

UNIT III Structure of nucleic acids: DNA and its A, B and Z conformations, t-RNA, r-RNAs; DNA replication: (Unit of replication, enzymes involved, replication origin and replication fork). machinery and mechanism in prokaryotes and eukaryotes; Genetic code and exceptions to its universality.

UNIT IV Transcription and Translation: RNA transcription- machinery and mechanism in prokaryotes and eukaryotes; RNA processing: processing of hnRNA; RNA editing; Translation machinery and mechanism (tRNA charging, initiation in prokaryotes and eukaryotes, elongation and termination); Regulation of gene expression in prokaryotes and eukaryotes; post translational processing, turnover in cells.

UNIT V Gene mutation: Mutagens, Molecular basis of mutation, Mechanism of Spontaneous and induced mutation. DNA damage and repair mechanisms, homologous and site-specific recombination.

MBOC 2.42
CELL BIOLOGY & MOLECULAR BIOLOGY (PRACTICAL)

Practical Credit: 2

Practical
1. Study of mitosis using onion root tip

2. Study of meiosis using flower bud
3. Staining of nucleolus
4. Study of giant chromosomes/ polytene chromosomes in C*hironomous* larva
5. Isolation of plant DNA using CTAB method
6. Agarose gel electrophoresis of DNA
7. Spectrophotometric estimation of DNA
8. DNA digestion by general restriction endonucleases

Recommended Books and References:

1. Alberts B. et al. (2002). Molecular Biology of the cell. Gerland.
2. Alberts, B., Bray, D., Lewis, J. Raff, M., Roberts, K. and Watson, J.D. 1989. Molecular Biology of the cell, Garland Publishing Inc., New York
3. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D.I 999.Molecular Biology of the cell. Garland Publishing, Inc. New York.
4. Arthur G (1979) (5th Edn). Cell Physiology, Toppan company Ltd., Tokyo, Japan.
5. Birge, E.A. (2000). Bacterial and bacteriophage genetics. Springer.
6. Brown, T.A. (1989).Genetics a molecular approach. Van Nostrand.
7. Buchanan B.B. et al. (eds) (2004). Biochemistry and Molecular Biology of Plants. Amer. Soc. Plant Physiol.
8. Cooper G.M and Hausman R.E. (2007) (4th Edn). The Cell molecular approach Sinauer associate, Inc, Suderland (USA).
9. David S. (2004) (1st Indian Edition). Cell Biology, New Delhi. 9. Albert et al (2002). (4th Edn). Molecular Biology of the cell, Garland Science (Taylar and Francis) New York Group (wt)
10. De Robertis and De Robertis (2005). (8th edition) (Indian) Cell and Molecular Biology, Lippincott Williams, Philadelphia. [B.I Publications Pvt. Ltd. New Delhi].
11. De Robertis, De Robertis (1988). Cell and Molecular Biology, 8th Edn. Info-Med,
12. De, D.N. 2000. Plant cell vacuoles. An introduction. CSIRO Publication, Collingwood, Australia.
13. Evolution, Ecology. S.Chand and Company, New Delhi.
14. Gunning B.E.S. and Steer, M.W. 1996. Plant cell biology, structure and function. Jones and Bartlet Publishers, Boston, Massachusetts
15. Hall, J.L. and Moore, A.L. 1983. Isolation of membranes and organelles from plant cells. Academic Press, London, U.K,
16. Harris, N. and Opataks, K. J. 1994. Plant Cell Biology: A practical approach. IRL Press at Oxford University Press, Oxford, U.K. 7. Shaw, C.H. (Ed.) 1988. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.
17. Hongkong
18. Karp G. (1999). Cell and Molecular Biology- Concept and Expts. John Wiley and
19. Kleinsmith, I.J. and Kish, V.M. 1995. Principles of Cell and Molecular Biology (End Edition). Harper Collins College publishers, New York, U.S.A.
20. Lea P.J. and Leagood R.C. (1999). Plant Biochemistry and Molecular Biology. Wiley.
21. Lewin B. (2002). Genes VIII. Oxford.
22. Lewin, B. 2000, Genes VII, Oxford University Press, New York.
23. Lodish et al (2004). 5th Edn). Molecular Cell Biology, W H Freeman and company, New York.
24. Lodish H, Berk A, Kaiser CA and Krieger M. (2008) Molecular Cell Biology, 6th Edition, W.H. Freeman and Company, New York, USA.
25. Lodish H. et al. (1996). Molecular Cell Biology. Sc. American Books.
26. Lodish S., Baltimore B., Bek C., Lawrence K. (1995).Molecular Cell Biology. 3rd Edn. Scientific American Books, New York.
27. Lpdish, H., Berk, A., Zipursky, S.Z., Matsudaira, P., Baltimore, D. and Darnell,J., 2000. Molecular Cell Biology. (4thEdition). W.H. Freeman and company, New York, U.S.A. Review Journals
28. Powar C.B. (2005) (3rd Edn). Cell Biology, Himalaya Publishing, Mumbai.
29. Roy S.C and De K.K. (2005). (2ndEdition). Cell Biology, New central Book Agency Private Ltd., Kolkata.
30. Scne Ine., USA.

31. Verma P.S and Agarwal V.K. (2006) Cell Biology, Genetics, Molecular Biology,
32. Watson J.D. et al. (2004). Molecular Biology of the gene. Pearson Education
33. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. 2004. Molecular Biology of the Gene, Pearson Education, Singapore
34. Wolfe, S.L. 1993. Molecular and cellular biology. Wodsworth Publishing Company, California, U.S.A.

SEMESTER – III

MBOC 3.11
GENETICS, CYTOGENETICS & PLANT BREEDING

Theory Credit: 4

UNIT I Modern gene concept. Mendel's laws of inheritance. Gene interactions. Organization of eukaryotic chromosomes; Linkage and genetic recombination, linkage groups; Mutations: induced and spontaneous; Physical and chemical mutagens; Molecular mechanism of mutation and recombination.

UNIT II Chromosomal aberrations in plants: structural aberrations, numerical aberrations; Interchange tester sets; Euploidy-autopolyploidy and allopolyploidy; aneuploidy-monosomy, trisomy and nullisomy; Interchange hetorozygotes, permanent hybrids.

UNIT III Origin and meiotic & breeding behaviours of haploids, autopolyploids and allopolyploids; Genome constitution and analysis; Genome and Chromosome engineering: Synthesis of tetraploid, hexaploid and octoploid triticales; Alien chromosome additions and substitutions; Chromosome fragment transfers and crop improvement; Giemsa banding of chromosomes; FISH.

UNIT IV Gene frequency in a population, genetic equilibrium and Hardy-Weinberg law, barriers to gene flow and mechanism of speciation; Heterosis, hybrid vigour, and inbreeding depression. Concept of combining ability; Conventional methods of plant breeding: selection methods. Hybridization: pedigree method, bulk method, backcross, test cross.

UNIT V Concept of combining ability; Phenotypic and genotypic variance and its components; Heritability of traits and its estimation; Population improvement, inbred improvement, cultivar development. Male sterility and its application in hybrid seed production. Breeding for diseases and pest resistance and stress resistance.

MBOC 3.12
GENETICS, CYTOGENETICS & PLANT BREEDING (PRACTICAL)

Practical Credit: 2

Practical

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 mitosis and 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 X 2 for independence of attributes and goodness of fit
8. Giemsa banding of chromosomes
9. Experiment to perform self- and cross-pollination and fertilization.

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. Elrod S. and Stansfield W. (2004). Genetics. Tata McGraw-Hill.
8. Fukui K. and Nakayam S. (1996). Plant Chromosomes: Laboratory Methods. CRC Press.
9. Griffiths A.J. F. et al. (2000). An Introduction to Genetic Analysis. W. H. Freeman.
10. Gupta P. K. (1995). Cytogenetics. Rastogi & Co.
11. Gupta P. K. (1998). Genetics and Biotechnology in Crop Improvement. Rastogi & Co.
12. Hartl D. L. (1991). Basic Genetics. Jones & Bartlett.
13. Hartl D. L. and Jones E. W. (2001). Genetics-Analysis of Genes & Genomes. Jones and Bartlett.
14. Jain H. K. (1999). Genetics. Oxford-IBH.
15. Poehlman J. M. and Sleper D. A. (1995). Breeding Field Crops. Iowa State University Press.
16. Sharma A. K. and Sharma A. (1999). Plant Chromosomes: Analysis, Manipulation and Engineering. Harwood Academic Publishers.
17. Sharma J. R. (1994). Principles & Practices of Plant Breeding. Tata-McGraw Hill.
18. Simmonds N. W. (1979). Principles of crop improvement. Longman.
19. Snustad D. P. and Simmons M. J. (2000). Principles of Genetics. John Wiley and Sons.
20. Stansfield W. D. (1969). Theory and Problems of Genetics. McGraw-Hill.
21. Strickberger M. W. (1985). Genetics. Macmillan.
22. Sybenga J. (1972). General Cytogenetics. North Holland.
23. Tamarin R. H. (2002). Principles of Genetics. Tata 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; ascent of sap. Stress biology: water, temperature, salt and biotic stress.

UNIT II 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 fixation in photosynthesis and its regulation.

UNIT III Glycolysis and its regulation; 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 IV 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. Secondary metabolites: synthesis of terpenes, phenols and nitrogenous compounds and their roles in plants.

UNIT V 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)

Practical Credit: 2

Practical

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. Acadmeic Press.
7. Encyclopedia of Plant Physiology. Springer-Verlag. (Annual Series).
8. Gressholf 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. Mercel Deker.
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.

SEMESTER – IV

MBOC 4.11
PLANT DEVELOPMENT AND REPRODUCTIVE BIOLOGY

Theory Credit: 4

UNIT I **General Features of Plant Development:** Plant growth kinetics and patterns of growth. Seedling growth: Tropisms; Photomorphogenesis of seedling; Shoot Development: Organization of shoot apical meristem (SAM); tissue differentiation in the shoot.

UNIT II **Leaf, Root and Flower Development:** Leaf growth and differentiation: Determination; phyllotaxy; control of leaf form; differentiation of epidermis (with special reference to stomata & trichomes) and mesophyll. Root Development: Organization of root apical meristem (RAM); vascular tissue differentiation; lateral root hairs; root microbe interactions. Flower Development: Physiology of flowering, florigen concept and photoperiodism, Pollination mechanisms and vectors.

UNIT III **Development of Reproductive Structures:** Male Gametophyte: Structure of anther, microsporogenesis, tapetum; pollen development and gene expression; male sterility; sperm dimorphism; pollen germination; pollen tube growth and guidance. Female Gametophyte: Ovule types; megasporogenesis; organization of embryo sac; structure of embryo sac cells. Pollen-pistil interaction, self-incompatibility and fertilization; Structure of the pistil; pollen-stigma interactions, double fertilization; in vitro fertilization.

UNIT IV **Fruit and Seed Development:** Seed Development and fruit growth: Endosperm development; embryogenesis; ultrastructure and nuclear cytology; storage proteins of endosperm and embryo; polyembryony; apomixes; embryo. Fruit development and growth. Dormancy; Importance and types of dormancy; seed dormancy; overcoming seed dormancy; bud dormancy.

UNIT V **Palynology:** Scope and branches; Palynotaxonomy: Pollen morphology and plant taxonomy of Angiosperms; Paleopalynology: Principles, microfossil groups and oil exploration; Aeropalynology: Principles, techniques, pollen analysis, pollen and spore allergy, allergic properties of pollen, pollen calendar and importance; Melittopalynology: Bee colony, foraging behaviour of bees, unifloral multifloral honey, application in crop productivity; Agropalynology: Pollen viability, pollen germination, pollen storage and their significance.

MBOC 4.12
PLANT DEVELOPMENT AND REPRODUCTIVE BIOLOGY (PRACTICAL)

Practical Credit: 2

Practical

1. Study of microsporogenesis in sections of 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. Examination of modes of anther dehiscence and collection of pollen grains for Microscopic examination (maize, grasses, *Crotolaria, Tradescantia, Brassica, Petunia, Solanum* etc.).
7. Test for pollen viability using stains and in vitro pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture
8. Estimation of percentage and average pollen tube length in vitro
9. Study of ovules and embryo sacs.
10. Field study of types of flowers and pollination mechanism.
11. Study of nuclear and cellular endosperms.

Recommended Books and References:

1. Bhattacharya, Hait & Ghosh. 2013 (Reprint). A text Book of Botany.
2. Bhattacharya, K., M R Majumdar and S G Bhattacharya 2006: A Text book of Palynology.
3. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.
4. Erdtman, G.1988 : Pollen morphology and plant taxonomy.
5. Fageri, K and J Inversen, 1964: Text book of pollen analysis.
6. Heslop-Harrison, Y. 1971: Pollen development and physiology.
7. Johari, B M. 1963: Experimental embryology of vascular plants.
8. Maheshwari, P. 1950: An introduction to the embryology of Angiosperm.
9. Maheshwari, P.1963: Recent advances on the embryology of Angiosperm.
10. Nair, P K K1964: Advances in Palynology.
11. Nair, P K K1966 : Essentials of Palynology
12. Pandey and Chadha, 1992: Plant Anatomy and Embryology.
13. Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge
14. Raven, P.H., Evert, R.F. and Eichhorn, S.E. 1992. Biology of Plants (5th Edition).worth, New York.
15. Shivanna K R and B M Johari, 1985: The Angiosperm Pollen, structure and function.
16. Shivanna K R and N S Rangaswami1992: Pollen Biology, A Laboratory manual.
17. Shivanna, K. R. and B M Johari 1989: The Angiosperm pollen, structure
18. Shubhrata R Mishra 1993Morphology of Plants.
19. Stanley, R G and F.L. Linkens 1974: Pollen biology, Biochemistry management
20. Tilak, S T. 1989: Airborne pollen and fungal spores.

MBOC 4.21
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 (niche width and overlap, fundamental and realized niches); edge effect and ecotones. Ecosystem concept, ecosystem organization.

UNIT II Population ecology: Population growth; survivorship curves and life-table analysis; population dynamics and plant population regulation; Life history strategies, *r & k* selection; population interactions with emphasis on resource competition and allelopathy, ecotypes.

UNIT III Community Ecology: Structure and attributes of plant community, life forms and biological spectrum, species dominance, keystone stone species and species diversity (α, β, γ), measures of biodiversity and biodiversity indices.

UNIT IV Ecosystem function: Primary productivity and its measurement; Primary productivity of terrestrial and aquatic ecosystems of the world; energy dynamics: trophic organization, energy flow pathways, ecological efficiencies. Decomposition: mechanism and controlling factors. Biogeochemical cycles with particular reference to cycling of carbon, nitrogen, phosphorus and sulphur.

UNIT V Ecosystem dynamics: development of ecosystem; Ecological succession - models and mechanisms of ecological succession changes in ecosystem properties during succession, concept of climax; Ecosystem stability- ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems; ecosystem resistance and resilience.

MBOC 4.22
ECOLOGY AND ECOSYSTEM ANALYSIS (PRACTICAL)

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. Begon M.Harper J.L. and Townsend C. R. (1990). Ecology: Individual, Populations and Communities. Blackwell Scientific Publisher.
3. Daubernmire R. (1974). Plants and environment. John Wiley & Sons.
4. Hanson H. C. and Churchill E. D. (1963). Plant Communities. Reinhold.
5. Kormondy E. J. (1996). Concepts of ecology. Prentice-Hall.
6. Misra R. (1968). Ecology Workbook. Oxford & IBH.
7. Muller-Dombois D. and Ellenberg H. (1974). Aims and Methods of vegetation ecology. John Wiley & Sons.
8. Odum E. P. (1971). Fundamentals of Ecology. W. B. Saunders.
9. Odum E. P. (1983). Basic Ecology. Holt Saunders International.
10. Odum, E. P. (1971). Fundamentals of Ecology. W. B. Saunders.

11. Poole R. W. (1974). An Introduction to Quantitative Ecology. Mc Graw Hill Inc.
12. Underwood A. J. (1997). Experiments in ecology. Cambridge University Press.
13. White J. (1985). Studies on plant demography. Academic Press.
14. Whittaker R. H. (1975). Communities and Ecosystems. McMillan.
15. Wild A. (1994). Soils and the environment. Cambridge University Press.
16. Zar J. H. (1984). Biostatistical analysis. Prentice-Hall International.

DISCIPLINE SPECIFIC ELECTIVE 1

MBOD 3.11(a)
PLANT SYSTEMATICS

Theory Credit: 4

UNIT I **Approaches To Plant Systematics:**
Principles and procedures of plant systematics; Plant speciation: Allopatric, abrupt, sympatric, hybrid, apomictic speciation, isolating mechanisms; Biosystematics: Steps in biosystematics, Biosystematic categories, Importance of Biosystematic studies.

UNIT II **Developing Classification:**
Systems of Angiosperm Classification: Phenetic versus phylogenetic systems. Principles of Taxometrics. Cladistics in taxonomy-Phylogenetic terms; plesiomorphic and apomorphic characters; homology and analogy; parallelism and convergence; monophyly, paraphyly, polyphyly; phylogenetic diagram; phylogenetic data analysis.

UNIT III **Variation Types and Causes:**
Types of variation; variance analysis; reproductive system-types; outbreeding; Hybridization introgressive hybridization; recognition of hybrids; stabilization of hybrids; outbreeders with internal barriers; inbreeding. Evolution-mutation; random genetic drift; natural selection; Darwinian fitness and fitness coefficient; molecular evolution.

UNIT IV **Phylogeny of Angiosperm:**
Origin of angiosperms; age of angiosperm; molecular dating. Monophyletic and polyphyletic origin of angiosperms; possible ancestor and theories; origin of monocot, basal living angiosperms. Evolutionary trends- evolution of inferior ovary.

UNIT V **Modern Trends IN Angiosperm Taxonomy:**
Embryology in relation to taxonomy; Anatomy in relation to taxonomy; Palynotaxonomy; Cytotaxonomy; Chemotaxonomy; Molecular Systematics.

MBOD 3.12(a)
PLANT SYSTEMATICS (PRACTICAL)

Practical Credit: 2

Practical

1. Specimens collection and handling
2. Taxonomic literatures – Check lists, Floras, Keys, Monographs and Laboratory identification manuals.
3. Preparation of artificial keys.
4. Palynotaxonomy – Study of pollen characters of taxonomic significance.
5. Numerical taxonomy-study attributes, coding, statistical analysis
6. Molecular Taxonomy: Specimen collection, Isolation of DNA
7. DNA-purification, quantification.

Recommended Books and References:

1. Angiosperm Phylogeny Group (2003) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. Botanical Journal of the Linnaean Society 141: 399-436.
2. Cracknell AP, Hayes L (2009) Introduction to Remote Sensing. CRC Press, Boca Raton, USA (Special Indian Edition).
3. Crawford DJ (2003) Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
4. Cronquist A (1981). An integrated system of classification of flowering plants. Columbia Evolution. Taylor and Francis, London.
5. Jain S.K. (1995). Manual of Ethnobotany. Scientific Publisher; Second edition (1995).
6. Judd WS, Campbell CS, Kellogg EA, Stevens PA and Donoghue MJ (2002). Plant Systematics: A Phylogenetic Approach. Sinauer Associaes, Inc., Massachusetts.
7. Nei M and Kumar S (2000). Molecular Evolution and Phylogenetics. Oxford University Press, New York.
8. Raven PH, Begr LR, Hassenzahl DM (2008). Environment. 6th edition. John Wiley & Sons, Inc., New York.
9. Semple C and Steel MA (2003). Phylogenetics. Oxford University Press, Oxford. 10. Simpson MG (2006). Plant Systematics. Elsevier, Amsterdam.

MBOD 3.11(b)
MEDICINAL PLANTS

Theory Credit: 4

UNIT I Introduction: Medicinal plants, Ayurveda - Basic concepts, Tibetan system of medicine, Unani system of medicine, Siddha system of medicine, Medicinal plants in Homoeopathy system. Medicinal plants classification, Diseases of medicinal plants.

UNIT II Medicinal value of food plants (only a couple of examples): cereals, pulses, spices, fruits, vegetables and wild food plants. Medicinal and nutritive values of mushrooms.

UNIT III Herbal remedies: Plants used for treatment of heart and blood circulation, nervous 23 disorders, respiratory and intestinal disorders, jaundice, urinary, skin, hair, diabetics, cancer, gynecological disorders and infertility. Plants used as general tonics.

UNIT IV Ethno-botany and ethno-medicine: Importance of Ethno-botany and ethno-medicine in modern health care system, methods of collecting traditional knowledge on medicinal plants. Primary and secondary metabolites.

UNIT V Medicinal plants of Northeast India with special reference in Nagaland: identification and uses of at least ten plants.

MBOD 3.12(b)
MEDICINAL PLANTS (PRACTICAL)

Practical Credit: 2

Practical

1. Collection and identification of medicinal plants
2. Qualitative analysis of primary and secondary metabolites
3. Estimation of flavonoids
4. Estimation of phenol
5. Separation of secondary metabolites (TLC)
6. Pharmacological and Pharmacognostic analysis of crude plant drug

Recommended Books and References:

1. Harborne, J. 1984. Phytochemical methods. Ed Chapman & Hall, London
2. Kirtikar K.R. and Basu, B. D. 1932. Indian Medicinal Plants.
3. Maheshwari, J. K. 2000. Ethno-botany and Medicinal Plants of Indian Subcontinent, Scientific Publishers, India.
4. Mann, J., Davidson, R. S., Hobbs, J. B., Benthorpe, D. V, and Harborne Natural Products, Longman Scientific and Technical Co., Essex.
5. Nadkarni, A. K. 1954. Indian Materia Medica Vol. I & II.
6. Prajapati et al., 2003. A Hand Book of Medicinal plants - A complete Source Book. Agrobios, Jodhpur, India.
7. Prajapati., Purohit., Sharma and Kumar. 2007. Hand Book of Medicinal Plants: A complete Source Book, Agrobios India.
8. Rastogi R. P. and Meharota B. N. 1991. Compendium of Medicinal Plants. Vol. I & II. 1993. CDIR, Locknow and publication and information directorate New Delhi India.
9. Sivarajan, V.V. and Indira, B. 1994. Ayurvedic drugs and their plant sources. Oxford & IBH publishing Co., New Delhi
10. Smith, P.M 1976. The Chemotaxonomy of Plants. Edward Arnold, London.
11. Trease, G, E. and Evans, W. L, 1983. Pharmacognosy 12th ed. Baillie Tindal, London
12. Vaidya, B, 1982. Some controversial drugs in Indian Medicine. Chaukamba Oriental, Varanasi

MBOD 3.11(c)
BIODIVERSITY AND CONSERVATION

Theory Credit: 4

UNIT I Species concept: Concept and importance of biodiversity, Earth summit 1992, and Agenda 21, species diversity, genetic diversity, ecosystem diversity,

UNIT II Biodiversity of the world and India, Hotspots of world and India, Mega biodiversity centers of world and India. Origin centers of crop plants.

UNIT III Loss of Biodiversity: Casual factors of threat, Impact of habitat loss and habitat fragmentation, Categories of treat endangered, vulnerable, rare, threatened and extinct. Red Data Book. Environmental impact assessment, sustainable development.

UNIT IV Biodiversity Conservation: Objectives, implication and action plans, International and National organizations for conservation of natural resources, *in situ* conservation – protected areas, biosphere reserves, national parks, sanctuaries and sacred groves, *ex situ* – conservation, botanical gardens, gene banks, medicinal conservation parks, herbal gardens.

UNIT V Biodiversity conservation Legal aspects: Legal aspects of biodiversity in India. Policy and priority setting. Biodiversity conservation future strategies for India.

MBOD 3.12(c)
BIODIVERSITY AND CONSERVATION (PRACTICAL)

Practical Credit: 2

Practical:

1. Field survey of important plants of the region.
2. Study of the characters and threatened plants included in the theory.
3. Survey of important timber yielding trees of the region.
4. Determination of the minimum size of the quadrat suitable for an area using 'species area curve' method.
5. Determination of Importance Value Index (IVI) of the plant species in the community by quadrant method.
6. Study of Phytogeographic maps of world and India.
7. Map of Hot spots, Continental drift.

Recommended Books and References:

1. CSIR 1986. The Useful Plants in India.
2. Glasson, J., Therivel, R. & Chadwick, A. 1995. - Introduction to environment impact assessment. UCL Press Ltd., London.
3. Heywood, V.H. & Wyse Jackson, R.S. (eds.), 1991. - Tropical Botanical Gardens- their role in conservation and development. Academic Press, San Diego.
4. Heywood, V.M. and Watson, R.T. 1985. Global Biodiversity Assessment, Cambridge Univ. Press, Cambridge.
5. Kothari, 1987. Understanding biodiversity, life sustainability and equity, Orient Longman.
6. Nayar, M.P. & Sastry, A.R.K. 1987, 1989, 1990. - Red Data Book of Indian Plants (3 vols.).
7. Nayar, M.P. 1996. - Hot spots of endemic plants of India, Nepal, and Bhutan. TBGRI, Trivandrum.
8. Negi, S.S. 1993. Biodiversity and its Conservation in India.
9. Peter B. Kaufman et al., 1999. Natural Products from Plants.
10. Richard B. Primack. 1993. Essentials of Conservation Biology. 6. Heywood, V.H. & Watson, R.T. 1995. Global Biodiversity Assessment.
11. Swaminathan, M.N. & Jain, R.S. Biodiversity: Implications for global security, Macmillan, 1982.
12. Walter, K.S. & Gillett, H.J. 1998. - IUCN Red List of threatened plants. The World Conservation Union, Cambridge.

DISCIPLINE SPECIFIC ELECTIVE 2

MBOD 3.21(a)
RESEARCH METHODOLOGY&BIOSTATISTICS

Theory Credit: 4

UNIT I **Research Principles**

Meaning of research; objectives of research; Types of research: descriptive, analytical, applied, fundamental, quantitative, qualitative, conceptual, empirical and other types of research; identifying research problems and approaches; research

methods vs. Methodology; research and scientific method; research process: steps of research process; case study; criteria of good research.

UNIT II **Research Ethics**

Intellectual property and protection of intellectual property rights; International horrmonization of patent laws: TRIPS, India and TRIPS; Protection of biotechnological inventions.

Plant breeder's rights; Management of IPR; Benefits and problems from IPR; Geographical Indications; International convention on biological diversity (ICBD). Copyrights, Trade Marks; protection of plant variety and farmers rights PPVFR. Acquisition and management of IPRs.

UNIT III **Experiment Design& Data Collection**

Introduction to experiment design; Unpaired and paired designs; completely randomized design; randomization complete block design; factorial designs; and split-plot design; Null and alternative hypotheses; Sampling, Sample size determination;dependent and independent variables;Primary and secondary data; plan for data collection; methods of data collection; Plan for data processing and analysis.

UNIT IV **Statistical Analysis**

Introduction to statistical software; Calculating means, median, standard deviation, standard error, frequency distribution, coefficient of variance, degrees of freedom;Concept of normality, *p*-value, confidence interval, outliers, correlation, test of independence, test of homogeneity; Mean comparison procedures; Test of significance: Students' 't' test, Z test,chi square test;Analysis of variance and 'F' test; Type I & Type II errors; Correlation and regression analysis.

UNIT V **Scientific writing**

Meaning of Scientific and non-scientific writings; Structures of Research proposals, Synopsis, Dissertations, Thesis, Research paper writings (Abstract, Introduction, Review literature, methodology, Results, Discussions, Summary, Conclusion, Bibliography); Presentations: Graphical, Tabular, Animation, Power point. Scientific paper presentation in seminar and conference: oral and poster.

MBOD 3.22(a)
RESEARCH METHODOLOGY & BIOSTATISTICS (PRACTICAL)

Practical Credit: 2

Practical:

1. Laboratory on handling data analysis software.
2. Laboratory on scientific writing.
3. Laboratory session on peer review.
4. Laboratory of poster preparation.
5. Seminary presentation

Recommended Books and References:

1. Research Methodology - Methods and Techniques, Kothari, C.R., 2004 (2011), New Delhi, Wishwaprakashan.
2. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publishing House, New Delhi.

MBOD 3.21(b)
METHODS IN PLANT SCIENCES

Theory Credit: 4

UNIT I Microscopy: Micrometry, different types of microscopes & their working. Microbial Techniques: Sterilization methods, Fungal and bacterial stains, isolation from soil, air, water and other substrates. Dilution plate technique, Culture media, single spore isolation.

UNIT II Chromatography: Principle, Classification of Chromatographic methods, Paper Chromatography, Thin layer Chromatography (TLC), Column Chromatography, Gas Chromatography, High performance Liquid Chromatography – Application of Chromatography. Centrifugations: Introduction, Centripetal & Centrifugal force; Factors affecting Sedimentation, Sedimentation coefficient and Sedimentation constant, different types of Centrifuges.

UNIT III pH & pH Meters: Introduction, Glass electrode, Reference electrode, Combination Electrode, working of PH meter Electrophoresis: Introduction, Principles, Component of an Electrophoresis Unit, Factors affecting Electrophoretic mobility, Support medium Buffers, Different types of Electrophoresis and their applications, Blotting techniques.

UNIT IV Spectroscopy: Introduction, Principle of Beer- Lamberts Law, Colorimetry & Spectrophotometry, ultra violet and visible spectroscopy (UV-VIS) Flame photometry, Spectroscopy.

UNIT V Polymerase Chain Reaction: Principle and working mechanism. The cycling reactions, constraints in PCR, Inverse PCR, RT-PCR, Real time PCR, - Applications of PCR techniques. Nuclear Magnetic Resonance (NMR), Mass Spectrometry (MS), Infra- Red Spectrometry (IR) and Flow cytometry.

MBOD 3.22(b)
METHODS IN PLANT SCIENCES (PRACTICAL)

Practical Credit: 2

Practical:

1. Demonstration of sterilization methods
2. Isolation of bacteria and fungi from soil and plant parts
3. Demonstration of serial dilution technique
4. Demonstration of pH meter,
5. Demonstration of UV-Visible spectra,
6. Demonstration of Chromatography
7. Demonstration of PCR
8. Chromatography – separation of pigments

Recommended Books and References:

1. Birren B. E. et al., (2006): Genome Analysis – A Laboratory manual Vol.-I: Analyzing DNA. Panima Publishing House (reprinted) New Delhi/Bangalore.
2. Bold. R. W., and Primerose, S. B. Principles of gene manipulation- An introduction to genetic engineering. Black Well Scientific Publications. London, Edinbarg, Boscon,
3. C. T. Ingold. Funal spores, their liberation and dispersal oxford University Press, London. (1971)

4. Datta, A. (2009). Experimental Biology-A Laboratory Manual. Narosa Publishing house New Delhi.
5. Gurumani, N. (2006). Research methodology for Biological Sciences M.J.P.
6. Introduction to plant Biotechnology Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
7. K. R. Aneja. Experiments in microbiology, Plant Pathology and Tissue culture, Wiswa Prakashan, New Delhi, (1993) 16. V. N. Pathak. Laboratory Manual of Plant Pathology (2Ed.) Oxford and IBH Publishers, New Delhi (1984)
8. Marimuthu, R. (2011). Microscopy and microtechnoques.
9. P. H. Gregery. Microbiology of Atmosphere (2 Ed.) Leonard Hill Books 24 market Square, Aylesbury, Bucks (1961)
10. Pratibha Devi (2000). Principles and Methods of plats molecular Biology, Biochemistry and Genetics. Agrobios (India).
11. Purohit S.D. (2007). Molecular Biology and Biotechnology-A practical manual. Apex Publishing house, Udaipur/Jaipur
12. R. T. V. Fox. Principle of diagnostic techniques in pant pathology CAB International, Wallingford, UK. (1993).
13. Rick Wood D and Hames B. D. (1990). Gel electrophoresis of Nucleic acid – A practical approach. III edition IRL presses Oxford. New York.
14. Shukla, Y. M. Dhruve, J. J. Patel. N. J. Bhatnagar, R. Talati, J. G. and Kathiria K. B. (2009). Plant Secondary Metabolites New India Publishing House New Delhi.
15. Veera kumari, (2006). Bioinstrumentation MJP Publication.

MBOD 3.21(c)
AGROECOSYSTEMS – PRINCIPLES AND APPLICATIONS

Theory Credit: 4

UNIT I Concept of agroecosystem; experimentation in agriculture; basic chemical process-carbon cycle; Climate and adaptation of agricultural crops; Physical factors affecting crop-water; Energy flow in agroecosystems; Plant succession and competition;

UNIT II Cropping systems and agro-ecosystems in the landscape; crop rotation and cover crops; Intercropping; conservation tillage; Dry-land agriculture, irrigation and salinity; Tropical agro-ecosystems; intensive agriculture.

UNIT III Soil type and soil properties; Nitrogen in agroecosystems; application of fertilizers; Macro and micronutrients and their availability to crops; Decomposition: beneficial soil organisms; Mulches and organic amendments.

UNIT IV Weed ecology and management; Distribution and sampling of agricultural pests; introduction to insects; pesticides and the environment; traditional knowledge systems and agrodiversity management.

UNIT V Plant disease and environment; integrated pest management; plant-parasitic nematodes; host plant resistance and conservation of genetic resources; impact of GMOs on crop biodiversity and agroecology; Food production and security; sustainable agriculture.

MBOD 3.22(c)
AGROECOSYSTEMS – PRINCIPLES AND APPLICATIONS (PRACTICAL)

Practical Credit: 2

Practical:

1. Soil sampling and analysis for macro and micro nutrients
2. Plant water requirement assessment
3. Assessment of fertilizer inputs on crop growth
4. Assessment of planting density on crop growth
5. Ecological foot print analysis

Recommended Books and References:

1. Gliesmann, S.R. (2006). Agroecology: The Ecology of Sustainable Food Systems.
2. Technology & Engineering.
3. Gliesmann, S.R. (2006). Field and Laboratory Investigations in Agroecology. Technology & Engineering.
4. Paul A. Wojtkowski, P.A. (2004). Landscape agroecology, Haworth Press, Inc., New York. 330 pp.
5. Warner, K.D. (2007). Agroecology in Action: Extending Alternative Agriculture Through Social Networks. The MIT Press, Cambridge, Massachusetts, USA, 291 pp.

DISCIPLINE SPECIFIC ELECTIVE 3

MBOD 4.11(a)
PLANT RESOURCE UTILIZATION

Theory Credit: 4

UNIT I **Plant Resources:** Diversity and distribution of exploited/underexploited/unexploited plants of economic value of Himalaya and the north eastern region; Use of plants by indigenous communities in Himalaya and the north eastern India for subsistence, medicine and cultural and religious rituals; value addition and product development of some economically important plants.

UNIT II **Ethnobiology & Ethnopharmacolgy of North East India:** Major ethnic group in North East India, their social institutions, livelihood, cultural and religious practices Shamanism and other belief systems, sacred groove and methods of biological resource conservation. Current status of Ethnobiology. Role of Ethnobotany in drug discovery. Ethnopharmacological validation of traditional medicine; approaches to drug discovery from ethnobotanical leads.

UNIT III **Traditional Knowledge:** Traditional knowledge system of plant resource utilization by the indigenous communities of Nagaland. Application and practices of traditional knowledge system in agriculture, healthcare and livelihood with reference to plant resources. Traditional methods of soil conservation in agricultural lands. Sustainable utilization of biological resources and protection of traditional knowledge.

UNIT IV **Forest Resources of Nagaland:** Management of timber yielding plants: *Phoebe*spp (bonsom). *Duabanga grandiflora*, *Pinus* spp. *Tectonagrandis*.
Management of firewood: *Quercus* spp., *Castanea* spp. (chestnut), *Alnusnepalensis* (alder), *Schimawallichi*.
Production, processing and management of bamboo species and canes
Management of other forest resources: edible wild fruits, vegetable, fodder, mushrooms, and economically beneficial products.

UNIT V **Plant Resource Monitoring:** Human impacts on natural ecosystems - forest, grassland and mountain ecosystems; Soil erosion and its control; Shifting

cultivation and its ecological implications; Biosafety and Environmental Monitoring of GEMs; Bio-pesticides; Bioconversion of waste products by microbes with special reference to biogas; Intellectual Property Rights in Biotechnology. Principles of bioprocess control, products with representative examples.

MBOD 4.12(a)
PLANT RESOURCE UTILIZATION (PRACTICAL)

Practical Credit: 2

Practical

1. Case study on Bamboo & canes utilization in Nagaland.
2. Case study on forest resources.
3. Field visits to identify and tabulate some traditional plant resource of local importance in Nagaland.
4. Preparation of herbarium on some ethnobotanically important plants.

Recommended Books and References:

1. Sapu Changkija and P. B. Gurung. 2017. Flora of Nagaland. Volume I &II. Department of Forest, Environment and Climate Change, Government of Nagaland.
2. Deorani S. C.., Sharma, G. D. 2007. Medicinal Plants of Nagaland. BSMPS, Dehra Dunz.
3. Nagaland Bioresource Mission, "Plant resources of Nagaland".
4. Kirtikar, K. R. and Basu, B. D. 1935. Indian Medicinal Plants. Lalit Mohan Basu; Allahabad

MBOD 4.11(b)
PHYTOGEOGRAPHY AND EVOLUTION

Theory Credit: 4

UNIT I Phytogeographical regions of the World. India: Western Himalaya, Eastern Himalaya, Indus plane, Gangetic sub-mountain zone, Temperate zone, Alpine zone. General characters of flora of India. Native taxa, naturalization of exotic taxa.

UNIT II Floristics: Floristic study of the world and India. Continental drift: A general account, tectonic movements, disjunct distribution, dispersal, migration and endemics.

UNIT III Patterns of geographic distribution, Disjunction and Vicariance, Vicariance biogeography, Endemism, Centres of diversity; Major plant communities; Type of Vegetation distribution in India and Nagaland.

UNIT IV Darwin and origin of species, models of speciation- Allopatric speciation, Sympatric speciation, Statispatric speciation. Isolating mechanism and rate of speciation. Genetic variation-inbreeding depression, protein polymorphism, variation in nucleotide sequences. Formation of species.

UNIT V Evolution of sex in plants-Asexual reproduction, origin and evolution of sex organs, alternation of generations. Parthenogenesis and its applications.

MBOD 4.12(b)
PHYTOGEOGRAPHY AND EVOLUTION (PRACTICAL)

Practical Credit: 2

Practical:

1. Floristic regions of India.
2. Evolutionary concepts
3. Drawing maps of continental drift
4. Listing plants of GUG campus
5. Listing of wild edible plants
6. Studying species distribution and its measurements
7. Examples of exotic / invasive species

Note:

- Submission of 5 maps / photographs / herbaria during practical Examination
- Botanical Study Tour of about seven days is compulsory.

Recommended Books and References:

1. Walter's Vegetation of the Earth: Ecological Systems of the Geo-Biosphere (4th Edition) by Heinrich Walter, Siegmar-Walter Breckle. Paperback - October 2002
2. Edible Wild Plants of the Prairie: An Ethnobotanical Guide by Kelly Kindscher (1987)
3. Advanced Plant Geography Author:Shiv Manikant Dube. 2011 Swastik Publications.
4. Textbook of the Plant Geography of India. by F.R. Bharucha
5. Plant geography by George Simonds Boulger (Jan 1, 1912)

MBOD 4.11(c)
BIOFERTILIZERS AND BIOPESTICIDES

Theory Credit: 4

UNIT I Biofertilizers – Definition, Classification, Advantages and Constraints. Role of biofertil izers in modern agriculture. Bacterial biofertilizers - A general account of Azospirillum, Azotobacter, Frankia, Phosphobacteria and Rhizobium. Mass production of Azospirillum, Azotobacter and Phosphobacteria.

UNIT II Cyanobacteria (BGA) as biofertilizers - A general account of Anabaena, Cylindrospermum, Gloeocapsa, Lyngbya, Nostoc, Plectonema and Tolypothrix. Symbiotic association of Cyanobacteria. Field application of Cyanobacterial inoculants. Azolla as biofertilizer.

UNIT III Mycorrhizae as biofertilizers - A general account and applications of mycorrhizae. Methods of collection, wet sieving and decanting method and inoculum production. Culturing of mycorrhizae in Modified Melin - Norkrans (MMN) agar medium. Applications of Mycorrhizae. Trichoderma as biofertilizer.

UNIT IV Biopesticides - Uses and limitations of Biopesticides and their application. Advantages over chemical pesticides. Biocontrol of plant diseases. Cross protection. Fungal and Bacterial Biopesticides – Trichoderma, Bacillus thuringiensis. Bioinsecticides – Insecticidal plants (Neem and others).Virus, bacteria and fungi as insecticides.

UNIT V Organic Manure: Green manure, organic fertilizers, recycling of biodegradable municipal and agricultural wastes, methods of biocomposting, types and methods of vermicomposting.

MBOD 4.12(c)
BIOFERTILIZERS AND BIOPESTICIDES (PRACTICAL)

Practical Credit: 2

Practical

1. Isolation and culturing of Cyanobacteria (BGA)- Anabaena, Cylindrospermum, Gloeocapsa, Lyngbya, Nostoc, Plectonema and Tolypothrix.
2. Cultivation of Azolla
3. Isolation of Nitrogen fixing bacteria - Azobacter and Azospirullum
4. Demonstration and isolation of root nodules (Rhizobium)
5. Isolation and identification of fungal and insect biocontrol agents
6. Isolation and culturing of Aspergillus, Trichoderma and Bacillus sps.
7. Experiments on Fungal and bacterial Antagonism 8. Trap crops, mixed crops and crop rotation in Gulbarga Region
8. Demonstration of procedure for vermicomposting.

Recommended Books and References:

1. Agrios, G. N. Plant Pathology, Fourth Edition 1997, Academic Pre
2. Dubey, R. C. (2008): A Textbook of Biotechnology. S. Chand & Co., New Delhi.
3. Ilan chet (Ed.). Innovative Approaches to plant disease Control. Wiley Inter Science Publication, Ihon Wiley and Sons New York (1987)
4. Newton, W. E. et al. (1977): Recent Developments in Nitrogen Fixation. Academic Press, New York.
5. Schwintzer, C. R. and Tjepkema, J. D. (1990): The Biology of Frankia and Actinorhizal Plants. Academic Press Inc., San Die go, USA.
6. Stewart W. D. P. and Gallon J. R. 1980): Nitrogen Fixation. Academic Press, New York.
7. Subba Rao, N. S. (1982): Advances in Agricultural Microbiology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
8. Subba Rao, N. S. (2002): Soil Microbiology. 4th ed. Soil Microorganisms and Plant Growth. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
9. Subba Rao, N. S. and Dommergues, Y. R. (1998): Microbial Interactions in Agriculture and Forestry. Vol. I, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
10. Verma, A. (1999): Mycorrhiza. Springer Verlag, Berlin. 17 9. Wallanda, T. et al. (1997). Mycorrhizae. Backley's Publishers, The Netherlands.

DISCIPLINE SPECIFIC ELECTIVE 4

MBOD 4.21
DISSERTATION

Credit: 6

Total Max. Marks-150

The Department offers following specializations for dissertation at M. Sc. Part-II:

1. Higher Plant Ecology
2. Taxonomy and diversity of angiosperms
3. Development and Reproduction of angiosperms
4. Lower plants
5. Plant pathology
6. Applied botany
7. Ethnobotany

8. Economic botany
9. Plant Tissue Culture
10. Molecular Biology
11. Microbiology

- The dissertation topics will be allocated based on the merit, willingness and availability of seats offered by the Department of Botany.
- The synopsis for the dissertation must obtain approval of board of studies.
- The dissertation work has to be defended through viva voce.
- The preliminary copy of dissertation must be approved by the board of studies to appear for viva voce.
- The final copy of the dissertation has to be submitted to the department within one week after the viva voce.

SYLLABUS FOR
Master of Science

CHEMISTRY

Under CBCS guidelines

COURSE STRUCTURE

SEMESTER	COURSE CODE	COURSE TITLE	CREDITS
I	MCHC 1.11	Inorganic Chemistry-I	4
	MCHC 1.21	Organic Chemistry-I	4
	MCHC 1.31	Physical Chemistry-I	4
	MCHC 1.41	Physical Chemistry-II	4
	MCHC 1.12	Organic Chemistry (Practical)	8
II	MCHC 2.11	Inorganic Chemistry-II	4
	MCHC 2.21	Organic Chemistry-II	4
	MCHC 2.31	Organic Chemistry-III	4
	MCHC 2.41	Physical Chemistry-III	4
	MCHC 2.12	Inorganic Chemistry (Practical)	8
III	MCHC 3.11	Inorganic Chemistry-III	4
	MCHC 3.21	Physical Chemistry-IV	4
	MCHC 3.12	Physical Chemistry (Practical)	8
	MCHD 3.11	DSE 1 (OPTIONAL*)	4
	MCHD 3.21	DSE 2 (OPTIONAL*)	4
IV	MCHC 4.11	Inorganic Chemistry-IV	4
	MCHC 4.21	Organic Chemistry-IV	4
	MCHC 4.31	Project work/Course Work	8
	MCHD 4.11	DSE 3 (OPTIONAL**)	4
	MCHD 4.21	DSE 4 (OPTIONAL**)	4

*** DISCIPLINE SPECIFIC ELECTIVE 1 & 2**

MCHD 3.11 & MCHD 3.21

COURSE TITLE	CREDITS
Analytical Chemistry & Catalysis	4
Natural Products & Bio Organic Chemistry	4
Nuclear Chemistry	4

**** DISCIPLINE SPECIFIC ELECTIVE 3 & 4**

MCHD 4.11 & MCHD 4.21

COURSE TITLE	CREDITS
Nano Chemistry & Polymer Science	4
Applied Inorganic Chemistry	4
Applied Organic Chemistry	4
Nanotechnology and Polymer Technology	4

SEMESTER – I

MCHC 1.11
INORGANIC CHEMISTRY - I

Theory 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. Brief review of group theory, Matrix representation; Reducible and irreducible representations.

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:***

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;

UNIT IV ***Crystal field theory:***

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 V ***Electronic Structure of Transition Metal Complexes***

Electronic absorption spectra of octahedral and tetrahedral complexes, Orgel diagrams, Tanabe-Sugano diagrams, calculation of Dq, B and ß values, selection rules, band intensities and bandwidths, 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 π-bonding), MO diagrams for octahedral and tetrahedral complexes and charge-transfer spectra.

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. P. Atkins, T. Overton, J. Rourke, M. Weller & F. Armstrong. *Shriver and Atkins Inorganic Chemistry*, Oxford University Press (2006).
5. N. N. Greenwood & A. Earnshaw. *Chemistry of the Elements*, Pergamon Press (1984).
6. F. Basolo & R. G. Pearson, *Mechanism of Inorganic Reactions*, Wiley Eastern (1967).

7. F. A. Cotton, G. Wilkinson, C. A. Murillo & M. Bochmann. *Advanced Inorganic Chemistry* (6th edition), John Wiley (1999).
8. 8 S. F. A. Kettle, *Physical Inorganic Chemistry*, Spectrum (1996).
9. B. Douglas, D. McDaniel and J. Alexander. *Concepts and Models of Inorganic Chemistry* (3rd edn.), John Wiley & Sons (1994).

MCHC 1.21
ORGANIC CHEMISTRY – I
(Stereochemistry and Organic Reaction)

Theory Credit: 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 Reaction***

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 π and σ bonds, Anchimeric assistance; Synthetic applications of nucleophilic substitution involving alcohols, thiols and amines; Aromatic nucleophilic substitutions.

UNIT III ***Elimination Reaction***

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 IV ***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-Loefller-Freytag reaction, di-π- methane rearrangement; Singlet molecular oxygen reactions; Photo-cleavages.

UNIT V ***Pericyclic Reaction***

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 (*hν* and *Δ*), 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*, 2nd Edn, New Age International (1994).
2. J. March. *Advanced Organic Chemistry: Reactions, Mechanisms and Structure* (4th edn.), Wiley Student Edition, John Wiley & Sons Asia Pte. Ltd. (2005).
3. P. S. Kalsi. *Stereochemistry, Conformation and Mechanism* (7th edn.), New Age (2008).
4. C. Depuy & O. L. Chapman. *Molecular Reactions and Photochemistry*, Prentice-Hall of India (1975).
5. asic Stereochemistry of organic molecules, Subrata Sen Gupta Oxford university press
6. 6.F. A. Carey & R. J. Sanburg. *Advanced Organic Chemistry*, Part A and B, 3rd edn. (1990).

7. 7.Wamser & Harris, *Fundamentals of Organic Reaction Mechanisms*, John Wiley (1990).
8. 8.R. B Woodward & R. Hoffman, *Conservation of Orbital Symmetry*; Verlag-Chemie Academic Press (1970).
9. 9.I. Fleming. *Frontier Orbital Theory and Organic Reactions*, John Wiley & Sons (1976).A. P. Marchand & R. E. Lehr, *Pericyclic Reactions*, Academic Press (1977).
10. 10.P.S. Kalsi, Stereochemistry conformation and mechanism (7th Edn), New Age International (2008).

MCHC 1.31
PHYSICAL CHEMISTRY –I
(Quantum, Surface, Solid State Chemistry & Spectroscopy)
Theory Credit: 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 eigen value 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_2 – 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 subtractional solid solutions & distortions.

Metals, insulators and semiconductors; Electronic structure of solids—band theory; intrinsic and extrinsic semiconductors, p-n junction.

UNIT V ***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 non-rigidity; 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.

Recommended Books and References:

1. *Quantum Chemistry*, I. N. Levine. Prentice Hall India (2001).
2. *Quantum Chemistry*, D. A. McQuarrie. Viva Books Pvt Ltd (2003)
3. *Introductory Quantum Chemistry*,A. K. Chandra. Tata McGraw Hill (1994).
4. *Micelles: Theoretical and Applied Aspects*, Y. Moroi. Plenum (1992).
5. *Solid State Chemistry and its Applications*, A. R. West. John Wiley (1998).
6. *Fundamentals of Molecular Spectroscopy*, C. N. Banwell and E. M. McCash. 4th edn., Tata McGraw-Hill, New Delhi (1994).
7. *Physical Chemistry*, D. A. McQuarrie and J.D. Simon –VIVA Students Ed. (2003).
8. *Principle of physical chemistry*, B.R.Puri & L.R.Sharma & M.S.Patiana (2013) edition.
9. *Molecular Quantum Mechanics*, P. W. Atkins. Oxford University Press (1986)
10. *Coulson's Valence*, R. McWeeny. ELBS (1979).
11. *Molecular Spectroscopy*, J. D. Graybeat. McGraw-Hill International Edition (1988).

MCHC 1.41
PHYSICAL CHEMISTRY -II
(Electrochemistry & Thermodynamics)
Theory Credit: 4

UNIT I ***Electrolyte Solution***

Structure of water, effect of an ion on the structure of water, solvation number, activity, activity coefficients and ion – ion interactions, physical significance of activity coefficient of an electrolyte, determination of mean ionic activity coefficient by freezing point depression and e.m.f. measurement methods, derivation of Debye – Hückel – Onsager equation, limiting law, electro – chemical potential.

UNIT II ***Electrochemistry***

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.
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 III ***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.

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.

UNIT V ***Statistical Thermodynamics***

Concept of distribution, Thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers). Partition function - Translational, Rotational, Vibrational and Electronic partition functions, calculation of thermodynamic properties in terms of partition function. Applications of partition functions. Heat capacity behaviour of solids - Chemical equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law and applications to metal. Bose-Einstein statistics - distribution law and application to helium.

Recommended Books and References

1. *Modern Electrochemistry* J. O. M. Blockris and A. K. N. Reddy: Vol. 1: Ionics, 2nd Ed., Plenum Press, New York, (1998).
2. *Modern Electrochemistry*, J. O. M. Blockris and A. K. N. Reddy and M. Gamboa – Aldeco: Vol. 2A, Fundamentals of Electrodics, 2nd Ed. Plenum Press, New York, (2000).
3. *Electrochemical Methods: Fundamentals and Applications* A. J. Bard and L. R. Faulkner, 2nd Ed., John Wiley & Sons: New York, (2002).
4. *Non-Equilibrium Thermodynamics – Principles and Applications* C. Kalidas and M. V. Sanganarayana., Macmillan India (2002).
5. *Statistical Thermodynamics* (Hardback) By (author) M.C. Gupta, Publisher: New Age International. (1998).
6. Thermodynamics, J. Rajaram and J.C. Kuriacose, Educational Publishers.(2013).
7. Thermodynamics, R. C. Srivastava, Subit K. Saha, Abhay K. Jain, Prentice Hall of India, Pvt. Ltd. (2004).
8. Electrochemical Methods: Fundamentals and Applications A. J. Bard and L. R. Faulkner, 2nd Ed., John Wiley & Sons : New York, (2002).
9. Statistical Thermodynamics, B.J. McClelland, Chapman and Hall & Science Paperbacks, London, (1973).
10. 10 Physical Chemistry, T. Engel and P. Reid, Pearson Education and Dorling Kindersley (India) (2006).
11. Introduction to Thermodynamics of Irreversible Processes, I. Prigogine Interscience (1960)

MCHC 1.12
LABORATORY COURSE – I
ORGANIC CHEMISTRY (PRACTICAL)

Practical Credit: 8

PART A

1. Purification Techniques of organic compounds and their spectroscopic identifications.
    a. Separation/ purification of binary mixtures by Thin Layer Chromatography (TLC) and Column chromatography (CC).
    b. 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(Vll)
    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. eterocyclic 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:

1. IR

2. HPLC and GC
3. Microwave

Recommended Books and References

1. R. K. Bansal. *Laboratory Manual of Organic Chemistry* (3rd edn.), Wiley-Eastern (1994).
2. R. G. Brewster & W.E. Mcwedn. *Unitized Experimental Organic Chemistry* (4th edn.), East-West Press (1977).
3. A. I. Vogel. *Practical Organic Chemistry* (3rd 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* (5th edn.), John Wiley & Sons (1964).

SEMESTER - II

MCHC 2.11
INORGANIC CHEMISTRY – II

Theory Credit: 4

UNIT I ***Transition Metal π-acid Complexes and Supramolecular Chemistry***
Bonding, synthesis and reactivity of transition metal complexes with CO, NO, O_2, N_2 and tertiaryphosphine 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.

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 andracemisation of tris-chelate complexes; electron transfer reactions; stereochemical nonrigidity and fluxional molecules.

UNIT III ***Transition Metal–Carbon Bond***
(a) Transition Metal–Carbon σ-Bond: Brief review of metal alkyl compounds; transition metalcarbene and transition metal-carbyne compounds; transition metal vinylidene and transition metal allenylidene compounds.
(b) Transition Metal-Carbon π-Bond: Cyclopropenyl cation (C_3R^{3+}) as a ligand; C_4R_4 as a ligand (R = H, Me, Ph)

UNIT IV ***Syntheses of Cyclopentadienyl and Arene Metal Analogues***
Synthesis and reactions of cyclopentadienyl metal carbonyls, cyclopentadienyl metal hydrides, cyclopentadienyl metal halides, arene metal group complexes, η6-arene-chromium tricarbonyl inorganic synthesis.

UNIT V ***Applications to Organic Synthesis and Homogeneous Catalysis***
(a) In Organic Synthesis: Hydrozirconation of alkenes and alkynes; Carbonylation of Colman's reagent; η4-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. M. Bochmann. Organometallics-I Complexes with Transition Metal-Carbon σ-Bonds, Oxford Chemistry Primers (1994).
2. M. Bochmann. Organometallics-2 Complexes with Transition Metal–Carbon π-bonds, Oxford
3. J. E. Huheey, E. A. Keiter, R. L. Keiter & O. K. Medhi, *Principles, Structure and Reactivity* (1st impression), Pearson Education (2006).
4. F. A. Cotton, G. Wilkinson, C.A. Murillo & M. Bochmann, *Advanced Inorganic Chemistry* (6th edn.), John Wiley (1999).
5. J. W. Steed & J. L. Atwood. *Supramolecular Chemistry*, John Wiley (2002
6. B. R. Puri, L. R. Sharma, and K. C. Kalia, *Principles of Inorganic Chemistry*, Milestone.
7. P. Atkins, T. Overton, J. Rourke, M. Weller & F. Armstrong. *Shriver and Atkins Inorganic Chemistry*, Oxford University Press (2006).
8. T. Moeller. *Inorganic Chemistry: A Modern Approach*, John Wiley (1982).
9. J. W. Steed & J. L. Atwood. *Supramolecular Chemistry*, John Wiley (2002).

MCHC 2.21
ORGANIC CHEMISTRY – II
(Redox Reaction and Reactive Intermediates)

Theory Credit: 4

UNIT I ***Redox Reaction-I***

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.

UNIT II ***Redox Reaction-II***

(a) Use of hydroboration in reduction, oxidation and carbonylation, regioselectivity, stereo-selectivity and synthetic utility of alkyl boranes; Reduction of carbonyl group with hydrazine.

(b) 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_2.

UNIT III ***Reactive Intermediates-I***

(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.

(b) ***Nitrenes*****:** Stability, structure and spin states of nitrenes; C-H bond insertions and aziridine formation; Rearrangement of acylnitrenes (Hoffmann, Curtius and Schmidt reactions with applications in organic synthesis).

UNIT IV ***Reactive Intermediates-II***

(a) ***Free Radicals*****:** Stability and fate of organic free radicals; Radical cyclisation and coupling reactions; Addition to multiple bonds; Aromatic substitution by radicals; Allylic bromination by NBS and decarboxylative bromination.

(b) ***Arynes*****:** Generation, structure and stability of arynes; Benzyne mechanism for aromatic nucleophilic substitution; Direction of aryne bond formation and of nucleophilic addition.

UNIT V ***Carbon-Carbon bond formation***

(a) ***Nucleophilic C-C bond formation:*** Henry reaction, Wittig reaction and Horner-Wordwoth-Emmons reaction and their selectivities; Chemistry of enolates – *E, Z* geometry of enolates, stereoselective enolate reactions, alkylation, aldol condensation (Zimmerman models), Mukaiyama reaction.

(b) ***Electrophilic C-C bond formation:*** Prins reaction, Vilsmeier-Hack reaction, Pictet-Sprengler reaction, Heck reaction, Stille coupling, Suzuki coupling, Neigishii reaction, Acylation of carbonyl carbon; Carbonyl cyclizations and cleavages.

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* (4th 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).

5. R. M. Silverstein, G. C. Basseler & T. C. Morill. *Spectroscopic Identification of Organic Compounds*, 7th Edn., John Wiley (2005).
6. W. Kemp. *Organic Spectroscopy* (3rd edn.), McMillan Press Ltd. (1991).

MCHC 2.31
ORGANIC CHEMISTRY – III
(Synthesis & Retrosynthesis in Organic Chemistry)

Theory Credit: 4

UNIT I ***Reagents in organic synthesis*:**
K-selecteride and L-selecteride, sodium cyanoborohydride, super hydrides, Dess-Martin periodinane, manganese dioxide, Fetizon reagent, dioxiranes, ceric ammonium nitrate, Gilman's reagent, lithium disopropylamide, dicyclohexylcarbodimide, trimethysilyl iodide, tri-n-butyltin hydride, Tebbe reagent, baker's yeast, lipase, Mosher's reagent.

UNIT II 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.

UNIT III One group C-C disconnections – alcohols and carbonyl compounds, regioselectiviity, alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis. Two group C-C disconnections – Diels-Alder reaction, α,β-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.

UNIT V ***Miscellaneous reactions****:* Biginelli reaction, Hantzsch reaction, Passerini reaction, Ugi reaction, McMurry olefination, Ring closing metathesis (RCM) - Grubb's reaction, Mitsonobu reaction, Nef reaction, Sharpless asymmetric epoxidation and asymmetric dihydroxylation. Carboxylic acids and derivatives, decarboxylation reactions, 1,3-dithiane reactivity.

Recommended Books and References

1. Stuart Warren, *Organic Synthesis The Disconnection Approach*, John Wiley & Sons (1982)
2. Nicolaou and Sorensen; *Classics in Total Synthesis*, Wiely-VCH (2003)
3. F. A. Carey & R. J. Sundberg. *Advanced Organic Chemistry* Part B, Plenum Press (2007).
4. M. B Smith. *Organic Synthesis* (2nd end.), McGraw-Hill, Inc. (2001).
5. J. March. *Advanced Organic Chemistry: Reactions, Mechanism and Structure* (4th edn.), John Wiley & Sons (2005).
6. Fundamentals of Organic synthesis Vol.II NCBA publication Ratan Kumar Kar
7. Organic synthesis Krishna Prakash publication Ltd M.P.Saluja
8. M. Harmata. *Strategies and Tactics in Organic Synthesis* 4 & 5, Academic Press (2004).
9. W. Carruthers. *Some Modern Methods of Organic Synthesis* (4th edn.), Cambridge University Press (2004).
10. B. M Trost & I Fleming. *Comprehensive Organic Synthesis*, Vols 1-9, Pergamon (1991).

MCHC 2.41
PHYSICAL CHEMISTRY – III
(Chemical Kinetics & Polymer Chemistry)

Theory Credit: 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 and Enzyme 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. Enzyme catalysis, Simple enzyme mechanisms, single-intermediate mechanism, influence of substrate concentration, Michaelis-Menten equation- single and double intermediates, Lineweaver - Burk plot, Eadie-Hofstee plots, Complex enzyme mechanism.

UNIT III ***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 IV ***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.

UNIT V ***Polymer Chemistry***

Definition, Classification of polymers, Chain configuration of macromolecules, Isotactic polymers, Atactic polymers, Syndiotactic polymers, Graft polymers, Electrically conducting polymers, Polymerizations reactions, Kinetics of polymerization, Mechanism of polymerization. Molecular mass of polymers, Number and Mass average molecular mass, Determinations of molar masses of polymers (Osmometry, Viscometry and Light scattering methods), Sedimentation, Calculation of average dimensions of various chain structures.

Recommended Books and References

1. *Chemical Kinetics*, K. J. Laidler, (4th Edn.), Pearson Eductions (2007).
2. *Chemical kinetics and Reaction Mechanism* by James H. Espenson, 2nd Ed., McGraw-Hill, (1995).
3. *Chemical Kinetics and Reaction Dynamics* by Santosh K. Upadhyay, Anamaya Publishers, New Delhi, (2006).

4. *Chemical kinetics and Reaction Mechanism* by James H. Espenson, 2nd Ed., McGraw-Hill,(1995).
5. *Atkin's Physical Chemistry* Atkins, P. W. & Paula, J. de 8th Ed., Oxford University Press (2006).
6. *Chemical Kinetics and Reaction Dynamics* by Santosh K. Upadhyay, Anamaya Publishers, New Delhi, (2006).
7. *Introduction to Polymer Science*, V. R. Gowarikar, N. V. Vishwanathan and J. Sridhar - Wiley Eastern,(2006)
8. *Chemical Kinetic Methods: Principles of Relaxation Techniques and Applications* by C. Kalidas, New Age International (P) limited, Publishers, (1996).
9. *Chemical Kinetics and Dynamics*, J.I. Steinfeld, J.S. Francisco and W.L. Hase, 2nd Edition, Prentice Hall International, Inc., (1999).
10. *Chemical Kinetics: From Molecular Structure to Chemical Reactivity*, by L. Arnaut, Sebastiao Formosinho, Hugh Burrows, Elsevier, (2007).

MCHC 2.12
LABORATORY COURSE – II
INORGANIC CHEMISTRY (PRACTICAL)

Practical Credit: 8

1. Quantitative estimation involving volumetric (redox and complexometry), gravimetric and spectrophotometiric 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):
   (i) Reinecke's salt
   (ii) Tris(oxalate) manganese(III)
   (iii) Tetrapyridinesilver(II)peroxidisulphate
   (iv) Tris(acetylacetonato) iron(III)
   (v) Bis(N,N-diethyldithiocarbamato)nitrosyliron(I)
   (vi) Optical isomers of tris(ethylenediamine)cobalt(III)chloride
   (vii) Linkage isomers of nitro and nitritopentamminecobalt(III) chloride
   (viii) Ferrocene or dibenzene chromium
   (ix) Hydridochlorocarbonyl tris(triphenylphosphine)ruthenium(II)
   (x) Tris(2,2'-bipyridine)ruthenium(II) perchlorate
   (xi) $[(p\text{-(cymene)}RuCl_2]_2$
   (xii) Tri(acetylacetonato)manganese(III)
   (xiii) Prussian Blue
   (xiv) 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. Danney, 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* (2nd edn.), Chapman & Hill (1974)
4. .J. Basset, R. C. Denney, G.H. Jeffery & J. Mendham. *Vogel's Text Book of Quantitative Analysis* (4th edn.), English Language Book Society (1978).
5. H. H. Willard, L. L. Merrit & J. A. Dean. *Instrumental Methods of Analysis* (4th 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

Theory Credit: 4

UNIT I ***Infrared and Raman Spectroscopy***: Structural studies (involving IR and Raman spectroscopy) of coordination compounds containing the following molecules/ions and ligands - NH3, H2O, OH−, SO_4^{2-}, CN−, SCN−, NO. Application of IR and Raman spectroscopy.

UNIT II. ***Magnetic Resonance Spectroscopy***
Electron spin resonance spectroscopy: ESR of d1 to d9 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 31P, 19F, 119Sn and 195Pt NMR Spectroscopy in the structural assessment of inorganic compounds.

UNIT III ***Mass spectrometry:*** Basic principles, ionization techniques, isotope abundance, molecular ion, deduction of structure through mass spectral fragmentation. ESI-MS and MALDIMS- applications in biomolecules. Studies of inorganic/ coordination and organometallic representative compounds. Instrumentation.

UNIT IV ***Mossbauer Spectroscopy***: Principles, Doppler shift and recoil energy, isomer shift and its interpretation, quadrupole interactions, effect of magnetic field on Mossbauer spectra, applications to metal complexes, metal carbonyls, iron and tin compounds.

UNIT V ***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.

Recommended Books and References:

1. K. Nakamoto. *Infrared and Raman Spectra of Inorganic and Coordination Compounds*, (6th 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
PHYSICAL CHEMISTRY – IV
(Surface Chemistry & Solid State Chemistry)

Theory Credit: 4

UNIT I ***Introduction***

(a) Characteristic Features of Surfactants: General structural features & behavior of surfactants, classification of surfactants, hydrophobic/solvophobic interaction, Kraft point.

(b) 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 & Mixed Surfactants***

Micelle formation by surfactants: Critical micelle concentration, cmc meaurement, conductance behaviour of ionic micellar solution, micellar structure and shape, factors affecting cmc, temperature dependence of cmc, thermodynamics of micellization, counterion binding constant.Different types of mixed micelle, cmc of mixed micelle, Clint's equation for cmc, Rubingh's treatment, Rodenas treatment, conterion binding in mixed surfactants.

UNIT III ***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.

UNIT IV ***Packing in Crystals Structures***

Cubic close packing, hexagonal close packing, packing of ions, alloys and molecular structures atomic coordinates and nomenclature , structural relationships, polyhedral representation of crystal systems, packing of structures in terms of the distribution of tetrahedral sites, octahedral sites and packing ions .Structural elucidation and distribution of interstitial sites in hcp structures: AX type - wurtzite (ZnS);AX_2 type-rutile (TiO_2) ,Structural elucidation and distribution of interstitial sites in ccp structures : AX type - rock salt (NaCl), AX_2 type - cadmium chloride ($CdCl_2$)

UNIT V ***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. *Surfactants and Interfacial Phenomena,* M. J. Rosen. (3rd edn.), John Wiley (2004).
2. *Micelles*, Y. Moroi. Plenum (1992).
3. *Solid State Chemistry and its applications*, Anthony R. West, John Wiley & Sons.(2014)
4. *Principals of Nanoscience and Nanotechnology*, M. A. Shah and Tokeer Ahmad, Narosa Publications, (2010).
5. *Solid State Chemistry*, Lesley Smart and Elaine Moore, Chapman & Hall.(1995)

6. *New Directions in Solid State Chemistry* C. N. R. Rao and J. Gopalakrishnan, , Cambridge University Press.(2010)
7. *Surfactants*,K. R. Lange. Hanser Pub. (1999).
8. *Dynamics of Surfactant Self-Assemblies*, R. Zana (ed.). CRC Press (2005).
9. *Mixed Surfactant Systems*, M. Abe & J. F. Scamehorn. CRC Press (2004).
10. `10. *Principles of the Solid State*, H. V. Keer, New Age International Publishers. (2017)
11. *Solid State Chemistry*, D. K. Chakrabarty, New Age International Publishers. (2006)
12. *Solid State Chemistry Techniques*, A. K. Cheetham and Peter Day, Oxford Science Publications. (1987).

MCHC 3.12
LABORATORY COURSE – III
PHYSICAL CHEMISTRY (PRACTICAL)

Practical Credit: 8

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 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. *Experiments in Physical Chemistry* D. P. Shoemaker, C. W. Garland & J. W. Nibler. (5th edn.), McGraw Hill (1989)
2. *Experimental Physical Chemistry*, V. D. Athawala & P. Mathur. New Age International. Publishers (2001).
3. *Experiments in Physical Chemistry*, R.C. Das and B. Behra – Tata McGraw Hill. (1983).
4. *Advanced Practical Physical Chemistry*, J.B. Yadav - Goel Publishing House. (1981).

5. *Advanced Experimental Chemistry*, Vol. I - Physical, J.N. Gurtu and R. Kapoor, S. Chand & Co. (2016)
6. *Selected Experiments in Physical Chemistry*, N.G. Mukherjee – J.N. Ghose & Sons.
7. *Experiments in Physical Chemistry*, J.C. Ghosh - Bharti Bhavan.(2007)
8. *Senior Practical Physical Chemistry*, B.D.Khosla; V.C.Garg, Adarsh Khosla R. Chand & Co.(2007).

SEMESTER - IV

MCHC 4.11
INORGANIC CHEMISTRY - IV

Theory Credit: 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 crownether complexes of Na+ and K+; ATP and ADP; photosynthesis: chlorophyll, PS I and PS II. Rubredoxin and ferredoxins.

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, model systems; 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.

UNIT V ***Photochemistry of Metal Complexes and Metal–Metal Multiple Bonds***

Excited states, ligand field states, charge-transfer states and Thexi states; Phosphoresence and fluorescence; Photochemical reactions: substitution and redox reactions of Cr(III), Ru(II) and Ru(III) complexes; Applications: synthesis and catalysis, chemical actinometry and photochromism; Metal-metal multiple bonds, major structural types, quadrupole bonds and one dimensional solids.

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. F.A. Cotton & G. Wilkinson. *Advanced Inorganic Chemistry* (5thedn.), John Wiley (1988)
6. D.M.Roundhill. *Photochemistry and Photophysics of Metal Complexes*, Plenum Press(1990).
7. A.W. Adamson &P.D. Fleischauer. *Concepts of Inorganic Photochemistry*, John Wiley & Sons (1975).
8. H. Kraatz & N. Metzler-Nolte (Eds.). *Concepts and Models in Bioinorganic Chemistry*, Wiley
9. S. J. Lippard & J. M. Berg. *Principles of Bio-Inorganic Chemistry*, Panima Publ. Corpn. (2005).
10. A.W. Adamson &P.D. Fleischauer. *Concepts of Inorganic Photochemistry*, John Wiley & Sons (1975).

MCHC 4.21
ORGANIC CHEMISTRY – IV
(Organic Spectroscopy)

Theory Credit: 4

UNIT I ***Infrared (IR) 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 anydrides); Effects of H-bonding and solvent effect on vibrational frequency, extension to various organic molecules for structural assignment.

UNIT II ***Electronic Spectroscopy:***
UV & Visible Electronic spectra: Frank-Condon principle, Fluorescence, Phosphorescence, electronic spectra of diatomic molecules, chromophores, auxochromes, absorption and intensity shifts, solvent effects, Woodward Fieser rules. Calculation of λmax of various compounds.

UNIT III ***Nuclear Magnetic Resonance (NMR) Spectroscopy-I***:
Nuclear Magnetic Resonance Spectroscopy: Basic principles, origin of chemical shifts, factors affecting the chemical shifts and their interpretation, spin-spin coupling, relaxation processes, coupling constants. 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).

UNIT IV ***Nuclear Magnetic Resonance (NMR) Spectroscopy-II***:
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. Applications of IR, NMR and Mass spectroscopy for structure elucidation of organic compounds

UNIT V ***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

Recommended Books and References

1. W. Kemp. *Organic Spectroscopy* (3rd edn.), McMillan Press Ltd. (1991).
2. D Williams & I. Fleming. *Spectroscopic Methods in Organic Chemistry*, McGraw Hill (1989).
3. C. N. Banwell & E. M. McCash. *Fundamentals of Molecular Spectroscopy*, Tata McGraw-Hill, New Delhi (2006).
4. R. M. Silverstein, G. C. Basseler & T. C. Morill. *Spectroscopic Identification of Organic Compounds*, 7th Edn., John Wiley (2005).
5. Elementary Organic spectroscopy (Principle & chemical application) Y.R.Sharma

MCHC 4.31
PROJECT WORK/COURSE WORK

Credit: 8

DISCIPLINE SPECIFIC ELECTIVE 1 & 2
MCHD 3.11 & MCHD 3.21

ANALYTICAL CHEMISTRY & CATALYSIS

Theory Credit: 4

UNIT I **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.

UNIT II **Analytical instrumentation and methods (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

UNIT III ***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

UNIT IV **Non-aqueous Solvents**

Classification of solvents; general properties of ionizing solvents; chemical reactions; liquid sulfur dioxide as solvent; liquid dinitrogen tetra-oxide; liquid hydrogen fluoride; liquid hydrogen sulfide; liquid hydrogen cyanide; acetic acid; liquid bromine trifluoride; oxyhalides.

UNIT V **Study of some 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* (2nd edn.), New Age International (2000
2. F.A. Cotton & G.Wilkinson. *Advanced Inorganic Chemistry* (5thedn.), JohnWiley (1988)
3. A. K. De. *Environmental Chemistry* (4th edn.), New Age International Limited (2006).
4. P. M. S. Monk. *Fundamentals of Electroanalytical Chemistry*, John Wiley & Sons (2001).
5. H. H. Willard, L.L. Merritt, J.A. Dean & F. A. Settle. *Instrumental Methods of Analysis* (7th edn.), Wadsworth Publishing Company, California (1988).
6. J. Mendham, R. C. Denney, J. D. Barnes and M. Thomas. *Vogel's Textbook of Quantitative Chemical Analysis*, Peterson Education (2000).
7. C. Cutal & A.W. Adamson,.*Comprehensive Coordination Chemistry*, Vol. 1, Editor-in-Chief G. Wilkinson (1985).
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*

10. *Chemistry*, Oxford University Press (2006).
11. J. W. Moore & E. A. Moore. *Environmental Chemistry*, Academic Press, London (1976).
12. I. Pulford & H. Flowers. *Environmental Chemistry at a Glance*, Blackwell Publishing (2006).
13. S. E. Manahan. *Environmental Chemistry* (6th edn.), Lewis Publishers, London (1994).

NATURAL PRODUCTS & BIO ORGANIC CHEMISTRY

Theory Credit: 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 ***Enzymes***

Mechanism of enzyme action and models, kinds of reactions catalyzed by enzymes, nomenclature, stereochemical aspects, cofactors, co-enzyme chemistry. Structure and function of NADH, FAD, ADP and ATP.

UNIT III ***Alkaloids***

Structure, synthesis and biosynthesis of common alkaloids: Strychnine, lysergic acid, reserpine, nicotine, morphine, emitine.

UNIT IV ***Heterocyclic compound***

(a)Small Ring Heterocycles: Synthesis of aziranes, oxiranes & thiiranes; Ring openings and heteroatom extrusion; Synthesis & reactions of azetidines, oxetanes.
(b)Bicyclic Heterocycles: Synthesis of indole, quinolines, isoquinolines, benzofused diazines, phenothiazines and carbazoles; electrophilic substitution reactions

UNIT V ***Terpenoids***

General biosyntheses of mono- and sesquiterpenes diterpenes, and higher terpenes, *trans*-chrysanthemic acid, cyclo-pentato monoterpene lactones, Synthesis of α-vetinone, β-eudesmol, hirsutene, *cis* juvenile hormone; *trans* annular cyclisation of caryophyllene, synthesis of caryophyllene and isocaryophyllene; Rearrangements of santonic acid and thujospene.

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 Natual aproducyts; Chemistry & Applications, Alpha Science International Ltd. (2011).
3. M. Harmata. *Strategies and Tactics in Organic Synthesis* 4 & 5, Academic Press (2004)
4. Modern Organic chemistry Vishal publishing co. M.K Jain & S.C Sharma
5. Natural Product vol -I& II O.P. Agarwal
6. A. L. Lehninger. *Biochemistry*, Kalyani Publishers (1983).
7. T. L. Gilchrist. *Heterocyclic Chemistry* (2nd edn.), Longman Scientific & Technical Publicns. (1992).
8. R. K. Bansal. *Heterocyclic Chemistry: Synthesis, Reactions and Mechanisms*, Wiley Eastern (1991).

NUCLEAR CHEMISTRY

Theory Credit: 4

UNIT I ***Introduction***

Natural radioactivity, half life, mean life. Units of radioactivity, the natural radioactive series, secular and transient equilibrium. The nuclear atom, neutron-proton model of the atom, isotopes and their separation, neutron decay, β-spectrum, the neutrino, electron capture and internal conversion; nuclear stability, stability lines, exotic nuclei.Standard α, β, γ and neutron laboratory sources. Nuclear sizes, binding energy per nucleon, nuclear saturation, liquid drop model leading to Weizsacker formula. Regions of fission and fusion. Magic numbers, shell model, ground state nuclear spins. Qualitative idea of collective models.

UNIT II ***Nuclear Reactions I***

Nuclear scattering and reactions, cross-sections, units, phase shifts, Resonance, Breit-Wigner formula. Qualitative idea of Bohr's picture of a nuclear reaction.Qualitative idea of the nucleon-nucleon and the complex nucleon-nucleon potential (the optical model). Different types of reactions, notation. Nuclear reaction cycles in stars, the p-p chain and the C-N cycle. Artificial radioactivity, radioactive isotopes of the elements. The Szilard-Chalmers process. Preparation of suitable compounds containing ^{35}S and ^{131}I.Slow neutron absorption in nuclei. Discovery of induced fission its important features.Discovery of spontaneous fission.

UNIT III ***Nuclear Reactions II***

Broad ideas of research reactors, power reactors. Recovery of unused fuel and waste disposal. Broad idea of Breeder reactors. Broad sketch of a fusion reactor.Metallurgy of U and Th. Enrichment of Uranium, separation of heavy water from ordinary water.Production of the Trans-Uranic elements. A somewhat detailed study of Pu. Energy loss suffered by charged particles in traversing matter-excitation, ionisation, Bremsshtrahlung and Cerenkov radiation. Attenuation of γ-rays in traversing matter-photoelectric effect, Compton effect and pair production.

UNIT IV ***Instrumentation in Nuclear Chemistry***

Instruments for detection and measurement of charged particles and neutrons-G.M. counter, solid state detectors and neutron counters. Cloud chamber. Instruments for γ-rays-scintillation counters.A broad idea of counting and scaling circuits. Shielding of charged particles, γ-rays and neutrons.Van de Graaff and heavy ion beam accelerators. Cyclotron. Very broad idea of Synchrotron principle leading to the era of super-energy machines. Electron Synchrotron and Synchrotron radiation. Radio-dating of wood and Pb-containing minerals

UNIT V ***Application to Chemistry***

Finding the elements in a mixture by activation analysis, extraction of radionuclides and transuranic elements by use of carriers. Study of reaction mechanisms like esterification, hydrolysis, oxidation of CO in the presence of MnO, study of PCl_5 with respect to the presence of the last two chlorine atoms and structure of the thiosulphate ion.Radiometric titration including radiometric indicators. Brief introduction to radio-chromatography. Direct isotope dilution analysis and inverse isotope dilution analysis. Selection rules for γ-emission (or absorption), Nuclear isomerism, PIXE, Pair production chemistry, Muon chemistry, Mössbauer effect, Cow and Milk system. Applications of nuclear chemistry to biology, medicine, agriculture, industry etc.

Recommended Books & References

1. *Nuclear and Radiochemistry* G. Friedlander, J. W. Kennedy and J. M. Miller, , John Wiley (1981).
2. *Radiochemistry and nuclear chemistry* G. Choppin, J. O. Liljenzin and J. Rydberg, , Butterworth (1996).
3. *Essentials of Nuclear Chemistry,*H. J. Arnikar, Wiley Eastern Ltd. (1995).
4. Indian Association of Nuclear Chemistry & Allied Scientists (2004
5. Nuclear and radiation Chemistry B.K.Sharma , Krishna Publication (2011)

DISCIPLINE SPECIFIC ELECTIVE 3 & 4

MMAD 4.11 & MMAD 4.21

NANO CHEMISTRY & POLYMER SCIENCE

Theory Credit: 4

UNIT I ***Fundamentals of Nanoscience and Nanotechnology***

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, Quantum structures, Quantum confinement, Bright future of nanotechnology. Nanomaterial metal oxides: Zinc oxide, Magnesium oxide, Aluminum oxide.

UNIT II ***Synthesis of Nanomaterials***

Introduction, Nanomaterials synthesis, Top-Down and Bottom-Up Approaches, Solvothermal 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. Theory, Experimental conditions, Kinetics of solid state reactions and molten–salt routes.

UNIT III ***Introduction to Polymers***

Polymer Molecules, Conformation and Molecular Dimensions of Polymer Molecules, Properties of Isolated Polymer Molecules, Elasticity and Swelling of Polymer Gels, Molecular Motion of Polymers in Dilute Solutions, Amorphous Polymers, Structure of Amorphous Phase in Bulk Polymers, Mobility in Polymers, Glass Transition-Measurement of T_g , Effect of Various Parameters on T_g, Theoretical Interpretations, Crystallinity in Polymers.

UNIT IV ***Polymer Characterization***

Thermodynamics of Polymer Solutions, Flory-Huggins and Lattice Theory of Polymer Solution, Entropy and Enthalpy of Mixing, Theta Temperature, Molecular Weight and Molecular Dimensions by Osmometry, Light Scattering, Viscometry and Gel Permeation Chromatography, Thermal Analysis of Polymers: Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA) and Differential Thermal Analysis (DTA), Polymer Degradation and Stabilization.

UNIT V ***Polymer Rheology***

Definition of Rheology, Geometry of Deformation, Newtonian and Non-Newtonian Behaviors, Measurement of Rheological Properties, Power Law, Free Volume Theory of Polymer Fluidity, Dynamic Flow Behavior, Time-Dependent Fluid Responses, Viscoelastic Properties, Mechanical Models of a Viscoelastic Material, Stress Relaxation, Creep and Relaxation behavior of Plastics.

Recommended Books & References

1. *Principals of Nanoscience and Nanotechnology*, M. A. Shah and Tokeer Ahmad, Narosa Publications, (2010).
2. *Nano Materials*, B. Viswanathan, Narosa Publications, (2009).
3. *Nano: The Essentials*, T. Pradeep, Tata Mcgraw Hill, (2009).
4. *Chemistry of Nanomaterials: Synthesis, Properties and Applications* by C.N.R. Rao, A. Muller and A. K. Cheetham (eds.), Wiley-VCH, Weinheim, (2004).
5. *Text Book of Polymer Science* By F. W. Billmeyer, Wiley-Blackwell; 3rd edition (1984)

6. *Introduction to Polymers* by R. J. Young and P. A. Lovell, Springer-science, Buisness Media, B.V(1991)
7. *Polymer Chemistry* by G. Challa, Ellis Horwood Ltd ,(1993)
8. *"Nanomaterials Chemistry: Recent Developments and New Directions"*, ed. by C.N.R. Rao, A. Muller & A.K. Cheetham (Eds.), Wiley-VCH, (2007).
9. *Solid State Chemistry and its applications*, Anthony R. West, John Wiley & Sons.(2017).
10. *Polymers: Chemistry and Physics of Modern Materials* by JMG Cowie,CRC press Taylor & Francis group,(2007)
11. *Principles of Polymerization* by George Odian, Wiley-Interscience; 4 edition (February 9, 2004)

APPLIED INORGANIC CHEMISTRY

Theory Credit: 4

UNIT I **Inorganic Polymers**: Introduction, importance of Inorganic Polymers, Types of Inorganic Polymers. Characterization of Inorganic Polymers: Molecular Weights, Molecular Weight Distributions, Other Structural Features, Chain Statistics, Solubility Considerations, Crystallinity, Transitions, Spectroscopy, Mechanical Properties.

UNIT II **Polyphosphazenes**: Introduction, Ring-opening polymerization and Condensation polymerizations. Surface Reactions of Polyphosphazenes, Hybrid Systems through Ring-Linked Copolymers, Composites, Organometallic of Polyphosphazenes, Small-Molecule Models, Molecular Structure of Linear Polyphosphazenes, Structure–Property Relationships, Applications of Polyphosphazenes,

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 electrophoretic 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. **Nuclear Chemistry**

Basic concepts, models of nuclear structure and stability. Nuclear reactions: nuclear fission, nuclear fusion. Detection and measurement of radioactivity. Application of radioisotopes as tracers in chemical analysis. Isotope effect, isotopic exchange reactions, isotope dilution techniques and radiometric titrations. Radiopharmaceutical, radioimmunoassay and radiation sterilization. Hot atom chemistry.

UNIT V **Agricultural Chemistry**

Introduction and classification of soil and survey; Properties of soil; soil texture; soil water, soil temperature, soil colloids, soil minerals, soil pH; acidity and alkalinity, buffering soil, soil fertility, soil formation. Methods of pest controls. Methods of using pest control, insecticides, fungicides. Rodenticides and herbicides, ill effects of pesticides. Fertilizers – Classification and its ill effects. Framyard manure, compost, green manure crops, saw dust.

Recommended Books and References:

1. James E. Mark, Harry R. Allcock, Robert West, Inorganic Polymers, Second Edition, Oxford University Press (2005)
2. P.B. Saxena, Inorganic Polymers, Discovery Publishing House, 2007

3. Roger De Jaeger, Mario Gleria , Inorganic Polymers, Nova Science Publishers, 2007
4. Ronald D. Archer, Inorganic and Organometallic Polymers, John Wiley & Sons, 2001
5. F.A.Cotton & G. Wilkinson, Advanced Inorganic Chemistry, 5th Edition 1988.
6. J.E. Hukeey, E.A.Keiter And R.L.Keiter, Inorganic Chemistry, Principles Of Structure And Reactivity, 4th 7. G.Zhong Cao.*Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, Imperial College Press (2004).
7. M. Ratner & D. Ratner.*Nanotechnology: A Gentle Introduction to the Next Big Idea*, Pearson Education (2003).
8. G. Friedlander, J. W. Kenendy& J. M. Miller. *Nuclear and Radiochemistry*, Wiley Int.
9. H. J. Arnikar. *Essentials of Nuclear Chemistry*, Wiley Eastern.
10. Haissionsky, *Nuclear Chemistry and its applications*, Addison Wesley.
11. Fundamental concepts of applied chemistry - Jayashree Ghosh (2006)

APPLIED ORGANIC CHEMISTRY

Theory Credit: 4

UNIT I ***Environmental Chemistry***

Chemistry and environmental pollution: Chemical hazards, chemical disasters, environmental biochemistry, toxicological chemistry

Environmental analysis: Analysis of water and wastewater, solid-wastes. toxic biochemicals effect of arsenic, lead and mercury.

Environmental protection: pollution prevention, green chemistry, biodegradation, water and wastewater purification – removal of arsenic, iron, fluoride, etc waste minimization, industrial and municipal waste treatment and soil remediation

UNIT II ***Green Chemistry***

Green chemistry principles: Principles of green chemistry, atom economy, less hazardous chemical syntheses, designing safer chemicals, safer solvents and auxiliaries, design for energy efficiency, renewable feedstock, catalysis, design for degradation, real time analysis for pollution prevention, and inherently safer chemistry for accident prevention. Design of green synthesis: Ideal synthesis, clean routes, supercritical solvents, ionic liquids, green catalyst, auto-exhaust catalyst and clean technology

UNIT III ***Polymer chemistry***

Introduction, importance of polymers as a class of material, polymer raw materials

Polymerization techniques: Special features of polymerization, step polymerization, radical chain polymerization, living and non-living chain polymerization, co-ordination polymerization, co- olymerization, ionic polymerization, ring opening polymerization, characterization of polymers, Structure-property relationship: Stereochemistry of polymers, modification of polymers, cross- linking, polymer architecture, polymer processing and fabrication, polymer composites Applications, degradation and future trends

UNIT IV ***Medicinal chemistry***

History of medicinal chemistry, interaction between drug molecule and receptor sites, drug action mechanism, drug metabolism, approaches to drug design Concept of drug, lead compound and lead modification, prodrugs and soft drugs; Structure-activity relationship (SAR), quantitative structure-activity relationship (QSAR);

Concept of drug receptors – elementary treatment of drug-receptor interactions; Factors affecting modes of drug administration, absorption, metabolism and elimination

UNIT V ***Biochemistry***

***Nucleic acid*:** Structure of purines and pyrimidine bases and their biosynthesis, nucleosides and nucleotides and their nomenclature Primary, secondary and tertiary structure of DNA; DNA replication and heredity; Structure and function of mRNA, tRNA and rRNA., structure of RNA and DNA, replication of DNA and mutagenesis, codon, anticodon, t-RNA, structure and genetic code, transcription and translation

Recommended Books and References

1. Medicinal Chemistry Pearson, D.Sriram, P.Yogeeswari
2. Introduction to Drug Design, New Age International, S.S. Pandeya & J.R.Dimmock
3. Introduction to Medicinal Chemistry Graham & Patrick
4. Medicinal chemistry and Drug discovery M.E .Wolff,John Wiley
5. Environmental Chemistry New Age International limited A.K De.
6. Environmental Pollution Monitoring and Control New Age International Publisher, Khopkar S.M
7. Environmental Chemistry Lewis Publishers, London E.E.Manahan
8. Environmental Chemistry Academic Press, London J.W .Moore & E.A . Moore
9. A Textbook of Polymer Chemistry S.Chand Publication. M.S.Bhatnagar
10. Polymer Science Wiley Easten limited V.R.Gowariker, N.V Viswanathan, Jyadev Sreedhar
11. Green Chemistry Environmentally Benign Reaction V.K Ahluwalia
12. New trends in Green chemistry, Anamalaya Publishers Ahluwalia V.K. & Kidwai M.R
13. Green Chemistry: An Introductory Text RSC Publishing M.Lancaster
14. Green Chemistry-Theory and Practical Oxford University Press Anastas, P.T & Warner ,J.K
15. Bio-Organic Chemistry Pragati Publising, Meerut Vinay Prabha Sharma

NANOTECHNOLOGY AND POLYMER TECHNOLOGY

Theory Credit: 4

UNIT I ***Characterization of Nanomaterials I***

X-Ray Diffraction Technique: Structure of nanomaterials, X-ray diffraction (XRD), The Laue method, The Rotating crystal method, The Powder method, Determination of grain size/crystallite size using X-ray line broadening studies (Scherrer's formula), Determination of crystallite size distribution using X-ray line shape analysis. Dynamic Light Scattering (DLS) Studies: Principle, Theory and methodology.

UNIT II ***Characterization of Nanomaterials II***

Electron Microscopic Techniques: Principles of electron microscopy, Scanning Electron Microscopy (SEM), Strengths and limitations of Scanning electron microscopy, Energy dispersive X-ray analysis (EDX), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM) and Scanning Tunneling microscopy (STM). BET Surface Area Studies: Principle, Theory and Methodology.

UNIT III ***Applications of Nanomaterials***

Importance of Nanomaterials (Gold, Silver, Dielectric and Magnetic Oxide Nanoparticles), Some selected applications like, Nanomaterials in medicine, Nanomaterials for energy sector, Kinetic energy (KE) penetrators with enhanced lethality, High energy density batteries, Nanomaterials in Next-Generation Computer, Nanomaterials in catalysis and sensors, Nanomaterials for water purification, Nanomaterials in communication sector, Nanomaterials in food, Nanomaterials for the environment, Nanomaterials in automobiles, Nanomaterials in ceramics industry.

UNIT IV ***Polymer Technology***

Polymers of Commercial Importance, Mass Polymerization: Solution, Emulsion and Suspension Polymerizations, Ziegler Natta Coordination Polymerization, Methathesis Polymerization. Additives for Plastics: Fillers, Plasticizers, Stabilizers, Lubricants, Flame Retardants, Foaming Agents, Crosslinking Agents, Manufacture, Properties and Applications of Major Thermoplastics and Thermosetting Polymers: PE, PP, PVC, PS, Polyamides, Polyesters, Phenolic Resins, Amino Resins and Epoxy Resins, Polymeric Coatings.

UNIT V ***Biopolymers & Special Polymers***

Structure, Functions and Properties of Naturally Occurring Polymers such as Proteins, Polysaccharides and DNA, Polymer Chemistry of Biological Processes, Synthetic Biopolymers, their Fabrication and Applications Conductive Polymers: Theory of Conduction, Synthesis and Applications of Conductive Polymers, Biodegradable Polymers, Biomaterials, Polymers in Medicine, Drug Delivery Systems, Recycling of Polymers.

Recommended Books and References:

1. *Principals of Nanoscience and Nanotechnology*, M. A. Shah and Tokeer Ahmad, Narosa Publications, (2010).
2. *Nano Materials*, B. Viswanathan, Narosa Publications, (2009).
3. *Nano: The Essentials*, T. Pradeep, Tata Mcgraw Hill, (2009).
4. *Introduction to Atomic Force Microscopy,* Paul E. West, Pacific Nanotechnology, USA. (2010)
5. *Scanning Probe Microscopy and Spectroscopy*, Ronald Weisendanger, Cambridge University Press. (1994).
6. *Text Book of Polymer Science* by F. W. Billmeyer, Wiley-Blackwell; 3rd edition (1984)
7. *Introduction to Polymers* by R. J. Young and P. A. Lovell, Springer-science, Buisness Media, B.V(1991)
8. *"Nanomaterials Chemistry: Recent Developments and New Directions"*, ed. by C.N.R. Rao, A. Muller & A.K. Cheetham (Eds.), Wiley-VCH, (2007).
9. *Physical Principles of Electron Microscopy: An introduction to TEM, SEM and AFM* by R.F. Eqerton, Springer, (2008).
10. *Principles of Polymerization* by George Odian, Wiley-Interscience; 4 edition (February 9, 2004).

SYLLABUS FOR
Master of Science

GEOLOGY

Under CBCS guidelines

COURSE STRUCTURE

SEMESTER	COURSE CODE	COURSE TITLE	CREDITS
I	MGLC 1.11	Mineralogy, Crystallography and Analytical Techniques	4
	MGLC 1.21	Structural geology and Geodynamics	4
	MGLC 1.31	Igneous and Metamorphic Petrology	4
	MGLC 1.41	Sedimentology	4
	MGLC 1.12	Mineralogy, Crystallography and Analytical Techniques (Practical)	2
	MGLC 1.22	Structural geology and Geodynamics (Practical)	2
	MGLC 1.32	Igneous and Metamorphic Petrology (Practical)	2
	MGLC 1.42	Sedimentology (Practical)	2
II	MGLC 2.11	Palaeontology	4
	MGLC 2.21	Stratigraphy and Quaternary Geology	4
	MGLC 2.31	Mineral Exploration and Mining geology	4
	MGLC 2.41	Geomorphology and Oceanography	4
	MGLC 2.12	Palaeontology (Practical)	2
	MGLC 2.22	Stratigraphy and Quaternary Geology (Practical)	2
	MGLC 2.32	Mineral Exploration and Mining geology (Practical)	2
	MGLC 2.42	Geomorphology and Oceanography (Practical)	2
III	MGLC 3.11	Engineering Geology and Hydrogeology	4
	MGLC 3.21	Economic and Ore Geology	4
	MGLD 3.11(a)	Fuel Geology and Geochemistry	4
	MGLD 3.11(b)	Sedimentary Environment and Sedimentary Basins	4
	MGLD 3.11(c)	Advanced Hydrogeology	4
	MGLD 3.21(a)	Geology of North East India	4
	MGLD 3.21(b)	Petroleum Exploration	4
	MGLD 3.21(c)	Marine Geology	4
	MGLC 3.12	Engineering Geology and Hydrogeology (Practical)	2
	MGLC 3.22	Economic and Ore Geology (Practical)	2
	MGLD3.12(a) MGLD3.12(b) MGLD3.12(c)	Fuel Geology and Geochemistry (Practical) Sedimentary Environment and Sedimentary Basins (Practical) Advanced Hydrogeology (Practical)	2 2 2
	MGLD 3.22(a)	Geology of North East India (Practical)	2
	MGLD 3.22(b)	Petroleum Exploration (Practical)	2
	MGLD 3.22(c)	Marine Geology (Practical)	2
IV	MGLC 4.11	Environmental Geology and Climatology	4
	MGLC 4.21	Remote Sensing and GIS	4
	MGLD 4.11	Fieldwork	4
	MGLD 4.21	Dissertation	4
	MGLC 4.12	Environmental Geology and Climatology (Practical)	2
	MGLC 4.22	Remote Sensing and GIS (Practical)	2
	MGLD 4.12	Seminar	2
	MGLD 4.22	Report and Presentation	2

SEMESTER – I

MGLC 1.11
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. Systematic mineralogy (chemical composition, atomic structure, mineral chemistry, PT-stability and mode of occurrence of olivine, garnet, aluminosilicate (Al_2SiO_5), epidote groups.

UNIT II Systematic mineralogy of melilite, beryl, pyroxene and amphibole, kaolinite, mica, chlorite groups.

UNIT III Systematic mineralogy of feldspar group, cordierite, native elements (diamond and graphite), sulfides (pyrrhotite and sphalerite), sulfosalts (enargite), oxides (periclase and corundum), hydroxides (brucite and gibbsite) 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 Gem and semi- Precious minerals. 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. ISBN-10: 0582300940.
2. Klein, C. and Hurlbut, C.S. (Jr) 1993: Manual of mineralogy. John Wiley. ISBN 0135615801.
3. Putnis, A. 1992: Introduction to mineral sciences. Cambridge University Press. ISBN-10: 9780521429474.
4. Spear, F.S. 1993: Mineralogical phase equilibria and pressure-temperature-time paths.
5. Mineralogical Society of America Publications. ISBN 0-939950-34-0.
6. Phillips, W.R. and Griffin, D.T. 1986: Optical mineralogy. CBS Publishers. ISBN, 9788123910642
7. Hutchinson, C.S. 1974: Laboratory handbook of petrographic techniques. John Wiley. ISBN-10: 0471425508; ISBN-13: 978-0471425502.

MGLC 1.21
STRUCTURAL GEOLOGY AND GEODYNAMICS

Theory Credit: 4

UNIT I Stress: Concept and types of stress (hydrostatic, uniaxial, compressional, tensional, triaxial, deviatoric, differential and effective stress); Two dimensional stress analyses; Behaviour of rocks under stress: elastic, plastic and viscous materials.

Strain: Concept and types of strain; Principal axes of strain; Strain markers and methods of strain measurements in naturally deformed rocks.

UNIT II Mechanics of folding; Fold development and distribution of strain in folds; Causes and dynamics of faulting; Strike-slip faults, Normal faults, Thrust faults. Planar and linear fabrics in deformed rocks, their origin and significance; Stereographic and equal area projections for presenting different types of fabrics, and π and β diagrams.

UNIT III Phase transitions and seismic discontinuities in the earth. Heterogenity of earth's crust. Isostasy, Continental drift and sea floor spreading (geological and geophysical evidences). Mechanism of plate motion (mantle drag mechanism and edge force mechanism). Types of plate boundaries and their inter-relationship. Major tectonic features of the oceanic and continental crust.

UNIT IV Rock magnetism and its origin; Paleomagnetism; magnetic and gravity anomalies at MOR, trenches, continental shield and mountain chains. Polarity reversals polar wandering and supercontinental cycles. Heat flow patterns at MOR.

UNIT V Brief study on geodynamic evolution of Indian Cratons (Dharwar, Singhbhum, Bastar and Bundelkhand). Structure and origin of Himalaya. Neotectonics concepts and evidences.

Recommended Books and References:

1. Badgley, P.C. 1965: Structure and Tectonics. Harper & Row.
2. Bailey, B. 1992: Mechanics in Structural Geology. Springer Verlag. ISBN 9781461391661
3. Condie, K.C. 1982: Plate Tectonics and Crustal Evolution (2nd ed). Pergammon Press. ISBN 0750633867
4. Davis, G.H. 1984: Structural Geology of Rocks and Regions. John Wiley. *ISBN*: 9780471152316
5. Fossen, H. 2010: Structural Geology. Cambridge University Press. *ISBN*: 9780511777806.
6. Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Developments. Pergamon Press.
7. Ghosh, S.K. 1995: Structural Geology - Fundamentals of Modern Developments. Pergammon Press. ISBN9780080418797, 9780080983998.
8. Hobbs, B.E., Means, W.D. and Williams, P.F. 1976: An Outline of Structural Geology. John Wiley.
9. Keary, P., Klepeis, K.A and Vine, F.J. 2009: Global Tectonics (3rd ed). Blackwell. ISBN: 9788126532957
10. Keary, P. and Vine, F.J. 1990: Global Tectonics. Blackwell.
11. Moores, E. and Twiss, R.J. 1995: Tectonics. Freeman.
12. Passchier, C.W. and Trouw, R.A.J. 2005: Microtectonics (2nd ed). Springer Verlag.
13. Pluijm, B.A. van der and Marshak, S. 1997: Earth Structure: An Introduction to Structural Geology and Tectonics. McGraw Hill.
14. Price, N.J. and Cosgrove, J.W. 1990: Analysis of Geological Structures. Cambridge University Press.
15. Ramsay, J.G. 1967: Folding and Fracturing of Rocks. McGraw Hill. ISBN 070511705
16. Ramsay, J.G. and Huber, M.I. 1987: Modern Structural Geology (vol. 1 & 2). Academic Press.
17. Ramsay, J.G. and Huber, M.I. (1987): Techniques of Modern Structural Geology. Vol. II. Folds and Fractures. Academic Press.
18. Storetvedt, K.N. 1997: Our Evolving Planet: Earth's History in New Perspective. Bergen (Norway), Alma Mater Fortag.
19. Summerfields, M.A. 2000: Geomorphology and Global Tectonics. Springer Verlag. ISBN 0471971936
20. Suppe, J. 1985: Principles of Structural Geology. Prentice Hall.
21. Twiss, R.J and Moores, E.M. 2007: Structural Geology (2nd ed), Freeman.
22. Valdiya, K.S. 1998: Dynamic Himalaya. University Press, Hyderabad.
23. Edwards J.Plate Tectonics and Continental Drift, Published by Creative Co. ISBN 10: 1583407308 ISBN 13: 9781583407301
24. Keary P. Klepels K.A and Nive F.J. Global Tectonic, Wiley & Sons, Incorporated, John ISBN 10: 0865429243 ISBN 13: 9780865429246
25. Valdiya. K.S, Aspects of Tectonics. McGraw-Hill Education (1 October 1985)
26. ISBN-10: 0074519727: ISBN-13: 978-0074519721
27. Valdiya. K.S. Making of India, Springer (2015) ISBN 10: 3319250272
28. ISBN 13: 9783319250274.

MGLC 1.31
IGNEOUS AND METAMORPHIC PETROLOGY

Theory Credit: 4

UNIT I Magma: Factors affecting magma generation; Magmatism in relation to plate settings; Classification of Igneous rocks: CIPW norm and IUGS classification.

UNIT II Petrology and petrogenesis of Major Igneous rock types: Ultramafic rocks-Komatites, Flood Basalts (Deccan Trap, Sylhet Trap), Granite, Alkaline rocks, Carbonatites and Ophiolites.

UNIT III Geochemical characteristics of Igneous rocks: Chemical analyses, REE, major, trace and isotopic composition of Igneous rocks; Application of trace elements and isotope geology in Petrogenesis and source characterization.

UNIT IV Metamorphic textures, P-T-t path, Metamorphic reactions, Barrovian Zones of metamorphism; Elemental exchange and P-T conditions of Isograds; Regional metamorphism of pelitic and basic metamorphic assemblages; metamorphic reaction involved during regional metamorphism of rocks.

UNIT V Metamorphic Facies: low pressure (albite-epidote-hornfels, pyroxene-hornfels), medium-high pressure (greenschist, granulite) and very high pressure (eclogite) with special reference to characteristic minerals and PT conditions; Application of geo-thermometry and geobarometry.

Recommended Books and References:

1. Best, M. G. 1986: Igneous and metamorphic petrology. Blackwell Publishers. ISBN: 1-40510-588-7.
2. Kretz, R. 1994: Metamorphic crystallization. John Wiley. ISBN: 0471942146, 9780471942146.
3. Philipotts, A, R. and Ague, J. J. 1990: Principles of Igneous and metamorphic petrology. Prentice Hall. ISBN: 9780521880060.
4. Raith, M.M, Raase, P. and Reinhardt, J. 2012: Guide to thin section microscopy. 2ndEdition.ISBN: 9783000376719.
5. Turner, F.J. and Verhoogen, J. 1960: Igneous and Metamorphic petrology. CBS Publishers. ISBN: 8123911017.
6. Winter, J. D. 2014: Principles of Igneous and Metamorphic Petrology.2nd Edition. Pearson Education Limited. ISBN 10: 1-292-02153-5; ISBN 13: 9781292021539.
7. Yardley, B.W. D. 1989: An Introduction of metamorphic petrology. Longman. ISBN: 0582300967.

MGLC 1.41
SEDIMENTOLOGY

Theory Credit: 4

UNIT I Liberation of flux of sediments: Physical and chemical weathering, submarine weathering. Fluid flow and sediment transport: laminar Vs turbulent flow, Reynolds number, Froude number and Hjulstrom effect. Concept of flow regimes and bedforms. Classification of primary and secondary sedimentary structures.

UNIT II Sedimentary environments and facies: classification, lithofacies assemblages from fluvial, deltaic, marine, glacial and arid environment. Ichnofossils and their significance in depositional environments.

UNIT III Tectonics and sedimentation: tectonic control of sedimentation, plate tectonics and sediment accumulation, sedimentary basins and their classifications, Basin analysis, Palaeoclimate and palaeoenvironment analyses.

UNIT IV Shallow coastal clastics and shallow water carbonates, Deep water sedimentation, Volcaniclastic- land and marine, Diagenesis of sandstones and carbonate rocks.

UNIT V Field and laboratory techniques in sedimentology: Recording of sedimentary structures and preparation of litho-logs. Palaeocurrent analysis, Provenance determination using heavy minerals, quartz, feldspars and rock fragments.

Recommended Books and References:

1. Allen, J.R.L. 1985: Principles of physical sedimentation. George Allen & Unwin. *ISBN* 978-1-4613-2545-1
2. Allen, P. 1997: Earth surface processes. Blackwell. . *ISBN* 0 632 03507 2.
3. Nichols, G. 1999: Sedimentology and stratigraphy. Blackwell. *ISBN* 978-1-4051-9379-5
4. Reading, H.G. 1996: Sedimentary environments. Blackwell. Publisher: *Blackwell* Scientific Publications; 2 edition (1986); Language: English; *ISBN*-10: 0632015721
5. Davis, R.A. (Jr) 1992: Depositional systems. Prentice Hall. *ISBN*-10: 9780132029124
6. Einsele, G. 1992: Sedimentary basins. Springer Verlag. *ISBN* 0-387-54743-6
7. Reineck, H.E. and Singh, I.B. 1980: Depositional sedimentary environments. Springer Verlag. *ISBN* 978-3-642-81498-3
8. Prothero, D.R. and Schwab, F. 1996: Sedimentary geology. Freeman. *ISBN* 0716727269. - Volume 134
9. Miall, A.D. 2000: Principles of sedimentary basin analysis. Springer Verlag. *ISBN* 978-3-662-03999-1
10. Pettijohn, F.J., Potter, P.E. and Siever, R. 1990: Sand and sandstone. Springer Verlag. 978-0-387-96350-1, Springer-Verlag New York
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. *ISBN*: 978-3-319-20576-2
13. Boggs, S. (Jr) 1995: Principles of Sedimentology and Stratigraphy. Prentice Hall. *ISBN*-13: 978-0321643186
14. Sengupta, S. 1997: Introduction to sedimentology. Oxford-IBH. ISBN: 9789054102304

SEMESTER - II

MGLC 2.11
PALAEONTOLOGY

Theory Credit: 4

UNIT I General principles of palaeontology: Origin of life and mechanisms of evolution. Trace fossils and their classification. Concept of Taphonomy. Environmental factors controlling distribution and abundance of life.

UNIT II Functional morphology and evolutionary trends in molluscs (Pelecypoda, Gastropoda, Cephalopoda), Brachiopoda, Echinodermata and Trilobites.

UNIT III Major events in the history of Precambrian and Phanerozoic life.Vertebrate fossil records of Siwaliks. Evolution of horses and elephants.

UNIT IV Sampling methods and processing of microfossils. Classification, morphology and palaeoecological significance of Foraminifers, Ostracods and Conodonts. Morphology, classification and biogeography of Radiolarians. Application of micropalaeontology in hydrocarbon exploration.

UNIT V Morphology, classification and application of pollen and spores. Morphology, environmental application and stratigraphic significance of dinoflagelates, Calcareous nannofossils and Calcareous algae.

MGLC 2.12
PALAEONTOLOGY (PRACTICAL)

Practical Credit: 2

Recognition of fossil groups in an assorted assemblage and identification of their classes.
Study of morphological features, systematic classification and stratigraphic age of Molluscs, Brachiopods, Echinodermata and Trilobites.
Identification of important Calcareous, Siliceous, phosphate and organic walled microfossils, plant fossils and vertebrate fossils.

Recommended Books and References:

1. Clarkson, E.N.K., 1998: *Invertebrate Palaeontology and Evolution*. IV Ed. Blackwell. ISBN: 9780632052387.
2. Stearn, C.W. & Carroll, R.L., 1989: *Palaeontology -the Record of Life*. John Wiley. ISBN: 9780865424395.
3. Smith, A.B., 1994: *Systematics and the Fossils Record*-Documenting Evolutionary Patterns. *Blackwell. ISBN-10: 0632036427.*
4. Prothero, D.R., 1998: Bringing Fossils to Life -An Introduction to Palaeobiology. *McGraw Hill.*
5. Pomerol, C., 1982: *The Cenozoic Era*: Tertiary and Quaternary. Ellis Harwood Ltd. ISBN 9780939950812.
6. Brasier, M.D. (1980). Microfossils. Unwin Hyman, London.ISBN 13: 1598000530140.
7. Kethal, P.K. (1998). Microfossils and their applications. CBS Publishers & Distributors. ISBN: 9788123905921.
8. Jones, R.W. (1998). Micropalaeontology in petroleum exploration. Oxford University Press.ISBN 10: 0198526474, ISBN 13: 9780198526476.
9. Brooks, J. (1981). Organic Maturation studies and fossil fuel exploration. Academic Press.SBN-10: 9780121357603.

10. Traverse, A. (1994) Sedimentation of organic particles. Cambridge University Press. ISBN 10: 0521384362 / ISBN 13: 9780521384360.
11. Foote, M & Miller, A.I. (2001). Principles of Palaeontology. W.H. Freeman &Company.ISBN 10: 0716702479 / ISBN 13: 9780716702474.
12. Doyle, P. (2002). Understanding fossils an introduction to invertebrate palaeontology. Wiley, ISBN-10: 9780471963516.
13. Bignot, G. (1985). Elements of Micropalaeontology. Graham & Trotman, Paris, ISBN 10: 0860104907 / ISBN 13: 9780860104902.
14. Traverse. A (2007). Palaeopalynology. Springer.SBN 9781402056109 (e-book) ISBN 9781402066849 (PB), ISBN 9781402056093 (HB).
15. Haslett, S.K. (2002). Quaternary environmental micropalaeontology. Arnold. ISBN: 0340761970 9780340761977 0340761989 9780340761984.
16. Ray, A.K. (2008). Fossils in Earth Sciences. Prentice Hall of India Private Limited, New Delhi. ASIN: B00K7YG2H4
17. Skelton, P.W., Spicer, R.A., Keller, S.P. and Gilmour, L. (2003). The Cretaceous world. Cambridge University Press.ISBN-10: 0521538432; ISBN-13: 9780521538435.

MGLC 2.21
STRATIGRAPHY AND QUATERNARY GEOLOGY

Theory Credit: 4

UNIT I Controls on the development of stratigraphic records. Lithostratigraphy: correlation and stratigraphic code. Biostratigraphy: controlling factors, zonation, time significance, quantitative stratigraphy. Pedostratigraphy. Geochronology and Chronostratigraphy. Completeness/ incompleteness of stratigraphic records.

UNIT II Event stratigraphy, Magnetostratigraphy, Cyclostratigraphy, Seismic Stratigraphy, and Sequence Stratigraphy. Geophysical and chemostratigraphic correlation.

UNIT III Stable isotopes and palaeoclimates. Study of palaeogeography, palaeoclimate, igneous and mountain building activities in the Indian subcontinent.

UNIT IV The Quaternary Period and its division, Neogene-Quaternary and Pleistocene-Holocene boundary, the Anthropocene, Quaternary dating methods-Cosmogenic radionuclides-C^{14}, Luminescence chronology, Dendrochronology (principles, application and limitations).

UNIT V Quaternary sedimentary records from India- Himalayan foreland, Son-Narmada valley, Gangetic plains, coastal plains, Brahmaputra plains and other parts of NE India.

MGLC 2.22
STRATIGRAPHY AND QUATERNARY GEOLOGY (PRACTICAL)

Practical Credit: 2

Exercises on stratigraphic classification and correlation. Exercises on interpretation of seismic records of stratigraphy. Study of palaeogeographic maps of all geological periods.
Quaternary chronology, preparation of litholog in Quaternary stratigraphic sections/fluvial sequences. Soil profile/ weathering profile analysis.

Recommended Books and References:

1. Ager, D.V. 1980: Introduction to Palaeoecology. McGraw Hill.

2. Bayer, U. and Seilacher, A. 1985: Sedimentary and Evolutionary Cycles. Springer Verlag.
3. *ISBN* 978-3-540-39162-3;
4. Boggs, S. (Jr) 1995: Principles of Sedimentology and Stratigraphy. Prentice Hall.
5. *ISBN*-13: 978-0321643186
6. Dasgupta, A.B. and Biswas, A.K. 2000: Geology of Assam. Geological Society of India.
7. *ISBN* No: 81-85867-44-5.
8. Dodd, J.R. and Stanton, R.J. 1983: Palaeoecology: Concepts and Application. John Wiley.
9. *ISBN*: 978-0-471-85711-2
10. Doyle, P. and Bennet, M.R. 1996: Unlocking the Stratigraphic Record. John Wiley. ISBN 0-471-97463-3
11. Karunakaran, C. 1972: Geology and Mineral Resources of the States of India. Misc. Publ., GSI, vol. 30.
12. Kennett, P. and Ross, C.A. 1983: Palaeoecology. Longman.
13. Krishnan, M.S. 1982: Geology of India and Burma (6th ed). CBS Publishers.
14. Kumar. G. 1997: Geology of Arunachal Pradesh. Geological Society of India.
15. Kumar, R. 1985: Fundamental of Historical Geology and Stratigraphy of India (3rd ed). Wiley Eastern. *ISBN* 0 85226 745.
16. Ladd, H.S. 1957: Treatise on Marine Ecology and Palaeoecology (vol. 2). Palaeoecology
17. Moullade, M. and Nairn, A.E.M. 1983: Palaeozoic, Mesozoic and Cenozoic (vol. 1-3). Elsevier.
18. Nandy, D.R. 2001: Geodynamics of Northeastern India and the Adjoining Region. ACB Publications. *ISBN*, 8187500042.
19. Naqvi, S.M. 2005: Geology and Evolution of the Indian Plate (4 Ga to 4 Ka). Capital Publishing Co.*ISBN*: 8185589399 9788185589398.
20. Naqvi, S.M. and Rogers, J.J.W. 1987: Precambrian Geology of India. Oxford University Press.
21. Pascoe, E.H. 1968. A Manual of Geology of India and Burma (vol. 1-4). GoI Press.
22. Pomerol, C. 1982: The Cenozoic Era: Tertiary and Quaternary. Ellis Harwood.
23. Sheriff, R.E. 1980: Seismic Stratigraphy. International Human Resources Dev. Corp., Boston. *ISBN* 10: 0934634084.
24. Tarling, D.H. 1983: Palaeomagnetism - Principles and Applications in Geology, Geophysics and Archaeology. Chapman &Hall.*ISBN* 0412239205 (hardback), 0412251000 (paperback).
25. Wadia, D.N. 1957: Geology of India (3rd ed). Macmillan. *ISBN*: 9781330260791.

MGLC 2.31
MINERAL EXPLORATION AND MINING GEOLOGY

Theory Credit: 4

UNIT I Concept of prospecting and exploration. Criteria and guides to prospecting. Geological models in exploration planning. Geological exploration methods: Regional and detailed geological mapping, pitting, trenching, drilling and sampling methods.

UNIT II Seismic methods: Seismic waves used in seismic survey and their velocities in different rocks, basic principles of seismic wave reflection and refraction seismic methods, data acquisition, processing, interpretation and applications. Concept and principle of gravity method of prospecting.

UNIT III Basic concepts and principles of magnetic, electrical resistivity and radioactive methods of prospecting. Introduction to airborne geophysical survey.

UNIT IV Basic principles of exploration geochemistry: geochemical environment, geochemical dispersion and association of elements. Geochemical rock surveys: types of geochemical survey. Geobotanical methods: plants as indicators of mineralization, biogeochemical methods. Application of remote sensing in mineral exploration.

UNIT V Mining strategies: Planning, exploration and exploratory mining of surface and underground mineral deposits involving diamond drilling, shaft sinking, drifting, cross-cutting, winzing, stoping, room and pillaring, top-slicing, sub-level caving and block caving. Mining hazards: mine inundation, fire and rock burst.

MGLC 2.32
MINERAL EXPLORATION AND MINING GEOLOGY (PRACTICAL)

Practical Credit: 2

Interpretation of underground structure on the basis of seismic data.
Study of prospecting procedures of some important deposits.
Study and interpretation of geological maps/mine plans and sections of mineral deposits.
Calculation of assay values, ore and mineral reserves from maps and data.
Study of geochemical and geophysical anomalies, and their interpretation.

Recommended Books and References:

1. Evans, A.M. 1995: Introduction to mineral exploration. Blackwell Science.ISBN-10: 0632024275.
2. Rose, A.W., Hawkes, H.E. and Webb, J.A. 1979: Geochemistry in mineral exploration. Academic Press.ISBN-13: 9780060427108.
3. Govett, G.J.S. 1983: Handbook of exploration geochemistry. Elsevier. ISBN: 9780444818546, 9781483290461.
4. Levinson, 1974: Introduction to exploration geochemistry.ISBN-10: 0915834014; ISBN-13: 978-0915834013
5. Sharma, P.V. 1986: Geophysical methods in geology. Elsevier ISBN:9780080220727, 9781483293486.
6. Vogelsang, D. 1995: Environmental geophysics - A practical guide. Springer Verlag.ISBN: 3540579931 9783540579939.
7. Dobrin, M.B. 1976: Introduction to geophysical prospecting. McGraw Hill.ISBN 10: 0070171955.
8. Stanislave, M. 1984: Introduction to applied geophysics. Reidel Publications.ISBN-10: 0393926370.
9. Peters, W.C. 1978: Exploration and mining geology. John Willey and Sons.ISBN-10: 0471838640; ISBN-13: 978-0471838647.
10. McKinstry, H.E. 1962: Mining geology (2nd ed). Asia Publishing House. ASIN: B003I2VY84.
11. Clark, G.B. 1967: Elements of mining (3rd ed). John Wiley.ISBN-10: 0471533319; ISBN-13: 978-0471533313.
12. Arrogyaswami, R.N.P. 1996: Courses in mining geology (4th ed). Oxford IBH. ISBN: 9788120409378.

MGLC 2.41
GEOMORPHOLOGY AND OCEANOGRAPHY

Theory Credit: 4

UNIT I Concept and perception of geomorphology. Landscape development: Davisian model and its merits and demerits. Penck's and King's models geomorphic process: endogenetic and exogenetic; anthropogenic: biological and extra-terrestrial.

UNIT II Morphometric analysis: Drainage patterns, drainage basin asymmetry, stream length-gradient index. Slope: types and evolution. Tectonic geomorphology, geomorphic indices of active tectonics: Hypsometric curve and Hypsometric integral, mountain-front sinuosity and ratio of valley-floor width to valley heights.

UNIT III Applied geomorphology: regional planning, hazard management: hydrogeology, urbanization, engineering works and mineral exploration.

UNIT IV History of development of marine geology and oceanography. Ocean floor morphology, Zones of marine environment and its communities (Pelagic and Benthic). Ocean sediments. Factors controlling deposition and distribution of oceanic sediments. Law of the sea.

UNIT V Ocean circulation: Corioliseffect and Ekman spiral; convergence and downwelling, divergence and upwelling; El Nino. Thermohaline circulation and oceanic conveyor belt and its role in global climate change. Concept of mixed layer, thermocline and pynocline. Formation of bottom water, major water masses of world's ocean.

MGLC 2.42
GEOMORPHOLOGY AND OCEANOGRAPHY (PRACTICAL)

Practical Credit: 2

Drainage patterns and morphometric analysis.
Geomorphic indices.
Identification of ocean currents (warm-water and cold-water currents) in Northern Hemisphere and Southern Hemisphere.
Global conveyor Belt and its path.

Recommended Books and References:

1. Summerfield M.A (1991) *geomorphology and global tectonics* Wiley and sons ISBN10:0471971936 ISBN 13: 9780471971931
2. Summerfield, M. Global Geomorphology, Longmans (1991)ISBN 10: 0582301564
3. ISBN 13: 9780582301566
4. Valdiya K.S 1998, Dynamic Himalayas. Universities Press (India) Pvt. Ltd.ISBN 10: 8173710945 ISBN 13: 9788173710940
5. Edward A. Keller and Nicholas Pinter, Active Tectonic- Earthquakes, Uplift and Landscape Prentice Hall, ISBN 10: 0023632615 ISBN 13: 9780023632617
6. W.Burbank and Robert S.Anderson, Tectonic Geomorphology, Douglas Blackwell Science, ISBN 10: 0632043865 ISBN 13: 9780632043866
7. Gross, M.G, 1977. Oceanography: A view of the Earth, Prentice Hall. ISBN 10: 0136307167 ISBN 13: 9780136307167
8. Tolmazin, D. 1985. Elements of Dynamic Oceanography, Springer (1985)ISBN 10: 0045510709 ISBN 13: 9780045510702
9. Tom S. Garrison,Essentials of oceanography,Cengage LearningISBN 10: 0534392598 ISBN 13: 9780534392598

SEMESTER - III

MGLC 3.11
ENGINEERING GEOLOGY AND HYDROGEOLOGY

Theory Credit: 4

UNIT I Soil mechanics, Soil profile and classification, engineering properties of soils and their determination.
Engineering properties of rocks, Rocks as construction material. Rock Quality Designation (RQD).

UNIT II Impact of civil engineering projects on environment, nature's equilibrium, reservoir induced seismicity; alternatives for environment protection. Mass movement: landslide and causes of slopes instability.

UNIT III Origin and types of surface and subsurface water. Hydrological properties of rocks: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity and storage coefficient. Geological formations as aquifers.

UNIT IV Well hydraulics: steady and radial flow. Pumping test analysis, Groundwater exploration: Geologicaland Geophysical methods(Remote Sensing, electric resistivity and seismic refraction).

UNIT V Artificial recharge of groundwater. Consumptive and conjunctive uses of water. Chemical properties of groundwater in relation to domestic, industrial and irrigation purposes. Water contamination and pollution. Groundwater provinces of India.

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. Preparation of hydrogeomorphic maps using toposheets, aerial photos and satellite imagery. Analysis of rainfall data, estimation of average annual rainfall. Determination of porosity, hydraulic conductivity, etc. from mechanical analysis data of aquifer material.
Determination of aquifer parameters using Theis and Jacobs method.
Computation of Index properties of soil
Computation of Index properties of rock
Computation of RQD

Recommended Books and References:

1. Alley, W.M. 1993: Regional groundwater quality. VNR, New York. ISBN 0442009372, Wiley.
2. Davies, S.N. and Dewiest, R.J.M. 1966:.Hydrogeology. John Wiley. ISBN-10: 0894646389, Krieger Pub Co.
3. Todd, D.K. 1980: Groundwater hydrology. John Wiley.
4. Todd, D.K. Larry W. Mays: Groundwater hydrology 3rd Edition. John Wiley. ISBN-10: 9788126530038 Wiley India Pvt Ltd.
5. Van Te Chow, David R. Maidment, Larry W. Mays: Applied Hydrology. ISBN-10 9780070702424 McGraw Hill Education.

6. Fetter, C.W. 1990: Applied hydrogeology. Merrill ISBN-10: 0130882399 Pearson.
7. Freeze, R.A. and Cherry, J.A., 1979: Groundwater. Prentice Hall. ISBN 0133653129 Prentice Hall
8. Karanth, K.R. 1987: Groundwater assessment - Development and management. ISBN-10: 007517120 Tata-McGraw Hill.
9. Raghunath, N.M. 1982: Groundwater. Wiley Eastern. ISBN-10: 812219046 Newagepublishers.
10. Bhagu R. Chahar: Groundwater hydrology ISBN-10: 9339204638 McGraw Hill Education
11. A.R. Mahendra. Goundwater Technology Handbook: A field guide to extraction and usage of groundwater. ISBN-10: 1482812657 Partridge Publishing.
12. Krynine, D.H. and Judd, W.R. 1998: Principles of engineering geology. CBS Publishers.
13. Sharma, P.V. 1997: Environmental and engineering geophysics. Cambridge University Press.
14. Subramaniam. V. 2000: Water. Kingston Publications.
15. F.G. Bell, Basic Environmental and Engineering Geology, Whittles Publishing (2007) ISBN 10: 1420044702 ISBN 13: 9781420044706.
16. Gangopadhyay, Subinoy, Engineering Geology. Oxford University PressISBN 10: 0198086350 ISBN 13: 9780198086352.
17. Parbin Singh, Engineering and General Geology. ISBN 10: 9350142678ISBN13:9789350142677.

MGLC 3.21
ECONOMIC GEOLOGY AND ORE GEOLOGY

Theory Credit: 4

UNIT I Chemical composition, origin, occurrences and distribution in India – Bauxite, Lead, Tin, Tungsten, Magnesium and Mercury.

UNIT II Chemical composition, origin, occurrences and distribution in India – Diamond, Corundum, Talc, Clay, Ochre and Carbonate.

UNIT III Chemical composition, origin, occurrences and distribution in India – Rare Metals (Monazite, Antimony, Bismuth, Cadmium, and Platinum) andRare Earth Element (REE).

UNIT IV 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. Chemical composition of ores - bulk chemistry, trace elements, REE and isotopes. Organic matter in ores and their significance.

UNIT V 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.

MGLC 3.22
ECONOMIC GEOLOGY AND ORE GEOLOGY (PRACTICAL)

Practical Credit: 2

Preparation of maps showing distribution of important metallic and industrial minerals in India and the world. Megascopic identification of Indian metallic ores in hand specimen, megascopic study of structures and fabric of different ores and their associations, microscopic properties of ore forming minerals.

Recommended Books and References:

1. Craig, J.M. and Vaughan, D.J. 1981: Ore petrography and mineralogy. John Wiley. ISBN 0-471-55175-9.
2. Evans, A.M. 1993: Ore geology and industrial minerals. Blackwell. ISBN 9780632029532.
3. Sawkins, F.J. 1984: Metal deposits in relation to plate tectonics. Springer Verlag. ISBN 9783642967856.
4. Stanton, R.L. 1972: Ore petrology. McGraw Hill.ISBN. 0070608431.
5. Torling, D.H. 1981: Economic geology and geotectonics. Blackwell.ISBN-10: 0470271450.
6. Barnes, H.L. 1979: Geochemistry of hydrothermal ore deposits. John Wiley. ISBN 0471 050563.
7. Klemm, D.D. and Schneider, H.J. 1977: Time and strata bound ore deposits. Springer Verlag. ISBN 978364266806-7.
8. Guilbert, J.M. and Park, C.F. (Jr) 1986: The geology of ore deposits. Freeman.ISBN 10: 0716714566.
9. Mookherjee, A. 2000: Ore genesis - A holistic approach. Allied Publishers. ISBN 10: 8170235766.
10. Alan M. Bateman; Mead L. Jensen,Economic Mineral Deposits published by Wiley & Sons, Incorporated, John ISBN 10: 0471090433 ISBN 13: 9780471090434.
11. Anthony M. Evans, Ore Geology and Industrial Minerals: An Introduction (Geoscience Texts)Wiley (1993)ISBN 10: 0632029536 ISBN 13: 9780632029532.
12. Guilbert J.M. The Geology Of Ore Deposits (Pb 201*5)*.Cbs (2015)ISBN 10: 8123925662 ISBN 13: 9788123925660.
13. Laurence R. Introduction to Ore-Forming Processes.Wiley-Blackwell. ISBN:9780632063789.
14. Sarkar S.C. Gupta A Crustal Evolution and Metallogeny in India. Cambridge University Press; 1 editionISBN-13: 9781107007154 ISBN-10: 1107007151.

SEMESTER - IV

MGLC 4.11
ENVIRONMENTAL GEOLOGY AND CLIMATOLOGY

Theory Credit: 4

UNIT I 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, reservoirs and dams.

UNIT II Soil quality degradation due to irrigation, use of fertilizers and pesticides. Energy crisis: alternative energy resources. Waste management: solid, liquid and radioactive. Geologic aspects of environmental health.

UNIT III Earthquakes: causes, magnitude, intensity and distribution. Seismic hazards: Influence of neotectonics in seismic hazards assessment. Volcanism. Deforestation, its causes, impact and remedial measures.

UNIT IV Fundamental principles of climatology. Earth's radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity. Vertical and horizontal distribution of temperature. Clouds: formation and classification.

UNIT V Factors affecting wind direction and speed, upper level waves and jet streams, the monsoons. Weather disturbances: Properties of air masses, Cyclone: tropical and extratropical. Koppens and Thornthwaite's scheme of classification, Climate change.

MGLC 4.12
ENVIRONMENTAL GEOLOGY AND CLIMATOLOGY (PRACTICAL)

Practical Credit: 2

Preparation of geohazard maps, wind direction map, temperature distribution, etc.

Recommended Books and References:

1. Bell, F.G. 1999: Geological hazards. Routledge. *ISBN* 10: 8123908091.
2. Environmental Geology, James S. Richard. ISBN 9780070164864.
3. Environmental Geology, Mathew R. Bennett and peter Doyle Wiley. ISBN 9788126560202.
4. Bryant, E. 1985: Natural hazards. Cambridge University Press.ISBN-10: 0521537436.
5. Keller, E.A. 1978: Environmental geology. Bell and Howell. ISBN: 130224669.
6. Patwardhan, A.M. 1999: The dynamic earth system. Prentice Hall.ISBN-10: 9788120346550
7. Smith, K. 1992: Environmental hazards. Routledge.ISBN-10: 0415224640.
8. Subramaniam, V. 2001: Textbook in environmental science. Narosa International. ISBN 10: 0849324084 ISBN 13: 9780849324086.
9. Valdiya, K.S. 1987: Environmental geology - Indian context. Tata McGraw Hill.ISBN-10: 0074519719ISBN-13: 978-0074519714.

MGLC 4.21
REMOTE SENSING AND GIS

Theory Credit: 4

UNIT I Principles of Remote sensing, Electromagnetic energy and spectral response curves, electromagnetic spectrum, sensors and scanners, elements of aerial photo/image interpretation.

UNIT II Aerial photography: Types and geometry, stereopair and stereoscopes, photo-mosaics, principles and applications of photogrammetry.

UNIT III Satellite remote sensing, Satellite exploration programs and their characteristics: LANDSAT, METEOSAT, SPOT, IRS and KOMPSAT.

UNIT IV Digital image processing: Processing, correction, enhancement and classification. Geological interpretation of remotely sensed data for lithology, structure, ground-water potential and hazards.

UNIT V GIS: Introduction. Map projection and datum. GIS database: Spatial analysis, vector and raster data, Generation of DEM and interpretation. Applications and current trend of GIS.
GPS: Concepts of GPS and its application in earth system sciences.

MGLC 4.22
REMOTE SENSING AND GIS (PRACTICAL)

Practical Credit: 2

Drainage patterns and analysis. Study of nature of aerial photographs: resolution, mosaic and image parallax. Determination of scale, height, dip, slope, vertical exaggeration and image distortion. Identification of features on single vertical aerial photographs and satellite imagery. Interpretation of cultural details and preparation of land use map using satellite imagery. Exercises on MSS, TM, FCC, IR, Thermal IR, Radar and SPOT images for geological and geomorphological mapping and vegetation, water and mineral resource evaluation. Preparation of false color composites and study of multi-spectral scans and spectral patterns. Image rectification and registration. Exercises on digital image processing. GPS demonstration in the field.

Recommended Books and References:

1. Drury, S.A. 1987: Image interpretation in geology. Allen and Unwin. ISBN 0 04 550037 1, 0 04 550038 X
2. Gupta, R.P. 1990: Remote sensing geology. Springer Verlag. ISBN: 978-3-662-55874-4 ISBN: 978-3-662-57254-2
3. Lillesand, M.T. 2000: Remote sensing and image interpretation. John Wiley. ISBN: 978-1-118-34328-9
4. Lillesand, T.M. and Kieffer, R.W. 1987: Remote sensing and image interpretation. John Wiley. ISBN: 9781118343289.
5. Miller, V.C. and Miller, C.F. 1961: Photogeology. McGraw Hill.ISBN-10: 0788141619
6. ISBN-13: 9780788141614.
7. Moffitt, F.H. and Mikhail, E.M. 1980: Photogrammetry. Harper and Row. *ISBN*: 070022517X 9780700225170.
8. Paine, D.P. 1981: Aerial photography and image interpretation for resource management. John Wiley. ISBN: 9780470879382.
9. Pandey, S.N. 1987: Principles and applications of photogeology. Wiley Eastern, New Delhi.ISBN-10: 0470201266, ISBN-13: 9780470201268.

10. Ray, R.G. 1969: Aerial photographs in geologic interpretations. USGS Prof. Paper.
11. Rampal, K.K. 1999: Handbook of aerial photography and interpretation. Concept Publishing Co., New Delhi. *ISBN* 10: 8170225418 / *ISBN* 13: 9788170225416 *Concept Publishing Company*, *New Delhi* (*1999*).
12. Sabbins, F.F. 1985: Remote sensing - Principles and applications. Freeman. *ISBN* 9781577663539.
13. Siegal, B.S. and Gillespie, A.R. 1980: Remote sensing in geology. John Wiley. *ISBN*. 0471790524
14. Nag, P. and Sengupta, S. 2007: Geographical information system: Concepts and business opportunities. Concept Publishing Co., New Delhi.*ISBN* 10: 8170223849/*ISBN* 13: 9788170223849 *Concept Publishing Company*, *New Delhi*(1992).

DISCIPLINE SPECIFIC ELECTIVE 1

MGLD 3.11(a)
FUEL GEOLOGY & GEOCHEMISTRY

Theory Credit: 4

UNIT I Coal: definition, rank, grade and types. Chemical characterization: proximate and ultimate analysis. Macroscopic ingredients and microscopic constituents: concept of macerals and microlithotypes. Fundamentals of coal-bed methane exploration and production. Methods of coal prospecting and estimation of coal reserves.

UNIT II Nature of crude oil: composition and physical properties of oil. Transformation and maturation of organic matter into kerogen. Migration: primary and secondary migration. Trapping mechanism for oil and gas.

UNIT III Source rock and Cap rock. Reservoir rock types: sandstone, carbonate and fractured reservoir. Major oil bearing basins of India. Geology of the following oilfields of India: Digboi and Bombay High. Atomic fuels: mode of occurrence and association of atomic minerals in nature.

UNIT IV Origin and abundance of elements in the solar system and in the earth, and its constituents. Atomic structures and properties of elements in the periodic table. Special properties of transition and rare earth elements. Geochemical classification of elements.

UNIT V Radiogenic isotopes. Radioactive decay schemes of U-Pb, Sm-Nd, Rb-Sr, K-Ar, and growth of daughter isotopes. Radiometric dating of single minerals and whole rocks. Stable isotopes: nature, abundance and fractionation.

MGLD 3.12(a)
FUEL GEOLOGY & GEOCHEMISTRY (PRACTICAL)

Practical Credit: 2

Megascopic characterization of banded coals. Proximate analysis of coal. Completion of outcrops in the given maps and calculation of coal reserves. Identification of macerals in coal.

Interpretation of organic geochemical data for characterizing source rocks. Preparation of structural contour maps. Study of geological maps and sections of important oilfields of India. Estimation of oil reserves.

Calculation of mineral formulae from the concentration of various oxides in minerals. Calculation of normative minerals from rock composition. Presentation of analytical data. Estimation of pressure and temperature from important models of geothermometry and geobarometry.

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. ISBN 3443010369.
2. Chandra, D., Singh, R.M. and Singh, M.P. 2000: Textbook of coal (Indian context). Tara Book Agency, Varanasi. ISBN 0-306-30349-3.
3. Singh, M.P. (Ed) 1998: Coal and organic petrology. Hindustan Publishing Co., New Delhi. ISBN 10: 8170750520 ISBN 13: 9788170750529.

4. Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D. and Teichmuller, M.R. 1982: Statch's text book of coal petrology. Gebruder Borntraeger, Stuttgart. ISBN 10: 3443390684 / ISBN 13: 9783443390686.
5. Hobson, G.D. and Tiratsoo, E.N. 1982: Introduction to petroleum geology. Gulf Publishers, Houston.ISBN 10: 0872013995; ISBN 13: 9780872013995.
6. Tissot, B.P. and Welte, D.H. 1984: Petroleum formation and occurrence. Springer Verlag.ISBN 0-38713281-3: ISBN 10: 3642878156 / ISBN 13: 9783642878152.
7. Geology of Petroleum – A.I. Leverson, 2006. CBS Publishers & Distributors, 260pISBN 10: 8123909314 ISBN 13: 9788123909318.
8. Deshpande B.G: The World of Petroleum; Publisher: New Age International Publisher (1992); ISBN 10: 8122403700 / ISBN 13: 9788122403701.
9. Chandra.D & Singh B.M: Petroleum (Indian Context) Tara Book Agency (Kamachha, Varanasi).
10. Selley, R.C. 1998: Elements of petroleum geology. Academic Press.ISBN: 9780123860323. Hardcover ISBN: 9780123860316.
11. Durrance, E.M. 1986: Radioactivity in geology - Principles and application. Ellis Hoorwool.ISBN-10: 0853127611; ISBN-13: 978-0853127611.
12. Dahlkamp, F.J. 1993: Uranium ore deposits. Springer Verlag. ISBN 978-3-540-78557-6: ISBN 978-3-662-02892-6.
13. Boyle, R.W. 1982: Geochemical prospecting for thorium and uranium deposits. Elsevier.SBN 9780444420701, 9780444597632.
14. Mason, B. and Moore, C.B. 1991: Introduction to geochemistry. Wiley Eastern. ISBN 10: 0471575216 / ISBN 13: 9780471575214.
15. Krauskopf, K.B. 1967: Introduction to geochemistry. McGraw Hill. ISBN 10: 007035443X
16. Faure, G. 1986: Principles of isotope geology. John Wiley.SBN-10: 0471864129; ISBN-13: 978-0471864127.
17. Hoefs, J.M. 1980: Stable isotope geology. John Wiley. ISBN 9783540707080: ISBN 9783662022900.
18. Marshal, C.P. and Fairbridge, R.W. 1999: Encyclopaedia of geochemistry. Kluwer Academic. ISBN: 0412755009 9780412755002.
19. Govett, G.J.S. (Ed) 1983: Handbook of Exploration Geochemistry. Elsevier. ISBN 0444419322, 9780444419323.
20. Nordstrorm, D.K. and Munoz, J.L. 1986: Geochemical thermodynamics. Blackwell. ISBN 10: 0865423199 / ISBN 13: 9780865423190.
21. Henderson, P. 1987: Inorganic geochemistry. Pergammon Press. ASIN: B001THLQXI.
22. Rastogi, R.P. and Mishra R.R. 1993: An introduction to chemical thermodynamics. Vikash Publishing House.ISBN-10: 0706999355: ISBN-13: 978-0706999358.
23. Spear, F.S. 1993: Mineralogical phase equilibria and P-T-t Paths. Mineralogical Society of America. ISBN 0-939950-34-0.

MGLD 3.11(b)
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 and Estuaries.

UNIT IV Lithofacies, biofacies, dynamics and primary structures associated with the following environments: Clastic Shorelines, Clastic Shelves, Marine Evaporite Basins, Carbonate Platforms, Deep Sea and Ocean Bottom, Deep Sea Trench and Rise.

UNIT V Sedimentation pattern and depositional environment of selected, undeformed and deformed sedimentary basins of India representing Precambrain, Phanerozoic and Contemporary basins.

MGLD 3.12(b)
SEDIMENTARY ENVIRONMENT AND SEDIMENTARY BASINS (PRACTICAL)

Practical Credit: 2

Prepare facies maps based on borehole data and interpret them.
Correlation stratigraphic columns based on lithological, heavy mineral assemblage and palaeontological data.
Interpret geophysical logs.

Recommended Books and References:

1. Reading, J.G. 1986: Sedimentary Environment &Facies. Blackwell.ISBN-10: 0632015721; ISBN-13: 978-0632015726.
2. Reineck, H.E. and Singh, I.B. 1975: Depositional Sedimentary Environment. Springer Verlag. ISBN 3540073779.
3. Carver, R.E. 1971: Procedures of Sedimentary Petrology. John Wiley.ISBN: 047113855X 9780471138556.
4. Tucker, M. 1988: Techniques in Sedimentology. Blackwell.ISBN: 0632013613 9780632013616 0632013729 9780632013722.
5. Friedman, G.M. and Sanders, J.E. 1978: Principles of Sedimentology. John Wiley.ISBN-10: 0471752452.
6. Guy Plint, A. 1995: Sedimentary Facies Analysis. Spl. Publ. IAS No.22. Blackwell.ISBN-13: 9780865428980.
7. Miall, A.D. 1996: The Geology of Fluvial Deposits. Springer Verlag. ISBN. 3540591869; 9783540591863.
8. Miall, A.D. 1997: The Geology of Stratigraphic Sequences. Springer Verlag. ISBN 9783642050275.

MGLD 3.11(c)
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.

UNIT V Geological and geophysical methods of groundwater exploration: gravity, magnetic, resistivity and seismic refraction methods. Radiation /geophysical logging. Application of remote sensing in groundwater exploration. Stable isotopes in hydrogeological studies.

MGLD 3.12(c)
ADVANCED HYDROGEOLOGY (PRACTICAL)

Practical Credit: 2

Deciphering of hydro geological boundaries on water table contour maps, analysis of Hydrographs, Determination of permeability in laboratory and in field, determination of aquifer parameters using Theis and Jacob's methods.

Recommended Books and References:

1. Alley, W.M. 1993: Regional groundwater quality. VNR, New York. *ISBN* 1863202986.
2. Davies, S.N. and Dewiest, R.J.M. 1966: Hydrogeology. John Wiley. *ISBN* 10: 0471199001.
3. Fetter, C.W. 1990: Applied hydrogeology. Merrill Publishing. *ISBN* 10: 0675208874.
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.ISBN-10: 0849330157.
7. Karanth, K.R. 1987: Groundwater assessment- Development and management. Tata-McGraw Hill.ISBN*:* 0074517120, 9780074517123.
8. Mahajan, G. 1990: Evaluation and development of groundwater. D.K. Publishers.
9. Mahajan, G. 1995: Groundwater. D.K. Publishers.ISBN-10: 0756631114.
10. Pitchaiah, P.S. (Ed) 1995: Groundwater. Ashish Publishing House, New Delhi.
11. Raghunath, N.M. 1982: Groundwater. Wiley Eastern. ISBN 10: 8122419046.
12. Singhal, B.B.S. 1986: Engineering geosciences. Savita Prakashan.
13. Subramaniam, V. 2000: Water. Kingston Publications, London. *ISSN*: 21670447
14. Todd, D.K. 1980: Groundwater hydrology. John Wiley. *WILEY*. *John Wiley* & Sons, Inc.*ISBN* 0471059374.
15. USDI, 1993: Groundwater manual. Scientific Publishers, Jodhpur. *ISBN*: 9789383692828. E-*ISBN*: Scientific Publisher-USDI.
16. Viessman, W., Knapp, J.W., Lewis, G.L. and Harbaugh, T.E. 1977: Introduction to hydrology. Harper and Row.*ISBN* 10: 0673991652.

17. Walton, W.C. 1988: Groundwater resource evaluation. McGraw Hill, McGraw Hill Text (January 1970)ISBN-10: 0070680515.

DISCIPLINE SPECIFIC ELECTIVE 2

MGLD 3.21(a)
GEOLOGY 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.

MGLD 3.22(a)
GEOLOGY OF NORTHEAST INDIA (PRACTICAL)

Practical Credit: 2

Megascopic studies on rocks and minerals in North East India.
Preparation of maps on minerals, tectonics and geomorphology.

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).

MGLD 3.21(b)
PETROLEUM EXPLORATION

Theory Credit: 4

UNIT I Identification and characterization of petroleum source rocks. Amount, type and maturation of organic matter (kerogen) and its types. Characteristics of reservoir rocks. Porosity and permeability of reservoir rocks. Effects of diagenesis on the reservoir quality.

UNIT II Elements of geophysical methods of exploration. Physical properties of rock-density, resistivity and elastic wave velocities. Principles of gravity exploration, concept of gravity anomaly, reduction of data, interpretation of anomaly maps, identification of folds, faults and contacts. Principles of seismic reflection and refraction methods. Bright spots.

UNIT III Types of wells: exploration, appraisal and development wells. Drilling rigs and its components. Types of drilling fluid, properties and functions. Elements of well drilling: Cable-tool drilling, rotary drilling. Conventional and sidewall coring. Duties of Wellsite geologists. Mud logs and mud circulation, well kicks and blowouts.

UNIT IV Elements of logging: Electric, radioactivity and the sonic logs. Reservoir drive mechanisms- depletion drive, displacement drive and combination drive. Estimation of oil and gas reserve: volumetric and simulation method. Principles of Enhanced oil recovery method.

UNIT V Tectonic classification, stratigraphic evolution and hydrocarbon accumulations in the following basins of India- Cambay basin, Bombay Offshore, Cauvery basin, Krishna-Godavari basin, Upper Assam basin, Mahanadi basin, Naga Hills, Tripura and Rajasthan basins.

MGLD 3.22(b)
PETROLEUM EXPLORATION (PRACTICAL)

Practical Credit: 2

Preparation and interpretation of structure contour map and location of oil and gas.
Interpretation of isopach maps.
Evaluation of organic matter (kerogen) type and maturity of source rocks.
Interpretation of 2D seismic section.
Reserve calculation.

Recommended Books and References:

1. North, F.K. 1985: Petroleum geology. Allen & Unwin. ISBN: 0045530033 9780045530038 0045530041.
2. Tissot, B.P. and Welte, D.H. 1984: Petroleum formation and occurrence. Springer Verlag. ISBN 9783642878138.
3. Selley, R.C. 1998: Elements of petroleum geology. Academic Press. ISBN: 9780123860323.
4. Deshpande B.G: The World of Petroleum; Publisher: New Age International Publisher (1992); ISBN 10: 8122403700 / ISBN 13: 9788122403701.
5. Chandra.D& Singh B.M: Petroleum (Indian Context) Tara Book Agency (Kamachha, Varanasi). ISBN 10: 8176462349 / ISBN 13: 9788176462341.
6. Sahay Bhagwan: Petroleum Exploration and Exploitation Practices; Allied Publishers Limited. ISBN: 8170231620, 9788170231622.

7. Laudon Robert C: Principles of Petroleum Development Geology; PTR Prentice Hall; ISBN, 0136494684, 9780136494683.
8. Hunt John M: Petroleum Geochemistry and Geology(2nd Edition); ISBN 10: 0716710056.

MGLD 3.21(c)
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 Topography of the ocean floor, Oceanic circulation, waves and currents, pelagic sediments, abyssal plain sediments

UNIT III Oceanic sediments and distribution of marine microfossils; stratigraphy and geochronometry of deep-sea deposits.

UNIT IV Movements of the sea floor, structure of the ocean basins, Tectonic history and chemistry of oceanic rocks.

UNIT V Igneous rocks of the ocean basin, Mineral resources of the oceans, geophysical techniques for the exploration of the sea floor.

MGLD 3.22 (c)
MARINE GEOLOGY (PRACTICAL)

Practical Credit: 2

Study of Rose diagram.
Study of annual wave period percentage frequencies and plot it on Bar diagram.
Study the pattern of tides and currents.

Recommended Books and References:

1. Kennett, J.P. 1982: Marine geology. Prentice Hall. ISBN: 0135569362 9780135569368
2. Seibold, E. and Berger, W.H. 1982: The sea floor. Springer Verlag. ISBN 10: 0387568840.
3. Pipkin, B.W., Gorsline, D.S., Casey, R.E. and Hammond, D.E. 1972: Laboratory exercises in oceanography. Freeman. ISBN 10: 0716737426.
4. Introduction to physical Oceanography: John A. Knauss. ISBN-10: 1577664299, Orange grove Books.
5. The sea floor: An introduction to marine geology: M.J. Keen. ISBN: 9780080125053.
6. Marine geology: Exploring the new Frontiers of the ocean (the living earth) ISBN-10 0816050775.

DISCIPLINE SPECIFIC ELECTIVE 3

MGLD 4.11
FIELD WORK

Theory Credit: 4

MGLD 4.12
SEMINAR

Practical Credit: 2

DISCIPLINE SPECIFIC ELECTIVE 4

MGLD 4.21
DISSERTATION

Theory Credit: 4

MGLD 4.22
REPORT AND PRESENTATION

Practical Credit: 2

SYLLABUS FOR
Master of Science

MATHEMATICS

Under CBCS guidelines

COURSE STRUCTURE

SEMESTER	COURSE CODE	COURSE TITLE	CREDITS
I	MMAC 1.11	Ordinary Differential Equations (Theory)	4
	MMAC 1.12	Ordinary Differential Equations (Practical)	2
	MMAC 1.21	Linear Algebra	5+1
	MMAC 1.31	Real Analysis	5+1
	MMAC 1.41	Abstract Algebra	5+1
II	MMAC 2.11	Partial Differential Equations (Theory)	4
	MMAC 2.12	Partial Differential Equations (Practical)	2
	MMAC 2.21	Topology	5+1
	MMAC 2.31	Number Theory	5+1
	MMAC 2.41	Complex Analysis	5+1
III	MMAC 3.11	Numerical Analysis	4
	MMAC 3.12	Programming in C (Practical)	2
	MMAC 3.21	Measure Theory	5+1
	MMAD 3.11	OPTIONAL*	5+1
	MMAD 3.21	OPTIONAL*	5+1
IV	MMAC 4.11	Mathematical Methods (Theory)	4
	MMAC 4.12	Mathematical Methods (Practical)	2
	MMAC 4.21	Rings & Modules	5+1
	MMAD 4.11	OPTIONAL**	5+1
	MMAD 4.21	OPTIONAL**	5+1 /6

*** DISCIPLINE SPECIFIC ELECTIVE 1 & 2**

MMAD 3.11 & MMAD 3.21

COURSE TITLE	CREDITS
Classical Mechanics	5+1
Tensor Analysis & Riemannian Geometry	5+1
Theory of Relativity	5+1
Functional Analysis	5+1
Graph Theory	5+1
Mathematical Statistics	5+1
Lie Algebra	5+1
Analytic Number Theory	5+1
Multivariable Calculus	5+1

**** DISCIPLINE SPECIFIC ELECTIVE 3 & 4**

MMAD 4.11 & MMAD 4.21

COURSE TITLE	CREDITS
Fluid Mechanics	5+1
Fourier Analysis	5+1
Algebraic Number Theory	5+1
Algebraic Topology	5+1
Differential Geometry of Manifolds	5+1
Commutative Algebra	5+1
Discrete Mathematics	5+1
Operation Research	5+1
Field Theory	5+1
Game Theory	5+1
Mathematical Modeling	5+1
Dissertation/Project	6

SEMESTER – I

MMAC 1.11
ORDINARY DIFFERENTIAL EQUATIONS

Theory Credit: 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 Non-homogeneous equations; homogeneous equations with analytic coefficients; Legendre equation, justification of power series method; Legendre polynomials and Rodrigues' formulae.

UNIT IV 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 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. E. A. Coddington - An Introduction to Ordinary Differential Equations, 2001, Prentice-Hall of India Private Ltd., New Delhi, ISBN-10:0486659429
2. W. T. Martainand E. Relssner, Elementary Differential Equations., 1995 (3rd Edition), Addison Wesley Publishing Company, Inc, ISBN-9780201045031
3. E. A. Codington and N. Levinson, Theory of Ordinary Differential Equations, 1999, Tata McGraw hill Publishing co. Ltd. New Delhi, ISBN-9780070992566
4. G F Simmons, Differential equation with applications and historical Notes, 2017, 2nd Ed, McGraw Hill Education, ISBN-9780070530713

MMAC 1.21
LINEAR ALGEBRA

Theory Credit: 5
Tutorial Credit: 1

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. K. Hoffman and R. Kunze, Linear Algebra (2nd edition), Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. Axler, Linear Algebra Done Right 3rd Edition
3. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, First Course in Linear Algebra, Wiley Eastern Ltd., New Delhi, 2000.
4. I. N. Herstein, Topics in Algebra (4th edition), Wiley Eastern Limited, NewDelhi, 2003.
5. G. E. Shilov,Linear Algebra, Prentice Hall, 1998.
6. P. R. Halmos, Finite Dimensional Vector Spaces, Va n Nostrand Inc., 1965.
7. D. T. Finkbeiner, D.B. Taraporevala, Introduction to Matrices and Linear Transformations (3rd edition), Bombay, 1990.
8. S. Kumaresan, Linear Algebra, A Geometric Approach, Prentice-Hall of India Pvt. Ltd., New Delhi, 2001.

MMAC 1.31
REAL ANALYSIS

Theory Credit: 5
Tutorial Credit: 1

UNIT I The real and complex number systems: Elements of set theory, ordered sets, fields, the real field, the complex field, Euclidean spaces, Basic topology: Finite, countable and uncountable sets, metric spaces, compact sets, perfect sets, connected sets.

UNIT II Numerical sequences and series: Convergent sequences, subsequences, Cauchy sequences, upper and lower limits, series, series of non-negative terms, the number *e*, the root and ratio tests, power series, summation by parts, absolute convergence, addition and multiplication of series, rearrangements.

UNIT III Limits of functions: continuous functions, continuity and compactness, continuity and connectedness, discontinuities, monotonic functions, infinite limits and limits at infinity.
The derivative of a real function, mean value theorems, the continuity of derivative, l'Hospital's rule, derivatives of higher order, Taylor's theorem, differentiation of vector-valued functions.

UNIT IV The Riemann-Stieltjes integral: Definition and existence of the integral, properties of the integral, integration and differentiation, integration of vector-valued functions, rectifiable curves.

UNIT V Sequences and series of functions: Uniform convergence, uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, equicontinuous families of functions, the Stone-Weierstrass theorem.

Recommended Books and References:

1. Walter Rudin, *Principles of Mathematical Analysis*, 3rd Edition, McGraw Hill Education, 1976, ISBN-9781259064784
2. Robert G. Bartle, *The Elements of Real Analysis*, 2nd Edition, John Wiley & Sons, 1975, ISBN-9780471054641
3. Tom M. Apostol, *Mathematical Analysis*, 2nd Edition, Addison-Wesley Publishing Company, Inc., 1974, ISBN-9788185015668
4. Terence Tao, *Analysis I*, 3rd edition, Hindustan Book Agency, 2014, ISBN-9789380250649
5. Terence Tao, *Analysis II*, 3rd edition, Hindustan Book Agency, 2014, ISBN-9789380250656
6. S Kumaresan, Topology of Metric Space, 2nd Ed, Narosa publication, 2011, ISBN-9788184870589

MMAC 1.41
ABSTRACT ALGEBRA

Theory Credit: 5
Tutorial Credit: 1

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.

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; 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 $f(x) \in Z[x]$;Eisenstein's criterion for irreducibility of $f(x) \in Z[x]$ 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. P.B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic Abstract Algebra, 2000, 3rd edition Cambridge University Press, ISBN 978-0-521-54548-8
2. N. Jacobson,Basic Algebra I,2002, 3rd edition,Hindustan Publishing corporation, New Delhi, ISBN-13: 978-0-486-47189-1, ISBN-10: 0-486-47189-6

3. J. A. Gallian,Contemporary Abstract Algebra, 1999, 4th edition, Narosa Publishing House, New Delhi, ISBN 978-81-7319-269-2.
4. I. N. Herstein,Topics in Algebra, 2016, 2nd edition,Wiley India Pvt. Ltd, ISBN 978-81-265-1018-4
5. J. B. Fraleigh,A First Course in Abstract Algebra, 2002, 7th edition, Pearson Education Inc.,ISBN 978-81-7758-900-9
6. D.S. Dummit, R.M. Foote, Abstract Algebra,2003, 2nd edition, Wiley India Pvt. Ltd., ISBN 978-81-265-1776-3

SEMESTER – II

MMAC 2.11
PARTIAL DIFFERENTIAL EQUATIONS

Theory Credit: 4

UNIT I PDE of the first order; Origin; Surfaces and normal; Curves and their tangents; Formation of partial differential equation; Solution of PDE of first order; Integral surfaces passing through a given curve; The Cauchy problem. Surfaces orthogonal to a given system of surfaces; First order non-linear equations – Cauchy method of characteristics; Compatible systems of first order equations; Charpit's method; Special types of first order equations.

UNIT II Origin of second order PDE; Classification of second order PDE; Canonical forms; Adjoint operators; Riemann's method; Linear second order PDE with constant coefficients – General method for finding complementary functions of (i) reducible non-homogeneous linear PDE (ii) irreducible non-homogeneous linear PDE; Methods for finding particular integrals; Homogeneous linear second order PDE with constant coefficients – methods for finding complementary functions and particular integrals; Linear second order PDE with variable coefficients; Monge's method of solution of non-linear PDE of second order.

UNIT III Occurrence of the Laplace and Poisson equations; Derivation of Laplace and Poisson equations; Boundary value problems; Properties of harmonic functions; The spherical mean; Mean value theorem for harmonic functions; Maximum-Minimum principle and consequences; Separation of variables; Dirichlet problem for a rectangle; The Neumann problem for a rectangle; Interior and exterior Dirichlet problem for a circle; Interior Neumann problem for a circle; Solution of Laplace's equation in cylindrical and spherical coordinates.

UNIT IV Occurrence of diffusion equation; Boundary conditions; Elementary solutions of diffusion equation; Dirac-Delta function; Separation of variables; Solution of diffusion equation in cylindrical and spherical coordinates; Maximum-Minimum principle and consequences; Non-linear equations – semi-linear, quasi-linear and Burger's equations; Initial value problem for Burger's equation.

UNIT V Occurrence of the wave equations; Derivation of one-dimensional wave equation; Solution of one-dimensional wave equation by canonical reduction; The initial value problem – D' Alembert's solution; Vibrating string – variables separable solution; Forced vibration; Boundary and initial value problem for two-dimensional wave equations – method of Eigen function; Periodic solution of one-dimensional wave equation in cylindrical and spherical polar coordinates; Vibration of circular membrane; Uniqueness of solution for the wave equation; Duhamel's principle.

Recommended Books and References:

1. I. N. Sneddon, Elements of Partial Differential Equation (3rd edition), McGraw Hill Book Company, 1998.
2. K. Sankara Rao, Introduction to Partial Differential Equations, Prentice Hall of India, 2017
3. E. T. Copson, Partial Differential Equations (2nd edition), Cambridge University Press, 1995.
4. TynMyint-U &Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, Birkhauser, 2007.

MMAC 2.12
PARTIAL DIFFERENTIAL EQUATIONS (PRACTICAL)

Practical Credit: 2

Problems from Partial Differential Equations (Theory) may be solved with the help of softwares like MAPLE / MATHEMATICA / MATLAB/ any open source softwares.

MMAC 2.21
MEASURE THEORY

Theory Credit: 5
Tutorial Credit: 1

UNIT I SETS AND CLASSES: Set inclusion, Unions and intersections, Limits, complements, and differences, Rings and algebras, Generated rings and sigma-rings, Monotone classes

UNIT II MEASURES AND OUTER MEASURES: Measure on rings, Measure on intervals, Properties of measures, Outer measures, Measurable sets

UNIT III EXTENSION OF MEASURES: Properties of induced measures, Extension, completion, and approximation, Inner measures, Lebesgue measure, Non measurable sets

UNIT IV MEASURABLE FUNCTIONS: Measure spaces, Measurable functions. Combinations of measurable functions, Sequences of measurable functions, Pointwise convergence, Convergence in measure.

UNIT V INTEGRATION: Integrable simple functions, Sequences of integrable simple functions, Integrable functions. Sequences of integrable functions, Properties of integrals. L^p Spaces.

Recommended Books and References:

1. Paul R Halmos, Measure Theory, 2008, Springer
2. Terry Tao, An Introduction to Measure Theory,
3. Robert G Bartle, The Elements of Integration and Lebesgue Measure
4. G B Folland, Real Analysis, Modern Techniques and their applications

MMAC 2.31
NUMBER THEORY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Review of Divisibility–Division algorithm, greatest common divisor, Euclidean algorithm, primes, fundamental theorem of arithmetic.
Review of Congruences–Basic properties of congruences, complete residue system, reduced residue system, Euler's phi-function, Fermat's theorem, Euler's theorem, Wilson's theorem, solutions of congruences, Chinese remainder theorem, prime power moduli, prime modulus.

UNIT II Primitive roots and power residues, Euler's criterion, Quadratic residues, Legendre symbol, Gauss's lemma, quadratic reciprocity, Jacobi symbol, binary quadratic forms.

UNIT III Diophantine equations **–** The equation $ax + by = c$, simultaneous linear equations, Pythagorean triples, sum of squares, assorted examples.

UNIT IV Farey fractions irrational numbers: Farey sequences, rational approximations, irrational numbers.
Recurrence functions, Fibonacci sequence, identities involving Fibonacci numbers.

UNIT V Simple continued fractions **–** Finite and infinite continued fractions, uniqueness, expansion of irrational numbers as infinite simple continued fractions, approximations to irrational numbers, Hurwitz theorem, periodic continued fractions, Pell's equation.

Recommended Books and References:

1. Ivan Niven, Herbert S. Zuckerman, and Hugh L. Montgomery, *An Introduction to the Theory of Numbers*, 5thEdition, John Wiley & Sons, 1991, ISBN-9788126518111
2. David M. Burton, *Elementary Number Theory*, 6th Edition, Tata McGraw-Hill, 2007, ISBN-9781259025761
3. G. H. Hardy, Edward M. Wright, and Roger Heath-Brown, *An Introduction to the Theory of Numbers*, 6thEdition, Oxford University Press, 2008, ISBN-9780199219865

MMAC 2.41
COMPLEX ANALYSIS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Convergence of sequences and series, Absolute and uniform convergence of power series, Integration and differentiation of power series, uniqueness of series representations.

UNIT II Taylor series, Zeros of analytic functions, Limit points of Zeros, Singularities and their classification, Behaviour of the function in a neighbourhood of isolated singularities, Laurent's series, Residues, Cauchy Residue Theorem.

UNIT III Evaluation of improper integrals and definite integrals involving sines and cosines, integration through a branch cut.

UNIT IV The winding number, Logarithmic residues and Rouche's theorem, the Argument Principle.

UNIT V Mapping by elementary functions, Linear fractional transformations, cross ratios, mappings of the half planes and circles, conformal mapping, Statement of Riemann Mapping Theorem.

Recommended Books and References:

1. Mathews, J. H. and Howell, R. W., Complex Analysis for Mathematics and Engineering, 2010, 5th Edition, Narosa, ISBN-10: 817319761X ISBN-13: 978-8173197611
2. Conway, J. B., Functions of One Complex Variable, 1994, 2nd Edition, Narosa Publishing House, India, ISBN 978-81-85015-37-8
3. Churchill, R. V. and Brown, J. W., Complex Variables and Applications, 2014, 8th edition, McGraw-Hill Education (India), ISBN-13: 978-93-392-0515-7, ISBN-10: 93-392-0515-4
4. Ahlfors, L. V., Complex Analysis, 1979, 3rd Edition, McGraw-Hill Education, ISBN-13: 978-1-25-906482-1, ISBN-10: 1-25-906482-4
5. Priestly, H.A., Introduction to Complex Analysis, 2003, 2nd Edition, Oxford University Press, ISBN-10: 0198525613, ISBN-13: 978-0198525615

6. Gamelin, T. W., Complex Analysis, 2006, 1st Edition, UTM, Springer-Verlag,.ISBN-10: 8181281144, ISBN-13: 978-8181281142
7. Narasimhan, R. and Nievergelt, Y., Complex Analysis in One Variable, 2001, 2nd Edition, Birkhäuser, ISBN-10: 1461266475, ISBN-13: 978-1461266471
8. Donald Sarasan, Complex Function Theory, 2008, 2nd Edition, Hindustan Book Agency, ISBN-10: 9788185931845, ISBN-13: 978-8185931845

SEMESTER – III

MMAC 3.11
NUMERICAL ANALYSIS

Theory Credit: 4

UNIT I **Introduction:** Algebraic and transcendental equations and their roots, direct and iterative methods, errors, truncation, initial approximations, error analysis, rate of convergence, algorithms.
Transcendental and polynomial equations: Bisection method. Methods based on first degree equation – secant method, regula falsi method. Methods based on second degree equation – Newton-Raphson method, Muller method, Chebyshev method, multipoint iteration methods.

UNIT II **System of linear algebraic equations and eigenvalue problems:** Direct methods – Cramer's rule, Gauss elimination method, Gauss-Jordan elimination method, triangularization method, Cholesky method, partition method.Iteration methods – Gauss-Jacobi iteration method, Gauss-Seidel iteration method.Eigenvalue problems – power method, inverse power method.

UNIT III **Interpolation and approximation:** Lagrange interpolation, Newton's divided difference interpolation, finite difference operators, relation between differences and derivatives, Gregory-Newton forward and backward difference interpolations, Stirling and Bessel interpolations, Hermite interpolation, piecewise and spline interpolations.

UNIT IV **Differentiation:** Numerical differentiation, methods based on interpolation, methods based on finite differences.
Integration: Numerical integration, methods based on interpolation, Newton-Cotes methods, methods based on undetermined coefficients, Gauss-Legendre integration methods

UNIT V **Ordinary differential equation:** Initial value problems, Picard method, Euler method, backward Euler method, mid-point method. Single-step methods – Taylorseries method, Runge-Kutta methods. Multistep methods – Adam-Bashforth methods, Nyström methods, Adams-Moulton methods, Milne-Simpson methods.

Recommended Books and References:

1. M. K. Jain, S. R. K. Iyenger and R. K. Jain, *Numerical Methods for Scientific and Engineering Computation*, 6th edition, New Age International Publisher, India, 2007, ISBN-9788122414615
2. V. Rajaraman, *Computer Oriented Numerical Methods*, 4th Edition, Prentice Hall India Prt. Ltd., 2018, ISBN-9789388028318
3. Kendall Atkinson, *An Introduction to Numerical Analysis*, 2nd edition, John Wiley & Sons, 1989, ISBN-9780471624899
4. F. B. Hildebrand, *Introduction to Numerical Analysis*, 2nd edition, Dover Publications Inc., 1987, ISBN-9780486653631

MMAC 3.12
PROGRAMMING IN C (PRACTICAL)

Practical Credit: 2

Flow chart and algorithms, character set, identifiers, keywords, data types, constants and variables, statements, expressions, operators, precedence of operators, input-output, assignments, control structures, decision making and branching, decision making & looping, user-defined and standard functions, formal and actual arguments, functions category, function prototypes, parameter passing, call-by-value, call-by-reference, recursion, storage classes,one-dimensional array, multidimensional array declaration and their applications.

C programs to perform the following: (real solution only)

1. Solving simple algebraic and transcendental equations using bisection method
2. Solving simple algebraic and transcendental equations using secant method
3. Solving simple algebraic and transcendental equations using regula falsi method
4. Solving simple algebraic and transcendental equations using Newton-Raphson method
5. Solutions of system of linear equations using Gauss elimination method.
6. Solutions of system of linear equations using Gauss-Seidel iteration method.
7. Matrix inversion using Gauss elimination method.
8. Matrix inversion using Gauss-Jordan method.
9. Power method for finding dominant eigen value.
10. Lagrange interpolation
11. Newton's divided difference interpolation
12. Numerical differentiation using Lagrange's formula.
13. Numerical differentiation using Newton's formula.
14. Numerical integration using trapezoidal rule.
15. Numerical integration using Simpson's rule.
16. Numerical solutions of ordinary differential equations (initial value problems) using Euler-Richardson method.
17. Numerical solutions of ordinary differential equations (initial value problems) using Runge-Kutta methods.
18. Numerical solutions of ordinary differential equations (initial value problems) using predictor-corrector method.

Recommended Books and References:

1. V. Rajaraman, *Computer Programming in C*, Prentice Hall India Prt. Ltd., 1994, ISBN-9788120308596
2. V. Rajaraman, *Computer Oriented Numerical Methods*, 4th Edition, Prentice Hall India Prt. Ltd., 2018, ISBN-9789388028318
3. Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*, 2nd edition, Pearson Education, Inc., 1988, ISBN-9789332549449
4. M. K. Jain, S. R. K. Iyenger and R. K. Jain, *Numerical methods for Scientific and Engineering Computation*, 6th edition, New Age International Publisher, India, 2007, ISBN-9788122414615

MMAC 3.21
TOPOLOGY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Topological spaces and Product spaces: Topological spaces. Accumulation points. Closed sets. Closure of a set. Interior, exterior, boundary points. Neighbourhoods and neighbourhood systems. Convergent sequences. Coarser and finer topologies. Subspaces, relative topologies. Equivalent definition of topologies. Bases and subbases. Topology generated by classes of sets. Local bases. Product spaces. Base for a finite product topology. Defining subbase and defining base for the product topology

UNIT II Continuity and Topological Equivalences: Continuous functions. Continuous functions and arbitrary closeness. Continuity at a point. Sequential continuity at a point. Open and closed functions. Homeomorphic spaces. Topological properties. Topology induced by functions. Quotient Topology.

UNIT III Countability and separation axioms: First countable spaces. Second countable spaces. Lindelof's theorems. Separable spaces. Hereditary properties. T1 spaces. Hausdorff spaces. Regular spaces. Normal spaces. Urysohn's lemma. Rieze extensions theorem. Function that separate points. Completely regular spaces.

UNIT IV Compactness: Covers. Compact sets. Subsets of a compact spaces. Finite intersection properties. Compactness and Hausdorff spaces. Sequentially compact sets. Countably compact sets. Locally compact spaces. Compactification. Totally bounded sets.

UNIT V Separated sets. Connected sets. Connected spaces. Connectedness on the real line. Components. Locally connected spaces. Paths. Arcwise connected sets. Homotopy paths. Simply connected spaces.

In all units a good number of examples need to be discussed.

Recommended Books and References:

1. James Munkres, Topology, Pearson Education India
2. K.D. Joshi, Introduction to General Topology, New age International Pvt ltd
3. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Ed.
4. Stephen Willard,General Topology, Dover publication

SEMESTER - IV

MMAC 4.11
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 identity; 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 Mikusinski'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. Michael Gambier Smith, Laplace Transform Theory, D. Van Nostrand Company Ltd., London, 2000.
2. Georgi. E. Shilov & Bernard Seckler, Generalized Functions and Partial Differential Equations, Gordon and Breach Science Publisher Inc., 1999.
3. David Porter and David S. G. S,Integral Equations, Cambridge University Press, 1993.
4. I. N. Sneddon,The Use of Integral Transforms, Tata McGraw Hill, New Delhi, 1974.
5. R. R. Goldberg L, Fourier Transforms, Cambridge University Press, 1970.
6. H. Widom, Lectures on integral equations, Van Nast Rand, 1969.

MMAC 4.12
MATHEMATICAL METHODS (PRACTICAL)

Practical Credit: 2

By using any mathematical software

1. Laplace Transforms.
2. Inverse Laplace Transforms.
3. Solution of Ordinary Differential Equation by Laplace Transforms.
4. Solution of Partial Differential Equation by Laplace Transforms.
5. Solving Initial Value Problem with Laplace Transforms.
6. The DiracDelta Function.
7. Convolution.
8. Solution of Integral Equation.
9. Fourier Transforms.

10. Inverse Fourier Transforms.
11. Plotting a Fourier Transform.
12. Integro-Differential Equations.
13. Boundary Value Problem.
14. Sturm-Liouville Eigenvalue Problems.
15. One-Dimensional Heat Equation.
16. Diffusion Problems over Infinite and Semi-infinite Domains.
17. Sturm-Liouville Problem for the Wave Equation.

Recommended Books and References:

1. Martha L. Abill and Jamis P. Brasilton, Differential Equations with Maple V®, Academic Press, Inc., London, 1962
2. George A. Articolo, Partial Differential Equations and Boundary Value Problems with Maple, Second Edition, Elsevier Inc., 2009

MMAC 4.21
RINGS AND MODULES

Theory Credit: 5
Tutorial Credit: 1

UNIT I Basic concepts of Rings, Division rings and Fields, Algebra of Ideals, Matrix Rings, Local Rings, Opposite Rings, Direct product of Rings, Endomorphism Rings, Embedding of Rings, Idempotent and Nilpotent elements in a ring.

UNIT II Modules, Submodules, Quotient Modules, Module Homomorphism, 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, 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 ArtinianModules, Noetherian Modules, Modules of Finite Length, Nil Radical and Jacobson Radical, Simple Rings, Semisimple Rings, Artinian Rings, Noetherian Rings.

Recommended Books and References:

1. C. Musili, Introduction to Rings and Modules, 2015, 2nd Revised Edition, Narosa Publishing House, ISBN 978-81-7319-037-2
2. I. T. Adamson, Elementary Rings and Modules, 1995, Oliver and Boyd, Edinburgh, ISBN-10: 0050021923, ISBN-13: 978-0050021927
3. J.J. Rotman, Notes on Homological Algebra, 1990, Van Nostrand Reinhold Inc., ISBN-10: 0442270607, ISBN-13: 978-0442270605
4. N. Jacobson, Basic Algebra II, 2002, 3rd Edition, Hindustan Publishing Corporation,New Delhi, ISBN-10: 071671079X, ISBN-13: 978-0716710790
5. S. Lang, Algebra, 1984, 2nd Edition, Addison-Wesley, Massachusetts, ISBN-10: 0201555409, ISBN-13: 978-0201555400
6. I. S. Luthar an d I.B.S. Passi, Algebra, Vol. 2: Rings, 1999, Narosa Publishing House, New Delhi, ISBN 978-81-7319-313-2
7. D.S. Dummit, R.M. Foote, Abstract Algebra, 2003, 2nd edition, Wiley India Pvt. Ltd., ISBN 978-81-265-1776-3

DISCIPLINE SPECIFIC ELECTIVE 1 & 2

MMAD 3.11 & 3.21

CLASSICAL MECHANICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Basic concepts; Constraints; Generalized coordinates; Principle of virtual work; D' Alembert's principle; Lagrange's equations from D' Alembert's principle; Non-conservative forces; Generalized potential; Hamilton's principle and Lagrange's equations; Gauge invariance of the Lagrangian; Symmetry properties of space and time; Conservation laws; Invariance under Galilean transformation.

UNIT II Generalized momentum; Cyclic coordinates; Conservation theorems; Hamiltonian function and conservation of energy; Jacobi's integral; Hamilton's equations; Hamilton's equations in different coordinate systems; Harmonic oscillator; Motion of a particle in a central force field; Charged particle moving in an electromagnetic field; Compound pendulum; Two-dimensional harmonic oscillator; Routhian.

UNIT III Calculus of variations; Euler-Lagrange's equations; Hamilton's principle from D' Alembert's principle; Modified Hamilton's principle; Deduction of Hamilton's principle from modified Hamilton's principle; Deduction of Lagrange's equations from variational principle for non-conservative systems (holonomic constraints); Lagrange's method of undetermined multipliers; Lagrange's equations of motion for non-holonomic systems; Physical significance of Lagrange's multipliers □;□-variation; Principle of least action; Jacobi's form of principle of least action.

UNIT IV Canonical transformations; Legendre transformations; Generating functions; Procedure for application of canonical transformations; Condition for canonical transformation; Bilinear invariant condition; Integral invariant of Poincare; Infinitesimal contact transformation;Poisson's bracket; Lagrange's bracket; Relation between Lagrange's and Poisson's brackets; Angular momentum and Poisson brackets; Invariance of Poisson bracket with respect to canonical transformations; Phase space; Liouville's theorem.

UNIT V Generalized coordinates of a rigid body; Body and space reference systems; Euler's angles; Infinitesimal rotations as vectors; Angular velocity; Components of angular velocity; Angular momentum and inertia tensor; Principle axes – Principle moments of inertia; Rotational kinetic energy of a rigid body; Symmetric bodies; Moments of inertia for different body systems; Euler's equations of motion for a rigid body; Torque-free motion of a rigid body; Force-free motion of a symmetrical top; Motion of a heavy symmetrical top; Fast top; Sleeping top; Gyroscope.

Recommended Books and References:

1. H. Goldstein, Classical Mechanics, Addison Wesley Publications, Massachusetts, 2002.
2. J. C. Upadhyaya, Classical Mechanics, Himalaya Publishing House, Mumbai, 2018.
3. K. Sankara Rao, Classical Mechanics, Prentice Hall of India, New Delhi, 2015.
4. C. R. Mondal, Classical Mechanics, Prentice-Hall of India, 2001.
5. T. W. B. Kibble, Classical Mechanics, Orient Longman, London, 1985.
6. L. D. Landau and E. M. Lipshitz, Mechanics, Pergamon Press, Oxford, 1976.
7. J. E. Marsden, Lectures on Mechanics, Cambridge University Press, 1992.

TENSOR ANALYSIS AND RIEMANNIAN GEOMETRY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Contravariant and Covariant vectors, Tensor, tensor field, addition, subtraction and multiplication of tensors, contraction, symmetric tensor, antisymmetric tensor, quotient law, reciprocal symmetric tensor, relative tensor, relative vector and relative scalar.

UNIT II Riemannian metric, fundamental tensor, length of curve, magnitude of vector, associated covariant and contravariant vectors, inclination of two vectors, orthogonal vectors coordinate hypersurfaces, coordinate curves, field of normals to hypersurface, principal directions for a symmetric covariant tensor of the second order, Euclidean space of n – dimension.

UNIT III Christoffel symbols, tensor law of transformation of Christoffel symbols, covariant derivative of covariant and contravariant vectors, covariant derivative of a covariant second rank tensor, divergence and curl of a vector, theorem related to divergence.

UNIT IV Curvature of a curve, geodesic, differential equation of a geodesic, Riemannian coordinates, geodesic form of line element, geodesic in Euclidean space, Levi-Civita's concept of parallelism, Subspaces of Riemannian manifold, Fundamental theorem of Riemannian geometry.

UNIT V Curvature tensor, Bianchi identities, covariant curvature tensor, theorem on Riemannian curvature, Schur's theorem, Wily tensor (projective tensor) mean curvature, Ricci principal directions, Einstein space, Ricci coefficient of rotation and its properties, curvature of congruence, Geodesic of congruence, curl of congruence, canonical congruence.

Recommended Books and References:

1. C. E. Weatherburn, An introduction to Riemannian Geometry and Tensor Calculus, Cambridge university press, 1986, ISBN-9780521091886
2. Leonor Godinho and JoseNatario, An Introduction to Riemannian Geometry, Springer nature, 2014, ISBN-9783319086651
3. Nail H. Ibragimov, Tensor and Riemannian geometry, De Gruyter, 2015, ISBN-9783110379648
4. T J Wilmore, An Introduction to Differential Geometry, Oxford University Press, 32nd impression, 2017, ISBN-9780195611106

THEORY OF RELATIVITY

Theory Credit: 5
Tutorial Credit: 1

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. R.K. Pathria, The Theory of Relativity (2nd edition), Hindustan Publishing co. Delhi, 1994.
2. J.V. Narlikar, General Relativity & Cosmology (2nd edition), Macmillan co. of India Limited, 1988.
3. S. K.Srivastava and K. P. Sinha, Aspects of Gravitational Interactions, Nova Science Publishers Inc. Commack, New York, 1998.
4. W. Rindler, Essential Relativity, Springer-Verlag, 1977.
5. R.M. Wald, General Relativity, University of Chicago Press, 1984.

FUNCTIONAL ANALYSIS

Theory Credit: 5
Tutorial Credit: 1

UNIT I General Banach space – Definition and Examples, continuous linear transformations between Normed linear spaces, Riesz Lemma, Hahn – Banach theorem and its consequences.

UNIT II Classical Banach space, L^P spaces, Holder's inequality, Minkowski inequality, Convergence and completeness, Riesz – Fischer theorem Subspace and Quotient spaces of Banach spaces, Riesz representation theorem.

UNIT III Embedding of a Normed linear space in its second conjugate space, open mapping theorem, closed graph theorem, uniform boundedness theorem, conjugate of an operator.

UNIT IV Hilbert's space , example and simple properties, orthogonal complement, orthonormal set, Bessel's inequalities, complete orthonormal set, 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. H. L. Royden, Real Analysis (4th edition), Macmillan Publishing co. inc. New York, 2005, ISBN-9789332551589
2. G. F. Simmons, Introduction to topology and Modern Analysis (4th edition), Tata McGraw-Hill Ltd, 2017, ISBN-9780070597846
3. W. Rudin,Functional Analysis, Tata McGraw hill, 1974, 2nd Ed. ISBN-9780070619883
4. B. V. Limaye, Functional Analysis, Willy Eastern ltd., 1991, 3rd Ed, ISBN-9789386286093
5. J B Conway, A course in functional analysis, Springer, 1997, 2nd Ed, ISBN-9783540960423

GRAPH THEORY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Graphs, Incidence and degree, Isomorphism, Sub graphs, walks, path & circuits, connected graphs, disconnected graphs and component, Euler graphs, Fluery's algorithm, Hamiltonian paths and circuits, the Chinese Postman Problem, the traveling salesman problem, Matrix representation of graph: Incidence matrix, Circuit matrix, Path matrix, Cut-set matrix and Adjacency matrix.

UNIT II Shortest Path Algorithms: Dijkstra's algorithm, Floyd-Warshall algorithm, Trees, distance diameters, radius and pendent vertices, rooted and binary trees, counting trees, spanning trees, finding all spanning trees of a graph and a weighted graph, Prim's and Kruskal Algorithms for minimal spanning tree.

UNIT III Cut sets and cut vertices, fundamental circuits and cut sets, network flows, 1-Isomorphism, 2-Isomorphism, Planar graphs, Kuratowski two graphs, detection of planarity, geometric dual, criterion of planarity, thickness and crossings.

UNIT IV Coloring, covering and partitioning of a graph, chromatic number, chromatic partitioning, chromatic polynomials, matching, covering, four color problem.

UNIT V Digraphs and binary relations, Euler digraphs, Vector and Vector space of a graph, basis vector, cut set vector, circuit vector, circuit and cut set subspaces, Orthogonal Vectors and Spaces

Recommended Books and References:

1. Harary. F, Graph Theory, Narosa Publishing House, 2001. ISBN-978-8185015552
2. Bondy and Murthy, Graph theory and application, Addison Wesley, 2011, ISBN-978-1447173601
3. Deo N, Graph theory with applications to Engineering and Computer Science, PHI Learning, 2009, ISBN-978-8120301450
4. V Balakrishnan, Schaum's Outline of Graph Theory: Including Hundreds of Solved Problems, Mcgraw Hill, 1997, ISBN-978-0070587182

MATHEMATICAL STATISTICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I The postulates of probability, Some elementary theorems, addition and multiplication rules, Bayes rule and future Bayes theorem, random variables, mathematical expectation, probability mass functions and probability density function, distribution function and its properties.

UNIT II Uniform, Bernoulli and binomial distribution, hypergeometric and geometric distribution, negative binomial and Poisson distribution, uniform and exponential distribution, gamma andbeta distributions, normal distribution, log-normal distribution.

UNIT III Moments and moment generating functions, probability generating functions and characteristic function Moments of binomial, hypergeometric, Poisson, gamma, beta and normal distributions, transformation of variables: one variable, Several variables.

UNIT IV The distribution of sample moments, the distribution of differences of means and variances, the Chi-Square distribution, the t distribution and the F distribution.

UNIT V Multiple linear regression, estimation of parameters using method of least square, use of dummy variables, binomial logistic regression and multinomial logistic regression-estimation of the regression coefficients and their interpretation.

Recommended Books and References:

1. J. E. Freund, Mathematical Statistics, Prentice Hall Inc., 1992
2. Bhattacharjee D. and Das K. K., A Treatise on Statistical Inference and Distributions, Asian Books, 2010
3. Hogg and Craig, Introduction to Mathematical Statistics, Collier Macmillan, 1958
4. Mood, Greyill and Boes, Introduction to the Theory of Statistics, McGraw Hill
5. R. E. Walpole, Introduction to Statistics, Macmillan Publishing Company, 1982
6. M. R. Spiegel and L. J. Stephens, Statistics, McGraw Hill Book Company, 1984

LIE ALGEBRA

Theory Credit: 5
Tutorial Credit: 1

UNIT I Generalities. Basic definitions and examples. Structure constants. Relations with Lie groups. Elementary algebraic concepts. Representations; the Killing form. Solvable and nilpotent. Engel's theorem. Lie's theorem. Cartan's first criterion. Cartan's second criterion. Representations of A1. Complete reduction for A1

UNIT II Cartan subalgebra. Roots. Roots for semisimple g. Strings. Cartan integers. Root systems. Weyl group. Root systems of rank two. Weyl-chevalley normal form, first stage. Weyl-chevalley normal form.

UNIT III Compact form. Properties of root systems. Fundamental systems. Classification of fundamental systems. The simple Lie algebras. Automorphisms.

UNIT IV The Cartan-Stiefel diagram. Weights and weight vectors. Uniqueness and existence. Complete reduction.

UNIT V Cartan semigroup; representation ring. The simple Lie algebras. The Weyl character formula. Some consequences of the character formula. Examples. The character ring. Orthogonal and symplectic representations.

ANALYTIC NUMBER THEORY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Arithmetical Functions and Dirichlet Multiplication: Introduction, the Mobius function $\mu(n)$ The Euler totient function $\phi(n)$, the relationship connecting ϕ and μ. A product formula for $\phi(n)$. The dirichlet product of arithmetical functions. Dirichlet inverse and Mobius inversion formula. The Mangoldt function $\Lambda(n)$. Multiplicative functions. Multiplicative functions and Dirichlet multiplication. The inverse of a completely multiplicative function.

UNIT II Liouville's function $\lambda(n)$. The divisor functions $\sigma_\alpha(n)$. Generalized convolutions. Formal power series. The Bell series of an arithmetical function. Bell series and Dirichlet multiplication. Derivatives of arithmetical functions. The Selberg identity.

UNIT III Averages of Arithmetical Functions: Introduction. The big oh notation. Asymptotic equality of functions. Euler's summation formula. Some elementary asymptotic formulas. The average order of d(n). The average order of the divisor functions. The average order of $\phi(n)$. An application to the distribution of lattice points visible from the origin. The average order of $\mu(n)$ and $\Lambda(n)$. The partial sums of a Dirichlet product. Applications to $\mu(n)$ and $\Lambda(n)$. Another identity for the partial sums of a Dirichlet product.

UNIT IV Some Elementary Theorems on the Distribution of Prime Numbers.Introduction. Chebyshev's functions $\psi(x)$ and $\vartheta(x)$. Relations connecting $\vartheta(x)$ and $\pi(x)$. Some equivalent forms of the prime number theorem. Inequalities for $\pi(n)$ and p_n. Shapiro's Tauberian theorem. Applications of Shapiro's theorem. An asymptotic formula for the partial sums $\sum_{p\le x}\frac{1}{p}$. The partial sums of the Mobius functions. Brief sketch of an elementary proof of the prime number theorem. Selberg's asymptotic formula.

UNIT V Dirichlet's theorem for primes of the form 4n – 1 and 4n + 1. The plan of the proof of Dirichlet's theorem. Proof of Lemma 7.4, 7.5, 7.6, 7.7 and 7.8. (refer Apostol Tom M., Introduction to analytic number theory) Distribution of primes in arithmetic progressions.

Recommended Books and References:

1. Tom M. Apostol, Introduction to analytic number theory,
2. Paul T Bateman, Harrold G. Diamond, Analytic Number Theory: Introductory Course, by

MULTIVARIABLE CALCULUS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Functions on Euclidean spaces, differentiability in several variables, partial and directional derivatives, chain rule, mean value theorem.

UNIT II Inverse function theorem, implicit function theorem, rank theorem, determinants, derivatives of higher order, differentiation of integrals.

UNIT III Riemann integration in higher dimensions, Fubini's theorem, change of variables, improper integrals, line and surface integrals, Green's theorem, divergence theorem, Stokes' theorem.

UNIT IV Tensors, wedge product, differential forms, Poincare's lemma, integration on chains, Stokes' theorem for integrals of differential forms on chains, fundamental theorem of calculus.

UNIT V Differentiable manifolds (as subspaces of Euclidean spaces), differentiable functions on manifolds, tangent spaces, differential forms on manifolds, orientations, integration on manifolds, Stokes' theorem on manifolds.

Recommended Books and References:

1. J.R. Munkres, *Analysis on Manifolds*, Westview Press, 1st edition, 1991.ISBN: 9780201315967
2. W. Rudin, *Principles of Mathematical Analysis*, McGraw-Hill, 3rd edition, 1984.ISBN: 9781259064784
3. M. Spivak, *Calculus on Manifolds, A Modern Approach to Classical Theorems of Advanced Calculus*, Westview Press, 1st edition, 1971.ISBN: 9780805390216
4. G. B. Folland, *Advanced Calculus*, Pearson Education, 1st edition, 2002.ISBN: 9780130652652
5. Tom M. Apostol, *Mathematical Analysis*, Addison-Wesley Publishing Company, Inc., 2nd Edition, 1974. ISBN: 9788185015668

DISCIPLINE SPECIFIC ELECTIVE 3 & 4
MMAD 4.11 & MMAD 4.21

FLUID MECHANICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Lagrangian and Eulerian methods of description; Governing equations of fluid motion; stream line; velocity potential; path line; 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; 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; Karman Vortex Street.

UNIT IV Viscous fluid; Navier-Stokes 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. S. W. Yuan, Foundation of Fluid Mechanics, Prentice-Hall, 1967
2. W. H. Besant & A. S. Ramsey, A Treatise of Hydromechanics (3rd edition), G. Bell and Sons Ltd, 1997.
3. Frank Chorlton, Text Book of Fluid Dynamics, D. Van Nostrand Company Ltd., London, 1990.
4. M.D. Raisinghania, Fluid Dynamics
5. Shanti Swarup, Fluid Dynamics

FOURIER ANALYSIS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Fourier Series. Fourier coefficients: basic properties. Fourier series: summability in norm. summability at a point. Fourier coefficients in $\ell^1(\mathbb{Z})$ (or $f \in A(T)$, $\ell^2(\mathbb{Z})$ (or $f \in L^2(T)$). Maximal functions. Fourier summability pointwise a.e. (almost everywhere).

UNIT II Fourier series: convergence at a point. Norm convergence. Hilbert transform on $L^2(T)$. Calderon – Zygmund decompositions. Hilbert transform on $L^p(T)$. Application of interpolation.

UNIT III Fourier integrals. Fourier transforms: basic properties. Summability in norms. Fourier inversion when $\hat{f} \in L^1(\mathbb{R}^d)$. Fourier transforms in $L^2(\mathbb{R}^d)$

UNIT IV Fourier integrals. Summability a.e. norm convergence. Hilbert and Riesz transforms on $L^2(\mathbb{R}^d)$. Hilbert and Riesz transforms on $L^p(\mathbb{R}^d)$

UNIT V Fourier series and integrals. Band limited functions. Periodization and Poisson summation. Uncertainty principles.

Recommended Books and References:

1. Richard S Laugesan, Harmonic Analysis Lecture Notes
2. Korner T.A,A First Look at Fourier Analysis
3. Kenneth B Howell, Principles of Fourier Analysis
4. Murray Spiegel, Schaum's Outline of Fourier Analysis with Applications to Boundary Value Problems

ALGEBRAIC NUMBER THEORY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Preliminaries from commutative Algebra: Basic definition. Ideals in products of rings. Noetherian rings. Noetherian Modules. Local rings. Rings of fractions. The Chinese remainder theorem. Review of Tensor products.

UNIT II Rings of Integers: First proof that the integral elements form a ring. Dedekind's proof that the integral elements from a ring. Integral elements. Review of bases of A-modules. Review of norms and traces. Review of bilinear forms. Discriminants. Rings of integers are finitely generated. Finding the ring of integers. Algorithms for finding the ring of integers.

UNIT III Dedekind Domains: factorization: Discrete valuation rings. Dedekind domains. Unique factorization of ideals. The ideal class group. Discrete valuations. Integral closures of Dedekind domains. Modules over Dedekind domains. Factorization in extensions. The primes that ramify. Finding factorizations. Examples of factorizations. Eisenstein extensions.

UNIT IV The Finiteness of the Class Number: Norms of ideals. Statement of the main theorem and its consequences. Lattices. Some calculus. Finiteness of the class number. Binary quadratic forms.

UNIT V The unit theorem. Statement of the theorem. Proof that U_K is finitely generated. Computation of the rank. *S*-units. Example: CM fields. Example: Real quadratic fields, Cubic fields with negative discriminant. Finding $\mu(K)$. Finding a system of fundamental units. Regulators.

Recommended Books and References:

1. J.S. Milne, Algebraic Number Theory
2. Pierre Samuel, Algebraic Theory of Numbers
3. N. Ram Murthy &Jody Esmonde, Problems in Algebraic Number Theory
4. Alaka S, & William K, Introductory Algebraic Number Theory

ALGEBRAIC TOPOLOGY

Theory Credit: 5
Tutorial Credit: 1

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 x 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 Π_1 and H_1; relative homology.

UNIT V Calculations of homology of $\mathbb{S}^n$; Brouwer's fixed point theorem for $f : \mathbb{E}^n \to \mathbb{E}^n$ $(n > 2)$ and its applications to spheres and vector fields; Meyer-Vietoris sequence and its application.

Recommended Books and References:

1. J. R. Munkres, Topology, a first course, Prentice- Hall of India Ltd., New Delhi, 2000.
2. M. J. Greenberg and J. R. Harper, Algebraic topology, a first course (2nd edition), Addison-Wesley Publishing co., 1997.
3. A. Hatcher, Algebraic Topology, Cambridge University Press, 2002.
4. E. H. Spanier, Algebraic Topology (2nd edition), Springer-Verlag, New York, 2000.
5. J. J. Rotma, An Introduction to Algebraic Topology, Graduate Text in Mathematics, No. 119, Springer, New York, 2004.
6. W. Fulton, Algebraic topology, a first course (2nd edition), Graduate Text in Mathematics, No. 153, Springer, New York, 1995.
7. S. Eilenberg and N. E. Steenrod, Foundations of Algebraic Topology (2nd edition), Princeton University Press, 1995.

DIFFERENTIAL GEOMETRY OF MANIFOLDS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Differentiable Manifold, Differentiable functions, tangent space, vector fields, maps, exterior algebra, exterior derivative.

UNIT II Lie group and Lie algebra, one parameter subgroup and exponential maps, homomorphism and isomorphism, principal fiber bundle, associated fiber bundle, induced bundle, bundle homomorphism.

UNIT III Linear connections, parallelism, pseudo tensorial forms, basic form, torsion and curvature form, Expression in local coordinates covariant derivative, torsion and curvature tensors, geodesic and lie derivative.

UNIT IV Riemannian manifold: Riemannian metric, Riemannian connection, curvature tensor, sectional curvature, projective curvature tensor, conformal curvature tensor.

UNIT V Submanifolds, normals, induced connections, Gauss formulae, Weingerten formulae, lines of curvature, mean curvature, the equation of Gauss and Codazzi.

Recommended Books and References:

1. Q. Khan, Differential Geometry of Manifolds, Prentice Hall India 2012, ISBN-9788120346505
2. Jeffry M . Lee, Manifolds and Differential Geometry, Orient Blackswan, 2012, ISBN-9780821887134
3. U C De & A A Shaik, Differential Geometry of Manifolds, Narosa Publishing, 2009, ISBN-9788173197772
4. T J Wilmore, An introduction to Differential Geometry, Oxford University Press, 32nd impression, 2017, ISBN-13:9780195611106

COMMUTATIVE ALGEBRA

Theory Credit: 5
Tutorial Credit: 1

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. M. F. Atiyah and I. G. Macdonald, Introduction to Commutative Algebra, Addison Wesley, 2000.
2. M. Reid, Undergraduate Commutative Algebra, London Math. Soc. Student Texts, No. 29, 1995.
3. I. S. Luther and I. B. S. Passi, Algebra (Volume 2: Rings), Narosa Publishing House, New Delhi, 1999.
4. I. S. Luther and I. B . S. Passi, Algebra (Volume 3: Modules), Narosa Publishing House, New Delhi, 1999.
5. S. Lang, Algebra, Addison-Wesley Publishing Company, London, 2000.
6. Gopalakrishnan, Commutative Algebra, Orient BlackswanPvt. Ltd. New Delhi

DISCRETE MATHEMATICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Introduction:** Sets, Algebra of sets, Representation of Relation on finite sets, Mapping, composition of mapping, countability of sets, relation, product set, equivalence relation, Principle of Mathematical induction

UNIT II **Logic:** Introduction, proposition and compound properties, basic logical operations, truth tables, tautologies and contradiction, algebra of proposition, conditional and biconditional statement, negation of compound statements, Normal form, negation of quantified statement

UNIT III **Boolean Algebra:** Introduction, Boolean Polynomial, Sum of products and product of sum form, Normal forms, minimal form of Boolean polynomial, prime implicant, Karnaugh Map and Quinn McCluskey method for simplification of Boolean expression, switching circuit and its applications

UNIT IV **Poset and Lattices:** Definition, Examples and basic properties of ordered sets, Hasse diagram, Isomorphic Ordered set, Lattice as Algebraic structure, sub lattices, lattice isomorphism, definition, examples and properties of modular and distributive lattices

UNIT V **Combinatorics:** Principles of addition multiplication, Permutation, combinations, Pigeonhole principle, binomial theorem, multinomial coefficient, Recurrence relation, solution of recurrence relation, homogeneous and non-homogeneous recurrence relation, generating function, solution of recurrence relation by method of generating functions

Recommended Books and References:

1. J P Tremblay and R P Manohar, Discrete Mathematics with Applications to Computer Science, McGraw Hill, 1989, ISBN-978-0074631133
2. C L Liu, Elements of Discrete Mathematics, Tata McGraw Hill, 2005, 4th Ed, ISBN-978-1259006395
3. V K Balakrishnan, Introductory Discrete Mathematics, ISBN-978-0486691152
4. B A Davey and H A Priestley, Introduction to Lattics and order, Cambridge Universtiy Press, Cambridge, 1990, ISBN-9780521134514
5. Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, Undergraduate text in mathematics, Springer, 2004, 3rd Ed, ISBN-9781441931177
6. Edgar G Goodaire and Micheal M Parmenter, Discrete Mathematics with Graph Theory, Pearson Education, 2003, 3rd Ed, ISBN-978-9332549777
7. S Lipschutz and M L Lipson, Schaum's Outline of Theory and Problems of Discrete Mathematics, 2nd Ed., Tata McGraw-Hill, 1999, ISBN-978-0071615877

OPERATIONS RESEARCH

Theory Credit: 5
Tutorial Credit: 1

UNIT I **OR Fundamentals**: Introduction to Operations Research: Basic definition, scope, objectives, phases, models and limitations of Operations Research. Linear Programming Problem – Formulation of LPP, Graphical solution of LPP. Simplex Method, Artificial Variables, big-M method, two-phase method, degeneracy and unbounded solutions, Sensitivity Analysis-Graphical Approach.

UNIT II **Non-Linear Programming:** Non-Linear Programming: Single Variable Optimization, Sequential Search Techniques, Fibonacci search, Convex functions, Multi-variable Optimizations without Constraints: the method of Steepest Ascent, Newton-Raphson method, Multi-Variable Optimizations with Constraints: Lagrange Multipliers, Newton-Raphson's method, Penalty Functions, Kuhn-Tucker conditions.

UNIT III **Deterministic Inventory Modeling:** Introduction to inventory systems, Selective inventory Classification and its use in controlling inventory. Deterministic inventory models: Economic Order Quantity (EOQ) model, EOQ with finite supply, EOQ with backorders, EOQ with constraints, All-units quantity discounts model.

UNIT IV **Network Analysis:** Networks, Minimum-span problems, Shortest route problems, Maximal flow problems, PERT/CPM. Critical path computations for PERT, Construction of Time schedules. LPP formulations for PERT.

UNIT V **Game Theory:** Concepts of Game problem. Two-person zero sum game. Pure and Mixed strategies. Saddle point and its existence. Fundamental theorem of Rectangular game. Concept of Dominance. Dominance and Graphical method of solving rectangular games. Relationship between rectangular game and Linear Programming Problem. Solving rectangular game by Simplex Method.

Recommended Books and References:

1. Hamdy A. Taha: Operations Research – An Introduction, Pearson Education,2007
2. F.S.Hillier, G.J.Lieberman : Introduction to Operations Research – Concepts and Cases, 9th edition, Tata Mc Graw Hill – 2010
3. J.K Sharma: Operations Research Theory and applications,Trinity Press , 6th edition
4. N.V.S Raju, Operations Research, HI-TECH,2002

FIELD THEORY

Theory Credit: 5
Tutorial Credit: 1

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 Relations to Splitting Fields, Frobenius Endomorphism, Roots of Unity and Cyclotomic Polynomials

UNIT III Algebraic 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. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic Abstract Algebra, Cambridge University Press
2. N. Jacobson, Basic Algebra I, Hindustan Publishing Corporation, New Delhi
3. Galois Theory, TIFR Mathematical Pamphlets, No. 3, 1965
4. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, New Delhi
5. J. B. Fraleigh, A Frist Course in Abstract Algebra, Narosa Publishing House, New Delhi
6. J. A. Gallian, Contemporary Abstract Algebra
7. Gopalakrishnan, University Algebra,

GAME THEORY

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Game Theory Fundamentals:** Historical background. Zero sum games; Non-zero sum games; Extensive Form Games ; Cooperative Games; Bargaining Games; Cooperative versus Non-Cooperative Games.

UNIT II **Two-Person Zero-Sum Games:** Saddle point; Minimax and Maximin Stategies; Solving 2xn and mx2 Games; Dominance; Mixed strategy; Linear Programming Methods to solve a Two- person Zero Sum Game.

UNIT III **Two-person Non-Zero-sum Games:** Basic Definitions; Nash equilibrium; Pure and mixed strategies in Nash equilibrium.

UNIT IV **Extensive Form Games:** The Extensive Form; The Strategic Form; Backward induction and subgame perfection; Perfect Bayesian equilibrium.

UNIT V **Cooperative Game Theory:** Cooperative Games with Transferable Utility; The Core; The Shapley value.

Recommended Books and References:

1. Y.Narahari, Game Theory and Mechanism Design, World Scientific,2014
2. S.R.Chakravarty, M. Mitra, P.Sarkar, A Course on Cooperative Game Theory, Cambridge University Press,2015
3. Hans Peter, Game Theory- A Multi-leveled Approach, Springer,2008.

MATHEMATICAL MODELING

Theory Credit: 5
Tutorial Credit: 1

UNIT I Mathematical modeling introduction, techniques, classifications, some illustrations: mathematical modeling through geometry/ algebra/ trigonometry/ calculus, mathematical modeling through ODE of first order: linear growth and decay model, non-linear growth and decay model, compartment models mathematical modeling of dynamics, geometrical problem.

UNIT II Mathematical modeling through systems of ordinary differential equations of first order: in population dynamics, epidemics, economics, medicine, dynamics, mathematical modeling through ODE of second order: of planetary motions and motion of satellites, modeling through linear ordinary differential equations of second order in electrical circuits, catenary.

UNIT III Mathematical modeling through difference equations with constant coefficients: in population dynamics and genetics, mathematical modeling through PDE: mass-balance equations, momentum balance equations, variational principles, model for traffic on a highway.

UNIT-IV Mathematical modeling through graphs: in terms of directed graphs in terms of signed graphs, in terms of weighted diagraphs and in terms of unoriented graphs.

UNIT-V Mathematical modeling through linear programming: of different industrial oriented problems, mathematical modeling through calculus of variations: on geometrical problems, problems of mechanics/ bioeconomics.

Recommended Books and References:

1. Kapur, J.N., Mathematical modeling, New Age International
2. Burghes, D.N., Mathematical modeling in social, management and life sciences, Ellios Horwood and John Wiley
3. Giordano, F.R., and Weir, M.D., A first course in Mathematical Modeling, Brooks Cole
4. Kapur, J.N., Insight into mathematical modeling, Indian National Science academy
5. Bellomo and Preziosi, Modeling Mathematical methods and Scientific computation, CRC

DISSERTATION/PROJECT

Credits: 6

SYLLABUS FOR
Master of Science

PHYSICS

Under CBCS guidelines

COURSE STRUCTURE

SEMESTER	COURSE CODE	COURSE TITLE	CREDITS
I	MPHC 1.11	Classical Mechanics	5+1
	MPHC 1.21	Quantum Mechanics-I	4
	MPHC 1.31	Mathematical Physics	4
	MPHC 1.41	Statistical Mechanics	5+1
	MPHC 1.22	Quantum Mechanics-I	2
	MPHC 1.32	Mathematical Physics	2
II	MPHC 2.11	Electrodynamics	4
	MPHC 2.21	Quantum Mechanics- II	5+1
	MPHC 2.31	Nuclear & Particle Physics	4
	MPHC 2.41	Condensed Matter Physics -I	4
	MPHC 2.12	Electrodynamics	2
	MPHC 2.32	Nuclear & Particle Physics	2
	MPHC 2.42	Condensed Matter Physics -I	2
III	MPHC 3.11	Embedded Systems: Introduction to microcontrollers	4
	MPHC 3.21	Atomic & Molecular Spectroscopy	4
	MPHC 3.12	Embedded Systems: Introduction to microcontrollers	2
	MPHC 3.22	Atomic & Molecular Spectroscopy	2
	MPHD 3.11(a)	Condensed Matter Physics-II	4
	MPHD 3.11(b)	Remote Sensing of the atmosphere	4
	MPHD 3.11(c)	High Energy Physics	5+1
	MPHD 3.21(a)	Astronomy and Astrophysics	4
	MPHD 3.21(b)	Digital Signal Processing	4
	MPHD 3.21(c)	Plasma Physics	5+1
	MPHD 3.12(a)	Condensed Matter Physics-II	2
	MPHD 3.12(b)	Remote Sensing of the atmosphere	2
	MPHD 3.22(a)	Astronomy and Astrophysics	2
	MPHD 3.22(b)	Digital Signal Processing	2
IV	MPHC 4.11	Computational Physics	4
	MPHC 4.21	Experimental Methods	4
	MPHC 4.12	Computational Physics	2
	MPHC 4.22	Experimental Methods	2
	MPHD 4.11(a)	Atmospheric Physics	4
	MPHD 4.11(b)	Applied Dynamics	5+1
	MPHD 4.11(c)	Communication Electronics	4
	MPHD 4.12(a)	Atmospheric Physics	2
	MPHD 4.12(c)	Communication Electronics	2
	MPHD 4.21	Dissertation	6

SEMESTER – I

MPHC 1.11
CLASSICAL MECHANICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Lagrangian Formulation:**
(a) Review on the following topics (derivations are not required): Newton's laws, dynamical systems, moment of inertia, non-inertial frames and pseudo forces.
(b) Lagrangian formulation: Generalized coordinates, conservation law of linear momentum and angular momentum, conservation of energy, cyclic coordinates, ignorable coordinates, Routh's procedure, Jacobi's integral, mechanics of a particle, mechanics of a system of particles, constraints, classification of constraints, degrees of freedom, generalized coordinates, generalized velocity, acceleration, force and potential, Calculus of variation, variational principle, advantages of Lagrangian approach over Newtonian mechanics, D'Alembert's principle, Euler's-Lagrange differential equation, Hamilton's variational principle,, Rayleigh's dissipation function, Lagrangian for a charged particle in an electromagnetic field, Geodesics, branchistochrone.

UNIT II **Hamiltonian Formulation:** Hamiltonian formulation in classical mechanics, Hamilton's canonical equations of motion, physical significance of Hamiltonian, Hamilton's canonical equations of motion in cylindrical coordinates, spherical coordinates and rotating coordinates, principle of least action, applications of Hamilton's equations of motion for simple pendulum, compound pendulum, linear Harmonic oscillator, two dimensional isotropic harmonic oscillators, particle in a central field of force, Hamiltonian for a charged particle in an electromagnetic field, advantages of introducing Hamiltonian formulation.

UNIT III **Canonical Transformations & Central Force Problem:** Canonical and point transformations, Conditions for a canonical transformation , generating function, Hamilton-Jacobi method, solution of Hamilton-Jacobi equation, solution of harmonic oscillator problem by Hamilton - Jacobi method, Poisson brackets and properties, invariance of Poisson's brackets under canonical transformation, Hamilton's equation in Poisson bracket notation, two body central problem, Reduction of two body problems to equivalent one body problem, Lagrangian for a two body problem, central force motions(Review only), general features of central force motion, conservation of energy and angular momentum under central force motion, Kepler's laws of planetary motion, Virial theorem, , twobodycollisions-scatteringinlaboratoryandcentreofmassframes(Review only), unbound motion in Rutherford scattering.

UNIT IV **Rigid Bodies:** Generalized coordinates of a rigid body, rigid body dynamics (Review only), Euler's angles, Euler's theorem, Eigen value equation, similarity transformation, orthogonal transformation, angular velocity of a rigid body, components of angular velocity vector, angular momentum and Inertia tensor, moment and product of inertia, moment of inertia coefficient, moment of inertia tensors, symmetric tensor, principal axes transformation, principal moment of inertia, diagonalisation of matrix, secular equation of inertia tensor , Euler's equations of motion for a rigid body, Lagrange method for the equation of motion of a rigid body, motion of a symmetrical top and its precession.

UNIT V **Small Oscillations:** Small oscillations, stable and unstable equilibrium, dynamic and metastable equilibrium, oscillations about equilibrium, Eigen vibrations, normal mode, normal coordinates theory of small oscillation for two coupled oscillators, double pendulum as a coupled oscillator, application of the theory of small oscillations to a systems with few degrees of freedom like a parallel pendulum, free vibrations of a linear tri atomic molecule, Small oscillations for a light elastic string.

Recommended Books and References:

1. Classical Mechanics – H. Goldstein, 2nd Edition, Addison-Wesley Pub. Co.
2. Classical Mechanics of particles and Rigid bodies – Kiran C. Gupta, New Age International (p) Ltd (2008).
3. Classical Dynamics – J. B. Marion, Saunders College Publishing.
4. Classical Electrodynamics_ J.D. Jackson, 3rd Edn., m1998, Wiley.
5. Classical Mechanics – A. K. Raichaudhuri Oxford University Press.
6. Mechanics- L.D. Landau and E.M. Lifschz (pergamon).
7. Classical Mechanics- J.W. Muller-Kirsten (world Scientific,2008).
8. Classical Mechanics – S.L. Gupta, V. Kumar and H.V. Sharma, Pragati Prakashan Publishers, Meerut, India (2010).
9. Classical mechanics – P.S. Joag and N.C. Rana, Tata McGraw - Hill Education (2001).
10. Classical Mechanics – J.C. Upadhyaya, Himalaya Publishing House, India (2010).

MPHC 1.21
QUANTUM MECHANICS-I

Theory Credit: 4

UNIT I **Review of Basic Concepts:** Statistical Interpretation of the Wave Function; Expectation Values of Discrete and Continuous quantities; Normalization of the Wave Function and conservation of Probability; Momentum and Ehrenfest's Theorem. Uncertainty Principle.
Stationary States– 1: One Dimensional Linear Harmonic Oscillator, Formulation of the Hamiltonian, its eigenvalues and eigenfunction – Algebraic Method (Operator Method) and Analytical Method. Free Particle, its position and momentum representation, Dispersion Relation, Gaussian Wave Packet.

UNIT II **Stationary States– 2:** Dirac Delta potential and its bound state wave function. Dirac-Delta Well and Scattering, Finite Square Well, Brief Introduction to the Scattering Matrix and Transfer Matrix.
Formalism of Quantum Mechanics – 1: Hilbert Space, Observables and Hermitian Operators, Eigenfunctions of a Hermitian Operator. Generalised Statistical Interpretation. Uncertainty Principle, Minimum Energy Wave packet, Energy-time Uncertainty.

UNIT III **Formalism of Quantum Mechanics – 2:** Dirac's Notation. Virial Theorem. Coherent States of the Harmonic Oscillator. Extended Uncertainty Relation, Translation of Space, Time and their Generators.
Stationary States in Three Dimensions: Commutation Relations of Position and Momentum in Three Dimensions. The Spherical Potential Well. Schrodinger Equation for the Hydrogen atom in Spherical Coordinates, Detailed solutions for the Eigen Values and Eigen Functions, Hydrogen Spectrum.

UNIT IV **Review of Angular Momentum:** Ladder Operators, Eigen Functions and Eigen Vectors. Uncertainty Principle for the Components of the Angular Momentum. Rigid Rotator- Eigen values and Eigen Functions. Spin ½ systems and Pauli's Spin

Matrices. Electron in a Magnetic Field and Larmor Precession. Addition of Angular Momenta, Singlet and Triplet States. Clebsch-Gordon Coefficients.

UNIT V **Identical Particles:** Two Particle Systems, Schrodinger Equation, Energy Eigenvalues for Positronium and Muonic Hydrogen. Bosons and Fermions, Exclusion Principle. Exchange forces. Slater's Determinant. Atoms - Helium Atom, Para and Ortho Helium, Periodic Table and Hund's Three Rules.

Recommended Books and References:

1. *Introduction to Quantum Mechanics* - *David J Griffiths*
2. *Quantum Mechanics* -*L. Schiff.*
3. *Quantum Mechanics* -*S.N.Biswas.*
4. *Quantum Mechanics* -*A.K.Ghatak and S.Lokanathan.*
5. *Introductory Quantum Mechanics* -*R.L.Liboff.*
6. *Principles of Quantum Mechanics* -*R. Shankar.*
7. *Quantum Mechanics: Concepts and applications* -*N.Zettili*

MPHC 1.31
MATHEMATICAL PHYSICS

Theory Credit: 4

UNIT I **Fourier Transform**

Fourier integral theorem, Fourier sine and cosine integral, Fourier complex integral, Fourier transform, Fourier sine and cosine transform, properties of Fourier transform, Perseval theorem, Fourier transform derivative, application of Fourier transform to solve differential equation , evaluation of integral and boundary value problems(1-D wave and heat flow equation).

UNIT II **Laplace transform**

Laplace transform, properties of Laplace transform, Laplace transform of elementary functions, Laplace transform of derivative f(t), Laplace transform of derivative of order n, Laplace transform of integration of f(t), Laplace transform of some special functions(periodic function , gamma function , Bessel functions $J_o(x)$ and $J_1(x)$, Convolution theorem, inverse Laplace transform, properties of inverse Laplace transform, solution of differential equations using Laplace transform.

UNIT III **Tensors**

n-dimensional space, sub space, subscript, superscript, Einstein summation convention, dummy suffix, real suffix, transformation of coordinates, Kronecker delta, contravariant vector, covariant vector, definition of tensor, gradient tensor field, addition and subtraction of tenors, multiplication of tensors, inner product, contraction, symmetric and anti-symmetric tensor, quotient law, reciprocal symmetric tensor, metric, g_{ij} as a second rank covariant symmetric tensor, Christioffel symbol of first and second kind, tensor law of transformation of Christioffel symbol.

UNIT IV **Special functions**

Legendre DE, Generating Function ,Orthogonality, simple recurrence relations, Associated Legendre polynomials, Bessel DE, Generating Function, simple recurrence relations Bessel function of First kind, Bessel function for integral, half integral orders, Neumann functions, Hankel functions, modified Bessel equation, spherical Bessel function , Characteristic of various Bessel functions,

Hermite DE, One dimensional linear harmonic equation as Hermite equation, energy quantization and zero point energy, Weber-Hermite functions and Laguerre DE, Associated Laguerre polynomials.

UNIT V **Group and symmetry**

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, Classes, Some special groups with operators. Matrix Representations: Reducible and Irreducible, characters, Great Orthogonality theorem and its consequences, Character table.

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. Mathematical Methods for Physicists: Weber and Arfken, Academic Press.
2. Introduction to Mathematical Physics: Charlie Harper, Prentice Hall India Learning Pvt Ltd
3. Mathematical Methods in Physical Sciences: Mary L Boas, Wiley India Pvt Ltd
4. Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, Cambridge Univ. Press.
5. Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.
6. Group Theory and its Applications to Physical Problems by Morton Hamermesh, Dover
7. Mathematical Physics: B. D. Gupta, Vikas Publication House Pvt Ltd
8. Mathematical Physics: B. S. Rajput, Pragati Prakashan
9. Mathematical Physics: H.K. Dass, S Chand

MPHC 1.41
STATISTICAL MECHANICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Classical Statistical Mechanics:** Statistical basis of thermodynamics, probability calculations, thermodynamic probability, macrostates and microstates, statistical definition of entropy, Boltzmann relation for entropy and Gibb's paradox, phase space and Liouville's theorem (classical), micro-canonical ensemble, Maxwell velocity distribution**,** canonical ensemble, system in canonical ensemble, calculation of thermo dynamical quantities, partition function, classical systems, energy fluctuations in canonical ensemble, system of harmonic oscillators, thermodynamics of magnetic system, negative temperature.

UNIT II **Quantum Statistical Mechanics:** Grand canonical ensemble, equilibrium between a system and a particle, energy reservoir; Grand partition function and derivation of thermodynamics; Fluctuations, density operator, density matrix , time dependence of density matrix, density matrix in microcanonical, canonical and grand canonical ensembles, Quantum Liouville's equation, quantum statistical microcanonical, canonical and grand canonical ensembles and their partition functions, ideal gas in microcanonical ensemble, Statistical weights and occupation number, distribution for ideal Bose, Fermi and Maxwell-Boltzmann gases.

UNIT III **Ideal Fermi and Bose Systems:** Ideal gas in quantum mechanics, Statistics of occupation numbers, Thermodynamic behaviour of an ideal Bose gas, phenomenon of Bose Einstein condensation, Thermodynamics of blackbody radiation and

Planck's radiation law, Thermodynamic behavior of an ideal Fermi gas, concept of Fermi energy, mean energy of fermions at absolute zero, Boltzmann limit of Boson and Fermions gases, Fermi energy as a function of temperature, behaviour of specific heat with temperature, Einstein and Debye's theory of specific heat of solids, Thermodynamic equilibrium of white dwarf stars.

UNIT IV **Non Equilibrium Statistical Mechanics:** Fluctuations and irreversible process. Fluctuations in ensambles, Brownian motion: as a random walk (Einstein-Smoluchowski theory), as a diffusion process; Langevin theory of Brownian motion; Fluctuation dissipation theorem, motion of fluctuating force and Fokker-Planck equation, Spectral analysis of fluctuation- Wiener-Khintchine relations. Electrical noice and Niquist theorem,

UNIT V **Phase transition:** Triple point, Phase transition, Vander Walls equation and phase transition, symmetry, order of phase transitions and order parameter, critical point, critical exponent and their scaling, Elementary ideas on Ising model, one dimensional Icing model, Yang and Lee Theory of phase transition, Landau's mean-field theory of phase transition , symmetry breaking. Heisenberg models of ferromagnetism, , Bethe approximation

Recommended Books and References:

1. Statistical Mechanics, R.K Patharia & P.D Beal, 3rd Edition, Elsevier 2011.
2. Statistical Mechanics, K Huang, 2nd edition, Wiley Indra Edition, 2009.
3. Statistical Physics of Particles, Karden M., Cambridge University Press, 2007.
4. Statistical mechanics, J.K. Bhattacharjee.
5. Statistical mechanics – Satya Prakash, Kedar Nath Ram Nath publication 2008.
6. Statistical mechanics- Loknathan and Gambhir
7. Statistical mechanics- Gupta, Kumar and Sharma, Pragati Edition
8. Statistical mechanics- Eisner and Sharma Agarwal.

SEMESTER – II

MPHC 2.11
ELECTRODYNAMICS

Theory Credit: 4

UNIT I **Boundary Value Problems & Potential Formulation:**
(a) Review on the following topics (derivations are not required): Gauss's law, Biot - Savart law, Ampere's theorem, electromagnetic induction, dielectrics and conductors, interference, coherence, diffraction, Maxwell's equations.
(b) Poisson's and Laplace's equations, solution of Laplace's equation in Cartesian Coordinates, spherical coordinates and cylindrical coordinates, Green Reciprocity theorem, electromagnetic scalar potential function, Lorentz condition, vector potential, the potential formulation in electrodynamics, gauge transformation, coulomb and Lorentz gauge, inhomogeneous wave equation in terms of electromagnetic potentials, D' Alembert equation, Non-uniqueness of electromagnetic potentials, gauge invariance, Lorentz force in terms of electromagnetic potentials.

UNIT II **Electromagnetic Waves Propagation:** Propagation of electromagnetic waves in vacuum, plane electromagnetic waves in non-conducting isotropic medium and anisotropic non-conducting medium, plane electromagnetic waves in a conducting medium, reflection, and transmission of electromagnetic wavesat normal and oblique incidence, polarization of electromagnetic waves, Brewster's angle, reflection and transmission of electromagnetic wave sat a conducting surface, complex susceptibility, complex dielectric constant, absorption coefficient, Cauchy's formula, anomalous dispersion, Lorentz dispersion.

UNIT III **Wave Guides & Resonant Cavities:** Wave guides, propagation of electromagnetic waves along a hollow conducting pipe, perfectly conducting wave guide, transverse magnetic (TM) mode, transverse electric(TE) mode, free space wave number, transverse electric and magnetic mode (TEM), modes of the guide, cutoff frequency modes, wave number of wave guides, group and phase velocity of wave guide, Rectangular wave guide, TE mode for rectangular wave guide, TM mode for rectangular wave guide, resonant cavities, rectangular resonant cavity for TE and TM mode, resonant frequency of the rectangular cavity, degenerate frequency.

UNIT IV **Retarded Potential & Radiation:** Retardation, Retarded potentials, retarded potential solution of the inhomogeneous wave equation, green function, retarded solution for scalar and vector potentials, scalar and vector potentials due to moving charge and current distributions, Lienard -Wiechert potentials for a moving point charge, electromagnetic field from the Lienard - Wiechert potentials of a moving point charge, radiation, electric dipole radiation, radiation from an accelerated charge at low velocity and Larmor's formula, instantaneous energy flux, power radiated, radiation from an accelerated charge at high velocity and relativistic generalization of Larmor's formula, verification of the relativistic generalization of Larmor's formula, bremsstrahlung , radiation reaction, Abraham-Lorentz formula,

UNIT V **Relativisic Electrodynamics:** Postulates of the special theory of relativity, Lorentz transformation equations, Minkowski four dimensional space time continuum, Lorentz transformation of space and time in four vector form, concept of invariant interval, space like, time like and light like interval, space – time diagram, invariance of charge, transformation of charge and current densities, electric field measured in different frame of reference, transformation of electromagnetic potentials, Lorentz

conditions in covariant form, invariance of Maxwell's field equation under Lorentz transformation, equation of continuity in covariant form, electromagnetic field tensors in terms of electromagnetic potential, electromagnetic anti symmetric tensor, Maxwell's equation in covariant form, Lorentz transformation of electric and magnetic fields.

Recommended Books and References:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Classical Electrodynamics, J.D. Jackson,3rd Edn., m1998, Wiley.
3. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
6. Foundations of Electromagnetic Theory, Ritz, J. R. and Millford, F. J. Prentice Hall India
7. Electromagnetism, Slater, J. C., and Frank, N. H., Dover Publications, 2011
8. Fundamentals of Electromagnetism, Miah, W., Tata McGraw Hill, 1982
9. Feynman Lecture Series Volume II, 4. Feynman, R. P., Addison Wesley Longman
10. Principles of Electrodynamics, Melvin Schwart, Dovers publication,198.7

MPHC 2.12
ELECTRODYNAMICS (PRACTICAL)

Practical Credit: 2

1. To verify the Stefan`s law of radiation and to determine Stefan's constant.
2. To determine the Boltzmann constant using V-I characteristics of PN junction diode.
3. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
4. Study of microwaves characteristics through different dielectric medium.
5. To study the reflection, refraction of microwaves
6. To study the magnetic parameters of a magnetic material by hysteresis loop tracer.
7. Study of temperature variation of refractive index of a liquid using hollow prism and laser source.

Computational Lab

8. Applications of Smith Chart:
   a) Admittance calculations on any transmission line, on any load.
   b) Impedance calculations on any transmission line, on any load.
   c) Calculation of the length of a short circuited piece of transmission line to provide a required capacitive or inductive reactance.
9. Plot the electric field lines an equipotential lines for an arbitrary configuration of point source.
10. To study the radiation pattern for a simple Dipole antenna.
11. Using the numerical methods, with the help of Laplace/Poisson equation Dtermine potential at the free nodes in the potential systems.
12. To study the attenuation characteristic of electromagnetic wave in different media.

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, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11thEd., 2011, Kitab Mahal.
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

MPHC 2.21
QUANTUM MECHANICS-II

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Time Independent Perturbation Theory:** Non degenerate Perturbation Theory, First-Order Theory, Second-Order Energies. Degenerate Perturbation Theory, Two-Fold Degeneracy, Higher-Order Degeneracy, Fine Structure of Hydrogen, Relativistic Correction, Spin-Orbit Coupling, Thomas Precession, Energy Eigenvalues, Zeeman Effect, Weak Zeeman Effect, Lande g-factor, Bohr magneton, Strong-Field Zeeman Effect, Intermediate Zeeman Effect. Hyperfine Splitting.

UNIT II **Variational Principle:** Ground State Energy for Harmonic Oscillator, Delta Function Potential. Triangular Trial Wave Function in Infinite Well. Ground State of Helium, Hydrogen Molecular Ion.

UNIT III **WKB Approximation:** Basic principles and applications to particle in a box, harmonic oscillator, hydrogen atom. WKB approximation: Qualitative development and condition for validity of WKB approximation, Bohr's quantization condition, Applications to tunneling such as alpha particle, field emission. Einstein's coefficients.

UNIT IV **Time-Dependent Perturbation Theory:** Two-Level Systems. Sinusoidal Perturbations. Rabbi Flopping Frequency. Emission and Absorption of Radiations, Incoherent Perturbations. Spontaneous Emission, Lifetime of Excited States, Selection Rules. Magnetic Resonance.

UNIT V **Scattering:** Classical Scattering Theory, Hard Sphere Scattering, Differential Scattering Cross-Section, Total Cross Section. Rutherford Scattering. Quantum Scattering. Partial Wave Analysis, Rayleigh's Formula, Quantum Hard-Sphere Scattering. Phase Shifts. Born Approximation – First Approximations, Low-Energy Soft-Sphere Scattering, Yukawa Scattering, Born Series.

Recommended Books and References:

1. Quantum Mechanics – Leonard I Schiff, McGraw-Hill
2. Introduction to Quantum Mechanics – David J Griffiths, Prentice Hall
3. Principals of Quantum Mechanics – P A M Dirac, Oxford University Press
4. Quantum Mechanics – Eugene Merzbacher, John Wiley & Sons
5. Quantum Mechanics – A Ghatak and S Lokanathan, Trinity Press
6. A Textbook of Quantum Mechanics – Mathews and Venkatesan, McGraw Hill
7. Advance Quantum Mechanics – B S Rajput, Pragati Prakashan
8. Quantum Mechanics – M P Khana, Har-Anand Publications

MPHC 2.31
NUCLEAR AND PARTICLE PHYSICS

Theory Credit: 4

UNIT I **Nuclear properties:** Nuclear Properties, Measurement of Nuclear size and estimation of R_0, Deuteron system and its characteristic, Estimate the depth and size of (assume) square well potential, 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),nucleon-nucleon scattering-qualitative discussion on results, Spin-orbit strong interaction between nucleon, double scattering experiment

UNIT II **Nuclear Decay:** Review of alpha decay, introduction to Beta decay and its energetic, Energy release in Beta-decay, Fermi's theory of β-decay, Information from Fermi–curieplots, Comparative half lives, selection rules: Fermi and G-T transitions, Gamma decay, energies of gamma decays, selection rules multipole radiation, Selection rule for gamma ray transitions, Gamma ray interaction with matter, and Charge-particle interaction with matter, Detection and properties of neutrino.

UNIT III **Nuclear Reactions:** Review of nuclear reactions and conservation laws, cross section (σ), mean free path, definition/expression for σ, Low energies , Discrete and Continuum Region, Discrete region Resonance scattering, Derivation of the resonance cross section from phase shift description of cross section, Transmission through a square well and resonances in continuum, Continuum Region, Bohr's compound nucleus model, and its experimental verifications, Statistical parameters and their estimates for the continuum region. Direct Reaction, Cross section in terms of the T-matrix. Phase space, and its evaluation for simple cases, Lippmann Schwinger equation for the scattering wave function, and its formal solution.

UNIT IV **Nuclear Models:** Microscopic Models, Fermi-Gas Model: Symmetry, surface and Coulomb energy; Deformed shell model, Nilsson Hamiltonian, Single-particle energies in a deformed potential, Shell corrections and the Strutinski method, Hartree-Fock approximation: general variational principle, Hartree-Fock equations and applications,
Collective model, Review of Liquid drop model and mass formulas, Fission barriers and types of fission; Parameterization of nuclear surface deformations, Prolate and oblate shapes, Types of multipole deformations, Rotational states in axially symmetric deformed even-even and odd-A nuclei, Rotation of axially asymmetric nuclei.

UNIT V **Elementary Particle Physics:** Introduction to the elementary particle Physics, The Eightfold way, the Quark Model, the November revolution and aftermath, The standard Model, Revision of the four forces, cross sections, decays and resonances, Introduction to Quantum Electrodynamics, Introduction to Quantum Chromo dynamics. Weak interactions and Unification Schemes (qualitative description), Revision of Lorentz transformations, Four-vectors, Energy and Momentum, Properties of Neutrino, helicity of Neutrino, Parity, Qualitative discussion on Parity violation in beta decay and Wu's Experiment, Charge conjugation, Time reversal, Qualitative introduction to CP violation and TCP theorem, discovery of K-mesons, and hyperons Gellmann and Nishijima formula and Charm, Elementary ideas of CP and CPT invariance, SU(2), SU(3) multiples.

Recommended Books and References:

1. *Nuclear Physics* - *D.C. Tayal, Himalaya Publishing Co. (Bsc level)*
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. Bsc level*
7. *Introductory Nuclear Physics* - *Kenneth S. Krane, John Wiley (1988).*
8. *Physics of Nuclei and Particles* - *E. Segre.*
9. *Elements of Nuclear Physics* - *M.L.Pandya, R.P.S Yadav*
10. *Basic Nuclear Physics* - *B.N.Srivastava.*

MPHC 2.32
NUCLEAR AND PARTICLE PHYSICS (PRACTICAL)

Practical Credit: 2

This course aims at experiments in Basics Nuclear 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 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 Energy Cs-137 Spectrum and calculation of FWHM and resolution for given Scintillation detector.

Recommended Books and References:

1. *Radiation Detection and Measurement G. F. Knoll, John Wiley (1988).*
2. *Nuclear Electronics P. W. Nicholson, Wiley, London (1974).*

MPHC 2.41
CONDENSED MATTERPHYSICS-I

Theory Credit: 4

UNIT I **Crystal Structure, Lattice Vibrations And Specific Heat Of Solids Lattice vibration:** Review of the crystal structure and Bragg's law, electronic specific heat, Einstein and Debye theory of specific heat of solids, Dispersion relation in linear monoatomic and diatomic liner lattices, quantization of lattice vibration-phonon, acoustical and optical mode, Scattering of X-rays, neutrons and light by phonons, Thermal conductivity- Umklapp process, imperfections
Free electron theory of metals: The free electron gas, Fermi energy and Fermi function, thermal conductivity and electrical conductivity, Wiedemann-Franz law, Limitation offree electron theory in metals.

UNIT II **Energy Bands In Solids:** Origin of the energy gap, Bloch theorem , Kronig Penny model (band theory of solids), Motion of electrons in periodic potential, effective mass of electrons and holes, nearly free electron approximation, the tight binding approximation, application to a simple cubic crystal, Brillouin zones in two and three dimension, Fermi surfaces of metals, de Hass-van Alphen effect, limitations of band theory.

UNIT II **Elements of Semiconductor Physics:** Intrinsic and extrinsic semiconductors, mobility, drift velocity and conductivity of intrinsic semiconductor, density of carriers in intrinsic and extrinsic semiconductors, recombination processes, photoconductivity Variation of Fermi level with temperature and carrier concentration, conductivity and their variation with temperature, direct and indirect band gap semiconductors, thermo electric effect, Zener tunneling

UNIT IV **Dielectrics and Ferroelectrics:** Langevin's theory of polarization in dielectrics, local field in liquid and solids, The electronic, ionic and orientation polarizabilities, measurement of dielectric constant of a solid, Clausius-Mosotti relation, relation between dielectric constant and refractive index Behavior of dielectrics in an alternating field, general properties of ferroelectric materials and classification, Dipole theory of ferro electricity, dielectric relaxation, anti-ferroelectricity, behavior of $BaTiO_3$ and theory of spontaneous polarization, Curie-Weiss law.

UNIT V **Magnetic Properties:** Review of classical and quantum theory of paramagnetism, susceptibilities of free electrons, molecular field theory of ferromagnetism, anti-ferromagnetism and ferrimagnetism, anisotropic energy, electron paramagnetic resonance and nuclear magnetic resonance, Bloch equations, Heisenberg, Hamiltonian for exchange interaction, relationship between exchange energy and molecular field, Pauli paramagnetism, exchange interaction, spin waves and magnons, dispersion relation, neutron scattering from magnetic materials-structure studies, elements of ferri-magnetism and antiferro-magnetism, Neel temperature.

Recommended Books and References:

1. Kittel, C., Introduction to Solid State physics 7th Edition (Wiley, Eastern Ltd., 1996).
2. Dekker, A. J., Solid State Physics (Macmillan India Ltd., 2003).
3. Ashcroft, N. W. & Mermin, N. D., Solid State Physics (Saunders, 1976).
4. Ibach, H. & Luth, H., Solid State Physics, (Springer-Verlag).
5. Azaroff, L.V., Introduction to Solids, (Tata McGraw Hill, 1977).
6. Pillai, S.O., Solid State Physics, (New Age International Publishers).
7. Ziman, J.M., Principles of theory of solids (Cambridge University Press)
8. Omar, M. A., Elementary Solid State Physics (Pearson).

MPHC 2.42
CONDENSED MATTERPHYSICS-I (PRACTICAL)

Practical Credit: 2

SEMESTER – III

MPHC 3.11
EMBEDDED SYSTEMS: INTRODUCTION TO MICROCONTROLLERS

Theory Credit: 4

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.
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 II **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, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation.

UNIT III 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 IV **Timer and counter programming**: Programming 8051 timers, counter programming.
Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051.
Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing.

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. Introduction to Arduino: Pin diagram and description of Arduino UNO. Basic programming.

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 microcomputor 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 3.12
EMBEDDED SYSTEMS: INTRODUCTION TO MICROCONTROLLERS (PRACTICAL)

Practical Credit: 2

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's.
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9. To toggle '1234' as '1324' in the seven segment LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard. Arduino based programs and experiments:
12. Make a LED flash at different time intervals.
13. To vary the intensity of LED connected to Arduino
14. To control speed of a stepper motor using a potential meter connected to Arduino
15. To display "PHYSICS" on LCD/CRO.

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 Microcomputor System: Real Time Interfacing, J.W. Valvano, 2000, Brooks/Cole
4. Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.
5. Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

MPHC 3.21
ATOMIC AND MOLECULAR SPECTROSCOPY

Theory Credit: 4

UNIT I **Spectra of atom:** Review (Bohr's atomic model and spectrum of hydrogen atom, Vector atom model: quantum numbers, selection rules, magnetic moments of an atom and Lande's g factor, spin-orbit coupling, spectral terms and selection rules) Sommerfeld theory of hydrogen atom: Sommerfeld elliptical orbits, total energy, relativistic correction. Fine structure of H_α and He^+ line, Stern and Gerlach experiment, Different series in alkali spectra, Ritz combination principle, Term values in alkali spectra and quantum defect, Spin orbit interaction, Non-penetrating and penetrating orbits, Hyperfine structure of spectral lines, Isotope shift, Width of spectral lines

UNIT II **Molecular structure:** Variation method of chemical bonding and its application, LCAO-MO wave functions, comparison of molecular orbital (MO) and valence bond

(VB) theories, Hydrogen molecule ion, Hydrogen molecule, Born Oppenheimer approximation, Rotation and vibration of diatomic molecule, Moment of inertia and bond length of diatomic and linear triatomic molecule, quantum theory of Raman effect

UNIT III **Molecular spectra:** Types of molecular energy states and associated spectra, Types of spectra Electronic spectra, Frank-Condon principle, Pure rotational spectra: rotational energy levels of diatomic molecule as rigid rotator, energy levels and rotational constant on applying Schrodinger's equation, Diatomic molecule as non-rigid rotator, pure rotational Raman spectra, Vibrational spectra: Vibrating diatomic molecule as a harmonic oscillator, Vibrational- rotational spectra, Vibrating diatomic molecule as anharmonic oscillator.

UNIT IV **Spin resonance spectroscopy I:** Nature of spinning particles, interaction between spin and a magnetic field, population of energy levels, Larmor precession, Nuclear magnetic resonance (NMR): energy levels, chemical shift, relaxation mechanisms, experimental method- continuous wave mode and Fourier transform mode, application of NMR in medicine. Electron spin resonance (ESR): interaction with magnetic field,g factor, ESR spectrometer, relaxation mechanism, fine and hyperfine structure of ESR, double resonance in ESR

UNIT V **Spin resonance spectroscopy II:** Nuclear quadrupole resonance (NQR): quadrupole nucleus, principle, transitions for axially symmetric and non-axially symmetric system with respect to integral and half integral spin, NQR instrumentation: regenerative continuous wave oscillator method, Mössbauer spectroscopy: Mössbauer effect, recoiless emission and absorption, Mössbauer spectrometer, chemical shift, quadrupole interaction, magnetic hyperfine interaction, Basics of Auger spectroscopy, X-ray photoelectron spectroscopy, Scanning tunnelling spectroscopy, circular dichroism spectroscopy.

Recommended Books and References:

1. Introduction to Atomic Spectra – H E White, McGraw-Hill
2. Fundamentals of Molecular spectroscopy – Colin N Banwell and Elaine M McCash, McGraw-Hill
3. Fundamentals of Molecular Spectroscopy – Walter S Struve, John-Wiley & Sons
4. Mössbauer Spectroscopy – N N Green wood and T C Gibb, Chapman and Hall Ltd
5. Nuclear Magnetic Resonance – E R Andrew, Cambridge University Press
6. Molecular Spectra and Molecular Structure – G Herzberg, Prentice Hall
7. Elements of Spectroscopy – Gupta, Kumar, Sharma, Pragati Prakashan
8. Molecular Structure and Spectroscopy – G Aruldhas, PHI Learning Private Limited

MPHC 3.22
ATOMIC AND MOLECULAR SPECTROSCOPY (PRACTICAL)

Practical Credit: 2

1. To study the absorption spectrum of iodine vapour and to calculate electronic energy gap, vibrational energies and force constant for its excited state.
2. To study fine structure of Hg spectral lines using constant deviation spectrometer.
3. To determine the value of Rydberg constant with the help of grating spectrometer using hydrogen gas discharge tube.
4. Study of Zeeman Effect.

Computational lab (by using SCILAB)

5. Analysis of atomic spectra.
6. Analysis of electronic spectra of molecule and liquid.
7. Analysis of rotational spectra of molecule and liquid.
8. Analysis of vibrational spectra of molecule and liquid.

Recommended Books and References:

1. BSc. Practical Physics – C L Arora
2. Experiments in Modern Physics – Mellissino
3. Advance Practical Physics – Worsnop and Flint.

SEMESTER – IV

MPHC 4.11
COMPUTATIONAL PHYSICS

Theory Credit: 4

UNIT I **Introduction of Numerical analysis & Algebraic Equations:** Introduction to numerical analysis, the need for numerical analysis and its limitations, Concept of different types of errors with examples, stable computation, successive approximations, Maclaurin's series, Taylor's series for two dimensional function, polynomial evaluation, error corrections using table of differences, Solution of transcendental equations, Solving an equation with Newton-Raphson method and bisection methods, comparison of their limitations, propagation of errors, Concept of numerical stability—von Neumann stability analysis with examples, importance Courant-Friedrichs - Lewy (CFL) condition, Implicit and explicit schemes,

UNIT II **Matrices and Linear Algebric Equations:** Pivotal condensation method, systems of linear equations, manipulation of matrix, Gauss Elimination method, Gauss Seidel iteration method, concept of pivoting, partial and complete pivoting, complete pivoting, Solution of linear equations, Gauss-Jordan elimination, matrix inversion, Eigen values and Eigen vectors.

UNIT III **Interpolation & Curve Fitting:** Concept of interpolation, linear interpolation, quadratic interpolation, Lagrange's interpolation, Richardson's extra polation, Newton's interpolation, Aitken's interpolation. Curve fitting, least square method, curve fitting for a straight line, curve fitting for a power law equation. interpolation by spline function

UNIT IV **Numerical Differentiation and Integration:** The concept of numerical differentiation and integration, differentiation for Taylor's series, partial differentiation
Integration method- quadrature, Trapezoidal and Simpson's rules and their relation to interpolation, Newton-Cotes formulae, Gauss quadrature.

UNIT V **Differential Equations:** Solution of ordinary differential equations (ODEs), concept of finite differencing, Solution of a first order ODE with Euler's method and its limitations, Euler-Richardson's method, Taylor's series method, need for a higher-order method — solution of a first order ODE with Runge-Kutta method, predictor-corrector methods, Milne's predictor corrector method, Solving higher order ODE — coupled ODEs, partial differential equations.
Partial differential equations (PDEs), the concept of initial and boundary value problems — solving the Poisson equation by Gauss-Siedel iteration, initial value problem.

MPHC 4.12
COMPUTATIONAL PHYSICS (PRACTICAL)

Practical Credit: 2

Write a algorithm for a given exercise and execute the algorithm by using a computer programming of choice (Fortran/C/C++/SCILAB)

1. To find the root of a given equation f(x) =0 in the interval [a,b] by any one of the following method (a).Bisection method (b) Newton-Raphsen method.

2. To solve the given linear systems AX=B by any one of the following methods (a) Gauss-Seidel iteration. (b) Gauss-Jordan elimination. (c) matrix inversion.
3. Find out the eigen values and eigen vectors of a given matrix.
4. Find a interpolated value for a any given set of data by any one of the following method (a) linear interpolation. (b) quadratic interpolation. (c) Lagrange's interpolation. (d) Richardson's extrapolation. (e) Newton's interpolation. (f) Aitken's interpolation.
5. Integrate a given function or series by any given method (a) Limits method (b). Extrapolation method.
6. Integrate a given function by any one of a given method (a) Quadrature formula (b). Trapezoidal rule (b) Simpson' s rule
7. Solve a given ODE by any one of the given method (a) Eulers method (b)Euler-Richardson method, (c). Taylor series method(d). Runge-Kutta method.
8. Solve a given parabolic partial differential equation (Heat equation) by any given method.
9. Solve a given elliptic partial differential equation (Laplace /Poisson/Helmholtz equation)by any given method.

Recommended Books and References:

1. K. E. Atkinson, Numerical Analysis, John Wiley (Asia) (2004).
2. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw Hill (2002).
3. J. D. Hoffman, Numerical Methods for Engineers and Scientists, 2nded. CRC Press, Special Indian reprint (2010).
4. J. H. Mathews, Numerical Methods for Mathematics, Science, and Engineering, Prentice Hall of India (1998).
5. S. S. M. Wong, Computational Methods in Physics, World Scientific (1992).
6. W. H. Press, S. A. Teukolsky, W. T. Verlling and B. P. Flannery, Numerical Recipes in C, Cambridge (1998).
7. Numerical Recipes, W H Press et al. (Cambrideg University Publication).
8. Introduction to Numerical Methods T. R. McCalla
9. An Introduction to Numerical Analysis K. E. Atkinson.
10. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
11. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
12. Getting started with Matlab, Rudra Pratap, 2010, Oxford University Press.

MPHC 4.21
EXPERIMENTAL METHOD

Theory Credit: 4

UNIT I **Measurements:** Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution.
Signals and Systems: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise

UNIT II Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference.
Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems.

Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration.

UNIT III Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector.

UNIT IV Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.
Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge.
Oscilloscope: Block diagram and working principles of CRO

UNIT V Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization.

Recommended Books and References:

1. Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
2. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
3. Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
4. Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
5. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
6. Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer.

MPHC 4.22
EXPERIMENTAL METHOD (PRACTICAL)

Practical Credit: 2

Experimental Techniques

1. An exercise for the statistical analyses of a given set of data.
2. Determine output characteristics of a LVDT & measure displacement using LVDT
3. Measurement of Strain using Strain Gauge.
4. Measurement of level using capacitive transducer.
5. To study the characteristics of a Thermostat and determine its parameters.
6. Study of distance measurement using ultrasonic transducer.
7. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
8. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
9. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
10. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.
11. To design and study the Sample and Hold Circuit.

12. Design and analyze the Clippers and Clampers circuits using junction diode
13. To plot the frequency response of a microphone.
14. To measure Q of a coil and influence of frequency, using a Q-meter.

Recommended Books and References:

1. Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill
3. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

DISCIPLINE SPECIFIC ELECTIVE 1

MPHD 3.11(a)
CONDENSED MATTER PHYSICS-II

Theory Credit: 4

UNIT I **Crystal Imperfections and Diffusion in Solids:** Classification of imperfection, crystallographic imperfections, point defects, Impurities, lattice Vacancies and interstitial atoms, Schottky and Frankel vacancies, Color centers and coloration of crystals, F-centres, Line defects (dislocations), Edge and screw dislocations, Berger Vector, slip and yields, shear strength of single crystals, edge dislocations, Burger circuit, screw dislocation, dislocation motion, climb ,strain due to dislocation motion, stress field around dislocation, plane defect, Planar (stacking) Faults, Grain boundaries, Low angle grain boundaries, dislocation and crystal growth, the Hydration energy of ions, Activation energy for formation of defects in ionic crystals, Ionic conductivity in pure alkali halides, Diffusion in solids, Fick's law.

UNIT II **Superconductivity:** The phenomenon of superconductivity, Perfect conductivity and Meissner effect, Electrodynamics of superconductivity: London's equations, Thermodynamics of the superconducting phase transition: Free energy, entropy and specific heat jump Ginzburg-Landau theory of superconductivity: GL equations, GL parameter and classification into Type I and Type II superconductors, The mixed state of superconductors ,Microscopic theory, the Cooper problem, The BCS Hamiltonian, BCS ground state Josephson effect: dc and ac effects, Quantum interference, Super conducting materials and applications: Conventional and High Tc superconductors, superconducting magnets and transmission lines, SQUIDs.

UNIT III **Nano Physics:** Nano materials, bottom up and top down approaches, elementary properties of nano materials and applications, tools to make nanostructures , electron beam evaporation, Sputtering, Ion beam assisted deposition, CVD, Sol-gel coating, Increased surface to volume ratio, Interface effect, Physics of low dimensional structures, Widening of band gap in quantum dots, Strong and weak confinement, Size dependent absorption spectra and blue shift, Coulomb blockade, Metallic nano particles, Surface Plasmon Resonance, Particle size and magnetic behavior, Super-para magnetism, Ultra soft-magnetism, Magneto transport, Ferro fluids, Spintronics, Magnetron sputtering, Pulsed laser deposition, , Lithography, Mechanical alloying .

UNIT IV **Thin Film Physics:** Mechanism of thin film formation, Formation stages of thin films, Condensation and nucleation, Thermodynamic theory of nucleation, Growth and coalescence of islands, Influence of various factors on final structure of thin films, Crystallographic structure of thin films, Properties of thin films, Conductivity of metal films, Electrical properties of semi conductor thin films, Transport in dielectric thin films, Dielectric properties of thin films, optical properties of thin films, Thin films of high temperature superconductors, Diamond like carbon thin films, Study of structure of thin films using X-ray diffraction method, Uses of thin film in Resistors, Capacitors, Field effect transistors.

UNIT V **Thin Films Preparation, Measurement & Characterization:** Vacuum evaporation, Cathode sputtering, Anodic oxidation, Chemical vapour deposition(CVD), Ion-assisted deposition(IAD), Laserablation, Longmuir Blochetfilm, Sol-gelfilm deposition, thickness measurements, Resistance, capacitance, microbalance, Quartz crystal thickness monitor, Optical absorption, Multiple beam interference, Chemical composition and Structural characterizations, Scanning electron

microscopy (SEM), Energy dispersive analysis of X-rays (EDAX), UV-VIS spectroscopy, Raman spectroscopy, Electron spin resonance(ESR), X-ray fluorescence (XRF), Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), Scanning tunneling microscopy(STM), Atomic force microscopy (AFM).

Recommended Books and References:

1. Kittel, C., Introduction to Solid State physics 7th Edition (Wiley, Eastern Ltd., 1996).
2. Dekker, A. J., Solid State Physics (Macmillan India Ltd., 2003).
3. Ashcroft, N. W. &Mermin, N. D., Solid State Physics (Saunders, 1976).
4. Ibach, H. & Luth, H., Solid State Physics, (Springer-Verlag).
5. Azaroff, L.V., Introduction to Solids, (Tata McGraw Hill, 1977).
6. Pillai, S.O., Solid State Physics, (New Age International Publishers).
7. Ziman, J.M., Principles of theory of solids (Cambridge University Press)
8. Omar, M. A., Elementary Solid State Physics (Pearson).
9. A. Goswami, "Thin film Fundamentals", New Age International Publishers, (1996).
10. K. Seshan, "Hand Book of Thin Film Deposition Technique", William Andrew INC, (2002).
11. D. L. Smith, "Thin film deposition", McGraw-Hill Professional (1995).
12. A. Elshabini-Riad and F. D. Barlow, "Thin Film Technology Hand Book", McGraw-Hill Professional, (1997).
13. K. D. Sattler (Ed.), Handbook of Nanophysics, CRC Press, 2011.
14. Bhushan (Ed.), Springer Handbook of Nanotechnology, Springer, 2004.
15. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press,2004.
16. C. P. Poole, J. F. J. Owens, Introduction to Nanotechnology, Wiley Interscience, 2003.
17. B. D. Cullity and S. R. Stock, Elements of X-ray Diffraction, Prentice Hall, 2001.

MPHD 3.12(a)
CONDENSED MATTER PHYSICS-II (PRACTICAL)

Practical Credit: 2

List of Experiments

1. Characterization of thin films using XRD and particle size determination using Scherrer's formula, lattice parameters, Strains etc.
2. Determine the average particle size and elemental analysis from FESEM and EDS images
3. Surface morphological characterization of nanomaterials from AFM images
4. Surface morphological characterization of nanomaterials from TEM images
5. Analysis of UV/Vis Absorption spectrum of nanomaterials
6. Analysis of Photoluminescence spectrum of nanomaterials
7. Analysis of FTIR image spectrum of nanomaterials
8. Determination refractive index, thickness and band gap of a semiconductor sample using UV-VIS-NIR Spectroscopy

MPHD 3.11(b)
REMOTE SENSING OF THE ATMOSPHERE

Theory Credit: 4

UNIT I **Satellite Meteorology:** Remote Sensing, Principles of Remote Sensing, Application in Meteorology, Introduction to Satellite Meteorology including Orbital Mechanics.) Meteorological Satellites, Polar Orbiting, Geostationary satellites, Current and future meteorological satellites of the world. Payloads on Meteorological Satellites, NOAA, INSAT -3D, Metop.
Processing of data from Imagers, INSAT Meteorological Data Processing System (IMDPS). Generation of images in various channels. Retrievals of meteorological products from the imager data including water vapor. Atmospheric motion vectors, Sea Surface Temperature and Upper Troposphere Humidity (UTH), Outgoing Long wave Radiation (OLR), Quantitative Precipitation Estimates (QPE), Rainfall, Fog, Minor atmospheric constituents/aerosols/ Fire /smoke,

UNIT II Principles of Sounding, Processing of data from Infrared and Microwave Sounders. Retrieval of products from sounder, Vertical temperature, humidity and ozone profiles. Interpretation of Satellite images of various channels and identification of typical clouds and weather systems from cloud imageries, use of various satellite derived products, satellite Bulletin and its interpretation. Tropical cyclone, its identification and grading using Dvorak's technique.

UNIT III Radar Meteorology Radar principles. Doppler Radar, Wind profiler, MST Radar, LIDARS Scattering of microwaves by precipitation / precipitating particles. Scattering by a sphere, Scattering by rain and ice crystals. Minimum detectable power, receiver noise, radar equation for a point target, part played by various parameters in the radar equation. Radar equation for an extended target. Practical importance of radar set constants and the radar cross section. Effect of wavelength, wave lengths commonly used. Types of scans used in weather radar, their merits. Classification of radar echoes. Convective and stratiform types, bright band echo from lightening, tornadoes, squall lines. Study of severe storms and cyclones, Measurement of rate and amount of precipitation, effect of circular polarization, use of circular polarization in weather radar research, non-precipitating / precipitation echoes, super-refraction, limitations of weather radar.

UNIT IV Doppler radar Doppler radar principles and its limitations. Doppler principle of velocity measurement, unambiguous velocity and range. Doppler dilemma. Spectrum width. Introduction to DWR (Physical visualisation/inspection), RAINBOW workstation.
Principles of dual polarized doppler radar. Advantages over conventional doppler radar techniques. Radar base products and derived products Introduction to reflectivity products and their utilization. Detection of turbulence, shear, gust front, microburst, and tornado, , icing hail probability and hail size, determination and tracking, TC structure, intensity, rainfall distribution and other parameters, inputs for storm surge prediction

UNIT V **Digital Image Processing:** Basic principal of Digital Image Processing, Digital Image, Digital Image data formats, Enhancement techniques, Gray scales, Pseudo Color Images. 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.

MPHD 3.12(b)
REMOTE SENSING OF THE ATMOSPHERE (PRACTICAL)

Practical Credit: 2

1. To simulate the brightness temperature from the radiance observations at various spectral bands.
2. Interpretation of Satellite images of various channels and identification of typical clouds and weather systems from cloud imageries
3. To study the of temperature sounding observations from a geostationary satellite
4. To study the of humidity sounding observations from a geostationary satellite
5. To compute radar reflectivity factor from the rain DSD observations.
6. To compute the rain intensity and rain accumulation from the time series data of rain DSDs.
7. Identify the bright band structure from the reflectivity profiles during the stratiform rain.
8. To estimate the height and width of the bright band from the Micro rain radar observations.
9. Identify the convective core region and startiform region from the volume observation from DWR.
10. Develop a empirical Z-R relation for a given set of radar and rain intensity observations.

Recommended Books and References:

1. Radar Observation of the Atmosphere By Battan (1973),
2. Polarimetric Doppler Weather Radar By Bringi and Chandrasekar (2001), , Cambridge Press
3. Doppler Radar and Weather Observations By Doviak and Zrnic (1984, 1993), , Academic Press
4. Radar in Meteorology, Atlas (1990), AMS (Battan Memorial volume)
5. Radar and Atmospheric Science: A Collection of Essays in Honor of David Atlas (2003), AMS
6. Theory of Satellite Orbit in the Atmosphere by King Hele
7. Numerical Analysis by Shastri
8. Weather Satellite by L.F. Hubert
9. Meteorological Satellite by W.K. Widger
10. A guide to Earth Satellite by D. Fishlock
11. Advances in Satellite Meteorology by VinnichenkoGoralik
12. Satellite meteorology by Henri W. Brandli
13. Satellite Meteorology - WMO Technical Notes No. 124 and 153.
14. Satellite Meteorology, by R.R. Kelkar AS-19-L:

MPHD 3.11(c)
HIGH ENERGY PHYSICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Four fundamental interactions, classification, Classification of elementary particles by masses, interactions and conserved quantum numbers, selection rules for particle decays and scattering, Particle detectors and accelerators, cloud and bubble chambers, emulsion techniques, electronic detectors, proportional counters, fixed target and collider machines, basic idea of cyclotron and synchrotron, Relativistic energy-momentum relation, Klein-Gordon equation, solutions of the equation, probability conservation problem, relation with negative energy states.

UNIT II Dirac equation, algebra of matrices, conservation of probability, solutions of Dirac equation, helicity and chirality, Lorentz covariance, bilinear covariant, trace relations and similar identities, C, P and T invariance of the Dirac equation, structure of the QED Lagrangian, gauge invariance and conserved current, scalar electrodynamics, Feynman rules for QED (no derivation), Feynman diagram calculation for $e^+ e^- \longrightarrow \mu^+ \mu^-$.

UNIT III phase space integration, Møller and Bhabha scattering, polarisation vectors, Compton scattering and pair creation/annihilation, Klein-Nishina formula, concept of multi-loop diagrams (no computation), momentum integral, UV and IR singularities, idea of regularisation, running coupling constant, Isospin and strangeness, introduction to unitary groups, generators, Casimir invariants, fundamental and adjoint representations, root and weight diagrams, meson and baryon octets, baryon decuplet and the prediction of the Ω^-, Gell-Mann-Nishijima formula.

UNIT IV Product representations andirreps, symmetry group, Youngtableaux, quarkmodel, meson and baryon wave functions, elastic scattering off a point particle, form factors, Rosenbluth formula, Breit frame, inelastic scattering, structure functions, dimensionless variables. Bjorkenscaling, parton model, structure functions interms of PDFs, Callan - Gross relation, kinematic regions, valence and sea quarks, gluons.

UNIT V Betadecay,FermiandGamow-Tellertransitions,current-currentformofweak interactions, Fermi constant, unitarity violation at high energies, Intermediate vector boson, $W^{\pm}$bosons, requirement of conserved currents, muon decay, pion decay, form facto, Parity violation, intrinsic parity, parity conservation in strong and electromagnetic interactions, parity violation in weak interactions, maximal parity violation, flavour Mixing and CP Violation, FCNC suppression, Cabibbo hypothesis, kaon decays, theta-tau puzzle, regeneration experiment, GIM mechanism, CKM matrix and quark mixing.

Recommended Books and References:

1. 1.Introduction to Elementary Particles, by D. Griffiths (Wiley 1987).
2. 2.Quarks and Leptons, by F. Halzen and A.D. Martin (Wiley 1984).
3. 3.Particle Physics, by B.R. Martin and G. Shaw (Wiley 2008).
4. 4.Quarks and leptons : An introductory course in Modern Particle Physics - Francis Halzen and Alan D Martin.
5. Gauge Theory of Elementary Particle Physics – Ta-Pei Cheng and Ling Fong Li.
6. 6.Quantum Field Theory - L H Ryder.
7. 7.Relativistic Quantum Fields - James D Bjorken and Sidney D Drell

DISCIPLINE SPECIFIC ELECTIVE 2

MPHD 3.21(a)
ASTRONOMY AND ASTROPHYSICS

Theory Credit: 4

UNIT I **Positional astronomy:** Basics of spherical trigonometry, the celestial sphere, circles on celestial sphere, cardinal points, spherical triangle, season, motions of earth-spin, revolution, obliquity, tilt, eccentricity. Equinotical points, solstices, constellations Geographic coordinate systems, Astronomical coordinate systems-equatorial, ecliptic and galatic. Diurnal motion of stars, circumpolar star. Measurement of time, sidereal time, apparent solar time, mean solar time, equation of motion.

UNIT II **Astronomical Measurements and Telescopes:** Magnitude systems, apparent and absolute magnitudes, distance modulus, color index, Atmospheric extinction, seeing and scintillation. 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 couples devices(CCD), detection limits with telescopes.

UNIT III **Energy transport and structure formation in stars:** Energy transport in star-concept of flux, intensity and temperature formation of emission and absorption line, limb darkening, ionization and the concept of mean molecular weight, Saha's ionization equation, stellar opacity, transfer equation. Structure formation: Interstellar medium (ISM), various nebulae, Jeans condition for collapse, proto star, star formation, stellar cluster-open and Globular, Variable stars, period-time relation, Binary star-type of binaries.

UNIT IV **Stellar structure and evolution:** Virial theorem, hydrostatic equilibrium, integral theorem on pressure, density and temperature, polytropes gas sphere, Lane-Eamden equation and its solutions, energy generation in stars P-P and C-N cycles. Stellar evolution: H-R diagram, Hayashi phase, main sequence, Horizontal branch and red giant and asymptotic giant branches.

UNIT V **Compact objects and high energy astrophysics:** Compact objects: white dwarfs and Chandrasekhar limit, Neutron star and Black hole, Pulsars, X-ray and gamma-ray sources. Radiation processes: Thermal radiation- Black body, Bramstrahlung, Non thermal- cyclotron, synchrotron, inverse Compton emission, interaction of high energy particle and photon with matter.

Recommended Books and References:

1. R.C. Smith Observational Astrophysicvs; CUP 1995
2. F. Shu,The Physical universe: an introduction to Astronomy; Unversy Science Books, Saualito
3. C.R. Kitchin, Astrophysical techniques; Adam Hilger,1984
4. Text Book of Spherical Astronomy – W.M.Smart
5. R.J. Tayler, The stars: their structure and evolution; CUP 1994.
6. H.Harwit, Astrophysical concepts: Springer Verlag 1988.
7. M.S. Longair, High energy Astrophysics, Vols I and II ; CUP
8. G.B. Rtbicki and A.P. Lightman, Radiative Processes in Astrophysics; wiley-VCH
9. Modern Astrophysics, B.W. Carroll and D.A. Ostlie, Addison-Wesley Publishing co.
10. Fundamentals of Astronomy (fourth Edition), H. Karttunen et al. Springer
11. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
12. An Introduction to Astrophysics, B. Basu, T Chattopadhyay and S.N. Biswas. PHI learning private limited.

MPHD 3.22(a)
ASTRONOMY AND ASTROPHYSICS (PRACTICAL)

Practical Credit: 2

1. Polar aligning a telescope and measuring declination of polaris.
2. Determination of plate scale of a given astronomical telescope.
3. Determination of diameter of moon by transit.
4. Determination of diameter of sun by transit.
5. Measuring the distance to Moon by parallex method.
6. Measuring rotation speed of sun using sunspots.
7. Application of Image processing software (IRAF) to determine magnitude of different stars in a star field.

8. Application of Image processing software (IRAF) to determine angular separation of different stars in a star field.
9. Installation of HEAsoft software and plotting light curve.

Note:
Also, the above list is tentative, changes in the list of experiments may be made, depending on the availability of the equipment and other considerations

MPHD 3.21(b)
DIGITAL SIGNAL PROCESSING

Theory Credit: 4

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.

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.

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.

UNIT IV **Fast Fourier Transform**: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), 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.

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.

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, 3rd Edn. Oxford University Press.
4. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris
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 D.G. Manolakis, 2007, 4th Edn., Prentice Hall.

MPHD 3.22(b)
DIGITAL SIGNAL PROCESSING (PRACTICAL)

Practical Credit: 2

Scilab based simulations experiments based problems like

1. Write a program to generate and plot the following sequences:(a) Unit sample sequence δ(n), (b) unit step sequence u (n), (c) ramp sequencer(n) , (d) real valued exponential sequence $x(n)(0.8)^n$ u(n) for$0 \le n \ge 50$.
2. An LTI system is specified by the difference equation Y(n) = 0.8 y(n-1)+x(n)
   (a) Determine $H(e^{j\omega})$
   (b) Calculate and plot the steady state response to $y_{ss}(n)$to x(n) =cos(0.5πn) u(n)
3. Given a casual system y(n) =0.9y(n-1)+x(n)
   (a) Find H(z) and sketch its pole-zero plot
   (b) Plot the frequency response$\left| H(e^{j\omega}) \right|$ and $\angle H(e^{j\omega})$
4. Design a digital filter to eliminate the lower frequency sinusoid of x (t) =sin7t + sin200t. The sampling frequency is 500 Hz. Plot its pole zero diagram, magnitude response, input and output of the filter.
5. Using a rectangular window, design a FIR low pass filter with a pass band gain of unity, cutoff frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.
6. Design a FIR filter to meet the following specifications
   Pass band edge Fp = 2 KHz;Stopband edge Fs = 5 KHz
   Passband attenuation Ap= 2dB; Stopband attenuation As =42 dB;
   Sampling frequency Fs = 20 KHz
7. The frequency response of a linear phase digital differentiator is given by

$$H_d(e^{j\omega}) = j\omega(e^{-j\tau\omega}) |\omega| \le \pi$$

   Using a Hamming window of length M= 21, design a digital FIR differentiator. Plot the amplitude response.

MPHD 3.21(c)
PLASMA PHYSICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Fundamentals of Plasma Physics:** Plasma State: Ionized gas, Saha's ionization equation; Collective degrees of freedom, Definition of Plasma, Concept of Plasma temperature, Debye shielding, Quasi-neutrality, Plasma parameters, Plasma approximation, Natural existence of Plasma.
Single-particle motion: Dynamics of charged particles in electro-magnetic fields, Particle drifts, EXB drifts, Grad-B drift, Curvature drift, Polarization drift, Adiabatic invariants and their technological applications.
Kinetic theory of Plasma: Vlasov equations, Solution of linearized Vlasov equation, Langmuir waves, Ion-sound waves, Wave-particle interaction and Landau damping.
Fluid theory of Plasma: Plasma oscillations, Electron-acoustic waves, Ion-acoustic waves Electrostatic ion-waves perpendicular to magnetic field, Electromagnetic waves perpendicular to magnetic field.

UNIT II **Plasma Generation:** Basic principles of gas discharge physics: Electrical breakdown, Generation of thermal and nonthermal plasma, DC and RF (radiofrequency) discharges, Microwave discharge, Dielectric barrier discharge. Fundamentals of vacuum technology: Vacuum pumps- rotary, diffusion and turbo-molecular pumps, Low pressure measurement systems in laboratory plasma-pressure gauges. Plasma diagnostic methods: Electric probes (Langmuir and emissive probe), Electric probe characteristics and measurement of plasma parameters (plasma potential, electron & ion density, electron temperature etc.), Magnetic probes, Mass and optical spectroscopy.

UNIT III **Application of Plasma**: Thermonuclear fusion- present status and problems, Requirements for fusion plasmas- confinement, beta, power and particle exhaust, Tokamak fusion reactors. Dusty plasma in laboratory and space, Dust charging processes, Waves in dusty plasma, Dust crystal. Laser plasma interaction, Inertial confinement, High-harmonic generation, Laser wakefield electron accelerator, X-ray laser. Plasma engineering, Industrial applications of plasma.

UNIT IV **Nonlinear Plasma Physics:** Nonlinear Debye shielding, Evacuation of the Debye sphere, Basics of exotic plasma effects: Plasma as exotic medium, Shielding in three spatial dimensions.
Weakly nonlinear processes: Concept of nonlinearity and dispersion, Weakly nonlinear and weakly dispersive waves, Wave energy alteration with dispersion and dissipation mechanisms, Shock & soliton formation, Nonlinear wave equations and asymptotic integrations.
Strongly nonlinear processes: Excitation of strongly nonlinear and strongly dispersive waves, Energy integral methods, Nonlinear coherent structures in complex plasmas, Astrophysical cosmic-space applications.

UNIT V **Plasma in space:** Introduction to the interstellar medium: Neutral and ionized gas, gaseous nebulae, HII regions, supernova remnants, photo-dissociation regions, different phases of the interstellar medium: cold neutral medium, warm neutral and ionized medium, hot medium, diffuse clouds, dense clouds, Radiative processes: Radiative transfer, emission and absorption coefficients, emission and absorption lines, the role of thermal and free electrons

Recommended Books and References:

1. Bellan, P. M., Fundamentals of Plasma Physics, 1st edition (Cambridge University Press, 2008)
2. Chen, F. F., Introduction to Plasma Physics and Controlled Fusion, 2nd edition, Vol. 1, (Plenum, New York, 1984)
3. Nicholson, D.R., Introduction to Plasma Theory (Wiley, USA, 1983).
4. Swanson, D. G., Plasma Waves (IoP, Bristol, 2003).
5. Bittencourt, J. A., Fundamentals of Plasma Physics (Springer, New York, 2004).
6. Cap, F. F, Handbook on Plasma Instabilities (Academic Press, New York, 1976).
7. Hutchinson, I. H., Principles of Plasma Diagnostics, 2nd edition, (Cambridge University Press, 2002)
8. Shukla, P. K. and Mamun, A. A., Introduction to Dusty Plasma Physics (IoP, Philadelphia, 2001)
9. Vinod, K., Astrophysical Plasmas and Fluids (Springer, New Delhi, 1998)
10. Piel, A., Plasma Physics: An Introduction to Laboratory, Space and Fusion Plasmas (Springer, Heidelberg, 2010).
11. Pecseli, H. L., Waves and Oscillations in Plasmas (CRC Press, New York, 2013).

DISCIPLINE SPECIFIC ELECTIVE 3

MPHD 4.11(a)
ATMOSPHERIC PHYSICS

Theory Credit: 4

UNIT I **Thermodynamics of the Atmosphere:** Thermodynamics of dry and moist air: specific gas constant, Moisture variables, virtual temperature; law of thermodynamics, adiabatic and iso – entropic processes, Clausius – Clapeyron equation, adiabatic process of moist air; entropy, thermodynamic diagrams (T-φ gram) and its application. Hydrostatic equilibrium: Hydrostatic equation. Vertical stability and instability of the atmosphere: Dry and moist air parcel. Tropical convection. Understanding the development of thunderstorms in terms of CAPE and CIN. *Detection of thunderstorms from radar*

UNIT II **Cloud Physics and Atmospheric Electricity:** Cloud classification. Warm cloud microphysics: homogeneous and hetrogenious cloud condensation nuclei, formation of cloud drop Kohler theory. growth of cloud drops. coalescence process – Precipitation of warm clouds. rain drop spectra. Cold cloud microphysics: ice nucleation and ice-crystals, precipitation mechanisms: Bergeron, Findeisen process, hail formation. Structure and dynamics of thunder storms, mesoscale convective systems and cyclone.

Ionization in the atmosphere, fair weather electricity, electrical current in the atmosphere, global electrical circuit, Electrical structure of the storms. Theories and experiments on cloud electrification. Lightning discharge and mechanism. Lightning electric fields and light location systems.

UNIT III **Dynamic Meteorology:** Inertial and non inertial frame. basic equations of fundamental forces: Pressure, gravity, centripetal and Corolis forces. Equation of motion in rotating coordinates in tangential local coordinates, spherical coordinates and isobaric coordinate system. Scale analysis of the equation of motion. Thermodynamic energy equation. Equation of Continuity in cartesian and isobaric 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; Bjerknese circulation theorem and

applications sea breeze and land breeze). vorticity and divergence equations, scale analysis, potential vorticity, stream function and velocity potential.

UNIT IV **Atmospheric Instability (Synoptic Scale Motion), Planetary (Atmospheric) Boundary Layer, Atmospheric Waves:** Atmospheric instability: Dynamical instability, barotropic instability and baroclinic instability. Necessary condition of barotropic and baroclinic instability. Kelvin-Helmholtz instability. Structure, evolution and properties of planetary boundary layer. Convective, neutral and stable boundary layers. Eddy transport of heat, moisture and momentum. Mixing length theory, boundary layer turbulence. Goverening equations in planetary boundary layer, surface layer, Ekman layer, Linear Perturbation Theory: Internal and external gravity waves, inertia waves, gravity waves, Rossby waves, wave motion in the tropics,

UNIT V **General Circulation, tropical dynamics and Numeric Modeling:** 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, walker circulation. Climate variability and forcing; feedback processes, low frequency variability- MJO (Madden-Julian oscillation), ENSO. Basic principles of Numerical Weather Prediction model; grid-point and spectral NWP model, primitive equation model; Data assimilation. Brief idea about the different parameterization schemes for atmospheric radiation, atmospheric boundary layer, convection and cloud microphysics. 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 K Hamazu, Springer Japan, 2014.

MPHD 4.12(a)
ATMOSPHERIC PHYSICS (PRACTICAL)

Practical Credit: 2

1. To measure the dew point temperature and relative humidity with the help of wet and dry bulb temperature.
2. Compute the mixing ratio, saturation mixing ratio, relative humidity, vapour pressure and saturation vapour pressure from the Skew T log P diagram.
3. Compute the equivalent temperature, potential temperature and equivalent potential temperature and virtual temperature from the Skew T log P diagram.
4. Find out the lifting condensation level (LCL), convection condensation level(CCL), convection temperature, Level of free convection (LFC) and equilibrium level (EL) from the Skew T-log P diagram.
5. Compute the CAPE and CIN from the Skew T-log P diagram.
6. Find out the type of instability of the air parcel for a given height profile of temperature and dew point temperature by using the Skew T-log P diagram.
7. Computation of divergence and vorticity by finite difference technique.
8. Computation of vertical velocity using equation of continuity.
9. Analyze the given rain DSD spectrum during various types of rain.
10. Analyze the height profile of radar reflectivity and rain intensity by using micro rain radar (MRR) observations.

11. Characterize the temporal variation of electric field in terms of given statistical parameter.
12. Find the dominant frequency components (first three) for a given time series data of rainfall.

MPHD 4.11(b)
APPLIED DYNAMICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I **Introduction to Dynamical systems:** Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems: the free particle, particle under uniform gravity, simple and damped harmonic oscillator. Sketching flows and trajectories in phase space; sketching variables as functions of time, relating the equations and pictures to the underlying physical intuition.

UNIT II **Different dynamical systems:**
In Biology: Population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits.
In Chemistry: Rate equations for chemical reactions e.g. auto catalysis, bistability
In Economics: Examples from game theory. Illustrative examples from other disciplines.
Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems, with applications to the above examples. Computing and visualizing trajectories on the computer using software packages. Discrete dynamical systems. The logistic map as an example.

UNIT III **Introduction to Chaos**: Examples of 2-dimensional billiard, Projection of the trajectory on momentum space. Sinai Billiard and its variants. Computational visualization of trajectories in the Sinai Billiard. Randomization and ergodicity in the divergence of nearby phase space trajectories, and dependence of time scale of divergence on the size of obstacle. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems; visualization of their trajectories on the computer. Self similarity and fractal geometry:

UNIT IV **Introduction to Fractals:** Fractals in nature, trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Fractals in dynamics – Serpinski gasket and DLA. Chaos in nonlinear finite-difference equations- Logistic map: Dynamics from time series. Parameter dependence- steady, periodic and chaos states. Cobweb iteration. Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period- Doubling route to chaos. Nonlinear time series analysis and chaos characterization: Detecting chaos from return map. Power spectrum, autocorrelation, Lyapunov exponent, correlation dimension.

UNIT V **Elementary Fluid Dynamics:** Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis- concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform & non-uniform flows, viscous & inviscid flows, incompressible & compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated & unseparated flows. Flow visualization - streamlines, path lines, Streaklines.

Recommended Books and References:

1. Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. An Introduction to Fluid Dynamics, G.K. Batchelor, Cambridge Univ. Press, 2002
4. Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

MPHD 4.11(c)
COMMUNICATION ELECTRONICS

Theory Credit: 4

UNIT I Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio

UNIT II Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver.

UNIT III Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

UNIT IV Introduction to Communication and Navigation systems: Satellite Communication– Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink

UNIT V Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). GPS navigation system (qualitative idea only).

Recommended Books and References:

1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2. Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
3. Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
4. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
5. Communication Systems, S. Haykin, 2006, Wiley India
6. Electronic Communication system, Blake, Cengage, 5th edition.
7. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

MPHD 4.12(c)
COMMUNICATION ELECTRONICS (PRACTICAL)

Practical Credit: 2

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

DISCIPLINE SPECIFIC ELECTIVE 4

DISSERTATION

Credits: 6

SYLLABUS FOR
Master of Science

ZOOLOGY

Under CBCS guidelines

COURSE STRUCTURE

SEMESTER	COURSE CODE	COURSE TITLE	CREDITS
I	MZOC 1.11	Genetics & Cytogenetics	4
	MZOC 1.21	Animal Physiology	4
	MZOC 1.31	Biosystematics & Evolutionary Biology	4
	MZOC 1.41	Developmental Biology	4
	MZOC 1.12	Genetics & Cytogenetics (Practical)	2
	MZOC 1.22	Animal Physiology (Practical)	2
	MZOC 1.32	Biosystematics & Evolutionary Biology (Practical)	2
	MZOC 1.42	Developmental Biology (Practical)	2
II	MZOC 2.11	Cell & Molecular Biology	4
	MZOC 2.21	Biochemistry	4
	MZOC 2.31	Proteomic & Enzymology	4
	MZOC 2.41	Immunology	4
	MZOC 2.12	Cell & Molecular Biology (Practical)	2
	MZOC 2.22	Biochemistry (Practical)	2
	MZOC 2.32	Proteomic & Enzymology (Practical)	2
	MZOC 2.42	Immunology (Practical)	2
III	MZOC 3.11	Parasitology	4
	MZOC 3.21	Techniques in Biology	4
	MZOC 3.12	Parasitology (Practical)	2
	MZOC 3.22	Techniques in Biology (Practical)	2
	MZOD 3.11(a)	Endocrinology – I	4
	MZOD 3.11(b)	Fish Biology – I	4
	MZOD 3.11(c)	Limnology – I	4
	MZOD 3.11(d)	Entomology – I	4
	MZOD 3.12(a)	Endocrinology – I (Practical)	2
	MZOD 3.12(b)	Fish Biology – I (Practical)	2
	MZOD 3.12(c)	Limnology – I (Practical)	2
	MZOD 3.12(d)	Entomology – I (Practical)	2
	MZOD 3.21(a)	Ecology (Field Work)	6
	MZOD 3.21(b)	Applied Zoology (Field Work)	6
	MZOD 3.21(c)	Medical (Field Work)	6
IV	MZOC 4.11	Ecology & Environmental Biology	4
	MZOC 4.21	Animal Behaviour & Chronobiology	4
	MZOC 4.12	Ecology & Environmental Biology (Practical)	2
	MZOC 4.22	Animal Behaviour & Chronobiology (Practical)	2
	MZOD 4.11(a)	Endocrinology – I	4
	MZOD 4.11(b)	Fish Biology – I	4
	MZOD 4.11(c)	Limnology – I	4
	MZOD 4.11(d)	Entomology – I	4
	MZOD 4.12(a)	Endocrinology – I (Practical)	2
	MZOD 4.12(b)	Fish Biology – I (Practical)	2
	MZOD 4.12(c)	Limnology – I (Practical)	2
	MZOD 4.12(d)	Entomology – I (Practical)	2
	MZOD 4.21	Dissertation	6

SEMESTER – I

MZOC 1.11
GENETICS AND CYTOGENETICS

Theory Credit: 4

UNIT I Genome size and evolutionary complexity: C- value paradox
Organization of chromosomes: unique and repetitive sequences in eukaryotic genome. Non- Mendelian genetics: maternal effects (pigmentation in *Ephestia*); organelle heredity (mutations in Chlamydomonas, mitochondria- petite in Saccharomyces); infections hereditary –Kappa in *Paramecium*); mitochondrial diseases in man. Population and quantitative genetics: Hardy- Weinberg equilibrium, polygenic/ multifactorial inheritance

UNIT II Linkage and chromosomal mapping: crossing over as physical basis of recombination, chiasmata and the time of crossing over; mapping distance, two-point test cross, three point test cross, gene order, recombination frequency and map distance, interference and coincidence, Cytogenetic mapping. Somatic cell genetics: concept and applications, transfection of cells- principles and method, cell fusion, hybridoma, applications of embryonic stem cells.

UNIT III Gene mutation: molecular basis of transition and transversion, missense, neutral, silent, frameshift and reverse mutation; types of DNA damages; physical and chemical mutagen; DNA repair mechanisms (base excision repair system, nucleotide excision repair system, mismatch repair system, recombination repair system, SOS system). Diseases in man (sickle cell anaemia, thalessemia, cystic fibrosis. Structural and numerical alterations of chromosomes; deletion, duplication, inversion, translocation, polyploidy and their genetic implications. Transposable genetic elements in prokaryotes and eukaryotes: IS element, composite transposons, Tn3 element, mechanism of transposition, Pelement and hybrid dysgenesis in Drosophila, retrotransposons.

UNIT IV Microbial genetics: methods of gene transfer- transposition, transduction, conjugation, sexduction). Sex determination in *Drosophila, C.elegans*, human and other animals.
Dosage compensation of X-linked genes- hyperactivation of X-linked genes in male Drosophila, inactivation of X- linked genes in female mammals. Human cytogenetics: human chromosomes and karyotypes, autosomal and sex chromosomal anomalies, human genome project, prenatal diagnosis

UNIT V Oncogenes: tumour inducing retrovirus and viral oncogenes; chromosome rearrangement and cancer; tumour suppressor gene- cellular roles of tumour suppressor genes p^{RB}, p^{53}, P^{APC}, genetics pathways to cancer. Diseases (chronic myeloid leukaemia, Burkitts lymphoma, retinoblastoma, Wilm's tumour).

MZOC 1.12
GENETICS AND CYTOGENETICS (PRACTICAL)

Practical Credit: 2

1. Meiosis from grasshopper testis and calculations of chiasma frequency and coefficient of terminalisation.
2. Preparation and mapping of polytene chromosomes (from salivary gland of *Chironomus/ 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*.
5. Study of mutant phenotypes of *Drosophila*
6. Study of sex chromatin in buccal smear and hair bud cells (human)
7. Study of Hardy- Weinberg equilibrium in human population by taking example of blood group system (ABO).
8. Drosophila genetics: preparation of culture medium. (Study of wild type and mutant/ life cycle and morphology)
9. Mounting of sex comb of *Drosophila melanogaster*.

Recommended Books and References:

1. Snustad P and Simmons M.J. (2011) Principles of Genetics, 8th Ed,. John Wiley & sons Inc., USA.
2. Russels P(2006) Fundamentals of Genetics, Addison Wesley Longman Inc.
3. Brooker RJ (2009) Genetics: analysis and Principles, McGraw Hill
4. Griffiths A.J.F., Wesslers S.R., Lewontin R.C. and Carrol S.B. (2007) Introduction to Genetic Analysis
5. Brookers RJ 1999 Benjamin/ Cummings Genetic Analysis and Principles. Longman Inc.
6. Garner BP, Simmons EJ and Snustad MJ 1991, Principles of genetics. John Wiley & sons Inc.
7. Lewin B 2003. Genes 2003. Genes VIII. Oxford Univ. Press.

MZOC 1.21
ANIMAL PHYSIOLOGY

Theory Credit: 4

UNIT I Gastrointestinal hormones and digestive enzymes in vertebrates; secretion and regulation in mammal; mechanism of digestion and absorption of different component of food materials. The enteric nervous system.

UNIT II Neuroanatomy of the brain and spinal cord; Membrane potential, ions as current carriers (calcium, potassium), structure of cation permeable channels and chloride chemicals. Synaptic transmission: Electric transmission, chemical transmission, chemical transmitter-Neuropeptide, FMRF – amide family.

UNIT III Respiration: Regulation of respiration, Respiratory function of blood; respiratory pigments, respiratory acidisis and alkalosis, Alkali reserve, control and co – ordination of respiration, respiratory adjustment, Dyspnea, periodic breathing, respiratory buffering. Transport of oxygen and carbon dioxide; oxygen dissociation curve; Bohr effect and Root effect.

UNIT IV Structure of vertebrate kidney and nephron; formation of urine ; counter current mechanism of urine formation; renal control mechanism ; acid-base balance ; homeostasis; Osmoregulation in aquatic and terrestrial animals –mechanism and regulation. Thermoregulation – heat balance in animals; body temperature – physical, chemical and neural regulation.

UNIT V Cardiac cycle events, regulation of cardiac amplitude and frequency in mammals. Composition and functions of blood volume; haemopoesis; blood pressure; blood groups; blood coagulation; haemostasis. Ultra-structure and chemical composition of skeletal muscle; neuromuscular junction, molecular mechanism and regulation of muscle contraction; energetics of muscle contraction.

MZOC 1.22
ANIMAL PHYSIOLOGY (PRACTICAL)

Practical Credit: 2

1. RBC count in blood.
2. Hb concentration in the blood.
3. Measurement of blood pressure under different physiological conditions.
4. Estimation of casein in milk.
5. Estimation of glycogen content in liver of fish/goat.
6. Estimation of ascorbic acid in tomato, lemon and milk.
7. Determination of the rates of oxygen consumption by an aquatic animal
8. Determination of respiratory quotient of an air breathing animal.
9. 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, 2nd 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, 2nd Edn., CBS publishers & Distributors, New Delhi.
7. Schmidt-Nielsen K. (2005) Animal Physiology, Harper & Row, NY.
8. Withcrspoon 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.

MZOC 1.31
BIOSYSTEMATICS & EVOLUTIONARY BIOLOGY

Theory Credit: 4

UNIT I Definition, Importance of Biosystematics, Applications of Biosystematics in Biology; Neotaxonomy – Consequences of New Systematic o Chemotaxonomy – Kinds:- Immunological Approach, Chromatographic Approach, Histo-chemical Approach; Cytotaxonomy – Chromosomal behavior:- Karyotype test, Chromosome number, Chromosome morphology, Linkage, recombination frequency analysis,; Banding pattern – G,C,R,Q Banding
Molecular Taxonomy - Source of variation, satellite DNA (Mini and micro DNA), Molecular markers –RFLP, RAPD, and AFLP, Ribotyping and DNA sequencing.

UNIT II Principles - Principle of Binominal Nomenclature, Principle of Priority, Principle of Coordination, Principle of the First Reviser, Principle of Homonymy, Principle of Typification, Structure, Gender agreement, Commission. Species Indices – Shannon – Weiner Index, Dominance Index, Similarity & Dissimilarity, Association Index.

UNIT III Modern Theory of Evolution – Lamarcks Theory and Neo Lamarckism, Theory of Catastrophism, Theory of Darwin and Neo Darwinism, Weismann's Theory, Modern Synthetic Theory; Evolution of Man – Pre human ancestors, Evolution of man in

Pleistocene; Speciation – Modes of Speciation: - Phyletic Speciation, Quantum Speciation, Gradual Speciation.

UNIT IV Isolation & Isolating Mechanism- Definition; Pre-mating Mechanism: – Geographic isolation, Isolation due to distance, Climatic isolation, Seasonal isolation, Habitat isolation, Ethological isolation, Mechanical isolation, Physiological isolation; Post-mating Isolation: – Gametic Mortality, Zygotic Mortality, Hybrid Inviability, Hybrid Sterility; Origin of Reproductive Isolation – Muller's view, Dobzhansky's View.

UNIT V Kinds of Variation:- Meristic & substantive, Continuous & Discontinuous, Determinate & Indeterminate, Somatic & Germinal, Sources of Variation; Basis of Variation: – Chromosomal Aberration, Variations in chromosome number; Natural Selection – Types:– Stabilizing selection, Directional Selection, Disruptive Selection; Selection Pressure; Genetic Drift – Theory of genetic Drift, Salient Features of Genetic Drift Genetic basis of Random Genetic Drift, Hardy-Weinberg equilibrium & Genetic Drift; Mimicry – Kinds: – Protective, Aggressive, Conscious; Significance of Mimicry.

MZOC 1.32
BIOSYSTEMATICS & EVOLUTIONARY BIOLOGY (PRACTICAL)

Practical Credit: 2

1. Identification and classification of aquatic micro-organism
2. Analysis of morphometric variations in selected natural populations.
3. Preparation of taxonomic keys for identification of the studied populations.
4. Karyotype test for species identification.
5. Identifying specimen samples of vertebrates and invertebrates by Taxonomic procedures (collection, preservation, curating).
6. Study of homologous and analogous organs in vertebrates with photos and pictures.
7. Study of fossils.

Recommended Books and References:

1. Principles of Animal Taxonomy – G.G Simpson- Oxford & IBH Publication
2. Elements of Taxonomy – E. Mayer – Tata Mcgraw Hill Co
3. Biosystematics and Taxonomy – R.C. Tripathi- University Book House
4. Biodiversity, Taxonomy and Ecology – G K Singh- Alp Books
5. Theory and Practices of Animal Taxonomy- VC Kapoor – Oxford and Ibh Co
6. Fundamentals of Biodiversity and Taxonomy (HB) – J.Juneja- Cubertech Publications

MZOC 1.41
DEVELOPMENT BIOLOGY

Theory Credit: 4

UNIT I Cell fate and Commitment; Mechanism of Developmental Commitment; Totipotency and pluripotency; Stem cells, genomic equivalence and the cytoplasmic determinants; Cell hybridization and nuclear transplantation experiment; Concept of organizer-induction and competence.

UNIT II Spermatogenesis- formation of Spermatids and Spermiogenesis. Oogenesis- Oocyte growth; Maturation and Vitellogenesis; Fertilisaton: Fertilization in sea urchin, recognition of Egg and Sperm, Prevention of Polyspermy, Activation of Egg metabolism and Fusion of Genetic Material; Cleavage: Characteristics, plant and

Patterns of Cleavage, Mechanism and Products of Cleavage; Gastrulation and Formation of Germ Layers in Animals, Gastrulation in Amphibia.

UNIT III Axis pattern Formation in Drosophila and Chick;
Neurulation in Zebra Fish, Vulva Formation in Caenorhapditis elegans;
Organogenesis: Development of Vertebrate Brain and the Dynamics of Optic Development- the Vertebrate eye;
Regeneration: Epimorphic Regeneration of Salamander limbs, Morphallactic regeneration in Hydra, Compensatory regeneration in Mammalian Liver.

UNIT IV Reproductive cycles in Animals and Human: Estrous and menstrual cycle. seasonal and continuous breeders; Photoperiodic regulation of Breeding Cycle of Vertebrates; Puberty and Adolescence, Role of Hormones;
Control of Fertility and Sterility: Origin, Cause and Treatment of Male and Female Sterility.

UNIT V Contraceptive methods for male and Female; Surgical Sterilisation with reference to Tubectomy and vasectomy; Placenta and Placental Hormones; Types of Implantation and role of Hormones;
Pregnancy and Hormones of Pregnancy; Assisted Reproductive Techniques: IVF-ET; Stem cells-concepts, types and significance;
Teratogenesis: Teratogenic agents- malformations and disruptions.

MZOC 1.42
DEVELOPMENT BIOLOGY (PRACTICAL)

Practical Credit: 4

1. Study of developmental stages of frog from 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. Developmental Biology, Gilbert, (8th Ed,2006), Sinaur Associates Inc, Massachusetts, USA.
2. Principles of Development, Wolpert, Beddington, Brockes, Jessell, Lawrence, Meyerowitz,(3rd Ed,2006),Oxford University Press, New Delhi.
3. Analysis of Biological Development, Kalthoff, (2nd Ed,2000), McGraw-Hill Science, New Delhi.
4. Reproductive Endocrinology, Physiology, Pathophysiology and Clinical management, Samuei S.C Yen, Robert B. Jaffe, Robert. L. Barbieri (ed) Saunders Publishers, USA.
5. The Physiology of Reproduction, Vol.1 and 2, Ernst Knobil and Jimmy D. Neil (ed), Raven.

SEMESTER – II

MZOC 2.11
CELL AND MOLECULAR BIOLOGY

Theory Credit: 4

UNIT I Cell- chemical complexity and organization.
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.
Secretory pathway; receptor mediated endocytic pathway; protein sorting and transport to the cell organelles

UNIT II Chromatin: chemical composition, histones, molecular organization of nucleosomes, nucleoplasmin, chromatin to chromosomes, histone modifications, chromatin remodeling complex
Cell cycle- features and phases; cyclins and cyclin dependent kinases, regulation of CDK- cyclin activity, cell cycle check points.
Benign and malignant tumours; characteristic features of malignant cells.
Cell death: types, significance, salient features; mechanism: extrinsic and intrinsic pathways.

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- 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; Genetic code; Differences between prokaryotic and eukaryotic protein synthesis. Inhibitors of protein synthesis; posttranslational modifications of proteins.
Prokaryotic gene expression: positive and negative control of gene expression, lac operon and tryptophan operon in *E.coli.* Repression and attenuation

UNIT V Recombination DNA technology: tools-restriction enzymes, cloning vectors, plasmids, phages, viruses; methods of introduction- transformation, transduction, transfection, electroporation, microinjection, liposome fusion; applications: transgenic animals.

MZOC 2.12
CELL AND MOLECULAR BIOLOGY (PRACTICAL)

Practical Credit: 2

1. Study of metaphase plate in red corneal/ 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. Estimation of DNA by diphenylamine reagent.
6. Estimation of RNA by orcinol reagent.

7. Subcellular fractionation of functional mitochondria
   i. Isolation of mitochondria from mouse liver by differential centrifugation
   ii. Determination of protein yield in the fractions by Lowry method
   iii. Identification of mitochondrial fraction by assay of marker enzyme
8. Microtubules in vesicle transport in fish chromotophores
9. Mammalian cell culture
10. Assessment of proliferation in cultural cells by MTT assay
11. Over- expression and affinity purification of SH3- GCT recombinant protein from bacterial cells
12. Observation of DNA fragmentation in apoptotic cells.

Recommended Books and References:

1. Molecular Cell Biology, Lodish et al., (2007), W.H. Freeman & Company, Ner York, USA
2. Molecular Biology of the Cell, Alberts et al.,(2008), Garland Science, Taylor & Francis Group, New York, USA.
3. Karp G (2007) Cell Biology, 7th Edn). Wiley Publ., New York.
4. De Robertis E.D.P. and De Robertis E.M.F.,(2008) 8th Edn, Wolters Kluwer Pobl., New York
5. Verma P.S., Cell Biology, S.Chand Pvt. Ltd.
6. Co Kleinsmith L.J and Kish V.M (1995) Principles of Cell & Molecular Biology. Harper Collins Publishers, New York.
7. Lewin B. (2011) Gene XI, John CI, John Wiley & Sons.
8. Weaver R.F (2005) Molecular Biology, 3rdEdn., McGraw-Hill International.
9. 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

MZOC 2.21
BIOCHEMISTRY

Theory Credit: 4

UNIT I Acids, bases, pH and buffer; derivation of Henderson and Hasselbach equation and simple calculations on pH and buffer. Bioenergetics; glycolysis, coupled reaction, group transfer, Standard reduction potential; Gibbs free energy changes: mitochondrial electron transport chain complexes: oxidative photophosphorylation.

UNIT II Glycolysis, citric acid cycle, phosphate pentose pathway, gluconeogenesis, glycogenolysis and glycogenesis

UNIT III Amino acids: structure, classification based on structure, polarity, nutritional requirement and metabolic fate; properties of amino acids; derivatives of amino acids, non-transcribed amino acids as protein constituents, D-amino acids.
Organisation of protein structure: primary structure and peptide bond, secondary, tertiary and quaternary structure; conjugate protein- haemoglobin, cytochromes, myoglobin; bonds involved in protein organization.
Biological functions of proteins. biologically important peptides: glutathione, octa-, nona-, and deca-peptides.

UNIT IV Metabolism of amino acids: amino acid pool, transamination; oxidation and non-oxidative deamination; metabolism of branched chain amino acids; fate of carbon skeleton of amino acids. Metabolism of ammonia: Urea cycle. Metabolism of nucleic acids: Synthesis of ribonucleotides- a brief idea of de nova pathway and salvage pathway. Conversion of ribonucleotides to deoxyribonucleotides. Degradation of nucleotides.

UNIT V Integration of metabolism, energy demand and supply; integration of major metabolic pathways of energy metabolism; intermediary metabolism; organ specialization and metabolic integration. Metabolism in starvation.

MZOC 2.22
BIOCHEMISTRY (PRACTICAL)

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. Preparation of strandard acid and alkali and its standardization.
7. Study of osazone derivatives of sugar.
8. Estimation of tyrosine by folin phenol method and verification of beer's law.
9. To estimate the amount of α-amino nitrogen by formal titration.
10. To determine standard glucose curve by DNSA (3,5 dinitro salicyclic acid method)
11. Estimation of cholesterol.
12. To separate amino acids by paper chromatography.

Recommended Books and References:

1. Nelson D.L Cox. M.M (2013) Lehninger Principle of Biochemistry, 6thEdn., Worth Publisher, New York.
2. Moran L.A et al. (2011) Principles of Biochemistry, 5thedn., Prentice, 5thEdn. ASM, USA.
3. Cooper G.M and Hausman R.E (2009). The Cell: Molecular Approach, 5thedn, ASM Press, USA.
4. Metzler D.E. (2005) Biochemistry, vol. 1 and 2, 3rdedn., 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, 7thEdn., H. Freeman and Company, UA.
7. Muray R.K et al. (2010) Harpers Illustrated Biochemistry, 29thEdn.McGwat hill, London.
8. Alberts et al. (2008) Molecular Biology of the Cell, 5thEdn. Garand publishing.
9. Lewin B. (2011) Gene XI, John CI, John Wiley & Sons.
10. Weaver R.F (2005) Molecular Biology, 3rdEdn., 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, 2ndEdn., Taylor & Francis.

MZOC 2.31
PROTEOMIC AND ENZYMOLOGY

Theory Credit: 4

UNIT I Level of protein structure: secondary structure: H-bonding scheme, diversity in alpha-helices, Helix capping, Beta-stand and sheet, turns and loops, importance of loops.
Supersecondary structure: domains and motifs.
Tertiary structure: concept of subunits and protomers and their association, importance of quaternary structure, various examples.

UNIT II Anfinsen's classical experiment; folding curves and transitions; types of protein folding and intermediates; models of protein folding; assisted protein folding (chaperones). Post-translational processing, targeting and turnover.

UNIT III Absorbance, fluorescence, circular dichroism;
Structural methods: NMR; X-ray Crystallography. Microarray. 2D- electrophoresis, protein sequencing, mass spectrometry.

UNIT IV An introduction to enzyme, enzyme properties, active sites, specificity and enzyme classification; cofactors and coenzyme; energetic of enzyme-catalyzed reaction, transition state, binding energy. Effect of different physic-chemical factors on enzyme activity.

UNIT V Mechanism of enzyme action: Fischer's lock and key theory, koshland's Induced fit model; mechanism of enzyme catalysis.
Enzyme kinetic-Michaelis–Menten equation and its derivation, Lineweaver-Burk Plot; significance of Km: calculations on enzymes kinetics.
Inhibition of enzyme activity: allosteric enzyme; isoenzymes. Ribozyme.

MZOC 2.32
PROTEOMIC AND ENZYMOLOGY (PRACTICAL)

Practical Credit: 2

1. To study the effect of time on enzyme activity.
2. To study the effect of enzyme concentration on enzyme activity.
3. To study the effect of substrate concentration on enzyme activity and determination of Km and Vmax by Michaelis-Menten and Lineweaver-Burk plots.
4. Effect on activator and inhibitor on enzyme activity.
5. SDS-PAGE analysis of protein.
6. Separation of isoenzymes of malate dehydrogenase (MDH)/ lactate dehydrogenase (LDH) starch gel electrophoresis.

Recommended Books and References:

1. Nelson D.L Cox. M.M (2013) Lehninger Principle of Biochemistry, 6thEdn., Worth Publisher, New York
2. Principles Of Proteomics (2004) Publisher: CBS publishers & distributors- New Delhi.
3. Tanner Perry (2017) Proteomics: A Comprehensive Study of Proteins. Larsen and keller publisher.
4. Charles Malkoff (2016) Functional Genomics and Proteomics. Syrawood publishing house.
5. Daniel C. Liebler & john R. Yates. (2002) Introduction to proteomics. Springer science+ Business media, LLC
6. P L Bonner and Trevor Palmer (2001) Enzymes: Biochemistry, Biotechnology, Clinical Chemistry
7. Nicholas C. Price & Lewis Stevens (1999) Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins. Publisher: Oxford University Press.

MZOC 2.41
IMMUNOLOGY

Theory Credit: 4

UNIT I Innate and acquired immunity – components and characteristic features;
Lymphoid organ – primary and secondary lymphoid organ and their function;

Humoral and cell mediated immune response
Immunogen – Types, antigenicity and immunogenicity; Factor influencing immunogenicity; adjuvant, epitopes and haptens.

UNIT II Immunoglobulin –structure, classes and function; Antibody mediated effector function; Antigen – antibody reaction; Activation and differentiation of B and T cell; T and B cell receptor – structure and function. Cytotoxin

UNIT III Antigen presenting cell; Endogenous and exogenous pathways of antigen processing and presentation. Cytokines – property, types and functions. Interferon

UNIT IV MHC – structure and function of class I and class II; MHC in mouse and human. Complement system – characteristic features, classical and alternate pathway of complement activation. Hypersensitivity – types and features; mechanism of immediate hypersensitivity reaction.

UNIT V Immunodeficiency – types and diseases;
Immune response to bacterial (Tuberculosis), parasite (Malaria) and viral (HIV) infection. Immunological techniques – radio-immuno assay (RIA) and Enzyme-linked immunosorbent assay (ELISA)

MZOC 2.42
IMMUNOLOGY (PRACTICAL)

Practical Credit: 2

1. Dissection and histology of lymphoid organ in laboratory bred animal.
2. Determination of blood group in human.
3. Study of different cell in blood smear from laboratory bred animal.
4. Enumeration of total count of WBC.
5. Identification of WBC cells
6. Antigen-antibody interaction in vitro-Double immunodiffusion.
7. Demonstration of:
    a) Immunoelectrophoresis
    b) ELISA.

Recommended Books and References:

1. An introduction to immunology---By C.V.Rao.
2. Kuby Immunology, Richard Thomas, Barbara, Janis(5th Ed. 2003),W.H.Freeman and Company, New York,USA.
3. Immuno Biology- The immune system in health and disease, Janeway, Travers, Walport and Shlomchik,(6thEd,2005),Garland Science Publishing, New York, USA.
4. Immunology,David,Brostoff and Roitt,(7th Ed,2006),Mosby and Elsevier Publishing, Canada, USA.

SEMESTER - III

MZOC 3.11
PARASITOLOGY

Theory Credit: 4

UNIT I Introduction to parasites of man, scope and definition of parasites/parasitology; Animal associations; parasitic adaptations - morphological, anatomical, physiological, biochemical; types of parasites, types of hosts; Interrelationship between Host and Parasites responses and hosts to parasitic infection; anthroponoses and zoonoses.

UNIT II Morphology, life cycle, mode of infection of *Plasmodium,* molecular biology of plasmodium- drug targets, mechanism of drug resistance, vaccine strategies and proteomic approaches;
Morphology, life cycle, mode of infection of protozoan parasite, *Leishmania*; Morphology, biology, life cycle, mode of infection of intestinal flagellates, *Giardia.*; Morphology, biology, life cycle, mode of infection of cestodes, *Taenia.*

UNIT III Trematodes: Morphology, biology, life cycle, modes of entry of *Schistosoma, Fasciola, echinococcus.* Nematodes: Morphology, Life-cycle, Transmission, Pathogenecity, Treatment and Prophylaxis *Wuchereria, Ancylostoma,* and *Dracanculus*; vaccine strategies; Plant & Soil nematodes: Cyst nematode, citrus nematode.

UNIT IV Molecular biology of plasmodium- drug targets, mechanism of drug resistance and vaccine strategies; Trypanosoma: Diploid & Sexual stage, Molecular characteristics of surface coat, Variable surface glycoprotein (VSG) and VSG gene expression; Platyhelminthes: Inseminative behaviour, parthenogenesis and polyspermy, sex determination, sex linked inheritance in Schistosomes; Nematoda: chromosome germ line limited DNA & chromatin diminution in Ascaris.

UNIT V Microbial products; food microbiology; biocontrol; biological weapons; wastewater treatment.

MZOC 3.12
PARASITOLOGY (PRACTICAL)

Practical Credit: 2

1. Study of prepared slides and museum specimens of selected parasites of representatives groups of protozoans, parasites, helminthes and arthropods.
2. Culturing an insect parasitoid and studying their infection on an insect host.
3. Demonstration of *in vitro* culture of *plasmodium,* infection of mice with *Plasmodium*, chasing the process of infection by histopathology and immune reactions.
4. Studying the infection of tomato plant by root knot nematode.
5. Study of life cycle, role as vector & control measures of: a) Ticks (Argas, Boophilus) b) Mosquito - anyone from- Anopheles/ Aedes/ Culex c) Any two flies: Tabanus/ Phlebotomus/ Sarcophaga. Cyclops
6. Ectoparasites & Endoparasites of wild rat, cattle, dog, chick & human including stages in excreta.
7. Spotters based on theory.

Recommended Books and References:

1. Foundations of Parasitology, Roberts L.S. and Janovy J., McGraw-Hill Publishers, New York, USA.
2. Modern Parasitology: A Textbook of Parasitology, FEG Cox., Wiley-Blackwll. U.K.
3. Human parasitology-Burton J Bogtish
4. Introduction to Environmental Engineering & Science Gilbert M. Masters.
5. Parasitoses and Zoonoses, Bose,M., New central book agency (P) Ltd.
6. Parasitology (Protozoology and Helminthology) in relation to clinical medicine. Chatterjee, K. (2009). 13th Edn. CRC publisher New Delhi.
7. Genome sequence of the human malaria parasite Plasmodium falciparum nature 419:498-511. Gardner M.J. et al (2002) Practical exercises in Parasitology: Edited by D. W. Halton, Queen's University Belfast, J. M. Behnke, University of Nottingham I. Marshall, Liverpool School of Tropical Medicine.
8. Helminthes, Arthropods and Protozoa of domesticated animals. Soulsby, E.J.L. (1983). 7th Edn, Lea & Febiger, Philadelphia.
9. Parasitology by Chandler and Chands
10. Parasitology, medical Publisher Calcutta, 1987, K.D. Chaterjee.
11. Parasitology – by Ramnik Sood, C.B.S., Publisher, New Delhi – 1993.

MZOC 3.21
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: Spectroflourometry; 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. Sampling and Variables.
Frequency distribution: Simple and Grouped
Measure of central tendency: mean, median and mode
Measure of variation: Range, quartile deviation, mean deviation, Standard deviation, Coefficient of variation

UNIT IV Distribution: Normal, Binomial and Poisson distribution. Tests of statistical significance: t-test, Chi-square test, Introduction to one and two ways ANOVA, F-test
Correlation and Regression: Types of correlation, Coefficient of correlation, Linear regression, Coefficient of regression.

UNIT V Introduction to bioinformatics, Database concepts and biological databases (NCBI, EBI and DDBJ). Needleman-Wunsch and Smith-Waterman methods of local and global alignment. Pairwise alignment and Multiple sequence alignment. BLAST and FASTA. Database submission, Information retrieval.

MZOC 3.22
TECHNIQUES IN BIOLOGY (PRACTICAL)

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. Amplification of a target gene by PCR
5. Determination of molecular size by agarose gel electrophoresis.
6. Computation of average, variances, standard deviation.
7. Regression analysis and fitting straight line for a bivariate data.
8. Students' 't' test, chi-square test and computation of ANOVA for one-way.
9. Retrieval of DNA sequences and alignment.
10. Construction of phylogenetic tree and interpretation of result using DNA/Protein databases

Recommended Books and References:

1. Norman G. R and Striner D.L (2014) Biostatistics: The bare essentials, 4thEdn., 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, 6thEdn.
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, 3rdEdn., 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, 4thEdn. Maniatis T. et al. (1982) Molecular Cloning. A Laboratory Manual. Cold Spring.
8. Rodney F. Boyer (2000) Modern Experimental Biochemistry 3rdEdn., Prentice Hall.
9. Elston R.C. and Johnson W.D. (1994) Essential Biostatistics 3rdEdn., Prentice Hall.
10. Elston R.C and Johnson W.D. (1994) Essential Biostatistics, 2ndEdn. F.A Davis Company, USA.
11. Switzer R.L. and Garrity L.F (1999) Experimental Biochemistry. 3rdEdn.
12. Stiles et al. (1991) basic and clinical Immunology, 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 - IV

MZOC 4.11
ECOLOGY AND ENVIRONMENTAL BIOLOGY

Theory Credit: 4

UNIT I Concept of ecology, environmental concept- laws and limiting factors; Ecological niches- different niches and niches diversity; Environmental factors and their effects- light, water, temperature, humidity.

UNIT II Species richness- frequency, density, relative abundance, species diversity, dominance, equitability, carrying capacity; Population ecology: concept and characteristics- natality, mortality, growth patterns, density dependent and density independent; population dispersal; population interaction- prey-predator relationships, competition, mutualism, commensalism, symbiosis, parasitism; Life history strategies- K and r selection, age and sex ratio.

UNIT III Mode of ecological succession in terrestrial and aquatic ecosystems; types of change of communities; concept of climax and ecological stability; trophic dynamic- energy flow and Lindeman's trophic dynamics concept; Productivity- concepts of production, assessment of primary productivity.

UNIT IV Environmental stresses and their management, global warming, Atmospheric Ozone, acid and nitrogen deposition; Pollutants- Pesticides and other chemicals in Agriculture, industry; Bioindicators and biomarkers of environmental health; Biodegradation and bioremediation of chemicals.

UNIT V Assessment, conservation and management of wild animals, Wildlife Protection Act 1972 in India, biodiversity Act related international convention; biodiversity management approaches; major drivers of biodiversity changes in environment; anthropogenic impact on environment.

MZOC 4.12
ECOLOGY AND ENVIRONMENTAL BIOLOGY (PRACTICAL)

Practical Credit: 2

1. Study of ecological niches of soil organisms- litters, underground
2. Study of population density of terrestrial plants with quadrate method
3. Study of frequency of species of terrestrial plants with quadrate method
4. Case study of ecological succession in locality
5. Identification of bioindicators of any water body
6. Collection of literatures relating to wildlife conservation in Nagaland
7. Case study of anthropogenic impact on environment in the locality

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, Prentice 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
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, Kolkota

7. SilvyN.J.(2012) the wildlife Technique Manual, vol-2 Management, 7th edition Edn John Hopkins Univ. Press
8. Sharma BD (1999) Indian Wildlife Resourse, Ecology and Development, Daya Publishing House, Delhi
9. Hudson PJ, Rizzoli A., Grenfell B.t., Heestrbeek H. and Dobson A.P. (2002) The Ecology of Wildlife Disease, Oxford Uni. Press Oxford
10. KotwalPC., Banerjee S. (1998) Biodiversity Conservation in Manage and Protected Area, Agro-bios India
11. Singh K. (1998) Handbook of Environment, Forest, and Wildlife Protection Laws in India Natraj Publishers, Dehradun
12. Jim C. (2007) The Temple Tiger, Oxford Uni. Press, New Delhi

MZOC 4.21
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY

Theory Credit: 4

UNIT I Objectives and Mechanism of Behaviours
Types of reflexes, Characteristics of Reflexes and Complex Behaviour. Orientation: Primary and Secondary Orientation, Sun-Compass Orientation. Kinesis: Orthokinesis and Klinokinesis. Taxis: Different kind of Taxis.

UNIT II Learning: Types of Learning, Neural Mechanism of Learning. Communication: Types of Communication, Auditory Communication, Infrasound Communication among Elephants and Whales. Sonar- Navigation and Communications, Echolocation in Bats, Migration in Bird and Fish.

UNIT III Reproductive strategies: sexual selection, intrasexual selection (male rivalry), intersexual selection (female choice), infanticide, mate guarding.
Parental behaviour: care before birth, care after birth, types of parental care, parent offspring conflict, monogamous versus polygamous sexual conflict.

UNIT IV Chronobiology in 21st Century
Adaptive functional significance of biological clocks
Biological rhythms in Tidal, Lunar, Circadian and Circannual Rhythms
Centres of Biological Rhythms- Supra Chiasmatic nuclei, pineal gland, Optic Lobes.
Factors influencing biological Rhythms- Environmental, Photoperiod, Temperature.

UNIT V Methods of Measurement: Entrainment, Re-entrainment, Phase Angle difference, Phase Shift, Phase Response Curve, Arrhythmia. Molecular Clockworks in Drosophila and Mammals (Clock Genes).
Applied Chronobiology: Human circadian rhythms, Application of circadian rhythms and principles, jet-lag\shift work, Depression and sleep disorders. Chronopharmacology and Chronotherapy.

MZOC 4.22
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY (PRACTICAL)

Practical Credit: 2

1. Photo tactic response in earthworms/grain or pulse pests
2. Geostatic response of earthworm or pest.
3. Effect of toxicants on opercular movement and surfacing in fish.
4. Effect of toxicants on movement of fish.

5. Communication in earthworm by pheromones.
6. Learning by trial and error in rat with the help of Hebb-William Maze.
7. Food preference in tribolium or any other grain/pulse pest.
8. Movement and exploratory behavior of rats.
9. Food preference in catfish.
10. Geotaxis in snails/slugs.

Recommended Books and References:

1. Mechanism of Animal Behaviour, Peter Maler and J. Hamilton: John Wiley & Sons, USA.
2. Animal Behaviour, David McFarland, Pitman Publishing Limited, London, UK.
3. Animal Behaviour, John Alcock, Sinauer Associate Inc. USA.
4. Perpective on Animal Behaviour, Goodenough, McGuire and Wallace, John Wiley & Son, USA.
5. Exploring Animal Behaviour, Paul W. Sherman & John Alcock, Sinauer Associates Inc. Massachusetts, USA.
6. An Introduction to Animal Behaviour, A. Manning and M.S. Dawkins, Cambridge University Press, UK.
7. Gadagkar: Survival Strategies-Cooperation and Conflict in Animal Societies. Universities Press, 1998.
8. Chadrashekaran, M.K (1985). Biological rhythms. Madras science foundation, Chennai.
9. Binkley, S. (1990). The clockwork sparrow: time, clocks and calendars in biological organisms.
10. Chronobiology Biological timekeeping: Jay. C. Dunlap, Jennifer. J.Loros.
11. Insect Clocks D.S. Saunders, C.G.H Steel, X. Afopoulou R.D. Lewis (3rd Ed),2002 Barens and Noble Inc NewYork, USA.
12. Biological Rhythms: Vinod Kumar (ed 2002) Narosa Publishing House, New Delhi/ Springer-Verlag, Germany.

DISCIPLINE SPECIFIC ELECTIVE 1

MZOD 3.11(a)
ENDOCRINOLOGY - I

Theory Credit: 4

UNIT I Concept of hormones as chemical messengers: endocrine, paracrine and autocrine hormones; endocrine glands and the structural features of endocrine glands; classification of endocrine hormones; basic concept of hormonal effects and its regulation; biosynthesis and secretion of pancreas, adrenal, ovary, testis and thyroid hormones;

UNIT II Hormone and target organs: hormone receptors and their characteristics; hormonal transduction. Hypothalamus: hypothalamic neurosecratory centres; hypothalamic hormones; hormonal feedbacks. Pituitary: pituitary hormones and their functions.

UNIT III The thyroid gland: thyroid hormone biosynthesis and their functions; regulation of thyroid hormone secretion; feedback mechanism to control thyroid stimulating hormone or thyrotropin. Mechanism of action of thyroid hormones.

UNIT IV Comparative anatomy of adrenal glands in vertebrates: biosynthesis of adrenal hormones and their functions; adrenal medulla: catecholamine biosynthesis; release and its physiological functions. Parathyroid: calcitonin and vitamin D in calcitonin Homeostasis. Endocrine pancrease: glucose homeostasis and physiological functions of insulin and glucagon.

UNIT V Peptide hormones and steroid hormones; bionsynthesis, transport and metabolism of steroid hormones; mechanism of action of peptide and steroid hormones; factors influencing secretion of hormones in animals.

MZOD 3.12(a)
ENDOCRINOLOGY - I (PRACTICAL)

Practical Credit: 2

1. Dissect and display of adrenal gland in laboratory bred rat*
2. Pituitary gland of laboratory bred mouse-dissection, display and permanent slide preparation using metachromatic stains.
3. Histological study of endocrine glands of vertebrates.
4. Compensatory ovarian/ adrenal hypertrophy *in vivo* bioassay in laboratory bred rat*
5. Demonstration of Castration/ ovarectomy in laboratory bred rat*

Recommended Books and References:

1. Barington (1979) hormones and evolution volume I and II. Academic press, New York.
2. General endocrinology. Bagrara and Tumer, W.B. Saunders.
3. John F-Laycock and Peter H.Wise, Essential of Endocrinology.
4. Williams R.H. (1974). Textbook of Endocrinology V.Ed. Saunders Press, London.
5. Bentley P.J. (1998) comparative vertebrate endocrinology, Cambridge university press.
6. General Endocrinology C. Donnell Turner Pub- Saunders Toppan
7. Endocrinology: An Integrated Approach; Stephen Nussey and Saffron Whitehead.
8. Oxford: BIOS Scientific Publishers; 2001.
9. Hadley, M.E. and Levine J.E. 2007. Endocrinology, 6th Edition. Pearson Prentice-Hall, Pearson Education Inc., New Jersey.
10. Vertebrate Endocrinology by David O. Norris,

MZOD 3.11(b)
FISH BIOLOGY - I

Theory Credit: 4

UNIT I Taxonomic characterization; taxonomic keys; taxonomic methods for identification of fresh water fishes. Methods employed for phylogenetic studies and fish identification; Modern trends in fish taxonomy; fish barcoding, Biogeographic units of freshwater biodiversity; status and distribution of freshwater fish diversity of northeast India.

UNIT II Study of growth curve; absolute and relative growth, length – weight relationship, condition factor, relative condition factor. Hepatosomatic index, gonadosomatic index, index of fitness, ponderal index, fecundity. Growth rate and ageing. Stock assessment and management.

UNIT III Digestive system; anatomical differentiation and modification; feeding behaviour and feeding adaptation in fishes. Respiratory system in fishes: gill structure; mechanism of respiration; counter current principle; exchange of gases; accessory respiratory organs. Forms and function of swim bladder and weberian ossicles in tissues.

UNIT IV Types of excretion and regulation; osmotic regulation: Salt and water balance in freshwater, marine and brackish water fishes; acid-base balance.
Endocrine system in fish: hypothalamo - hypophysial system; neurosecretory system and neuro – hypophysial hormones; functional morphology of Pituitary gland.

UNIT V Reproductive system in teleosts; sexual maturation and breeding cycle; spermatogenesis, oogenesis and vitellogenesis; genetic structure of random mating populations. Test of equilibrium, application and properties of equilibrium population; Scope, application, role of genetics in fish selection and breeding; Sex reversal, hybridization, gynogenesis, polyploidy, hybrid vigour.

MZOD 3.12(b)
FISH BIOLOGY - I (PRACTICAL)

Practical Credit: 2

1. Identification of important freshwater fish species.
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. Gut content analysis of locally available fish species.
7. Estimation of protein in fish tissues.
8. Estimation of phospholipid in fish tissues.
9. 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, 3rdedn. 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) NitogenExcretin (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 Icthyology, 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) Icthyology, John Wiley and Sons.

MZOD 3.11(c)
LIMNOLOGY –I

Theory Credit: 4

UNIT I Introduction to Limnology, objectives, status and scope; concept of applied Limnology and Palaeolimnology; development of limnology in India; Inland aquatic environment- diversity of ecosystems, salient features of wetlands, lentic and lotic ecosystem.

UNIT II Limnological methods and equipments; techniques for quantitative and qualitative sampling for analysis of communities in water bodies; Keys for identification of plankton and other aquatic organisms- periphyton, benthos, nekton.

UNIT III Environmental factors I- Abiotic -light, temperature, thermal stratification, current of water, wind, turbidity, pressure, density.

UNIT IV Environmental factors II- Biotic communities- micro-organisms and macro-organisms; energy flow- food chain and food web.

UNIT V Water chemistry- sources of water, pH, alkalinity, Carbonate, nitrate, phosphorus, chloride, dissolved Oxygen and Free Carbon dioxide, dissolved inorganic solid nutrient cycles- nitrogen, phosphorus movement of water.

MZOD 3.12(c)
LIMNOLOGY –I (PRACTICAL)

Practical Credit: 2

1. Study of different equipment in limnological field works
2. Quantitative analysis of aquatic plankton in different water samples
3. Qualitative analysis of aquatic plankton in different water samples
4. Study of physical factors of water bodies- temperature, current, water movement
5. Determination of light penetration with Secchi's disk
6. Identification of food habit of aquatic organisms- herbivorous, carnivorous, omnivorous
7. Determination of dissolved O_2 content in water samples
8. Determination of free CO_2 content in water samples
9. Determination of pH and alkalinity of water samples
10. Determination of carbonate, nitrate, phosphorous and chloride in water samples

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.

MZOD 3.11(d))
ENTOMOLOGY – I

Theory Credit: 4

UNIT I Origin and evolution of insects; Classification of insects (up to orders with characters and examples); Mouthparts - structure and variations; Antennae - structure and variations; Wings - structural variations and venation. Leg - structure and variations; Genitalia - structure and variations.

UNIT II 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 off ammonia and uric acid; excretion of nitrogenous waste with special reference to uric acid excretion. Muscular system: types and structure of muscles, flight mechanism.

UNIT III Structure of insect eye; mechanism of vision; Basic components of nervous system; Endocrine centres; Neurosecretory cells; corpora cardiac; corpora allata; prothoracic glands. 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.

UNIT IV Structure of insect integument; chemistry and functions of various components of cuticle: Sclerotization in cuticle. Types and functions of hemocytes; chemistry and function of hemoloymph. Innate immunity in insects: role of hemocytes; antimicrobial peptides in insects. Glycerol-3-phosphate shuttle in flight muscles; proline metabolism; trehalose metabolism.

UNIT V 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.

MZOD 3.12(d)
ENTOMOLOGY – I (PRACTICAL)

Practical Credit: 2

1. Techniques of insect collection, data recording; preservation and display of insects.
2. Study of museum specimens representing major insect's orders.

3. Study of morphology of grasshopper to show various organs.
4. Study of different mouth parts, legs, antennae and wings
5. Preparation of external genitalia of grasshopper, cockroach and housefly.
6. Dissection of alimental canal of cockroach/grasshopper/honeybee.
7. Study of male and female reproductive systems in cockroach.
8. Dissection of nervous system of adult grasshopper/cockroach.
9. Assay of amylase from salivary gland of cockroach.
10. Estimation of total proteins in hemolymph.

Recommended Books and References:

1. Klowden M.J (2013) Physiological systems in insects, 3rdEdn., Academic Press.
2. Gilbert L.I (2011) Insect Endocrinology, 1stEdn. Academic Press.
3. Nation J.L (2008) insect Physiology and Biochemistry, 2ndEdn., 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, 4thEdn. 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 Entomology. Methuen Co., London.
11. Wiggleswoth, V.B. (1984) The Principles of Insect Physiology, 8thEdn. Chapman and Hall.

DISCIPLINE SPECIFIC ELECTIVE 2

MZOD 3.21(a)
ECOLOGY (FIELD WORK)

Credit: 6

MZOD 3.21(b)
APPLIED ZOOLOGY (FIELD WORK)

Credit: 6

MZOD 3.21(c)
MEDICAL (FIELD WORK)

Credit: 6

DISCIPLINE SPECIFIC ELECTIVE 3

MZOD 4.11(a)
ENDOCRINOLOGY-II

Theory Credit: 4

UNIT I Hormonal mechanism of integration, Neuro-secretion and neuro-endocrine system: 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 Hormones and reproduction: hormonal regulation of estrous and menstrual cycle; hormonal regulation in reproduction: metamorphosis; diapauses and osmoregulation and the role of hormones in animals. Hormonal regulation of reproductive behavior in vertebrates.

UNIT IV Neuro-endocrine regulation of immune system; stress hormones and immune responses; regulation of systemic homeostasis by nervous and immune system interactions. Neuro-endocrine disorders; genetic versus environmental cause.

UNIT V Hormones as therapeutic agents: current developments in design and production of hormonal contraceptives; recombinant protein hormones-production and application in regulation of fertility in farm animals and humans;

MZOD 4.12(a)
ENDOCRINOLOGY-II (PRACTICAL)

Practical Credit: 2

1. Study of endocrine glands in albino rat/mouse using charts/models/computer software
2. Histological study of endocrine glands (thyroid, adrenal, testis and ovary) using charts/models/ computer software.
3. Castration in albino rat/mouse.
4. Study of estrous cycle in albino rat/mouse.
5. Steroid and thyroid hormone assay by ELISA.

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, 4thEdn., Blackwell Science, London.
3. Covacs W.J and Odeja S.R. (2011) Textbook of Endocrine Physiology, 6thEdn., 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, wile International.
5. Hadley M.E. (2000) Endocrinology (5thEdn, 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 Endocrinolgy, 12thEdn., W.I Saunders Company.
9. Martine C.R (1985) Endocrine Physiology, Oxford University Press, London.
10. Noris D.O. and Carr J.A (2013) Vertebrate Endocrinology, 5thEdn., Academic Press.
11. Norman W.A and Litwack G. (1997) Hormones, 2ndEdn., 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 behavioural Endocrinology, Sinauer Associates, inc, Publishers.

MZOD 4.11(b)
FISH BIOLOGY - II

Theory Credit: 4

UNIT I Fishery resources of the major river system of India; Types of capture fishery resources; Cold water fish and fisheries of India; Floodplain (wetland) fisheries; Costal fisheries of India (Sardines & Mackerel fisheries); Estuarine fisheries.

UNIT II Principle of preservation, handling and packaging of fish for marketing; Importance and methods of fish preservation(refrigeration and freezing, drying, salting, smoking, canning, pickling, pasting, spicing and fermentation); Fishery by – products, their production and utilization(liver oils, body oils, fish meal, fish flour, fish silage, fish protein, fish guano and bone meal).

UNIT III Aquaculture systems – extensive, semi – extensive, intensive culture of fish; pen and cage culture in lentic and lotic water bodies; Brood stock management, induced breeding, physical and chemical inducing agents; sewage fed fisheries, integrated fish farming, composite fish culture; Aquarium keeping.

UNIT IV Different types of nutrient requirements; feed formulation (General principles, different steps of feed formulation and classification of feed ingredients) Importance of live feed and artificial feed, different type of feed available for larvae.

UNIT V Types of fish diseases, symptoms and prophylaxis; Diseases diagnostic tools; Technique for isolation and identification of fungi; isolation and culture of different types of bacteria; Biological indicators and indices of water quality; Sanitation in aquaculture systems; algal bloom and environmental microflora.

MZOD 4.12(b)
FISH BIOLOGY - II (PRACTICAL)

Practical Credit: 2

1. Induced breeding of IMC
2. Determination of primary productivity by LB – DB method.
3. Determination of percentage saturation of dissolved oxygen.
4. Estimation of free carbon dioxide of water samples.
5. Estimation of total alkalinity.
6. Estimation of total hardness of water samples.
7. Estimation of calcium and magnesium hardness.
8. Estimate of chloride content of water samples.
9. Rearing of live fish food
10. Study of fish diseases from chart and micrograph

Recommended Books and References:

1. Goldman, C.R and Horne, A.J. (1983) Limnology, McGraw-Hill International Book Company.
2. Sugunam V.V, and Bhaumik, U. (1990) Technologies for Inland Fisheries Development, Central Inland Capture Fisheries Research Institute.
3. Kumar S. and Tembhire M. (2011) Fish and Fisheries, New Central Book Agency (P) Ltd. (NCBA).
4. Ahmad S.H. and Singh A.K. (2011) Freshwater Aquaculture, Daya Publishing House, New Delhi, India.
5. Jhingran V.G. (2007) Fish and Fisheries of India, 3rdedn., Hindustan Publishing Corporation, India.
6. Talwar P.K. and Jhingran V.G. (1991) Inland Fisheries of India and Adjacent Countries, Oxford and IBH Publishing Co. Pvt. Ltd.

MZOD 4.11(c)
LIMNOLOGY-II

Theory Credit: 4

UNIT I Lotic- origin of lakes and their diversity- ponds, Bog lakes, Swamp; size, depth, elevation of lakes, lake margin, nature of lake bottom, composition of aquatic organisms.

UNIT II Lentic- Origin of rivers and their characteristics; water movement, temperature, light, dissolved gases, dissolved solids, pH.

UNIT III Biotic community- phytoplankton, zooplankton; adaptation of strong water current by aquatic organisms, vegetation around periphery of water bodies.

UNIT IV Biomonitoring of inland water- concept of biomonitoring; bio-indicators and bio-indices; Ganga Plan; Waste water- limnological characteristics, waste stability ponds, and their role in waste stabilization.

UNIT V Waste water treatment- mechanical, biological and chemical treatment, alternative system of treating raw sewage, reclamation and harvesting of water from sludge, recycling and reuse of waste water.

MZOD 4.12(c)
LIMNOLOGY-II (PRACTICAL)

Practical Credit: 2

1. Study of origin of lakes and ponds
2. Study of rivers and its tributaries
3. Determination of water chemistry of lotic samples in the locality
4. Determination of water chemistry of lentic samples in the locality
5. Qualitative analysis of plankton in lotic samples
6. Qualitative analysis of plankton in lentic samples
7. Study of water pollutants in the locality
8. Field study of water management

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.

MZOD 4.11(d)
ENTOMOLOGY – II

Theory Credit: 4

UNIT I Insect life history patterns; voltinism; polymorphism and polyphenism.
Eusocial insects from Hymenoptera and Isoptera - life cycle and development; polyethism in bees and mechanism of caste differentiation; parasites, predators and pathogens.

UNIT II Introduction of Lac culture - Life cycle of the lac insects; Lac cultivation, Composition & uses of Lac. Introduction to Sericulture - Life cycle of the silk moth, cultivation, composition and uses of silk. Introduction to Apiculture - Types of honey bees, Bee keeping, economic importance of honey bee. Insects as pollinators.

UNIT III Concepts of Insect pest; Principles and methods of cultural, biological and chemical control; Uses of sex attractants, Pheromones and hormones in insect control; Concept of IPM; Information required in dealing with a pest problem.

UNIT IV Plant feeding insects- plant host range, types of insect injury to plants, relationship of pest injury and quality of produce, Insect and plant disease;
Damage, life cycle and control of pest – Earias vitella, Sesamia inferens, leptocorisa acuta, Pyrilla perpusilla, Sitophilus oryzae,

UNIT V Medical entomology- Venoms and allergens; Life cycle, damage and control of – fleas, mosquitoes, bed bugs, human lice, sand flies, house flies.

MZOD 4.12(d)
ENTOMOLOGY-II (PRACTICAL)

Practical Credit: 2

1. Dissection of silk gland form silkworm larvae.
2. Study household and stored grain pests.
3. Study if insect pest of agricultural crops.
4. Study of insect medical and veterinary importance.
5. Study of insect pests of fruits.
6. Study of useful insects.
7. Study of appliances used in chemical control.
8. Determination LC50 value of some chemicals.

Recommended Books and References:

1. Blum M.S (1985) Fundamental of Insect Physiology, John Wiley and Sons.
2. Imms A.D. (1977). A General textbook of entomology, 10thEdn. Methuen & Co. London.
3. Gullan P.J and Cranston P.S (2010) The Insects: An Outline of Entomology. Wiley-Blackwell.
4. Hermes, W.B. (1995) Medical and Veterinary Entomology. CAB International U.K.

5. Hermes, W.B. (1950) Medical Entomology, Macmillan and Co. NY.
6. Hill D.S (1994) Agricultural Entomology, Oregon Timber Press.
7. Ramakrisnan, T.V. (1984). Handbook of Economic Entomology of South India, International Books and Periodicals Service India.
8. Lamb. K.P (1974). Economic entomology in the tropics, London, Academic Press.
9. Abhrol D.P (2009) Bees and Bee Keepings in India, Kalyani Publishers, New Delhi.
10. Fenemore P.G and Prakash Alka (1995). Applied Entomology, Wiley Eastern limited New Age International.

DISCIPLINE SPECIFIC ELECTIVE 4

MZOD 4.21
DISSERTATION

Credit: 6