KOHIMA SCIENCE COLLEGE

(An Autonomous Government P.G. College)

JOTSOMA, NAGALAND

NEP Syllabus
for
Bachelor of Science, Physics

2024

Course Structure

(A) Bachelor's Certificate Physics

Semester	Discipline specific Course Major(MJ)	Minor (MN)	Multi-Disciplinary Course (MDC) Credits:3	Ability Enhancement Course (AECC)	Value Addition Courses (VAC) Credits:3	Skill Enhancement Course (SEC) Credit:3	Total Credits
Sem-I	MJ-1 (Credits:4)	MN-1 (Credits:4)	MD-1 (Credits:3)	AEC-1 (Credits:3)	VAC-1 (Credits:3)	SEC-1 (Credits:3)	20
Sem-II	MJ-2 (Credits:4)	MN-2 (Credits:4)	MD-2 (Credits:3)	AEC-2 (Credits:3)	VAC-2 (Credits:3)	SEC-2 (Credits:3)	20

Award of Certificate in Physics after securing minimum 40 (forty) Credits and they secure 4 credits in work based vocational courses offered during summer term or internship/apprenticeship.

(B) Bachelor's Diploma in Physics

Semester	Discipline specific Course Major(MJ)	Minor (MN)	Multi-Disciplinary Course (MD) Credits:3	Ability Enhancement Course (AECC)	Value Addition Courses (VAC) Credits:3	Skill Enhancement Course (SEC) Credit:3	Total Credits
Sem-III	MJ-3 MJ-4 (Credits:8)	MN-3 (Credits:4)	MD-1 (Credits:3)	AEC-3 (Credits:2)	_	SEC-3 (Credits:3)	20
Sem-IV	MJ-5 MJ-6 MJ-7 MJ-8 (Credits:16)	MN-4 (Credits:4)					20

Award of Diploma in Physics after securing minimum 80 (eighty) Credits and additional 4 credits in skill based vocational courses offered during first year or second year summer term .

(C) Bachelor's Degree in Physics

Semester	Discipline Specific Course Major(MJ)	Minor (MN)					Total Credits
Sem-V	MJ-9 MJ-10 MJ-11 (Credits:12)	MN-5 (Credits: 4)			Internship (Credits: 4)		20
Sem-VI	MJ-12 MJ-13 MJ-14 MJ-15 (Credits:16)	MN-6 (Credits: 4)					20

Award of B Sc degree in Physics upon securing 120 credits

(D) Bachelor's Degree(Honours) in Physics

Semester	Discipline Specific Course Major(MJ)	Minor (MN)					Total Credits
Sem-VII	MJ-16 MJ-17 MJ-18 MJ-19 (Credits:16)	MN-5 (Credits: 4)					20
Sem-VIII	MJ-20 (Credits:04)	MN-6 (Credits: 4)			MJ-21 MJ-22 MJ-23 or Research Project /Dissertation (Credit:12)		20

Award of B Sc degree in Physics (Honours) upon securing 160 credits.

DISTRIBUTION OF COURSES

A. **Discipline Specific Core Courses(Major). All the courses have 4 credits (Theory-03, Practical-01) each.**

Semester	Paper code	Major Paper Name Credits : 04(Theory-03, Practical-01/Tutorial-01)
Sem-I	MJ-1	Mechanics (3T+1P)
Sem-II	MJ-2	Mathematical Physics-I (3T+1P)
Sem-III	MJ-3	Electricity and Magnetism (3T+1P)
	MJ-4	Wave & optics(3T+1P)
Sem-IV	MJ-5	Mathematical Physics-II (3T+1P)
	MJ-6	Thermal Physics (3T+1P)
	MJ-7	Elements of Modern Physics (3T+1P)
	MJ-8	Condensed Matter Physics- I (3T+1P)
Sem-V	MJ-9	Mathematical Physics -III (3T+1P)
	MJ10	Analog Electronics (3T+1P)
	MJ-11	Classical Mechanics (3T+1Tu)
Sem-VI	MJ-12	Quantum Physics-I (3T+1Tu)
	MJ-13	Statistical Mechanics (3T+1P)
	MJ-14	Electrodynamics (3T+1P)
	MJ-15	Digital Electronics (3T+1P)
Sem-VII	MJ-16	Advanced Mathematical Physics (3T+1Tu)
	MJ-17	Atomic and Molecular(3T+1P)
	MJ-18(A) MJ-18(B) MJ-18(C)	Condensed Matter Physics-II (3T+1P) or Computational Physics (3T+1P) or Bio -Physics (3T+1P)
	MJ-19(A) MJ-19(B) MJ-19(C)	Advance Statistical Mechanics (3T+1Tu) or Experimental Techniques (3T+1P) or Atmospheric Physics(3T+1P)
Sem-VIII	MJ-20	Quantum Mechanics-II (3T+1Tu)
	MJ-21	Nuclear and Particle Physics (3T+1P)
	MJ-22(A) MJ-22(B)	Embedded systems - Introduction to Microcontroller(3T+1P) or Geo-Physics(3T+1Tu)
	MJ-23(A) MJ-23(B)	Nano Physics (3T+1P) or Astronomy and Astrophysics (3T+1P)

B. Minor Papers

SEMESTER	PAPER CODE	Minor Paper Name Credits : 04(Theory-03, Practical-01/Tutorial-01)
Sem-I	MN-1	Mechanics (3T+1P)
Sem-II	MN-2	Mathematical Methods (3T+1P)
Sem-III	MN-3	Electricity and Magnetism (3T+1P)
Sem-IV	MN-4	Thermal and Statistical Physics (3T+1P)
Sem-V	MN-5	Electrodynamics (3T+1P)
Sem-VI	MN-6	Elements of Modern Physics (3T+1P)
Sem-VII	MN-7	Quantum Mechanics (3T+1P)
Sem-VIII	MN-8	Electronics (3T+1P)

*** Minor paper can be opted by non-Physics major students who had Physics as one of the paper in HSSLC.**

C. Multi-Disciplinary Courses

SEMESTER	PAPER CODE	Multi-Disciplinary** paper name Credits: 03 (Theory-03)
Sem-I	MD-1(A) MD-1(B)	General Physics-1 (3T) or Introduction to Atmospheric Physics(3T)
Sem-II	MD-2(A) MD-2(B)	General Physics-2 (3T) or Introduction to Astronomy (3T)
Sem-III	MD-3(A) MD-3(B)	Introduction to Nano Physics (3T) or Water Science (3T)

** MD courses are open to all those students who did not have Physics as one of the paper in HSSLC. Multi –disciplinary course and Minor should be different subjects.

D. Skill-Enhancement Courses

SEMESTER	PAPER CODE	Skill-Enhancement Course name Credits: 03 (Practical-02; Theory: 01)
Sem-I	SEC-1(A) SEC-1(B)	Basic Instrumentation Skill or Electrical Circuits and Network Skills
Sem-II	SEC-2(A) SEC-2(B)	Physics Workshop Skill or Radiation Safety
Sem-III	SEC-3(A) SEC-3(B)	Renewable Energy and Energy Harvesting or Introduction to Python

Only Physics major students can opt for SEC.

E. **Ability Enhancement course**:

English , Tenyidie and other Languages shall be offered.

F. **Value Added Courses**

Semester	Paper Code	Name of the Paper Credits: 03 (Theory:03)
Sem- I	**VAC-1**	Environmental Sciences
Sem-II	**VAC-2**	Foundation Course in Indian Knowledge System

MAJOR COURSE

MJ-1: Mechanics
Credits: (Theory-03, Practical-01) **Teaching hours: 45+30**

Course Objective

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with Newton's Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity. Students will also appreciate the Collisions in CM Frame, Gravitation, Rotational Motion and Oscillations. The students will be able to apply the concepts learnt to several real world problems.

Course Learning Outcomes

Upon completion of this course, students are expected to

• Understand laws of motion and their application to various dynamical situations.

• Learn the concept of inertial reference frames and Galilean transformations. Also, the concept of conservation of energy, momentum, angular momentum and apply them to basic problems

• Understand translational and rotational dynamics of a system of particles.

• Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.

• learn the phenomenon of simple harmonic motion.

• Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.

Unit 1:

Fundamentals of Mechanics: Reference frames: Inertial and non inertial frames. Newton's laws of motion, Galilean transformation equations (position and time); its application to transformation of length, velocity and acceleration, Galilean invariance to basic laws. Motion of Rocket. Centre of mass: its velocity and acceleration, total linear momentum about the centre of mass. Principle of conservation of linear momentum, Impulse.

Work and Energy: Concepts of work and energy, Kinetric energy, work-energy principle, conservative and non conservative force, potential energy, conservative force as gradient of potential energy, curl of conservative force, law of conservation of mechanical energy

Spherical polar co-ordinate systems: Velocity and acceleration

Uniformly rotating frame and fictitious force; centrifugal force, Coriolis force and its effects.

Properties of bulk matter: Relation between elastic constants, Twisting torque on a cylinder or wire, Poiseulle's equation for flow of liquid through a capillary tube (15 hours)

Unit 2:

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque and its relation with angular momentum, angular impulse. Principle of conservation of angular momentum. Angular momentum under central force. Rotation about a fixed axis: Moment of Inertia and radius of gyration. Theorem of perpendicular and parallel axes. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Oscillations: Simple harmonic motion (SHM), differential equation of SHM and its solutions in different forms, Velocity, acceleration, time period, frequency SHM. Energy of Simple Harmonic Oscillator. Damped oscillation; Differential equation of motion of damped harmonic oscillator and its solution. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance.

(15 hours)

Unit 3:

Gravitation and Central Force Motion: Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws.

Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Length contraction, Time dilation; Twin Paradox. Relativity of Simultaneity, Invariance of Space-time interval. Transformation of velocity- Relativistic addition of velocities. Variation of mass with velocity. Mass less Particles. Mass-energy Equivalence. (15 hours)

Reference Books:

1. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
2. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
3. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
4. Mechanics, Er. Tamana Jain, Mahaveer Publications.
5. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
6. Physics for Degree Students (B.Sc. First Year), C.L Arora and Dr. P.S.Hemne, S Chand.

Practical: Mechanics

Credit: 01 **Practical Hours: 30**

In the laboratory course, the student shall perform experiments related to mechanics: use of screw gauge and travelling microscope, and necessary precautions during their use.bar and Kater's pendulum, rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity), moment of inertia of irregular bodies.

1. Measurements of length (or diameter) using screw gauge and travelling microscope.
2. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus of rigidity.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
5. To determine the Young's Modulus of a Wire by Optical Lever Method.
6. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
7. To determine the elastic Constants of a wire by Searle's method.
8. To determine the value of g using Bar Pendulum.
9. To determine the value of g using Kater's Pendulum.
10. To determine the moment of inertia of an irregular body about an axis through its centre of gravity with a torsion pendulum

Reference Books:

1. BSc. Practical Physics, C L Arora, S Chand and Company Limited
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

MJ-2: MATHEMATICAL METHODS-I

Credits: (Theory-03 , Practical-01) **Teaching Hours: 45+30**.

Course Objective

The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

Course Learning Outcomes

After completing this course, student will be able to

•learn limits and continuity and draw and interpret graphs of various functions. Taylor and Binomial series.

• Solve first and second order differential equations and apply these to physics problems.

• Understand the concept of gradient of scalar field and divergence and curl of vector fields.

• Perform line, surface and volume integration and apply Green's, Stokes' and Gauss's Theorems to compute these integrals.
• Apply curvilinear coordinates to problems with spherical and cylindrical symmetries.
• Understand Dirac's delta function and its properties.

UNIT 1

Calculus: Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. (15 hours)

UNIT II

Vector Calculus: Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs) (20 hours)

UNIT III

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Dirac Delta function and its properties: Definition of Dirac delta function. Properties of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. (10 hours)

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning

3. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Mathematical Physics, Goswami, 1st edition, Cengage Learning
8. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley&M.P.Hobson, 2011, Cambridge Univ. Press

Practical: Mathematical Physics-I

Practical Credit: 1 **Practical Hours: 30**

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics. The course will consist of practical sessions and lectures on the related theoretical aspects of the Laboratory. The list of programs here is only suggestive.

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, memory and input/output devices.
Basics of Scientific Computing	Binary and Decimal arithmetic, Floating point numbers, algorithyms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow – emphasize the importance of making equations in terms of dimensionless variables. Iterative methods.
Review of C and C++ Programming fundamentals	Introduction of programming, constants, variables and data types, operators and expressions, I/O statements, scanf and printf, c in and c out, Manipulations for data formatting, Control statements, (decision making and looping statements)(If statement, If else statement, Nested if Structure, Else if statement, Ternary operator, Go to statement, Switch statement. Unconditional and Conditional looping. While loop, Do – while loop, FOR loop, Break and continue statements, Nested Loops) Arrays(1D and 2D)

	and strings, user defined functions, Structures and Unions, Idea of classes and objects.
Programs:	Sum and average of a list of numbers, largest of a given list of numbers, and its location in the list, sorting of numbers, in ascending, descending order, Binary search.
Random Number Generation	Area of circle, area of square, volume of sphere, value of π.
Solution of Algebraic and Transcendental equations,by bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equations, solving $\alpha = \tan\alpha, \; I = I_0(\frac{\sin\alpha}{\alpha}) \, in \, optics$
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation.	Evaluation of trigonometric functions, eg. $\sin\theta, \; \cos\theta, \; \tan\theta \; etc.$

Reference Books:

1. Introduction to Numerical Analysis, S.S. Sastry, 5thEdn., 2012, PHI Learning Pvt. Ltd.
2. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
3. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rdEdn., 2007, Cambridge University Press.
4. A first course in Numerical Methods, U.M. Ascher& C. Greif, 2012, PHI Learning.
5. Elementary Numerical Analysis, K.E. Atkinson, 3rdEdn., 2007, Wiley India Edition.
6. Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
7. An Introduction to computational Physics, T. Pang, 2ndEdn., 2006, Cambridge Univ. Press
8. Computational Physics, Darren Walker, 1stEdn., 2015, Scientific International Pvt. Ltd.

MJ-3: Electricity and Magnetism
Credits: (Theory-03, Practical -01) Teaching Hours: 45+30

Course Objective

This course reviews the concepts of electromagnetism learnt at school from a more advanced perspective and goes on to build new concepts. The course covers static and dynamic electric and magnetic fields, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. The students will be able to apply the concepts learnt to several real-world problems.

Course Learning Outcomes

At the end of this course the student will be able to

• Demonstrate the application of Coulomb's law for the electric field, and also apply it to systems of point charges as well as line, surface, and volume distributions of charges.

• Demonstrate an understanding of the relation between electric field and potential, exploit the potential to solve a variety of problems, and relate it to the potential energy of a charge distribution. • Apply Gauss's law of electrostatics to solve a variety of problems.

• Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)

• Understand the concepts of induction and self-induction and Maxwell's equations

• Understand the basics of electrical circuits and analyze circuits using Network Theorems.

UNIT I

Electric Field: Electric flux, Gauss' Law and Gaussian surface. Applications of Gauss' law to solid sphere and hollow cylindrical. Conservative field, Conservative nature of Electrostatic Field.

Electric Potential: Gauss's divergence theorem and differential form of Gauss's law. Laplace's and Poisson equations. The Uniqueness Theorem.

Electric dipole: Dipole moment, Potential and Electric Field of a dipole. Force and Torque on a dipole. Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor.

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Gauss's law in dielectrics

Capacitor: Capacitance of an isolated conductors, Spherical and cylindrical capacitors filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics.

Electrical Images: Method of electrical Images and its application to Plane Infinite Sheet and Sphere. (15 hours)

UNIT II

Magnetic field and force: Lorentz force, force on a current carrying conductor placed in a magnetic field. Biot-Savart's Law and its applications to circular loop (vector treatment). Current looop as a magnetic dipole and its dipole moment. Ampere's Circuital Law in integral and differential form and its application to solenoid and toroid. Curl and divergence of magnetic field, Magnetic vector potential. Torque on a current loop in a uniform Magnetic Field.

Magnetic Properties of Matter: Magnetization vector (**M**). Magnetic Intensity(**H**). Magnetic susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism. B-H curve and hysteresis.

Electromagnetic Induction: Magnetic flux, Faraday's law. Self and mutual inductance. Reciprocity theorem. Maxwell's equations, Maxwell's modification of Ampere's law and displacement current, displacement current density.

(15 hours)

UNIT III

Electrical Circuits: DC Transients: Current growth and decay in LR, CR, LCR circuits with a direct current input AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: Resonance and quality Factor, Parallel LCR Circuit.

Network theorems: Classification of circuit elements, Ideal voltage and current sources. Mesh currents and Mesh equations. Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem.

Ballistic Galvanometer: Description, Theory, Correction for damping, Conditions for the galvanometer to be ballistic and dead beat. (15 hours)

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Electricity and Magnetism, Er. Tamana Jain, Mahaveer Publications.
5. Electricity and Magnetism, T.S. Bhatia, Vishal Publications Co.
6. Electricity and Magnetism, D.Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd.
7. Undergraduate Physics Vol II, AB Bhattacharya, R Bhattacharya, New Central Book Agency (P) Ltd.

PRACTICAL: ELECTRICITY AND MAGNETISM

Credit: 01 **Practical Hours: 30**

In the laboratory course the student will get an opportunity to verify network theorems and study different circuits such as RC circuit, LCR circuit. Also, different methods to measure low and high resistance, capacitance, self-inductance, mutual inductance, strength of a magnetic field and its variation in space will be learnt.

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To compare capacitances using De'Sauty's bridge.
3. To verify the Thevenin theorems.
4. To verify Norton theorems.
5. To verify the Superposition theorem.
6. To verify Maximum power transfer theorems.
7. To study Series LCR circuit
8. To study parallel LCR circuit

References Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.
4. BSc. Practical Physics, C.L.Arora, S Chand and Company Limited

MJ-4 : WAVES AND OPTICS
Credit: (Theory-3 , Practical-01) **Teaching Hours: 45+30**
Course Objective

This course review the concepts of waves and wave optics learnt at school from a more advanced perspective and goes to build new concepts. It begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. The course also provides in depth understanding of wave phenomenon of light, namely, interference and diffraction with emphasis on practical applications of the same.

Course learning outcomes

On successfully completing the requirements of this course, the students will have the skill and knowledge to:

- Understand Simple harmonic oscillation and superposition principle.
- Understand different types of waves and their velocities. Plane, spherical, transverse, longitudinal.
- Understand concept of normal modes in transverse longitudinal waves.
- Understand interference as superposition of waves from coherent sources.

- Understand Fraunhofer and Fresnel diffraction.
- In the laboratory course, student will gain hands on experience of using various optical instruments.

UNIT I

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive Waves. Particle and Wave Velocities. Differential Equation of wave Equation. Energy Transport. Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. Newton's Formula for Velocity of Sound. Laplace's Correction. Superposition of two collinear oscillations having equal frequencies and different frequencies (Beats). Superposition of two perpendicular Harmonic Oscillations: Analytical Methods(Lissajous figures) with equal and an unequal frequency and their uses. Superposition of Two Harmonic Waves: Standing Waves in a String: Analytical Treatment. Phase and Group Velocities. (15 Hours)

UNIT II

Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. Interference: Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Newton's Rings:Reflected and tramsimtted light. Measurement of wavelength and Refractive index. Interferometer: Michelson Interferometer : Determination of Wavelength and Refractive Index . Fabry-Perot interferometer. (15 Hours)

UNIT III

Diffraction: Fraunhofer diffraction: Single slit and circular aperture .Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate, Zone plate as a convex lens. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. (15 Hours)

Reference Books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw Hill 17
3. Principles of Optics, Max Born and Emil Wolf, 7thEdn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

PRACTICAL: WAVES AND OPTICS
Credit:01 **Practical Hours: 30**

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. To determine refractive index of the Material of a prism using sodium source.
5. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
6. To determine the wavelength of sodium source using Michelson's interferometer.
7. To determine wavelength of sodium light using Fresnel Biprism. To determine wavelength of sodium light using Newton's Rings.
8. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
9. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.

MJ-5
MATHEMATICAL PHYSICS-II
Credits: (Theory-03 ,Practical-01) ***Teaching Hours: 45+30***

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Course Objective

The emphasis of course is to equip students with the mathematical tools required in solving problems interest to physicists and expose them to fundamental computational physics skills thus enabling them to solve a wide range of physics problems. This course will aim at introducing the concepts of Fourier series, special functions, linear partial differential equations by separation of variable method.

Course Learning Outcomes

On successfully completing this course, the students will be able to

• Represent a periodic function by a sum of harmonics using Fourier series and their applications in physical problems such as vibrating strings etc.

• Obtain power series solution of differential equation of second order with variable coefficient using Frobenius method.

• Understand properties and applications of special functions like Legendre polynomials, Bessel functions and their differential equations and apply these to various physical problems such as in quantum mechanics.

• Learn about gamma and beta functions and their applications.

• Solve linear partial differential equations of second order with separation of variable method.

UNIT I

Fourier Series: Periodic functions. Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Even and odd functions and their Fourier expansions. *(10 Hours)*

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). *(5 Hours)*

UNIT II

Frobenius Method and Special Functions: Frobenius method and its applications to differential equations like Legendre, Bessel, Hermite and Laguerre Differential Equation.

Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials.

Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions ($J_0(x)$ and $J_1(x)$) and Orthogonality. *(20 Hours)*

UNIT III

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Heat equation in 1-D and problems, Wave equation 1-D and its solution for vibrational modes of a stretched string, rectangular membrane, circular membrane , solution of Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. *(10 Hours)*

Reference Books:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
6. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press

7. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

Practical: Mathematical Physics-II
Credit: 01 **Practical Hours: 30**

Course Objective

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics. The course will consist of practical sessions and lectures on the related theoretical aspects of the Laboratory. The list of programs here is only suggestive. Students should be encouraged to do more practice. Emphasis should be given to assess student's ability to formulate a physics problem as mathematical one and solve by computational methods

1. Introduction to numerical computation software Scilab
   Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initializing variables in Scilab, Multidimensional arrays, Sub-array, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations,

   Built in Scilab functions, Introduction to plotting, 2D and 3D plotting, Branching Statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops.

   User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program.
2. Generation of special function by user defined function in Scilab.
3. Plotting of Legendre polynomials, Bessel function, Hermite and Laguerre polynomials
   Solving First order differential equation like
4. Radioactive decay law
5. Current in LR, Rc circuit with DC source
   Solving second order differential equation like
6. Spring mass system for (unforced system, F=0) damped and undamped oscillation.
7. Simple pendulum.
8. RLC circuit with AC or DC input.

Reference Books:

1. 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.
2. Documentation at the Scilab homepage: https://www.scilab.org/ and the Python home page https://docs.python.org/3/
3. Computational Physics, Darren Walker, Scientific International Pvt. Ltd (2015).
4. Applied numerical analysis, Cutis F. Gerald and P.O. Wheatley, Pearson Education, India (2007).
5. An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).

MJ-6 : THERMAL PHYSICS
Credits: (Theory-03, Practial-01) **Teaching Hours:45+30**
Course objective

This course will introduce Thermodynamics, Kinetic theory of gases and Statistical Mechanics to the students. This course deals with the relationship between the macroscopic properties of physical systems in equilibrium. It reviews the concepts of thermodynamics learnt at school from a more advanced perspective and develops them further. The primary goal is to understand the fundamental laws of thermodynamics and their applications to various systems and processes. In addition, it will also give exposure to students about the Kinetic theory of gases, transport phenomena involved in ideal gases, phase transitions and behavior of real gases.

Course Learning Outcomes

This coursework will also enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behaviour of the atoms .

UNIT I

Kinetic Theory of Gases Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas .Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas

Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. (15 hours)

UNIT II

Introduction to Thermodynamics: Zeroth and First Law of Thermodynamics: Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics . First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. Second Law of Thermodynamics: Reversible and Irreversible process with examples.Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem.

Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law ofThermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. (20 hours)

UNIT III

Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of C_p-C_v, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

(10 Hours)

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.

2. A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

PRACTICAL: THERMAL PHYSICS

Practical Credit: 01 **Practical Hours: 30**

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. 2. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers 4. A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, Vani Pub.

MJ-7: Elements of Modern Physics
Credit:(*Theory*-03, *Practical-01)* **_Teaching Hours: 45+30_**

Course Objectives
This course covers certain conceptual courses of physics for which the students will be able to understand some concepts of Quantum Mechanics including Schrodinger equation and its applications, fundamentals of Atomic Physics, Nuclear Physics and basic Laser principles and properties.

Course Learning Outcomes
Upon successful completion of this course, the students will be able to:

- Understand and explain the differences between classical and quantum mechanics.
- Solve Schrodinger equation for simple potentials and understand the commutation relations, tools to calculate components and total angular momentum
- properties of the nucleus and other sub-atomic particles.
- Describe theories explaining the structure of atoms and the origin of the observed spectra.
- Explain different Laser used and make a comparison between them.

UNIT I
Introduction to Quantum Mechanics
Inadequacy of classical physics and the Origin of Quantum theory**:** Black body radiation, Plank hypothesis, Photoelectric effect, Compton effect. Matter waves: De Broglie hypothesis and Davisson and Germer experiment. Wave particle Duality, phase velocity and group velocity. Postulates of Quantum Mechanics, Heisenberg's uncertainty relation, wave functions and its properties, Probability and probability current density, Normalization, Expectation value, Schrödinger equation (Time dependent and time independent), Ehrenfest's theorem (Definition only), Gaussian wave packet. *(15 hours)*

UNIT II
Applications of Schrödinger equation: Free particles, one dimensional square well potential, step potential, potential barrier, linear harmonic oscillator.
Operators: Basic properties of operators, Eigen values and Eigen functions, Operator of some observable quantities (Position, momentum and energy), Hermitian operator, commutator brackets using position, momentum and

angular momentum operator, ladder operator, parity and parity operator. *(15 hours)*

Unit III

Nuclear Physics: Basic properties and classification of nucleus, mass defect and binding energy, packing fraction, Nuclear stability, Radioactivity (concept of natural and artificial radioactivity and properties of α, β, γ-rays). Elementary particles and Quarks model, Nuclear models (Liquid drop model and shell model), nuclear reactions, compound nucleus, Q value equation. Bohr and Wheeler theory of Nuclear fission, Nuclear fusion and stellar energy. *(15 hours)*

Laser: Einstein A and B coefficient, Metastable states, Spontaneous and stimulated emissions, optical pumping and population inversion, Three-level and Four-level Lasers, Ruby Laser and He-Ne Laser. *(15 hours)*

Recommended Books and References:

1. Quantum Mechanics, A.K.Ghatak and S.Lokanathan.
2. Introductory Quantum Mechanics, R.L.Liboff.
3. Principles of Quantum Mechanics, R. Shankar.
4. Quantum Mechanics: Concepts and applications, N.Zettili
5. Quantum Mechanics, Mahesh C. Jain
6. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
7. Concepts of Nuclear Physics, B L Cohen, Tata McGraw Hill

Practical : Elements of Modern Physics

Credit: 01 **Practical Hours: 30**

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. To determine the Planck's constant using LEDs of at least different colours.
3. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
4. To show the tunneling effect in tunnel diode using I-V characteristics.
5. To determine the wavelength of Laser source using diffraction of single slits.
6. To determine the wavelength of Laser source using diffraction of double slits.

Recommended books and References:

1. Advanced practical physics for students, B.L. Flint and H.T Worsnop, 1971, Asia publishing House.
2. Advance level physics practicals, Michael Nelson and John M. Ogborn, 4th edition.
3. A textbook of practical physics, I. Prakash & Ramakrishna, 11th edition, 2001.

MJ-8: CONDENSED MATTER PHYSICS-I
Credits:(Theory-03, Prctical-01) Teaching Hours: 45+30

Course Objective

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. The gained knowledge helps to solve problems in solid state physics using relevant mathematical tools. It also communicates the importance of solid-state physics in modern society.

Learning Outcomes

On successful completion of the module students should be able to

• Elucidate the concept of lattice, crystals and symmetry operations.

• Understand the elementary lattice dynamics and its influence on the properties of materials.

• Describe the main features of the physics of electrons in solids: origin of energy bands, and their influence electronic behavior.

• Explain the origin of dia-, para-, and ferro-magnetic properties of solids.

• Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability.

• Understand the basics of phase transitions and the preliminary concept and experiments related to superconductivity in solid.

• In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

UNIT I
Crystal Structure and Elementary Lattice Dynamics: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Lattice Vibrations and Phonons: Linear

Monoatomic and Diatomic Chains. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. (15 hours)

UNIT II

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. (15 hours)

UNIT III

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Elementary band theory: Kronig Penny model. Band Gap. Conductor, Semiconductorand insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) (15 hours)

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
6. Solid State Physics, Rita John, 2014, McGraw Hill
7. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
8. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

PRACTICAL: Condense Matter Physics-I

Credit: 01 **Practical Hours: 30**

In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To measure the Dielectric Constant of a dielectric Materials with frequency
4. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
5. To determine the refractive index of a dielectric layer using SPR
6. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
7. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150oC) and to determine its band gap.
8. To determine the Hall coefficient of a semiconductor sample.

Reference Books:

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, 11th Ed., 2011, Kitab Mahal
4. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

MJ-9: MATHEMATICAL Physics-III
Credits: (Theory-03, Practical-01) ***Teaching Hours: 45+30***

Course Objective

The emphasis of the course is to develop mathematical skill. So, that they can use in solving problems of interest to physicists.

Course Learning Outcomes

At the end of this course Students will learn:

- Complex variables
- Fourier and Laplace transforms

UNIT I
Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions, Cauchy’s Integral

formula,Residues and Residue Theorem. Application in solving Definite Integrals. (15 hours)

UNIT II

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). (15 hours)

UNIT III

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. (15 hours)

Reference Books:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
3. Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
4. Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press 5. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
5. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett .

PRACTICAL: MATHEMATICAL PHYSICS-III

Practical Credit: 1 **Practical Hours: 30**

The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem. The aim of this Lab is to use the computational methods to solve physical problems. The instructor may choose to use Scilab/ Python

1. Dirac Delta function:
2. Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{-\frac{(x-2)^2}{2\sigma^2}}(x+3)dx \quad for \quad \sigma = 1, 0.1, 0.01$ and show it tends to 5.
3. Orthogonality of Legendre polynomial (using integration).

4. Show that $\int_0^\infty e^{-x} L_m(x)L_n(x)dx = 0$; $m \neq n$
5. Show that $\int_{-1}^{1} e^{x^2} H_m(x)H_n(x)dx = 0$; $m \neq n$
6. Evaluation of Fourier Coefficients for some simple problems.
7. Let f (x) $=x^2$ defined over the interval $(-\pi, \pi)$ write a Scilab code to evaluate the value of f(x) using Fourier series and also plot f(x) vs x.
8. Let f (x) = x defined over the interval $(-\pi, \pi)$ write a Scilab code to evaluate the value of f(x) at x=1 using Fourier series expansion.
9. Linear and quadratic curve fitting using least square method.
10. Fourier and inverse Fourier Transform of sinusoidal signal and Gaussian function(e^{-at^2}).
11. Compute the n^{th} roots of unity for $n = 2, 3$ and 4..
12. Find the two square roots of $-5+12j$.

Reference Books:

1. 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.
2. Documentation at the Scilab homepage: https://www.scilab.org/ and the Python home page https://docs.python.org/3/
3. Computational Physics, Darren Walker, Scientific International Pvt. Ltd (2015).
4. Applied numerical analysis, Cutis F. Gerald and P.O. Wheatley, Pearson Education, India (2007).
5. An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010)

MJ-10: ANALOG ELECTRONICS
Credits: (Theory-03, Practical-01) **Teaching Hours: 45+30**

Course Objective

This course introduces the concept of semiconductor devices and their applications. It also emphasizes on understanding of amplifiers, oscillators, operational amplifier and their applications.

Course Learning Outcomes

At the end of this course, the following concepts will be learnt

- Characteristics and working of p-n junction.
- Two terminal devices: Rectifier diodes, Zener diode, photodiode etc.

- NPN and PNP transistors: Characteristics of different configurations, biasing, stabilization and their applications.
- CE and two stage RC coupled transistor amplifier using h-parameter model of the transistor.
- Designing of different types of oscillators and their stabilities.
- Ideal and practical op-amps: Characteristics and applications.
- In the laboratory course, the students will be able to study characteristics of various diodes and BJT. They will be able to design amplifiers, oscillators and DACs. Also different applications using Op-Amp will be designed.

UNIT I

Semiconductor P-N junction diodes: P and N type semiconductors. PN Junction Fabrication (Simple Idea). Transport phenomena in semiconductors (Drift and Diffusion current).Electrical conductivity of semiconductors. Barrier Formation in PN Junction diode Field analysis of P-N junction. Derivation for barrier potential and space charge width for Step, Junction. P-N Junction under biased conditions. I-V characteristic and resistance of P-N junction diode. A brief idea about different types of P-N junction diode.

Applications of P-N junction diodes: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, (2) Zener Diode and Voltage Regulation. (15 hours)

UNIT II

Bipolar Junction transistors (BJT): n-p-n and p-n-p transistors, transistor in CB, CE and CC Configurations. Current gains α and β and their relation. Characteristic curve of transistor for CE configuration and its DC Load Line analysis, Transistor biasing and stabilization,Physical mechanism of Current Flow, Biasing of a CE transistor by using Voltage Divider network, AC resistance of the emitter diode, field effect transistor. Voltage Amplifier: CE amplifier, DC and AC equivalent circuit. AC load line.h-parameter model of a transistor. Analysis of a single-stage CE amplifier using h-parameter Model. Input and Output Impedance. Current and Voltage Gains. Emitter follower and its gain. Brief idea about the Class A, B & C power amplifiers.

Coupled Amplifier: Two stage RC-coupled amplifier, its frequency response and bandwidth Voltage gain in mid, low and high frequency range.

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift, Hartley & Colpitts oscillators. (15 hours)

UNIT III

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of virtual ground.

Applications of Op-Amps: Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier, Zero crossing detector and Wein bridge oscillator.

Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation) (15 hours)

Recommended Books and References:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Electronic Devices & circuits, S.Salivahanan&N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
4. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
5. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6thEdn., Oxford University Press.
6. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
7. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
8. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
9. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India 303

PRACTICAL: ANALOG ELECTRONICS
Credit: 01 **Practical Hours: 30**

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider
   bias.
2. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
3. To study the Colpitt`s oscillator.
4. To design a digital to analog converter (DAC) of given specifications.
5. To study the analog to digital convertor (ADC) IC.
6. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
7. To design inverting or non-inverting amplifier using Op-amp (741,351) and study its frequency response.
8. To study the zero-crossing detector and comparator.

9. To add two dc voltages using Op-amp in inverting and non-inverting mode.
10. To design a Half-WAVE rectifier with and without capacitor filter.
11. To design a FULL -WAVE rectifier with and without capacitor filter.
12. To investigate the use of an op-amp as an Integrator or Differentiator.

Recommended Books and References:

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-GrawHill.
2. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
3. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
4. Electronic Devices & circuit Theory, R.L. Boylestad& L.D. Nashelsky, 2009, Pearson

MJ-11: CLASSICAL MECHANICS
Credit: (Theory-03,Tutorial-01) **Teaching Hours: 45+30**

Course Objective:
Students will understand and comprehend the advantage of Lagrangian and Hamiltonian formulation in mechanics. The students will be able to apply the formulations in various physical system including central force problem and the theory of small oscillation. Students will be better equipped with the classical theory of field

UNIT I
Lagrangian & Hamiltonian Formulation: Mechanics of a particle, constraints, degrees of freedom, generalized coordinates, D'Alembert's principle, calculus of variation& principle of least action, Hamilton's variational principle, Euler's-Lagrange differential equation and its applications, Lagrangian for a charged particle in electromagnetic field, gyroscopic forces, advantages of Lagrangian approach over Newtonian mechanics.
Hamiltonian formulation in classical mechanics, physical significance of Hamiltonian, Hamilton's canonical equations of motion and its applications, Hamiltonian for a charged particle in an electromagnetic field, advantages of introducing Hamiltonian formulation, canonical transformations, conditions for a canonical transformation, generating functions, Poisson brackets.
(15 hours)

UNIT II

Central Force Problem & Rigid Bodies: Central force problem, reduction to the equivalent of one body problem, the equation of motion and first integrals, General features of central force motion, conservation of energy & angular momentum, Kepler's laws of planetary motion, Kepler's second law of planetary motion, Rutherford scattering.

Kinematics of a rigid body, Generalized coordinates for a rigid body motion, Euler angles, Euler's theorem, principal axes transformation, principal moment of inertia, diagonalization of matrix, secular equation of inertia tensor, torque free motion of a rigid body, heavy symmetrical top with one point fixed. (15 hours)

UNIT III

Small Oscillations & Introduction to Relativistic Mechanics: Small oscillations, normal modes of motion, stable and unstable equilibrium, framework on the theory of small oscillations, two coupled oscillators, normal modes of vibrations, normal co-ordinates, Lagrange's equation of motion for small oscillations.

Minkowski space, the invariant interval, four vectors, space-like, time-like and light-like, four-velocity, four acceleration, four-momentum, four force, Relativistic momentum and energy, Relativistic Doppler's effect, Lorentz transformation of force, Relativistic Lagrangian and Hamiltonian. (15 hours)

Recommended Books and References:

1. Classical Mechanics – H. Goldstein, 2^{nd} Edition, Addison-Wesley Pub. Co.
2. Classical Electrodynamics_ J.D. Jackson, 3rd Edn., 1998, Wiley.
3. Mechanics- L.D. Landau and E.M. Lifschz (pergamon).
4. Classical Mechanics- J.W. Muller-Kirsten (world Scientific,2008).
5. Classical Mechanics of particles and Rigid bodies – Kiran C. Gupta, New Age international (P) Ltd., 2008
6. Classical Mechanics – S.L. Gupta, V. Kumar and H.V. Sharma, Pragati Prakashan Publishers, Meerut, India (2010)
7. Classical mechanics – P.S. Joag and N.C. Rana, Tata McGraw - Hill Education (2001).
8. Classical Mechanics – J.C. Upadhyaya, Himalaya Publishing House, India (2010).

MJ-12: Quantum Mechanics-I

Credits: (Theory-03, Tutorial-01) **Teaching Hours: 45+30**

Course objectives

This course aims to extend the Quantum mechanical concept developed in the elements of modern physics. The main objectives of this course is to understand the stationary states, atoms in magnetic and electric fields, atoms with many electrons and identical particles.

Course Learning outcomes

After the successful completion of this course, the students will be well-versed in

- Linear vector spaces, Hilbert space, concepts of basis and operators and bra and ket notation.
- Theory of angular momentum and spin matrices, orbital angular momentum and Clebsh Gordan Coefficients.

- Connection between symmetry and conservation laws, commutation relations, tools to calculate components and total angular momentum.
- Solving the hydrogen atom problem which is a prelude to more complicated problems in quantum mechanics

Unit 1

Formulation of Quantum Mechanics and stationary states Dirac's Notation, Hilbert space, Virial Theorem, Coherent States of the Harmonic Oscillator. Dirac delta potential and its bound state wave function, Dirac-Delta well and scattering. Schrodinger Equation in spherical polar coordinates, Hydrogen atom in Spherical Coordinates, Shapes of the probability densities for ground and first excited states, Physical significance of quantum numbers, Hydrogen Spectrum. (15 hours)

Unit 2

Atoms in magnetic and electric fields

Angular momentum of electron: Space quantization, electron spin and spin angular momentum, total angular momentum. Spin ½ systems and Pauli's spin matrices, Larmor's theorem. Addition of angular momenta, singlet and triblet state, Clebsch-Gordon coefficients. Vector model of atom. Spin magnetic moment and Lande's g-Factor. Normal and Anomalous Zeeman effect, Stern-Gerlach experiment, Paschen Back Effect and Stark effect. (15 hours)

Unit 3

Atoms with many electrons: Identical particles, Pauli's exclusion principle, symmetric and anti-symmetric wave functions. Coupling schemes: L-S and J-J couplings. Fine structure of hydrogen atom: Relativistic correction and spin orbit coupling, spectra of hydrogen and Alkali atoms (Na etc.), hyperfine spitting.

Identical Particles: Two particle systems, Schrodinger equation, energy Eigen values for positron and Muonic Hydrogen. Bosons and Fermions, Exchange forces, Slater's Determinant. Helium atom, Para and Ortho Helium, Periodic table and Hund's threre rules. (15 hours)

Recommended Books and References:

1. Quantum Mechanics, A.K.Ghatak and S.Lokanathan.
2. Introductory Quantum Mechanics, R.L.Liboff.
3. Principles of Quantum Mechanics, R. Shankar.
4. Quantum Mechanics: Concepts and applications, N.Zettili
5. Quantum Mechanics, Mahesh C. Jain
6. Quantum Mechanics, A Ghatak and S Lokanathan, Trinity Press
7. A Textbook of Quantum Mechanics,Mathews and Venkatesan, McGraw Hill

MJ-13: STATISTICAL MECHANICS

Credits: (Theory-03 , Practical-01) **Teaching Hours: 45+30**

UNIT I

Classical Statistics: Microstate& Microstate, Elementary Concept of Ensemble, Phase space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. (15 hours)

UNIT II

Theory of Radiation: Properties of Thermal Radiation, Blackbody Radiation, Pure temperature dependence, Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. Planck's Law of Blackbody Radiation: Experimental Verification. (15 hours)

UNIT III

Quantum Statistics: Basic concept of Quantum Mechanics, Quantum statistics of identical particles, Symmetric and Antisymmetric wavefunctions, Statistical weight, Density matrix, Time dependence of density matrix.

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. (15 hours)

PRACTICAL: Statistical Mechanics

Credit: 1 **Practical Hours: 30**

The aim of this lab is to introduce the students in numerical simulations, which help them in visualization of concepts in Statistical Mechanics.

Instructor can use C/C^{++}/Scilab/or any other programming language for numerical simulations .

1. Write the code for plotting the Lennard - Jones potential. By taking the range as r = [3.0-10.0] Å, and the value of $\epsilon/k_B = 120\ K$ and $\sigma = 3.4$Å for argon.
2. Write the code and plot for Maxwell distribution curve
   (a) for oxygen gas at various temperature.
   (b) for different gas like hydrogen, nitrogen, chlorine at temperature

273K.

3. Write the code and plot :
   (a) the spectral density (u_λ) curve (Plank's law) for electromagnetic radiation emitted by a black body in thermal equilibrium at a temperature T with wavelength(λ)
   (b) Wein's law at different temperature (c) Rayleigh 'law at different temperature.
4. Write the code for plotting
   (a) Planck's law, Wein's law and Rayleigh Jean's law at same temperature for black body radiation.
   (b) Write the code for plotting Fermi-Dirac Distribution curve for for temperature.
   (c) Write the code for plotting Bose –Einstein's Distribution curve for different temperature.
5. Write the code for plotting specific heat at constant volume(c_v) of solids with temperature (T) for Dulong-Petit's, Debey's law and Einstein's law.

Reference Books:

1. Schaum's outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Publication
2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rdEdn., 2007, Cambridge University Press.
3. An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández.2014 Springer.
5. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
6. Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978-6133459274

MJ-14: ELECTRODYNAMICS

Credit: (Theory-03, Pratical-01) ***Teaching Hours: 45+30***

Course Objective

This course will help the students to learn the relationship between electric and magnetic field and further develop the theory of electromagnetic theory. It will impart the knowledge about propagation and polarization of electromagnetic waves and apply it in various areas. The students will be introduced to relativistic electrodynamics

Course learning outcome:

At the end of this course the student will be able to:

- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
- Understand electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma.
- Understand electromagnetic wave propagation in bounded media: reflection and transmission coefficients at plane interface in bounded media.
- Understand polarization of Electromagnetic Waves: Linear, Circular and Elliptical Polarization.

UNIT I

Maxwell Equations & Electromagnetic Wave Propagation in unbounded media: Maxwell's Equations, Maxwell's Equations in differential form, Equation of continuity, Displacement Current, Potential formulation of electrodynamics, Vector and Scalar Potentials, Gauge Transformations, Gauge invariance, non-uniqueness of electromagnetic potential, Lorentz and Coulomb Gauge, four dimensional Poisson's equations, D' Alembertian and D' Alemberts equations.

The wave equation, second order wave equation in terms of the field vector, Plane electromagnetic waves through vacuum, transverse nature of plane electromagnetic waves and to show that the electric and magnetic field vectors are mutually perpendicular to the propagation vector, wave impedance, calculation of the wave impedance of free space, Propagation of plane electromagnetic through conducting media skin depth. (15 hours)

UNIT II

Electromagnetic Wave propagation in Bounded Media & Wave Guides:
Reflection & transmission of plane electromagnetic waves at normal incidence, reflection and transmission coefficient for a plane electromagnetic wave at normal incidence, propagation of plane electromagnetic waves in accordance with the law of conservation of energy, Reflection &transmission of plane waves at oblique incidence, law of reflection, Snell's law, Fresnel's equation, Brewster's angle.

Wave guides, transverse magnetic (TM) wave, transverse electric (TE) wave, rectangular wave guide, cut off frequency. (15 hours)

UNIT III

Polarization of Electromagnetic Waves& Relativistic Electrodynamics
Polarised & unpolarized light, plane polarized light, plane of polarization, plane of vibration, dichroism, production of dichroism, birefringence and its application, double reflection, optic axis and principal plane of a crystal, uniaxial crystal, double refraction through uniaxial crystal, negative and positive crystal, construction and action of a Nicol prism, theory of plane, elliptical and circularly polarized light, theory and construction of quarter and half wave plate.

Transformation of Differential operator, invariance of D'Alembertian operator, invariance of charge, transformation of charge density, electric field measured in different frame of reference, transformation of charge and current densities, equation of continuity in covariant form, transformation of electromagnetic potentials, Lorentz conditions in covariant form Maxwell's field equation in terms of four vectors, electromagnetic field tensors. (15 hours)

Recommended Books and References:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
6. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.

PRACTICAL: ELECTRODYNAMICS

Credit: 1 **Practical Hours: 30**

Each Student is expected to perform at least 5-6 experiments out of the following experiments and the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study the reflection, refraction of microwaves
5. To determine the refractive index of liquid by total internal reflection using Wollaston's air- film.
6. To verify the Stefan`s law of radiation and to determine Stefan's constant.
7. To determine the Boltzmann constant using V-I characteristics of PN junction diode.
8. Study of microwaves characteristics through different dielectric medium.

Computational Lab

9. Generate Electromagnetic Wave using software.
10. To study the radiation pattern for a simple Dipole antenna.
11. To study propagation of wave using Rectangular Waveguide
12. To calculate phase & group velocity.
13. To plot radiation pattern of dipole antenna.

Reference books:

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 Publisher
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Spring

MJ-15: DIGITAL ELECTRONICS
Credits: (Theory 3, Prcctical-01) **Teaching Hours: 45+30**

Course Objective

This is one of the core papers in physics curriculum which introduces the concept of Boolean algebra and the basic digital electronics. In this course, students will be able to understand the working principle of Digital circuit, integrating circuit, data processing circuit, Arithmetic Circuit, sequential circuits like registers, counters etc. based on flip flops. In addition, students will get an overview of microprocessor architecture and programming.

Course Learning Outcomes

This course provides a fundamental understanding of digital logic circuits, their application in combinational and sequential logic circuit design, integrated circuit, microprocessor system architecture, memory, and input/output organization.

UNIT I
Digital Circuits: Difference between Analog and Digital Circuits. Analysis of a Transistor as a switch. Binary, Decimal and Hexadecimal number systems and their inter conversions. Binary and hexadecimal, addition and subtraction. Realization of AND, OR and NOT Gates using transistor.NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.
Integrated Circuits: (Qualitative treatment only), Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only, Configuration of Digital TTL lCs for AND, OR, NOT, NAND and NOR logic gates. (15 hours)

UNIT II
Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.
Data processing circuits: Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits: Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.
Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.
Timers: IC 555:Block diagram and applications: Astable and Monostable multivibrator.
Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).
(15 hours)

UNIT III
Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.
Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM), Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram, Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. Introduction to Assembly Language: 1 byte, 2 byte &3-byte instructions. (15 hours)

Recommended Books and Recommended Books and References:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2ndEdn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics G K Kharate ,2010, Oxford University Press.
5. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning.
6. Logic circuit design, Shimon P. Vingron, 2012, Springer.
7. Digital Electronics, SubrataGhoshal, 2012, Cengage Learning.
8. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill.
9. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

PRACTICAL : DIGITAL SYSTEMS AND APPLICATIONS
Credit: 1 **Practical Hours: 30**
N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. To design a switch (NOT gate) using a transistor.
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To design a combinational logic system for a specified Truth Table.

4. To convert a Boolean expression into logic circuit and design it using logic gate ICs.To minimize a given logic circuit.
5. Half Adder, Full Adder and 4-bit binary Adder.
6. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
7. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
8. To build JK Master-slave flip-flop using Flip-Flop ICs
9. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
10. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
11. To design an astable multivibrator of given specifications using 555 Timer.
12. To design a monostable multivibrator of given specifications using 555 Timer.
13. Write the following programs using 8085 Microprocessor a) Addition and subtraction of numbers using direct addressing mode b) Addition and subtraction of numbers using indirect addressing mode c) Multiplication by repeated addition. d) Division by repeated subtraction. e) Handling of 16-bit Numbers. f) Use of CALL and RETURN Instruction. g) Block data handling. h) other programs (e.g., Parity Check, using interrupts etc.).

Recommended Books and References:

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-GrawHill.
2. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
3. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
   Electronic Devices & circuit Theory, R.L. Boylestad& L.D. Nashelsky, 2009, Pearson.

MJ-16: ADVANCED MATHEMATICAL PHYSICS
Credits: (Theory-03, Tutoril-01) **Teaching hours:45+30**

Course Objective

The course is intended to impart the concept of generalized mathematical constructs in terms of signal processing by Fourier/Laplace transform, algebraic structures of Group/Symmetry elements and multi-directional approach of Tensors. Thus, the courser offers in-depth analysis of our physical system.

Learning Outcomes

At the end of this course, students will be able to

- Understand Fourier transform and its properties and will be able to solve the examples based on it.
- Have deep knowledge of Laplace Transformation and its real life application and solve initial value problem and boundary value problem using Laplace Transform.
- Understand algebraic structures in group theory and basic properties of group.
- Learn to assign matrix representation to various groups and analysis symmetry associated with different molecular structure.
- Learn basic properties of Cartesian and general tensors with physical examples such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor etc.
- Learn how to express the mathematical equations for the Laws of Physics in their co- variant forms.

UNIT I

Fourier and Laplace Transform: Fourier transform, Properties of Fourier transform, , Fourier transform derivative, application of Fourier transform to solve differential equationand boundary value problems. Laplace transform, properties of Laplace transform, transform of derivative ,Convolution theorem, inverse Laplace transform, properties of inverse Laplace transform, solution of differential equations using Laplace transform. (15 hours)

UNIT II

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, Christioffel symbol of first and second kind, tensor law of transformation of Christioffel symbol. (15 hours)

UNIT III

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. Matrix Representations: Reducible and Irreducible, 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. (15 hours)

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

MJ-17: Atomic and Molecular Spectroscopy
Credits: (Theory_03, Practical-01) **Teaching hours:45+30**

Course Objectives

The main objective is to teach the students the basic atomic and molecular (diatomic) structures with quantum mechanical approach leading to their fundamental spectroscopies. The fundamentals and properties of a coherent light source as Laser and its types will also be taught.

Course learning outcomes:

- Students will learn the details of atomic and diatomic molecular (diatomic) structures in terms of quantum mechanical treatment elaborately beyond the basic models.
- It will give the descriptions of fine structure of atoms and rotational, vibrational and electronic energies of molecules manifesting in their respective spectroscopies. The details of these spectroscopies would serve as the fundamentals for various concerned experimental results.

UNIT I
Atomic spectra: Sommerfeld theory of hydrogen atom: Sommerfeld elliptical orbits and energy, relativistic correction and energy. Fine structure of H_α and He^+ line. 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. 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. (15 hours)

UNIT II
Molecular spectra: Types of molecular energy states and associated spectra Rotation and vibration of diatomic molecule, Moment of inertia and bond length of diatomic and linear triatomic molecule. 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 an harmonic oscillator. (15 hours)

UNIT III
Spin resonance spectroscopy: 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, instrumentation- continuous wave mode, application of NMR in medicine. Electron spin resonance (ESR): interaction with magnetic field, g factor, relaxation mechanism, fine and hyperfine structure of ESR, double resonance in ESR.Nuclear quadrupole resonance (NQR): quadrupole nucleus, principle, detection, transitions for axially symmetric and non-axially symmetric system with respect to integral and half integral spin, NQR instrumentation: continuous wave oscillator. Mössbauer effect: recoiless emission and absorption, isomer shift, magnetic hyperfine interaction. (15 hours)

Recommended Books and References:

1. Introduction to Atomic Spectra – H E White, McGraw-Hill
2. Fundamentals of Molecular spectroscopy – Colin N Banwell and Elaine 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

PRACTICAL : ATOMIC AND MOLECULAR SPECTROSCOPY
Credit: 1 **Practical Hours: 30**

1. To find the dispersive power of the given prism using mercury vapour lamp.
2. To determine the wavelength of sodium light using plane diffraction grating.

3. To study the absorption spectrum of iodine vapour and to calculate electronic energy gap,vibrational energies and force constant for its excited state.
4. To study fine structure of Hg spectral lines using constant deviation spectrometer.
5. To determine the value of Rydberg constant with the help of grating spectrometer using hydrogen gas discharge tube.
6. Study of Zeeman Effect.

Recommended Books and References:

1. Experiments in Modern Physics – Mellissino
2. Advance Practical Physics – Worsnop and Flin

MJ-18(A): CONDENSED MATTER PHYSICS-II
Credits: (Theory-03, Practical-01) Teaching Hours: 45+30

UNIT I

Specific Heat Of Solids Lattice vibration And Energy Bands In Solids: Einstein and Debye theory of specific heat of solids, quantization of lattice vibration-phonon, Electronic specific heat, thermal conductivity and electrical conductivity, Wiedemann-Franz law, Kronig Penny model Effective Mass of electrons and holes, Distinction between metals, insulators and semiconductors, Nearly Free Electron Approximation, Tight Binding approximation, application to a simple cubic crystal. (15 hours)

UNIT II

Elements of Semiconductor Physics And Magnetic materials: Density of carriers in intrinsic and extrinsic semiconductors, Variation of Fermi level with temperature and carrier concentration, conductivity and their variation with temperature, Hall effect and magnetoresistance. Dia, para and ferro magnetism, Langevin theory of dia and para magnetism, Curie-Weiss law, Pauli paramagnetism, Weiss theory of Ferromagnetism, Heisenberg's exchange interaction, elements of ferrimagnetism and antiferromagnetism.
(15 hours)

UNIT III

Superconductors and Dielectrics: Superconducting materials, Types of superconductors, Meissner effect, London equation and penetration depth, Isotope effect, Flux quantization and Josephson effect, BCS theory, Applications of superconductors.
Concept of local field, The electronic, ionic and orientation polarizabilities, measurement of dielectric constant of a solid, Clausius-Mosotti relation, relation between dielectric constant and refractive index.
(15 hours)

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).

PRACTICAL: CONDENSED MATTER PHYSICS-II

Credit: 01 **Practical Hours: 30**

To measure the magnetic susceptibility of Solids.

1. To measure the Dielectric Constant of dielectric Materials with Frequency.
2. To draw BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
3. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150^0 C) and to determine its band gap.
4. To determine the Hall coefficient of a semiconductor sample.

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 Practical's, Michael Nelson and Jon M. Ogborn, 4^{th} edition, reprinted 1985, Heinemann Educational Publishers.
3. A text Book of Practical Physics, I.Prakash & Ramakrishna, 11^{th} Ed., 2011, Kitab Mahal.
4. Elements of solid state Physics, J.P. Srivastava, 2^{nd} Ed., 2006, Prentice Hall of India.

MJ-18(B): Bio-Physics

Credit: (Theory-03, Prcatical-01) **Teaching Hours: 45+30**

Course Objective

This course familiarizes the students with the basic facts and ideas of biology from a quantitative perspective. It shows them how ideas and methods of physics enrich our understanding of biological systems at diverse length and time scales. The course also gives them a flavour of the interface between biology, chemistry, physics and mathematics .

Course Learning Outcomes

At the end of this course , students will know basic facts about biological system, including single cells, multicellular organism and ecosystems from a quantitative perspective. Be able to apply the principles of physics from areas such as mechanics, electricity and magnetism, thermodynamics, statistical mechanics and dynamical system to understand certain living processes. Gain a systems level perspective on organisms and appreciate how networks of interactions of many components give rise to complex behavior. Students will also perform mathematical and computational modelling of certain aspect of living systems.

UNIT I.

Photochemistry: Interaction of photons with chemical compounds, photosensitive chemicals, photo induced his course electronic transitions in organic molecules, quantum yield, photo induced chemical reactions in air (troposphere, stratosphere, other spheres), examples, reaction mechanisms and applications, Chemiluminescence. (15 hours)

UNIT II.

Radiation Biophysics: Radiation in Environment: (i) Ionizing & Non-Ionizing Radiations and their origins; Dose Measurement; (ii) Nuclear Radiation:Radio-Isotopes, Radioactive decay kinetics. (iii) Electromagnetic Radiations and classification. Ionizing and non- ionizing radiation (a) X-Ray: Effects on Bio-macromolecules. (b) Gamma Radiation: Molecular Effects of Gamma Radiation. (15 hours)

UNIT III

Environmental Biophysics: The boundary , interior and exterior environment of living cells. Process: exchange of matter and energy environment, metabolism, maintenance,reproduction, evolution. Self - replication as a distinct property of biological systems. Time scales and spatial scales. Allometric scaling laws. Molecular motion in cell: Random walks and applications to biology.models of macromolecules. Entropic and chemical forces. Molecules of life: Metabolites, proteins and nucleic acids. Simplified mathematical models of transcription and translation. (15 hours)

Reference books:

1. Nuclear Physics, Theory and Experiment by Roy R.R& Nigam B.P. (Wiley)
2. Introductory Nuclear Physics by Halliday D, (John Wiley)
3. Biological Effects of Radiation by Coggle J.E.. (Taylor & Francis).
4. Molecular Theory of Radiation Biology by Chadwick K.H. &Leenbouts H.P. (Springer Verlag)

5. Introduction to Radiological Physics and Radiation Dosimetry by Atlik F.H. (John Wiley)
6. An Introduction to Environmental Biophysics by Campbell, Gaylon S., Norman, John M. (Springer)
7. Biological physics: Energy, information, life; Philips Nelson (W H Freeman & Co, NY,2004)

Practical: Bio Physics
Credit:1 **Practical Hours: 30**

1. Studying UV absorption spectra of DNA and protein, and effect of heat denaturation.
2. Studying secondary/tertiary structure of proteins through CD spectroscopy.
3. Studying interaction of dyes with DNA through fluorescence spectroscopy.
4. Studying dynamics of chlorophylls I& II through absorption spectroscopy.
5. Effect of light on Vitamins A (retinol) through spectroscopic methods

MJ-18(C): COMPUTATIONAL PHYSICS
Credit: (Theory-03, Practical-01) ***Teaching Hours: 45+30***

Course Objective
The objective of this course is to introduce the students to a common numerical methods and apply these numerical methods to obtain approximate solutions of mathematical problems.

Course Learning Outcome
On completing this course, the students will be able to:

- Solve algebraic and transcendental equations numerically.
- do interpolation and curve fitting on data sets.
- do Numerical Differentiation and Integration
- solve ODE of first and higher order and PDE with finite difference method

UNIT I
Algebraic Equations and curve fitting: Algebraic and transcendental equations, Solving an equation with Newton-Raphson method and bisection methods, comparison of their limitations.
Concept of interpolation, linear interpolation, quadratic interpolation, Lagrange’s interpolation, Richardson’s extrapolation, Newton’s interpolation, Sterling formula.
Curve fitting, least square method, curve fitting for a straight line, curve fitting for a power law equation. (15 hours)

UNIT II

Numerical Differentiation and Integration: The concept of numerical differentiation and integration, Derivative using Newton's forward and backward and Sterling's central difference formula

Integration method- Newton-Cotes formula, Trapezoidal and Simpson's 1/3 and 3/8 rules and their relation to interpolation, Gauss quadrature 2 point and 3 point. (15 hours)

UNIT III

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, 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,

Partial differential equations (PDEs), the concept of initial and boundary value problems, finite differencing approximation to partial differential equation -Laplace and Poisson equations. (15 hours)

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. VerllingandB. 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.

PRACTICAL: COMPUTATIONAL PHYSICS

Practical Credit: 1 **Practical Hours: 30**

In this lab, students will learn programming tactics, numerical methods and their implementation.

Instructor may use any of these computer programming Fortran/C/C++/SCILAB.

2. 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.
3. 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.
4. Find out the eigen values and eigen vectors of a given matrix.
5. 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.
6. Integrate a given function or series by any given method (a) Limits method (b). Extrapolation method.
7. Integrate a given function by any one of a given method (a) Quadrature formula (b). Trapezoidal rule (b) Simpson' s rule
8. 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.
9. Solve a given parabolic partial differential equation (Heat equation)by any given method.
10. Solve a given elliptic partial differentia 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. 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.
5. Computational Physics, Darren Walker, Scientific International Pvt. Ltd (2015)

MJ-19(A): Advanced Statistical Mechanics
Credits: (Theory 3 , Tutorials: 01) **Teaching Hours: 45+30**

OBJECTIVES: To introduce statistical mechanics as a subject that can be applied in various fields such as Astrophysics, Semiconductors, Plasma Physics, Bio-Physics, etc.

OUTCOME EXPECTED: At the completion of the course, the students will be able to understand the concept of microstate, microstate, phase space, thermodynamic probability and partition functions. They will be able to apply the Bose-Einstein distribution and Fermi-Dirac distribution to model problems.

UNIT I

Classical Statistics: Elementary Concept of Ensemble, phase space and Liouville's theorem (classical), partition function, Gibb's canonical ensemble. Micro-canonical ensemble, Canonical ensemble, Grand canonical ensemble and their thermodynamical functions.

Quantum Statistics: 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, Ideal gas in quantum mechanics, Thermodynamic behaviour of an ideal Bose gas, mean energy of fermions at absolute zero, Boltzmann limit of Boson and Fermions gases (15 hours)

UNIT II

Non-Equilibrium Statistical Mechanics: Fluctuations and irreversible process. Fluctuations in ensembles, Brownian motion: as a random walk (EinsteinSmoluchowski 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 noise (Niquist theorem), Thermodynamic irreversible processes- Onsager reciprocal relations. (15 hours)

UNIT III

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 meanfield theory of phase transition , symmetry breaking. Heisenberg models of ferromagnetism, Bethe approximation. (15 hours)

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.

MJ-19(B) :EXPERIMENTAL TECHNIQUES
Credits: (Theory-03, Practical-01) **Teaching Hours: 45+30**

Course objective

This course will introduce an experimental techniques, Measurement signals and system to the students. It reviews the concepts of instrumentation techniques learnt at school from a more advanced perspective and develops them further. The primary goal is to understand the fundamental laws and the applications to various systems and processes. In addition, it will also give exposure to students about Sensors and digital instrumentations.

Course Learning Outcomes

This coursework will also enable the students to understand the connection between observations of physical and signals system .

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)

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 (15 hours)

UNIT II

Shielding and Grounding: Methods of safetygrounding. Electrostatic shielding .Electromagnetic Interference.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.

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). (15 hours)

UNIT III

Transducers & Sensors:RTD, Semiconductor type temperature transducer(AD590, LM35, LM75). Linear variable differential transforme (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector.

Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter.

Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge. Q-meter and its working operation.

Oscilloscope: Block diagram and working principles of CRO. (15 hours)

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.
7. Signals and system A. Anand Kumar

PRACTICAL: EXPERIMENTAL METHODS

Credit: 1 **Practical Hours: 30**

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.

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

MJ-19(C): ATMOSPHERIC PHYSICS

Credit: (Theory-03, Prcatical-01) **Teaching Hours: 45+30**

Course Objective

The objective of this course is to give students a general idea about atmospheric physics anf to introduce about dynamics of atmosphere

Course Learning Outcomes

After completing this course, students will gain an understanding

- General features of Earth atmosphere.
- dynamics of atmosphere and general circulation
- *Numerical modeling & atmospheric aerosols.*

UNIT I

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Composition of atmosphere, thermodynamic process, isentropic process, potential temperature, equivalent temperature, equivalent potential temperature, virtual temperature Poisson's equation for pressure and temperature, Clausius–Clapeyron equation, parcel method, vertical stability of the atmosphere, determination of the stability of an air parcel, stable equilibrium, unstable equilibrium and neutral position for unsaturated and dry air, equilibrium states for saturated air parcel, condition for absolute instability, conditional adiabatic instability.

Clouds, Cloud classification, Raoult's Law, Kelvin equation, Kohler equation, Bergeron- Findeisen process, lifting condensation level (LCL), Level of free convection (LFC), Convective AvailablePotential Energy (CAPE) and Convective Inhibition Energy (CINE), precipitation, Local winds, monsoons, fogs, Cyclones and Anticyclones, Atmospheric ionization, global electrical circuit, basic characteristics of electrification theories, thunderstorms. (15 hours)

UNIT II

Atmospheric Dynamics, Waves& Boundary Layer: Inertial and non-inertial frame, fundamental forces, real and pseudo force, Body and surface force, Pressure gradient force, gravitational force, centripetal force, Coriolis force, viscous force, centrifugal force, curvature effect, equation of motion in rotating frame of reference, Hydrostaticequation, Scaleanalysis, Atmospheric oscillations, Quasi biennial oscillation, Mesoscale circulations, the general circulations.

Surface water waves, acoustic waves, buoyancy waves, Lamb wave, Rossby waves.

Structure, evolution and properties of planetary boundary layer, the Boussinesq approximation, mixing length theory, Ekman layer, surface layer, modified Ekman layer. (15 hours)

UNIT III

General Circulation, Numerical Modelling&Atmospheric Aerosols:

General circulation, Hadley circulation, zonally averaged circulation, Eulerian mean, zonal and meridional components of drag owing to small eddies, mean meridional motion, advantage of zonally averaged circulation, conventional eulerian mean, transformed eulerian mean, eddy potential vorticity, Eliassen-palm flux, angular momentum budget, ferrel's cells & polar cells, single cell model, three cell model, meridional circulation model, walker circulation, El NINO and the southern oscillation (ENSO) & LA NINA, MJO (Madden-Julian oscillation)

Basic principles of Numerical Weather Prediction, climate model, different types of climate model, basic governing equations in Numerical Weather Prediction model (without derivation), brief idea about parameterization schemes & Data assimilation, basic concepts of ocean – atmosphere coupled models.

Classification and properties of aerosols, Production and removal mechanisms, Radiative and health effects, Observational techniques for aerosols. (15 hours)

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; 3rdedn. 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, 2014323

Practical: ATMOSPHERIC PHYSICS

Credit: 1 **Practical Hours: 30**

Each Student is expected to perform at least 6-7 experiments out of the following experiments and the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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. Compute wet -bulb potential temperature from the Skew T- log P diagram.
5. 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.
6. Compute the CAPE and CIN from the Skew T-log P diagram.
7. To compute (for one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using Joss-Waldvogel disdrometer.
8. To compute (for more than one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using Joss-Waldvogel disdrometer.
9. To compute (for one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using Joss-Waldvogel disdrometer.
10. To compute (for more than one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using Joss-Waldvogel disdrometer.
11. To compute (for one minute interval) the radar reflectivity and weighted mean diameter of a rainfall event by using Joss-Waldvogel disdrometer.
12. To compute (for more than one minute interval) the radar reflectivity and weighted mean diameter of a rainfall event by using Joss-Waldvogel disdrometer.
13. To compute (for one minute interval) the number density, rainfall intensity, liquid water content of a rainfall event by using parsivel disdrometer.

14. To compute (for one minute interval) the radar reflectivity and weighted mean diameter of a rainfall event by using parsivel disdrometer.
15. Analyze the given rain DSD spectrum during various types of rain.
16. Analyze the height profile of radar reflectivity and rain intensity by using micro rain radar (MRR) observations.

MJ-20: Quantum Mechanics-II
Credits:(Theory-03, Tutorial-01) **Teaching Hours: 45+15**

Course Objectives

This is an advanced level course in Quantum mechanics which objects to teach about various approximation methods in Quantum mechanics to calculate the approximate values of energy for various systems and to study the different scattering theory.

Course Learning outcomes

After successful completion of this paper, the student will be well-versed in

- The basic knowledge about advanced techniques like approximation methods for time-independent and dependent Perturbation theory and the WKB approximation.
- Understanding the variational principle and its application to ground state of the hydrogen and Helium atom.
- Scattering theory and validity of Bonn approximations, partial wave analysis.

Unit 1

Time-Independent Perturbation theory: Non degenerate Perturbation theory, First-Order Theory, Second-Order Energies. Degenerate Perturbation Theory, Two-Fold Degeneracy, Higher-Order Degeneracy.
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. Adiabatic approximation- sudden approximation. (15 hours)

Unit 2

Variational Principle: Ground State Energy for Harmonic Oscillator, Delta Function Potential and particle in a box. Triangular Trial Wave Function in Infinite Well. Ground State of Helium, Hydrogen Molecular Ion.
WKB Approximation: Basic principles and applications to particle in a box, harmonic oscillator, hydrogen atom. Qualitative development and condition for validity of WKB approximation, Bohr's quantization condition, Applications to tunneling such as alpha particle, field emission. (15 hours)

Unit 3

Scattering Theory

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.

(15 hours)

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

MJ-21: NUCLEAR AND PARTICLE PHYSICS

Credits: (Theory-03 , Practical-01) **Teaching Hours: 45+30**

Course Objective

The objective of the course is to impart the understanding of the sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application. The course will focus on the developments of problem based skills.

Learning Outcomes

- To be able to understand the basic properties of nuclei as well as knowledge of techniques to study nuclear structure.
- To appreciate the formulations and contrasts between different nuclear models such as Liquid drop model, Fermi gas model and Shell Model and evidences in support.
- Knowledge of radioactivity and decay laws. A detailed analysis, comparison and energy kinematics of alpha, beta and gamma decays.
- It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub- atomic particles with the different conservation laws, concept of quark model.

- Learn, design and perform experiments in the labs to demonstrate the concepts, principles
  and theories learned in the classrooms.

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, Meson theory of nuclear forces (Yukawa's potential) Spin-orbit strong interaction between nucleon, double scattering experiment. (15 hours)

UNIT II

Nuclear Decay and Nuclear Models:: Review of alpha decay, introduction to Beta decay and its energetic, Fermi's theory of β-decay, selection rules: Fermi and G-T transitions, Gamma decay, energies of gamma decays, Selection rule for gamma ray transitions, Fermi-Gas Model: Symmetry, surface and Coulomb energy; Deformed shell model, Nilsson Hamiltonian, Single-particle energies in a deformed potential, Review of Liquid drop model and mass formulas, Fission barriers and types of fission; Parameterization of nuclear surface deformations, Prolate and oblate shapes, collective models, vibrational and rotational levels. (15 hours)

UNIT III

Elementary Particle Physics: Introduction to the elementary particle Physics, The Eightfold way, the Quark Model, the November revolution and aftermath, The standard Model,cross sections, decays and resonances, Introduction to Quantum Electrodynamics and Quantum Chromo dynamics. Weak interactions and Unification Schemes (qualitative description), Parity**,** 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. (15 hours)

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.

PRACTICAL: NUCLEAR AND PARTICLE PHYSICS
Credit: 1 **Practical Hours: 30**

Study of the characteristics of a GM tube and determination of its operating voltage, plateau length/ slope etc.

1. Verification of inverse Square law for gamma rays.
2. Estimation of efficiency of the GM detector for gamma Source / Beta Source.
3. To study Beta particle range and Maximum Energy (Feather analysis).
4. Backscattering of Beta particles.
5. Production and attenuation of Bremsstrahlung.
6. Study of energy resolution characteristics of a scintillation Spectrometer as a function of applied high Voltage and to determine the best operating Voltage.
7. 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)

MJ-22(A): Embedded systems - Introduction to Microcontroller
Credits: (Theor-03, Practical-01) **Teaching Hours: 45+30**

Course Objective

This course familiarizes students to the designing and development of embedded systems. This course gives a review of microprocessor and introduces microcontroller 8051.

Course Learning Outcomes

At the end of this course, students will be able to:

- Know the major components that constitute an embedded system.
- Understand what is a microcontroller, microcomputer embedded system.
- Describe the architecture of a 8051 microcontroller.

- Write simple programs for 8051 microcontrollers in C language.
- Understand key concepts of 8051 microcontroller systems like I/O operations,
  interrupts, programming of timers and counters.
- Interface 8051 microcontroller with peripherals
- Understand and explain concepts and architecture of embedded systems.

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.

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. (15 hours)

UNIT II

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.

Programming 8051: 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. (15 hours)

UNIT III

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. Programming Embedded Systems, Embedded system design and development.

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, emulatorand debugging, embedded product development life-cycle, trends in embedded industry.

Introduction to Arduino: Pin diagram and description of Arduino UNO. Basic programming. (15 hours)

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

PRACTICAL: EMBEDDED SYSTEMS: INTRODUCTION TO MICROCONTROLLERS
Credit: 1 **Practical hours: 30**

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. Program to glow the first four LEDs then next four using TIMER application.
2. Program to run a countdown from 9-0 in the seven segment LED display.
3. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
4. To toggle '1234' as '1324' in the seven segment LED display.
5. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard. Arduino based programs and experiments:
6. Make a LED flash at different time intervals.
7. To vary the intensity of LED connected to Arduino
8. 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 Microcomputer 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, C engage Learning

MJ-22(B): GEO-PHYSICS
Credits (Theory-03, Tutorial-01) **Teaching Hours: 45+15**

Course Objectives

1. To provide basic concepts for assessment, development and management of groundwater resources.
2. To introduce the importance of handling geophysical tools to the students having geology background and thereby help to develop their problem-solving attitude by incorporating geophysical data sets in their future research activities.
3. Exploring the employability in fields related to earth resources exploration and exploitation.

Course learning Outcome
The students are expected to have a deterministic approach to appreciate earth system science in a concrete manner and understand the real essence of nation building and help to improve the quality of life.

UNIT 1
GENERAL GEOPHYSICS: History of development and scope of geophysics, monistic and dualistic hypotheses for the origin of solar system, Kepler's law of planetary motion, planet and satellites of the system and their characteristics, shape and size of the earth, international gravity formula and rotation of the earth. Concept of isostasy, Airy, Heiskanan and Pratt-Hayford hypotheses.
Internal constitution of the earth, continental drift, ocean floor spreading, plate tectonics and its geological implications, new global tectonics and plate margin process, oceanic ridges, trenches and island arcs, geodynamics of Indian subcontinents and formation of Himalayas.

Origin of geomagnetic field, polar wandering, secular variations and westward drift, geomagnetic storms, earth's current, sun spot, solar flares, lunar and solar variations, Fundamentals of palaeo-magnetic studies and palaeo-magnetism of rocks. (15 hours)

UNIT II

HYDROGEOLOGY: Definition of Hydrology and its relation with other sciences. Hydrologic cycle. Origin, occurrence and distribution of subsurface waters. Porosity and different types of pore spaces in rocks. Aquifer-its definition and different types.

Groundwater levels and fluctuations: various causes of water level fluctuations.Dynamics of subsurface water: Darcy's law and its range of validity, steady and unsteady flow. Permeability/Hydraulic conductivity, specific yield, transmissivity, storage coefficient - their definitions, concepts and methods of determination.
Groundwater investigation: Geological, hydrogeological and geophysical approaches; Groundwater inventory. Water well drilling, design and construction. Hydrogeological studies in drilled wells. Basic concepts of groundwater management – equation of hydrologic equilibrium, groundwater basin, groundwater budgeting, safe yield and overdraft. Artificial recharge of groundwater and water logging. (15 hours)

UNIT III
GEOPHYSICAL EXPLORATION AND SURVEYING: Basic principles of geophysical exploration. Scope of the subject in relation to hydrocarbon, mineral and ground water exploration. Geophysical properties of minerals and rocks.
Electrical Method: Surveying natural potentials: Exploring shallow natural potentials, Telluric currents, Telluric current surveying, Magneto telluric surveying, Field examples.

Electromagnetic surveying: The principle of EM surveying, parallel line dip angle EM surveying, Horizontal-loop EM surveying, Airborne EM surveying, Field examples.

Induced polarization surveying: Source of induced potential, Measuring induced potentials, Results of IP surveying, Field examples.

Electrical resistivity surveying: Ohm's law and resistivity, current flow in three dimensions, current density, current flow across a boundary, measuring resistivity, Equipment for electrical resistivity surveying, Sounding and profiling, Forward and Inverse methods of resistivity data interpretation. The methods of characteristic curves and use of computer softwares, Resistivity profiles over faults and dykes, Resistivity and lithology.
(15 hours)

MJ-23(A) : NANO PHYSICS
Credits: (Theory-03 , Practical-01) ***Teaching hours:45+30***

UNIT I
Nanomaterials and Its Properties*:* 1D, 2D and 3D nanostructure , Quantum confinement, Carbon based materials, Inorganic nanotubes, nanoshells, Dendrimers, biological nanomaterials, diamondoids, Smart nanomaterials, Size dependence of properties, Properties of Nanomaterials (Chemcal reactivity, solubility, melting point, electronic energy levels), electrical conductivity (Surface scattering, change of electronic structure, Quantum transport, effect of microstructure),

Superparamagnetism, electron confinement, Integrated optics, Optical properties (Surface Pasmon Resonance, Quantum size effects), Mechanical properties, Thermodynamics properties. (15 hours)

UNIT II

Synthesis and Characterization of nanomaterials: Lithography (electron beam lithography, nanoimprint lithography, Dip pen nanolithography), Sputtering, Physical vapour deposition (PVD), Chemical vapour deposition(CVD), Sol-gel film deposition, Synthesis of carbon nanotubes (Arc-evaporation method, Laser ablation), X-ray Diffraction (XRD), Fourier transform Infrared (FTIR) spectroscopy, UV-Vis Spectroscopy, Scanning Tunnelling Microscope (STM), Atomic force microscopy (AFM), Scanning electron microscopy (SEM), Energy dispersive analysis of X-rays (EDAX), Transmission Electron Microscopy (TEM), Raman spectroscopy, X-ray photoelectron spectroscopy (XPS). (15 hours)

UNIT III

Applications of Nanomaterials: Carbon based materials (Fullerenes, carbon nanotubes (CNT), Quantum well, Quantum wires, Quantum dots, Molecular and nanoelectronic, Microbial fuel Cells, Hdrogen Storage, Nanomedicine, Biological application, Catalysis, Pollution control and filteration, Photonic Nanocrystals and Integrated Circuits, Nanomaterials in Communication sector. (15 hours)

Recommended Books and References:

1. "Nanostructured materials and nanotechnology", Concise Edition, Editor:-Hari Singh Nalwa; Academic Press, USA (2002).
2. "Hand book of Nanostructured Materials and Technology", Vol.1-5, Editor:Hari Singh Nalwa; Academic Press, USA (2000).
3. Nanoscale characterization of surfaces & interfaces, N John Dinardo, Weinheim Cambridge: Wiley-VCH, 2nd ed., 2000.
4. "Carbon nanotubes: preparation and properties", Editor: - T.W. Ebbesen, CRC Press, USA (1997).
5. Nanotechnology, Thomas Varghese, K.M. Balakrishna

PRACTICAL: NANO PHYSICS

Credit: 1 **Practical Hours: 30**

List of Experiments

1. Synthesis of semiconductor nanoparticles

2. Characterization of thin films using XRD and particle size determination using Scherrer's formula, lattice parameters, Strains etc.
3. Determine the average particle size and elemental analysis from FESEM and EDS images
4. Surface morphological characterization of nanomaterials from AFM images
5. Surface morphological characterization of nanomaterials from TEM images
6. Analysis of UV/Vis Absorption spectrum of nanomaterials
7. Analysis of Photoluminescence spectrum of nanomaterials
8. Analysis of FTIR image spectrum of nanomaterials
9. Determination refractive index, thickness and band gap of a semiconductor sample using UV-VIS-NIR Spectroscopy

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).

MJ -23 (B): ASTRONOMY AND ASTROPHYSICS

Credits: (Theroy-0 3, Practical-01) Teaching Hours: 45+30

Course Objective

The aim of this paper is to provide students with the basic knowledge about the theory and techniques of observational astronomy and physics of the astrophysical phenomenon.

Course Learning Outcomes

Students completing this course will gain an understanding of

- Different types of astronomical coordinate systems and their transformations , diurnal and yearly motion of astronomical objects,
- astronomical scales of mass time distance and Brightness scale for stars, classification of stars and HR diagram.
- Components of Solar System

Unit1

Positional Astronomy: Basics of spherical trigonometry, the celestial sphere, circles on celestial sphere, cardinal points, Equinoctial points, spherical triangle. Motions of earth- spin, revolution, obliquity, tilt, eccentricity. seasons, 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. (15 hours)

Unit 2

Astronomical scales: Astronomical distance, mass and time scales, Brightness, radiant flux and luminosity. apparent and absolute magnitudes, distance modulus, color index. Measurement of astronomical distances, stellar radii, masses of stars. Stellar classification of stars, Henry- Draper and modern M-K classification schemes, H-R diagram. (15 hours)

Unit 3

Solar system: The sun: solar parameters, solar photosphere, solar atmosphere, chromospheres, corona, solar activity, physical characteristics of sun-rotation, magnetic field, granulation, sunspots, other chromatic activities, Inner planets Jovian planets, dwarf planets.

Asteroids: classification, origin, Comets: physical nature, classification, origin, Meteors and meteorites. (15 hours)

Reference Books:

1. B.W. Corroll & DA Ostlie, An introduction to modern astrophysics, Addison Wesley.
2. F. Shu, The Physical universe: an introduction to Astronomy; University Science Books, Saualito
3. C.R. Kitchin, Astrophysical techniques; Adam Hilger,1984
4. Text Book of Spherical Astronomy – W.M.Smart
5. An Introduction to Astrophysics, B. Basu, T Chattopadhyay and S.N. Biswas.PHI learning private limited.

PRACTICAL: ASTRONOMY AND ASTROPHYSICS

Practical Credit: 1 **Practical Hours: 30**

In this lab students will learn how to use software to read sky charts. Using data , they will estimate distance of stars by various methods.

1. Use of Stellarium software. Reading of all sky charts and determine the alt –azimuth of stars.
2. Estimation of sun spot drift rate using images of sunspots.
3. H-R diagram plotting using B-V colour index and distance estimation.
4. Plotting of Period Luminosity curve for Cepheid variables using data and estimate the distance .
5. Measuring the angular size of galaxies and estimating the distance of galaxies using small angle formula.
6. Constructing a Hubble diagram using data and estimating Hubble constant.
7. Calculation of telescope parameters like F ration ,magnification, true filed of view resolution etc.
8. Plotting of solution of Lame Emden equation.

MINOR COURSE

MN-1: Mechanics

Credits (Theory-03, Practical-01) **Teaching Hours: 45+30**

Course Objective

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with Newton's Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity. Students will also appreciate the Collisions in CM Frame, Gravitation, Rotational Motion and Oscillations. The students will be able to apply the concepts learnt to several real world problems.

Course Learning Outcomes

Upon completion of this course, students are expected to

- Understand laws of motion.
- Learn the concept of inertial reference frames and Galilean transformations. Also, the concept of conservation of energy, momentum, angular momentum and apply them to basic problem.
- Understand translational and rotational dynamics of a system of particles.
- Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.
- Explain the phenomenon of simple harmonic motion.

- Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.

Unit 1

Review of Newton's Laws of Motion.

Reference frames and coordinate systems: Inertial and non inertial frames. Velocity and acceleration in spherical polar co-ordinate systems. Uniformly rotating frame and fictitious force; centrifugal force, Coriolis force and its effects.

Galilean transformation equations (position and time); its application to transformation of length, velocity and acceleration. Galilean invariance to basic laws. (15 hours)

Unit 2

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque and its relation with angular momentum, angular impulse. Principle of conservation of angular momentum. Angular momentum under central force. Rotation about a fixed axis: Moment of Inertia and radius of gyration. Theorem of perpendicular and parallel axes. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Properties of bulk matter: Relation between elastic constants, Twisting torque on a cylinder or wire, Poiseulle's equation for flow of liquid through a capillary tube

Oscillations: Simple harmonic motion (SHM), differential equation of SHM and its solutions in different forms, Velocity, acceleration, time period, frequency SHM. Energy of Simple Harmonic Oscillator, Time–average values of KE and PE. Damped oscillation; Differential equation of motion of damped harmonic oscillator and its solution. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance. (15 hours)

Unit 3

Variable mass system: Motion of Rocket. Centre of mass; its velocity and acceleration, total linear momentum about the centre of mass.

Gravitation and Central Force Motion: Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws.

Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Length contraction, Time dilation; Twin Paradox. Relativity of Simultaneity, Invariance of Space-time interval. Transformation of velocity- Relativistic addition of velocities. Variation of mass with velocity. Mass less Particles. Mass-energy Equivalence. (15 hours)

Reference Books:

1. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
2. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
3. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
4. Mechanics, Er. Tamana Jain, Mahaveer Publications.
5. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
6. Physics for Degree Students (B.Sc. First Year), C.L Arora and Dr. P.S.Hemne, S Chand.

Practical: Mechanics
Practical Credit: 01 **Practical Hours: 30**

In the laboratory course, the student shall perform experiments related to mechanics: use of screw gauge and travelling microscope, and necessary precautions during their use. Bar and Kater's pendulum, rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity), moment of inertia of irregular bodies.

1. Measurements of length (or diameter) using screw gauge and travelling microscope.
2. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus of rigidity.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
5. To determine the Young's Modulus of a Wire by Optical Lever Method.
6. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
7. To determine the elastic Constants of a wire by Searle's method.
8. To determine the value of g using Bar Pendulum.
9. To determine the value of g using Kater's Pendulum.
10. To determine the moment of inertia of an irregular body about an axis through its centre of gravity with a torsion pendulum.

Reference Books :

1. BSc. Practical Physics, C L Arora, S Chand and Company Limited
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

MN-2 : MATHEMATICAL PHYSICS-I
Credits: (Theory-03, Practical-01) **Teaching Hours: 45+30**

Course Objective
The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

Course Learning Outcomes

After completing this course, student will be able to

•learn limits and continuity and draw and interpret graphs of various functions. Taylor and Binomial series.

• Solve first and second order differential equations and apply these to physics problems.

• Understand the concept of gradient of scalar field and divergence and curl of vector fields.

• Perform line, surface and volume integration and apply Green's, Stokes' and Gauss's Theorems to compute these integrals.

• Apply curvilinear coordinates to problems with spherical and cylindrical symmetries.

• Understand Dirac’s delta function and its properties.

UNIT 1
Calculus: Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).
First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. (15 hours)

UNIT II
Vector Calculus: Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively.
Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. (15 hours)

UNIT III

Introduction to probability:

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing.

Dirac Delta function and its properties: Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. (15 hours)

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Mathematical Physics, Goswami, 1st edition, Cengage Learning
8. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

***Practical:* Mathematical Physics-I**

Practical Credit: 1 **Practical Hours: 30**

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics. The course will consist of practical sessions and lectures on the related theoretical aspects of the Laboratory. The list of programs here is only suggestive.

Emphasis should be given to assess student's ability to formulate a physics problem as mathematical one and solve by computational methods.

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and input/output devices.
Basics of Scientific Computing	Binary and Decimal arithmetic, Floating point numbers, algorithyms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow – emphasize the importance of making equations in terms of dimensionless variables. Iterative methods.
Review of C and C++ Programming fundamentals	Introduction of programming, constants, variables and data types, operators and expressions, I/O statements, scanf and printf, c in and c out, Manipulations for data formatting, Control statements, (decision making and looping statements)(If statement, If else statement, Nested if Structure, Else if statement, Ternary operator, Go to statement, Switch statement. Unconditional and Conditional looping. While loop, Do – while loop, FOR loop, Break and continue statements, Nested Loops) Arrays(1D and 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects.
Programs:	Sum and average of a list of numbers, largest of a given list of numbers, and its location in the list, sorting of numbers, in ascending, descending order, Binary search.
Random Number Generation	Area of circle, area of square, volume of sphere, value of π.
Solution of Algebraic and Transcendental equations, by bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equations, solving $\alpha = \tan\alpha,\ \ I = I_0(\frac{\sin\alpha}{\alpha})\, in\, optics$
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear	Evaluation of trigonometric functions, eg. $\sin\theta,\ \cos\theta,\ \tan\theta\ etc.$

interpolation.	

Reference Books:

1. Introduction to Numerical Analysis, S.S. Sastry, 5thEdn., 2012, PHI Learning Pvt. Ltd.
2. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
3. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rdEdn., 2007, Cambridge University Press.
4. A first course in Numerical Methods, U.M. Ascher& C. Greif, 2012, PHI Learning.
5. Elementary Numerical Analysis, K.E. Atkinson, 3rdEdn., 2007, Wiley India Edition.
6. Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
7. An Introduction to computational Physics, T. Pang, 2ndEdn., 2006, Cambridge Univ. Press
8. Computational Physics, Darren Walker, 1stEdn., 2015, Scientific International Pvt. Ltd

MN-3: Electricity and Magnetism
Credits (Theory-03, Practical-01) **Teaching hours:45+30**

Course Objective

This course reviews the concepts of electromagnetism learnt at school from a more advanced perspective and goes on to build new concepts. The course covers static and dynamic electric and magnetic fields, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. The students will be able to apply the concepts learnt to several real-world problems.

Course Learning Outcomes

At the end of this course the student will be able to

• Demonstrate the application of Coulomb’s law for the electric field, and also apply it to systems of point charges as well as line, surface, and volume distributions of charges.

• Demonstrate an understanding of the relation between electric field and potential, exploit the potential to solve a variety of problems, and relate it to the potential energy of a charge distribution. • Apply Gauss's law of electrostatics to solve a variety of problems.

• Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)

• Understand the concepts of induction and self-induction and Maxwell's equations

• Understand the basics of electrical circuits and analyze circuits using Network Theorems.

UNIT I

Electric Field: Electric flux, Gauss' Law and Gaussian surface. Applications of Gauss' law to solid sphere and hollow cylindrical. Conservative field, Conservative nature of Electrostatic Field.

Electric Potential: Gauss's divergence theorem and differential form of Gauss's law. Laplace's and Poisson equations. The Uniqueness Theorem.

Electric dipole: Dipole moment, Potential and Electric Field of a dipole. Force and Torque on a dipole. Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor.

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Gauss's law in dielectrics

Capacitor: Capacitance of an isolated conductors, Spherical and cylindrical capacitors filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics.

Electrical Images: Method of electrical Images and its application to Plane Infinite Sheet and Sphere. (15 hours)

UNIT II

Magnetic field and force: Lorentz force, force on a current carrying conductor placed in a magnetic field. Biot-Savart's Law and its applications to circular loop (vector treatment). Current looop as a magnetic dipole and its dipole moment. Ampere's Circuital Law in integral and differential form and its application to solenoid and toroid. Curl and divergence of magnetic field, Magnetic vector potential. Torque on a current loop in a uniform Magnetic Field.

Magnetic Properties of Matter: Magnetization vector **(M).** Magnetic Intensity**(H).** Magnetic susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism. B-H curve and hysteresis.

Electromagnetic Induction: Magnetic flux, Faraday's law. Self and mutual inductance. Reciprocity theorem. Maxwell's equations, Maxwell's modification of Ampere's law and displacement current, displacement current density.

(15 hours)

UNIT III

Electrical Circuits: DC Transients: Current growth and decay in LR, CR, LCR circuits with a direct current input AC Circuits: Kirchhoff's laws for AC

circuits. Complex Reactance and Impedance. Series LCR Circuit: Resonance and quality Factor, Parallel LCR Circuit.
Network theorems: Classification of circuit elements, Ideal voltage and current sources. Mesh currents and Mesh equations. Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem.
Ballistic Galvanometer: Description, Theory, Correction for damping, Conditions for the galvanometer to be ballistic and dead beat. (15hour)

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Electricity and Magnetism, Er. Tamana Jain, Mahaveer Publications.
5. Electricity and Magnetism, T.S. Bhatia, Vishal Publications Co.
6. Electricity and Magnetism, D.Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd.
7. Undergraduate Physics Vol II, AB Bhattacharya, R Bhattacharya, New Central Book Agency (P) Ltd.

PRACTICAL: ELECTRICITY AND MAGNETISM
Practical Credit: 1 **Practical Hours: 30**

In the laboratory course the student will get an opportunity to verify network theorems and study different circuits such as RC circuit, LCR circuit. Also, different methods to measure low and high resistance, capacitance, self-inductance, mutual inductance, strength of a magnetic field and its variation in space will be learnt.

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To determine an unknown Low Resistance using Carey Foster's Bridge.
3. To compare capacitances using De'Sauty's bridge.
4. To verify the Thevenin theorems.
5. To verify Norton theorems.
6. To verify the Superposition theorem.
7. To verify Maximum power transfer theorems.
8. To study Series LCR circuit
9. To study parallel LCR circuit

10. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.
4. BSc. Practical Physics, C.L.Arora, S Chand and Company Limited

MN-4: THERMAL PHYSICS AND STATISTICAL MECHANICS
Credits: (Theory-3, Pracical-01) Teaching Hours: 45+30

Course objective

This course will introduce Thermodynamics, Kinetic theory of gases and Statistical Mechanics to the students. The primary goal is to understand the fundamental laws of thermodynamics and their applications to various systems and processes.

Course Learning Outcomes

This coursework will also enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behaviour of the atoms and molecules through statistical mechanics.

UNIT-I

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CPand CV, Work Done during Isothermal and Adiabatic Processes, Carnot's cycle and theorem, Reversible and irreversible processes, Second law,

Entropy: Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. (15 hours)

UNIT- II

Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, ClausiusClapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations.

Kinetic Theory of Gases:Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases. (15 hours)

UNIT- III

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's law, Rayleigh-Jeans Law, Stefan Boltzmann Law & Wien's displacement law from Planck's law.

Statistical Mechanics:Maxwell-Boltzmann law - distribution of velocity - Quantum statistics –Macro-state and Microstate – Entropy and Thermodynamic Probability - Phase space - Fermi-Dirac distribution law - Bose-Einstein distribution law - photon gas - comparison of three statistics. (15 hours)

Reference Books:

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Searsand G.L.Salinger. 1988, Narosa University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

PRACTICAL : THERMAL PHYSICS AND STATISTICAL MECHANICS
Credit:01 Practical Hours: 30

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne‟s constant flow method. 2. Measurement of Planck's constant using black body radiation.
2. To determine Stefan's Constant.
3. To determine the coefficient of thermal conductivity of Cu by Searle‟s Apparatus.
4. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom‟s Method.
5. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton‟s disc method.
6. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.

7. To study the variation of thermos- emf across two junctions of a thermocouple with temperature.
8. To record and analyse the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system.
9. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

Reference Books:

1. Advanced Practical Physics for students, B.L.Flint&H.T.Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi. • A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal, 1985, Vani Publication.

MN-5: ELECTRODYNAMICS
Credits: (Theory-03, Practical-1) ***Teaching hours:45+30***

Course Objective
This course will help the students to learn the propagation of electromagnetic wave with the help of Maxwell's equation. The students will investigate the polarization of electromagnetic waves.
Course Learning Outcomes
Students will be able to understand more about the general features of the atmosphere and comprehend the atmospheric dynamics to apply on various atmospheric phenomenon.

UNIT I
Maxwell Equations& Electromagnetic Wave Propagation in unbounded media
Maxwell's Equations, Maxwell's Equations in differential form, Equation of continuity, Displacement Current, Potential formulation of electrodynamics, Vector and Scalar Potentials.

The wave equation, second order wave equation in terms of the field vector, Plane electromagnetic waves through vacuum, transverse nature of plane electromagnetic waves and to show that the electric and magnetic field vectors are mutually perpendicular to the propagation vector, wave impedance, calculation of the wave impedance of free space, Propagation of plane electromagnetic through conducting media skin depth. (15 hours)

UNIT II
Electromagnetic Wave propagation in Bounded Media:
Reflection &transmission of plane electromagnetic waves at normal incidence, reflection and transmission coefficient for a plane

electromagnetic wave at normal incidence, propagation of plane electromagnetic waves in accordance with the law of conservation of energy, Reflection &transmission of plane waves at oblique incidence, law of reflection, Snell's law, Fresnel's equation, Brewster's angle. (15 hours)

UNIT III

Polarization of Electromagnetic Waves:

Polarised & unpolarized light, plane polarized light, plane of polarization, plane of vibration, dichroism, production of dichroism, birefringence and its application, double reflection, optic axis and principal plane of a crystal, uniaxial crystal, double refraction through uniaxial crystal, negative and positive crystal, construction and action of a Nicol prism, theory of plane, elliptical and circularly polarized light, theory and construction of quarter and half wave plate. (15 hours)

Reference Books:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings
2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning

PRACTICAL: ELECTRODYNAMICS

Credit: 1 **Practical Hours: 30**

Each Student is expected to perform at least 4-5 experiments out of the following experiments and the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study the reflection, refraction of microwave
5. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
6. To verify the Stefan`s law of radiation and to determine Stefan's constant.

7. To determine the Boltzmann constant using V-I characteristics of PN junction diode.
8. Study of microwaves characteristics through different dielectric medium.

Computational Lab:

9. Generate Electromagnetic Wave using software.
10. To study the radiation pattern for a simple Dipole antenna.
11. To study propagation of wave using Rectangular Waveguide
12. To calculate phase & group velocity.
13. To plot radiation pattern of dipole antenna.

Reference books :

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, 11th Ed., 2011, Kitab Mahal
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Spring

MN-6: ELEMENTS OF MODERN PHYSICS

Credits:(Theory-03, Tutorial-01) ***Teaching Hours: 45+30***

Course Objectives

This course covers certain conceptual courses of physics for which the students will be able to understand some concepts of Quantum Mechanics including Schrodinger equation, fundamentals of Atomic Physics, Nuclear Physics and basic Laser principles and properties.

Course Learning Outcomes

Upon successful completion of this course, the students will be able to:

- Understand and explain the differences between classical and quantum mechanics.
- Understand and Solve the Schrodinger equation for simple potentials.
- Notice the different properties of the nucleus and other sub-atomic particles.
- Describe theories explaining the structure of atoms and the origin of the observed spectra.
- Explain different Laser used and make a comparison between them.

UNIT I

Introduction to Quantum Mechanics

Inadequacy of classical physics and the Origin of Quantum theory**:** Black body radiation, Plank hypothesis, Photoelectric effect, Compton effect. Matter waves: De Broglie hypothesis and Davisson and Germer experiment. Wave particle Duality, phase velocity and group velocity. Heisenberg's uncertainty relation, wave functions and its properties. Probability and probability current density, Normalization, Expectation value, Schrödinger equation (Time dependent and time independent, Gaussian wave packet, postulates of quantum mechanics. *(15 hours)*

UNIT II

Atomic structure: Thomson model, Rutherford model of atom, electron orbits, Bohr atom, Energy levels and spectra of hydrogen, vector atom model (concept of space quantisation and electron spin), quantum numbers, Atomic excitation and atomic spectra.

One and two valence electron system: Pauli's exclusion principal and electron configuration, quantum states, spectral notation of quantum states, spin-orbit interaction, energy level of Na atom, selection rules. Spectral terms of two electron atom, L-S and J-J coupling, spectra of Helium atom.

(15 hours)

Unit III

Nuclear Physics: Basic properties and classification of nucleus, mass defect and binding energy, packing fraction, Nuclear stability, Radioactivity (concept of natural and artificial radioactivity and properties of α, β, γ-rays). Elementary particles and Quarks model, Nuclear models (Liquid drop model and shell model), nuclear reactions, compound nucleus, Q value equation. Bohr and Wheeler theory of Nuclear fission, Nuclear fusion and stellar energy. *(15 hours)*

Laser: Einstein A and B coefficient, Metastable states, Spontaneous and stimulated emissions, optical pumping and population inversion, Three-level and Four-level Lasers, Ruby Laser and He-Ne Laser. *(15 hours)*

Recommended Books and References:

1. Quantum Mechanics, A.K.Ghatak and S.Lokanathan.
2. Introductory Quantum Mechanics, R.L.Liboff.
3. Principles of Quantum Mechanics, R. Shankar.
4. Quantum Mechanics: Concepts and applications, N.Zettili
5. Quantum Mechanics, Mahesh C. Jain
6. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
7. Concepts of Nuclear Physics, B L Cohen, Tata McGraw Hill
8. Introduction to atomic spectra, White H.E. (Mc-Graw Hill international edition)
9. Concept of Modern Physics: 4th edition- Arthur Baiser

Practical : Elements of Modern Physics

Credit: 01 **Practical Hours: 30**

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. To determine the Planck's constant using LEDs of at least different colours.
3. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
4. To show the tunneling effect in tunnel diode using I-V characteristics.
5. To determine the wavelength of Laser source using diffraction of single slits.
6. To determine the wavelength of Laser source using diffraction of double slits.

MN-7: Quantum Mechanics and Applications

Credits:(Theory-03, Tutorial-01) ***Teaching Hours: 45+30***

Course objectives

This course aims to highlights the basic foundation of quantum mechanics and the inadequacy of the classical physics. It also describes the importance of the wave functions, basic quantum mechanical operators and the formulation of Schrödinger equation and its applications.

Course Learning outcomes

Upon successful completion of this course, students will be able to:

- Understand and explain the differences between classical and quantum mechanics
- . Understand the concept of wave function and its physical interpretation.
- Solve Schrodinger equation for simple potentials and Harmonic oscillator.
- Apprehend Eigen values and Eigen functions and the basic operators of quantum mechanics.

UNIT I

Introduction to Quantum Mechanics

Inadequacy of classical physics and the Origin of Quantum theory**:** Black body radiation, Plank hypothesis, Photoelectric effect, Compton effect. Matter waves: De Broglie hypothesis and Davisson and Germer experiment. Wave particle Duality, phase velocity and group velocity. Heisenberg's uncertainty relation, wave functions and its properties, Probability and probability current density, Normalization, Expectation value, Schrödinger equation (Time dependent and time independent), Ehrenfest's theorem (Definition only), Gaussian wave packet. *(15 hours)*

Unit 2

Applications of Schrödinger's steady state equation

Free particle, Particle in infinite deep potential well (One-dimension), step potential, potential barrier (Qualitative discussion), Barrier penetration and tunneling effect, Linear harmonic oscillator (one-dimension), correspondence principle. *(15 hours)*

Unit 3

Operators in Quantum Mechanics

Basic properties of operators, Eigen values and Eigen functions, Operator of some observable quantities (Position, momentum and energy), Hermitian operator. Commutator brackets: Simultaneous Eigen functions, commutator algebra, commutator brackets using position, momentum and angular momentum operator, ladder operator, raising and lowering operator, parity and parity operator. *(15 hours)*

Recommended Books and References:

1. Quantum Mechanics, A.K.Ghatak and S.Lokanathan.
2. Introductory Quantum Mechanics, R.L.Liboff.
3. Principles of Quantum Mechanics, R. Shankar.
4. Quantum Mechanics: Concepts and applications, N.Zettili
5. Quantum Mechanics, Mahesh C. Jain
6. Quantum Mechanics, A Ghatak and S Lokanathan, Trinity Press
7. A Textbook of Quantum Mechanics,Mathews and Venkatesan, McGraw Hill

MN-8 : Electronics

Credits (Theory-3, Practical -01) Teaching Hours: 45+30

Course Objective

This is one of the core papers in physics curriculum which introduces the concept of semiconductor and its applications, voltage amplifier, operational amplifiers, Boolean algebra and the basic digital electronics. In this course, students will be able to understand the working principle of semiconductor, analog and digital circuit.

Course Learning Outcomes

This course provides a fundamental understanding of semiconductor P-N junction diodes, its characteristics and applications, transistors type its input and output characteristics, voltage divider network, amplifiers: voltage and coupled, feedbacks in amplifiers, Oscillators, Operational amplifiers, operational amplifiers, digital circuits, Boolean algebra, arithmetic circuits, shift registers and counters.

UNIT I

Semiconductor P-N junction diodes: P and N type semiconductors. PN Junction Fabrication (Simple Idea). Transport phenomena in semiconductors (Drift and Diffusion current).Electrical conductivity of semiconductors. Barrier Formation in PN Junction diode Field analysis of P-N junction. Derivation for barrier potential and space charge width for Step, Junction. P-N Junction under biased conditions. I-V characteristic and resistance of P-N junction diode. A brief idea about different types of P-N junction diode,

Applications of P-N junction diodes: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, (2) Zener Diode and Voltage Regulation.

Bipolar Junction transistors (BJT): n-p-n and p-n-p Transistors, transistor in CB, CE and CC Configurations. Current gains α and β and their relation. Characteristic curve of transistor for CE configuration and its DC Load Line analysis, Transistor biasing and stabilization,Physical mechanism of Current Flow, Biasing of a CE transistor by using voltage divider network, field effect transistor. (15 hours)

UNIT II

Voltage Amplifier: CE amplifier, DC and AC equivalent circuit. AC load line.h-parameter model of a transistor. Analysis of a single-stage CE amplifier using h-parameter model. Input and Output Impedance. Current and Voltage Gains. Emitter follower and its gain. Brief idea about the Class A, B & C power amplifiers.

Coupled Amplifier: Two stage RC-coupled amplifier, its frequency response and bandwidth Voltage gain in mid, low and high frequency range.Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift, Hartley & Colpitts oscillators.

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of virtual ground.

Applications of Op-Amps: Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier, Zero crossing detector and Wein bridge oscillator. Conversion: Resistive network (Weighted and R-

2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation). (15 hours)

UNIT III

Digital Circuits: Difference between Analog and Digital Circuits. Analysis of a Transistor as a switch. Binary, Decimal and Hexadecimal number systems and their inter conversions. Binary and hexadecimal, addition and subtraction. Realization of AND, OR and NOT Gates using transistor.NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits: Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.Sequential Circuits: SR, D, and JK Flip-Flops.

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers. Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. SynchronousCounter. (15 hours)

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Electronic Devices & circuits, S.Salivahanan&N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
4. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
5. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
6. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
7. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India 303.
8. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw.
9. Fundamentals of Digital Circuits, Anand Kumar, 2ndEdn, 2009, PHI Learning Pvt. Ltd.

Practical: Electronics
Practical Credit: 01 **Practical Hours: 30**

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
5. To design a switch (NOT gate) using a transistor.
6. To verify and design AND, OR, NOT and XOR gates using NAND gates.
7. To design a combinational logic system for a specified Truth Table.
8. To convert a Boolean expression into logic circuit and design it using logic gate ICs. To minimize a given logic circuit.
9. Half Adder, Full Adder and 4-bit binary Adder.

Multi-DISCIPLINARY COURSE

MD-1(A): GENERAL PHYSICS-I
Credits (Theory-03) **Teaching hours: 45**

N.B: The course is designed to understand the basic concept of physics by students from non-physics background and therefore, rigorous mathematical complexity can be avoided as far as possible

COURSE OBJECTIVE
The students will have a basic idea on various branches of physics like mechanics, Heat & thermodynamics, waves, oscillation and properties of matter.

COURSE LEARNING OUTCOMES
With the completion of the course, the students will have a basic knowledge in physics.

UNIT I : MECHANICS

Physics-scope and excitement, physics in relation to technology and society, forces in nature, physical quantity, system of units, SI unit, fundamental & derived unit, basic idea about Dimension, motion & rest, basic concept about vectors and scalars, Distance and displacement, speed, instantaneous speed, uniform and non-uniform speed, velocity, acceleration, equations of motion (derivation not required) and simple numerical based on the equations of motion, graphical representation of displacement -time and velocity- time and calculation of velocity and displacement from the graphs, ideas on projectile (derivation not required)

Newtons laws of motion and its statement (derivation not required), inertia, inertia of rest & motion, force, momentum , impulse, law of conservation of momentum (derivation not required), friction, friction as a necessary evil, work, kinetic energy, potential energy, conservation of momentum(derivation not required),mass- energy equivalence, power, centre of mass, moment of inertia ,radius of gyration, Gravitation, Newton's law of gravitation, acceleration due to gravity, gravitational field, Gravitational potential energy and gravitational potential, escape velocity, orbital velocity of a satellite.

UNIT II: HEAT & THERMODYNAMICS

Heat, temperature, thermal expansion; thermal expansion of solids, liquids and gases, anomalous expansion of water; specific heat capacity, latent heat capacity, Heat transfer-conduction, convection and radiation, thermal conductivity, qualitative ideas of Blackbody radiation, Wein's displacement Law, Stefan's law, Thermodynamics, Thermal equilibrium and definition of temperature, zeroth law of thermodynamics, heat, work and internal energy, First law of thermodynamics, Second law of thermodynamics, isothermal, adiabatic, reversible &irreversible process, Kinetic Theory of Gases, degrees of freedom, Avogadro's number.

UNIT III: WAVES, OSCILATION & PROERTIES OF MATTER

Oscillations, Periodic motion, time period, frequency. Simple harmonic motion (S.H.M), restoring force, force constant, simple pendulum, Waves, Transverse and longitudinal waves, principle of superposition of waves, standing waves, fundamental mode and harmonics, Beats, echo, Doppler effect.

Elasticity, Stress-strain relationship, Hooke's law, Young's modulus, bulk modulus, Pascal's law and its applications, hydraulic lift and hydraulic brakes, Viscosity, Stokes' law, terminal velocity, streamline and turbulent flow, critical velocity, Bernoulli's theorem and its simple applications, surface tension, capillary rise.

Reference Books:

1. NCERT PHYSICS TEXT BOOK OF CLASS 8, 10, 11 &12

MD-1(B): ATMOSPHERIC PHYSICS
Credit: (Theory-03) **Teaching hours:45**

Course Objective
The objective of this course is to give students a general idea about atmospheric physics anf to introduce about dynamics of atmosphere

Course Learning Outcomes
After completing this course, students will gain an understanding

- General features of Earth atmosphere.
- dynamics of atmosphere and general circulation
- Numerical modeling & atmospheric aerosols.

UNIT I
General features of Earth's atmosphere:
Introduction to the atmosphere, description of atmospheric behavior, mechanism involving atmospheric behaviour, composition and structure of atmosphere, atmospheric aerosols, clouds, Global energy budget, thermodynamic properties and process, parcel method, lifting condensation level(LCL), Level of free convection(LFC), Convective Available Potential Energy (CAPE) and Convective Inhibition Energy (CINE), precipitation, Local winds, monsoons, fogs, Sea breeze and land breeze, Cyclones and anticyclones, Atmospheric ionization, global electrical circuit, basic characteristics of electrification theories, thunderstorms.

UNIT II
Atmospheric Dynamics:
Inertial and non-inertial frame, fundamental forces, real and pseudo force, Body and surface force, Pressure gradient force, gravitational force, centripetal force, Coriolis force, viscous force, centrifugal force, curvature effect, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, Mesoscale circulations, the general circulations, Surface water waves, acoustic waves, buoyancy waves, Structure, evolution and properties of planetary boundary layer, Ekman layer, surface layer, modified Ekman layer.

UNIT III
General Circulation, Numerical Modeling&Atmospheric Aerosols:
General circulation, Hadley circulation, zonally averaged circulation, mean meridional motion, advantage of zonally averaged circulation, angular momentum budget, ferrel's cells & polar cells, single cell model, three cell model, meridional circulation model, walker circulation, El NINO and the southern oscillation (ENSO) & LA NINA, MJO (Madden-Julian oscillation)

Basic principles of Numerical Weather Prediction model, climate model, different types of climate model, basic governing equations in Numerical Weather Prediction model (without derivation), brief idea about parameterization schemes & Data assimilation.

Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols.

References Books:

1. Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rdedn. 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, 2014323

MD-2(A): GENERAL PHYSICS-II
Credits (Theory-02, Tutorial-01) **Teaching hours: 30+15**

N.B: The course is designed to understand the basic concept of physics by students from non-physics background and therefore, rigorous mathematical complexity can be avoided as far as possible

COURSE OBJECTIVE
The students will have a basic idea on various branches of physics electricity, optics, electromagnetic waves, modern physics & electronics.

COURSE LEARNING OUTCOMES
With the completion of the course, the students will be able to understand the basics of physics.

UNIT I
ELECTRICITY
Electric charges, Conservation of charge, Coulomb's law, Electric field, electric field due to a point charge, electric field lines, Electric flux, Electric potential, potential difference, Conductors, insulator and superconductors free charges and bound charges, capacitors and capacitance, Electric current, Ohm's law, V-I characteristics, Biot - Savart law, Ampere's law ,Current loop as a magnetic dipole, Bar magnet , Electromagnetic Induction ,Alternating Currents Faraday's laws, induced EMF and current; Lenz's Law, AC generator, Transformer. (10 hours)

UNIT II
OPTICS & ELECTROMAGNETIC WAVES
Reflection of light, spherical mirrors, mirror formula (derivation not required), refraction of light, total internal reflection, Mirage, optical fibres, lenses, thin lens formula (derivation not required), lens maker's formula (derivation not required), power of a lens, dispersion, simple and compound Microscopes, telescopes,

Electromagnetic waves and their characteristics, Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses and properties. (10 hours)

UNIT III
MODERN PHYSICS & ELECTRONICS:
Dual nature of radiation, Photoelectric effect, Compton's effect, particle nature of light, Matter waves, Atoms and Nuclei, composition, Rutherford's model of atom; Bohr model of hydrogen atom, Composition and size of nucleus, nuclear force, Mass-energy relation, mass defect; binding energy, nuclear fission, nuclear fusion.

Energy bands in conductors, semiconductors and insulators (qualitative ideas only), Intrinsic and extrinsic semiconductors, p and n type, p-n junction (10 hours)

Reference Books:
1. NCERT PHYSICS TEXT BOOKS OF CLASS 8, 10, 11 &12

MD-2(B): Introduction to Astronomy
Credits: (Theory-03) Teaching Hours: 45

Course Objective
The aim of this paper is to provide students with the basic knowledge about the astronomy.

Course Learning Outcomes
Students completing this course will gain an understanding of
- astronomical scales of mass, time, distance and Brightness scale for stars, classification of stars and H-R diagram.
- Solar System and its constituents.
- Galaxies and its classifications, Hubble's Law

Unit-1
Astronomical Scales: Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities, Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar.

Atomic Spectra Revisited, Stellar Spectra, Spectral Types. Black Body Approximation, Classification of stars, Luminosity Classification, H-R Diagram. (10 hours)

Unit -2

The Solar System:

The sun: solar parameters, solar photosphere, solar atmosphere, chromospheres, corona, solar activity, physical characteristics of sun-rotation, magnetic field, granulation, sunspots, other chromatic activities, Inner planets, Jovian planets and dwarf planets.

Asteroids: classification, origin, Comets: physical nature, classification, origin, Meteors and meteorites. (10 hours)

Unit- 3

Galaxies: Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies, Spiral and Lenticular Galaxies, Bulges, Disks, The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms.

Large Scale Structure & Expanding Universe, Hubble's Law, Distance-Velocity Relation , dark matter and energy (basic concept only). (10 hours)

Reference Books:

1. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
2. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
3. The Physical Universe: An Introduction to Astronomy, F. Shu, Mill Valley: University Science Books
4. Fundamentals of Astronomy (Fourth Edition), H. Karttunenetal. Springer
5. Astrophysics A Modern Perspective, K. S. Krishnasamy, Reprint, New Age.

MD-3(A): INTRODUCTION TO NANO PHYSICS

Credit: (Theory -3) ***Teaching Hours: 45***

UNIT I

Nanoscale Systems and properties: Increased surface to volume ratio, 1D, 2D and 3D nanostructure (nanodots, thin films, nanowires, nanorods), quantum confinement, Carbon based materials (Fullerenes, carbon nanotubes (CNT), nanobuds), Size dependence of properties, Properties of Nanomaterials (Chemcal reactivity, solubility, melting point, electronic energy levels), electrical conductivity (Surface scattering, change of electronic structure, Quantum transport, effect of microstructure), Superparamagnetism, electron confinement, Optical properties (Surface Pasmon Resonance, Quantum size effects. (10 hours)

UNIT II

Synthesis and Characterization of Nanostructure Materials: Bottom up and Top down approach, Physical vapour deposition (PVD), Chemical vapour deposition(CVD), Sol-gel film deposition, Hydrothermal synthesis, Synthesis of carbon nanotubes, X-Ray Diffraction, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy (10 hours)

UNIT III

Applications: Applications of nanoparticles, Quantum dots, nanowires and thin films, Single electron transfer devices (no derivation), Hdrogen Storage,Nanomedicine, Biological application, Catalysis, Pollution control and filteration, Photonic Nanocrystals and Integrated Circuits, Nanomaterials in Communication storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). (10 hours)

Recommended Books and References:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
5. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
6. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
7. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).
8. Nanotechnology, Thomas Varghese, K.M. Balakrishna

MD-3(B): WATER SCIENCE

Credits: (Theory-03) **Teaching Hours: 45**

The course structure is essentially divided into three units. The course emphasis on the major issues of water crisis in the local as well as global perspective. It is also devoted to address the connectivity of water with different branches of science and also discusses the problems related to ground water depletion, ground water pollution, salt water intrusion etc.

OBJECTIVES: To open up a multi-disciplinary approach in understanding the science of water.

OUTCOME EXPECTED

At the completion of the course, the students will be in a position to appreciate the study of water as a subject, will have greater awareness towards maintenance of water quality.

UNIT 1

The water crisis: Importance of studying water, Current global water balance, Water as the prime driver of socio-economic growth, Trans-boundary conflicts within states of India, River basin politics, Integrated Water Resources Management (IWRM) at different levels, International Organizations and Water Policy debates, Distribution and Classification of Aquatic Ecosystems, Drivers of Change in Inland Aquatic Ecosystems.

(10 hours)

UNIT 2

Global hydrology: The Earth System and Water, Water Reserves, Fluxes and Residence Time, Global water cycle, Global water-balance requirements, Precipitation, observation and measurement, Precipitation modelling, Precipitation and engineering design, Trends and variability in Global Evaporation, Interception, Infiltration, Observation of Hydrological Processes using Remote Sensing, Hydrogeophysics, Geophysical methods, Case Studies, Hydrological modelling, Uncertainty of Hydrological Predictions, Water Chemistry, Water biology, Quality of drinking water analysis.

(10 hours)

UNIT 3

Origin and age of groundwater: rock properties affecting groundwater, geologic formations as aquifers, Types of aquifers, Groundwater movement, Darcy' Law, Permeability, flow rates, flow directions, Groundwater levels and environmental influences, Quality of ground water, Pollutants of Ground Water and their social impact on health and remedial measures, Surface and subsurface geophysical investigations of groundwater, Artificial recharge of groundwater, Saline water intrusion in Aquifers. (10 hours)

Reference Books :

1. Advances in Water Science Methodologies, Aswathanarayana, U., 2005. Taylor and Francis.
2. Applied Hydrogeology,Fetter, C.W., 4th Edition, Prentice-Hall.
3. The Science of Water: Concepts and Applications, Spellman, Frank R., 2008., 2nd Edition, Taylor & Francis Group.
4. Groundwater Hydrology, Todd, David Keith. and Mays, Larry W. 2005. 3rd Edition, John Wiley & Sons.
5. Treatise on Water Science, Wilderer, Peter (Editor-In-Chief), 2011. 4 Volumes, Elsevier.

SKILL-ENHANCEMENT COURSES (SEC)

SEC – 2(A) : Basic Instrumentation Skills
Credit:03 (Practical-02;Theory-01)

Teaching hours: 4hrs/week

Course Objective:
To impart knowledge of design, operation and use of various electrical and electronic instruments in real life applications and their importance.

Course Learning Outcome:
On completion of this course students will be able to:

- familiarize and analyze the signal accordance to accuracy, precision, sensitivity, resolution, errors etc.
- use and measure frequency, phase etc. of the signal with CRO.
- acquire purpose, scope and concepts of signal generator and wave analyzer.
- understand different types of bridges and their construction to find unknown values.
- develop an understanding of construction and working of different analog and digital devices.

UNIT I
Basic of Measurement: Instruments accuracy, Precision, sensitivity, resolution range etc. Errors in measurements and loading effects.
Multimeter: Principles of measurement of de voltage and de Current, ac voltage, ac current and resistance, Specifications of a multimeter and their significance
Digital Instruments and Multimeter: Comparison of analogs& digital instruments Characteristics of a digital meter. Working principles of digital voltmeter. Block diagram and working of a digital multimeter
AC milli voltmeter: Type of AC millivoltmeters, Block diagram ac millivoltmeter, specifications and their significance.

UNIT II
Oscilloscope: Block diagram of basic CRO. CRT, electrostatic focusing and acceleration (Explanation only— no mathematical treatment), brief discussion on screen phosphor, visual persistence. Time base operation, synchronization. Front panel controls, Specifications of CRO and their significance.
Signal and pulse Generators: Block diagram, explanation and specifications of low frequency signal generator and pulse generator. Brief

idea for testing, specifications. Distortion factor meter, wave analysis.Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution.

Impedance Bridges: Block diagram of bridge. working principles of basic (balancing type) RLC bridge, Digital LCR bridges.

The test of lab skills will be of the following test items:

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Trouble shooting a circuit
8. Balancing of bridges

Laboratory Exercises:

1. To analyze the voltage divider resistive network.
2. To analyze a L-C-R circuit.
3. Verification of OHM'S LAW
4. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
5. Measurement of voltage, frequency, time period and phase angle using CRO.
6. Measurement of time period, frequency, average period using universal counter/ frequency counter.
7. Principle measurement of AC/DC voltage, DC Current and various electronic components.
8. Measurement of Series, Parallel, Series-Parallel Connection .

Recommended Books and References:

1. Performance and design of AC machines - M G Say ELBS Edn.
2. A text book in Electrical Technology - B L Theraja - S Chand and Co.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Electronic Devices and circuits, S. Salivahanan& N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.
7. Electronic circuits: Handbook of design and applications, U. Tietze, Ch. Schenk, 2008, Springer.

SEC – 1(B): Electrical circuits and Network Skills
Credit:03 (Practical-02;Theory-01)

Teaching hours: 45 hrs/week

Course Objectives

To develop an understanding of basic principles of electricity and its household applications. To impart basic knowledge of solid state devices and their applications, understanding of electrical wiring and installation.

Course Leaning Outcomes

At the end of this course, students will be able to :

• Demonstrate good comprehension of basic principles of electricity including ideas about voltage, current and resistance.

• Develop the capacity to analyze and evaluate schematics of power efficient electrical circuits while demonstrating insight into tracking of interconnections within elements while identifying current flow and voltage drop.

• Gain knowledge about generators, transformers and electric motors. The knowledge would include interfacing aspects and consumer defined control of speed and power.

• Acquire capacity to work theoretically and practically with solid-state devices. Delve into practical aspects related to electrical wiring like various types of conductors and cables, wiring-Star and delta connections, voltage drop and losses.

• Measure current, voltage, power in DC and AC circuits, acquire proficiency in fabrication of regulated power supply.

• Develop capacity to identify and suggest types and sizes of solid and stranded cables, conduit lengths, cable trays, splices, crimps, terminal blocks and solder.

Unit 1

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC and DC Electricity. Familiarization with multimeter, voltmeter and ammeter. (3 Lectures)

Electrical Circuits: Basic electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Power factor. Saving energy and money.

Unit 2

Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers. (2 Lectures) Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed & power of ac motor.

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

Unit 3

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Relay protection device.

Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, and solder. Preparation of extension board.

Network Theorems:(1) Thevenin theorem (2) Norton theorem (3) Superposition theorem (4) Maximum Power Transfer theorem.

PRACTICALS: Electrical circuits and Network Skills

Lab Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions. Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab. At least 05 Experiments from the following

1. Series and Parallel combinations: Verification of Kirchoff's law.
2. To verify network theorems: (I) Thevenin (II) Norton (III) Superposition theorem (IV) Maximum power transfer theorem
3. To study frequency response curve of a Series LCR circuit.
4. To verify (1) Faraday's law and (2) Lenz'slaw.
5. Programming with Pspice/NG spice.
6. Demonstration of AC and DC generator.
7. Speed of motor
8. To study the characteristics of a diode.
9. To study rectifiers (I) Half wave (II) Full wave rectifier (III) Bridge rectifier
10. Power supply (I) C-filter, (II) π- filter

11. Transformer – Step up and Step down
12. Preparation of extension board with MCB/fuse, switch, socket-plug, Indicator.

Reference Books:

1. Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
2. A text book in Electrical Technology - B L Theraja - S Chand & Co.
3. Performance and design of AC machines - M G Say ELBS Edn.
4. Electronic Devices and Circuits, A. Mottershead,1998, PHI Learning Pvt. Ltd.
5. Network, Lines and Fields, John D. Ryder, Pearson Ed. II, 2015.
6. Electrical Circuit Analysis, K. Mahadevan and C. Chitran, 2nd Edition, 2018, PHI learning Pvt. Ltd

SEC – 1(A) : Physics Workshop Skills
Credit:03 (Practical-02; Theory-01) **Teaching hours: 4hrs/weeks**

Course Objective

The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode. This course enable students to understand working of various measuring devices and different type of errors student can encounter in the measurement process. This course also develop the mechanical skills of the students by direct exposure to different machines and tools by demonstration and experimental technique.

Course Learning Outcomes

After completing this course, student will be able to:

• Learning measuring devices like Vernier callipers, Screw gauge, travelling microscope and Sextant for measuring various length scales.

• Acquire skills in the usage of multimeters, soldering iron, oscilloscopes, power supplies and relays. • Developing mechanical skill such as casting, foundry, machining, forming and welding and will become familiar with common machine tools like lathe, shaper, drilling, milling, surface machines and Cutting tools.

• Getting acquaintance with prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axle. Lever mechanism. Lifting of heavy weight using lever. braking systems, pulleys.

Unit 1
Introduction: Measuring devices: Vernier calliper, Screw gauge and travelling microscope. Measure the dimension of a solid block, volume of

cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.

Unit 2

Mechanical Skill: Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.

Unit 3

Introduction to prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment.

PRACTICALS: Physics Workshop Skills Lab

Instructor may conduct sessions on the use of equipment used in the workshop, including necessary precautions. Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab. Main emphasis is on taking observations, calculations, graph and result. Perform at least three practical from the following.

1. Use of Sextant to measure height of buildings.
2. Measurement of length and volume using Vernier clippers.
3. Comparison of diameter of a thin wire using screw gauge and travelling microscope.
4. Drilling of Hole in metal, wood and plastic.
5. Making of Simple joint in wood
6. Cutting of metal sheet.
7. Cutting of glass sheet
8. Lifting of heavy weights using simple pulley/lever arrangement.

N.B. According to availability more skill related practical /demonstration may be included.

References

1. A text book in Electrical Technology - B L Theraja – S. Chand and Company.
2. Performance and design of AC machines – M.G. Say, ELBS Edn.
3. Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.

4. Workshop Processes, Practices and Materials, Bruce J Black 2005, 3 rd Edn., Editor Newnes [ISBN: 0750660732] New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN0861674480].HSEC – 101 B: Computational Physics Skill.

SEC-2(B): RADIATION SAFETY
Credit:03(Practical-02;Theory-01)

Teaching hours: 4hrs/week

The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics

Unit 1
Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.

Unit 2
Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). **Radiation detection:** Basic concept and working principle of *gas detectors* (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), *Scintillation Detectors* (Inorganic and Organic Scintillators), *Solid States Detectors* and *Neutron Detectors, Thermoluminescent Dosimetry.*

Unit 3
Radiation safety management: *Biological effects of ionizing radiation*, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.
Experiments:

1. Study the background radiation levels using Radiation meter

Characteristics of Geiger Muller (GM) Counter:

2. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
3. Study of counting statistics using background radiation using GM counter.

4. Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
5. Study of absorption of beta particles in Aluminum using GM counter.
6. Detection of α particles using reference source & determining its half life using spark counter.
7. Gamma spectrum of Gas Light mantle (Source of Thorium)

Recommended Books and References:

1. W.E. Burcham and M. Jobes – Nuclear and Particle Physics – Longman (1995)
2. G.F. Knoll, Radiation detection and measurements
3. Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
4. W.J. Meredith and J.B. Massey, "Fundamental Physics of Radiology". John Wright and Sons, UK, 1989.
5. J.R. Greening, "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
6. Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001
7. A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
8. NCRP, ICRP, ICRU, IAEA, AERB Publications.
9. W.R. Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981

SEC-3(A): Renewable Energy and Energy Harvesting
Practical Credit: 03 (Practical-02;Theory-01)
Teaching Hours: 4hrs/week

Course Objective

To impart knowledge and hands on learning about various alternate energy sources to teach the ways of harvesting energy using wind, solar, mechanical, ocean, geothermal energy etc. To review the working of various energy harvesting systems which are installed worldwide.

Course Learning Outcomes

At the end of this course, students will be able to achieve the following learning outcomes:

- Knowledge of various sources of energy for harvesting
- Understand the need of energy conversion and the various methods of energy Storage.

- A good understanding of various renewable energy systems, and its components.
- Knowledge about renewable energy technologies, different storage technologies, distribution grid, smart grid including sensors, regulation and their control.
- Design the model for sending the wind energy or solar energy plant.
- The students will gain hand on experience of:
  (i) different kinds of alternative energy sources.
  (ii) conversion of vibration into voltage using piezoelectric materials.
  (iii) converseon of thermal energy into voltage using thermoelectric modules.

Unit 1

Fossil fuels and Alternate Sources of energy:
Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, bio-gas generation, geothermal energy tidal energy, Hydroelectricity.

Solar energy:
Solar energy, its importance, storage of solar energy, solar pond, nonconvective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photo-voltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

Unit 2

Wind Energy harvesting:
Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

Ocean Energy:
Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

Geothermal Energy: Geothermal Resources, Geothermal Technologies. Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. Rain water harvesting.

Unit 3

Piezoelectric Energy harvesting:
Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezo-electricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power Electromagnetic Energy Harvesting: Linear

generators, physical/mathematical models, recent applications Carbon captured technologies, cell, batteries, power consumption Environmental issues and Renewable sources of energy, sustainability. Merits of Rain Water harvesting.

PRACTICALS- Renewable Energy and Energy Harvesting Lab

Teacher may give long duration project based on this paper.

Sessions on the use of equipment used in the workshop, including necessary precautions. Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

Demonstrations and Experiments:

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric material.
3. Conversion of thermal energy into voltage-driven thermo-electric modules.

Reference Books

1. Non-conventional energy sources, B.H. Khan, McGraw Hill 60
2. Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
3. Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rd Edn., 2012, Oxford University Press.
4. Solar Energy: Resource Assessment Handbook, P Jayakumar, 2009
5. J.Balfour, M.Shaw and S. Jarosek, Photo-voltaics, Lawrence J Goodrich (USA)

SEC-3(B) : Introduction to Python
Credit: 03(Practical -02;Theory-01)

Teaching Hours: 4hrs/week

Course Objectives

Student will learn fundamental programming concepts of a programming language called Python and to provide exposure to basic problem –solving techniques using computers.

Course Learning Outcomes

At the end of this course, students will be able to

- understand why python is a useful scripting language for developers.
- learn how to use lists, tuples and dictionaries in Python
- learn how to how to write statements and loops.

- learn how to how to write function and arguments.
- learn how to how to read and write files and build modules.

Unit 1

Introduction to Python and operators: Python Introduction, History of Python, Introduction to Python Interpreter and program execution, Python Installation Process in Windows and Linux, Python IDE, Introduction to anaconda, python variable declaration, Keywords, Indents in Python, Python input/output operations

Python's Operators: Arithmetic Operators, Comparison Operators, Assignment Operators, Logical Operators, Bitwise Operators, Membership Operators, Identity Operators, Ternary Operator, Operator precedence.

Unit 2

Python's Built-in Data types, Statements & Loops and Functions: Data types: String, List, Tuple, Set, Dictionary (characteristics and methods).

Conditional Statements & Loop**:** Conditional Statements (If, If-else, If-elif-else, Nested-if etc.) and loop control statements (for, while, Nested loops, Break, Continue, Pass statements)

Introduction to functions: Function definition and calling, Function parameters, Default argument function, Variable argument function, in built functions in python, Scope of variable in python

Unit 3

File processing and Modules: File Processing: Concept of Files, File opening in various modes and closing of a file, Reading from a file, Writing onto a file, some important File handling functions e.g open(), close(), read(), readline() etc.

Modules: Concept of modularization, Importance of modules in python, Importing modules, Built in modules (ex: Numpy).

Reference books:

1. Learning Python , Mark Lutz , O'Reilly media , 5th Edition,2013
2. Python Crash course: A hands on ,Project based Introduction to Programming, 2nd Edition No starch Press 2019.
3. Head First Python,Paul Barry, O'Reilly media , 2nd Edition
4. Martic C Brown ,Python : The Complete refrence, 4th Edition Mc Graw Hill Publication, 2018

VAC-1 : Environmental Science

VAC-2: FOUNDATION COURSE IN INDIAN KNOWLEDGE SYSTEM

Credits: 03(Theory)

Course Objective: The objective of this paper is introduce the students about the traditional Indian knowledge system.

Course Learning Outcomes

After completing this course, student will be able to:

1. learn about India's rivers, plains etc.
2. learn about India's its population and its wealth.
3. learn about cultural and traditional practices in different tribes with regard to Nagaland
4. learn about basics of ancient Indian astronomy

Unit I : Bharatavarsha – A Land of Rare Natural Endowment

Largest cultivable area in the world . Protected and natured by Himalayas. The Sindhu –Ganga plain and the greatest coastal plains. The great rivers of India.

Abundant rains, sunshine and warmth, animals and mineral wealth. Most populous country in the world . India's prosperity held the world in thrall.

Splendid geographical isolation of India and Uniqueness of Indian culture.

Nagaland : its rivers , hills and its people.

Unit II : Land and Livelihood (with respect to Nagaland):

Tribes of Nagaland and its cultural practices, values and ethics, wild plant foods and Medicine, Jhum and Terrace cultivation, Use of animal in cultural practices , Festivals.

Food culture : edible and inedible animals (taboos and prohibitions), methods of preparing and preserving food in different tribal cultures

Material culture for house construction, musical instruments, basketry, pottery, fibers and dyes for clothing, community hunting and fishing.

Unit III: Basics of Indian Astronomy

Astronomy as earliest sciences in different civilizations, Introduction of Celestial sphere, The different coordinate systems (horizontal, equatorial and ecliptic), Indian names for the fundamental circles and the coordinates use in these systems.

Division of the celestial sphere /ecliptic into 12 and 27 equal parts- rasi and nakstara division.

The revolution numbers of various planets, nodes and apogees , Panchanga , adikmasses, solar and Luni-solar systems, solar and lunar Eclipses.

Reference Books:

1. S. N. Sen and K. S. Shukla, History of astronomy in India. 2nd ed., INSA, Delhi,2001
2. S. Balachnadra Rao, Indian Astronomy An Introduction, University Press, Hydrabad,2000
3. B.V. Subbarayappa and K.V Sarma, Indian Astronomy: A source Book, Nehru Centre Bombay,1985
4. Nagi, K., Traditional festivals of Nagaland Vol-!, Ed 2018, Heritage Publishing House, Dimapur, Nagaland
5. Hibo, Visakhonu and Ngullie, R.C. Taboos, Myths and Legends, Ed 2012, Nagaland Institute of Development studies, Dimapur, Nagaland.
6. Tetso, Talimernla, Ethomedicine of the Ao Nagas , Ed 2008, Heritage Publishing House, Dimapur, Nagaland