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ᱵᱟᱝᱠᱩᱲᱟ ᱩᱱᱤᱵᱷᱟᱨᱥᱤᱴᱤ
DEPARTMENT OF PHYSICS, SANTALI VERNACULAR
BANKURA UNIVERSITY

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Draft Syllabus For B.Sc in Physics, Santali vernacular
(To be effective from the academic session-2021-22)

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Table of contents:

Aims and Objectives of UG program in Physics:

The aims and objectives of our UG educational programs in sciences in general and Physics in particular should be structured to

- create the facilities and environment in all the educational institutions to consolidate the knowledge acquired at +2 level and to motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics.

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

- develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics.

- expose the student to the vast scope of Physics as a theoretical and experimental science with applications in solving most of the problems in nature spanning from 10-15 m to 1026m in space and 10-10 eV to 1025eV in energy dimensions.

[illegible]

emphasize the discipline of Physics to be the most important branch of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas.

● [illegible]

[illegible]

to emphasize the importance of Physics as the most important discipline for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment.

In view of opening the new windows in higher education and research and opening job opportunities at all levels from technicians to innovator scientists and engineers.

[illegible]

Program Learning Outcomes in B.Sc Physics (Honours)

[illegible]

The student graduating with the Degree B.Sc (Honours) Physics should be able to acquire

(i) [illegible]

a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas and applications in basic Physics like Astrophysics, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science, and its linkages with related disciplinary areas/subjects like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology;

(ii) [illegible]

[illegible]

procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in research and development, teaching and government/public service;

(iii) [illegible]

skills in areas related to one's specialization area within the disciplinary/subject area of Physics and current and emerging developments in the field of Physics.

● [illegible]

Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and tackling Physics-related problems and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Physics.

● [illegible]

Recognize the importance of mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

● [illegible]

Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories of Physics.

● Demonstrate relevant generic skills and global competencies such as

(i) [illegible]

problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary area boundaries;

(ii) [illegible]
investigative skills, including skills of independent investigation of Physics-related issues and problems;

(iii) [illegible]
communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;

(iv) [illegible]
analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Physics and ability to translate them with popular language when needed;

(v) [illegible]
ICT skills;

(vi) [illegible]
personal skills such as the ability to work both independently and in a group.

● [illegible]
Demonstrate professional behavior such as

(i) [illegible]
being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;

(ii) [illegible]
the ability to identify the potential ethical issues in work-related situations;

(iii) [illegible]
appreciation of intellectual property, environmental and sustainability issues;

(iv) [illegible]
promoting safe learning and working environment.

[illegible]

Programme Specific Outcomes:

i. [illegible]
Understand the core concept of Physics subjects

ii. [illegible]

Acquire analytical and logical skill for higher Education.

iii. [illegible]

Excel in Experimental and Theoretical Physics.

iv. [illegible]

Trained to take up jobs in allied fields.

v. [illegible]

Confident to take up competitive exams

[illegible]

Program Career Oppertunities:

[illegible]

After completing the B.Sc course, Candidates pursue job roles such as research analyst, teacher, and lab assistant also pursue further academic engagement through courses like M.Sc (Master of Science), M.Sc PhD dual degree or a PhD.

STRUCTURE IN PHYSICS(HONOURS)

Semester -I

Course Code	CourseTitle	Credit	Marks			No.ofHours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SHPHS/ 101/C-1	MathematicalPhysics-I (T1)MathematicalPhysics-I Lab(P1)	4 2	10	25 15	50	4		4
SHPHS/	Mechanics(T2)	4	10	25	50	4		4
102/C-2	MechanicsLab(P 2)	2		15				
SHPHS/ 103/GE-1	Mechanics,Electrostaticsand Sound (GET1)	4	10	25	50	4		4
	Mechanics,Electrostaticsand							
	SoundLab(GE P1)	2		15				
ACSHP/104/AECC-1	EnvironmentalStudies	4	10	40	50	4		
Totalin Semester-I		**22**	**40**	**160**	**200**	**16**		**12**

Semester-II

Course Code	CourseTitle	Credit	Marks			No.ofHours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SHPHS /201/C-3	Electricity and Magnetism (T3)ElectricityandMagnetism Lab(P3)	4 2	10	25 15	50	4		4
SHPHS/ 202/C-4	Waves and Optics (T4)WaveandOpticsLab(P4)	4 2	10	40	50	4		4
SHPHS/203/GE-2	ElectromagnetismandThermalPhysics (GE T2)ElectromagnetismandThermal PhysicsLab(GEP2)	4 2	10	40	50	4		4
ACSHP/204/AECC-2	English/Hind/MIL	2	10	40	50	2		
Totalin Semester-II		**20**	**40**	**160**	**200**	**14**		**12**

Semester-III

CourseCode	CourseTitle	Credit	Marks			No.ofHours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SHPHS/301 /C-5	Mathematical Physics-II (CT5)MathematicalPhysics-IILab(P5)	4 2	10	25 15	50	4		4
SHPHS/302 /C-6	Thermal Physics (T6)ThermalPhysicsLab(P6)	4 2	10	25 15	50	4		4
SHPHS /303/C-7	Digital Systems and Applications (T7)DigitalSystemsandApplications Lab (P7)	4 2	10	25 15	50	4		4
SHPHS/304/ GE-3	Physical Optics and ModernPhysics (GET3) Physical Optics and ModernPhysics Lab(GEP3)	4 2	10	25 15	50	4		4

SHPHS/305/SEC-1	ComputationalPhysics(SECT1)Or RenewableEnergyandEnergyHarvesting(SECT2)	2	10	40	50	1		2
Totalin Semester-III		**26**	**50**	**200**	**250**	**17**		**18**

Semester-IV

CourseCode	**CourseTitle**	**Credit**	**Marks**			**No.ofHours**		
			I.A.	**ESE**	**Total**	**Lec.**	**Tu.**	**Pr.**
SHPHS /401/C-8	Mathematical Physics III (T8)MathematicalPhysicsIIILab(P8)	4 2	10	25 15	50	4		4
SHPHS /402/C-9	ElementsofModernPhysics(T9)ModernPhysicsLab(P9)	4 2	10	25 15	50	4		4
SHPHS /403/C-10	AnalogSystemsandApplications(T10) AnalogSystemsandApplicationsLab(P10)	4 2	10	25 15	50	4		4
SHPHS /404/GE-4	Electronics and instrumentation(GET4) Electronics and instrumentationLab(GEP4)	4 2	10	25 15	50	4		4
SHPHS /405/SEC-2	RadiationSafety(SECT3)or WeatherForecasting(SECT4)	2	10	40	50	1		2
Totalin Semester -IV		**26**	**50**	**200**	**250**	**17**		**18**

Semester-V

CourseCode	**CourseTitle**	**Credit**	**Marks**			**No.ofHours**		
			I.A.	**ESE**	**Total**			
SHPHS /501/C-11	QuantumMechanicsandApplications(T11) QuantumMechanicsandApplications Lab(P11)	4 2	10	25 15	50	4		4
SHPHS /502/C-12	SolidStatePhysics(T12) SolidStatePhysics Lab(P12)	4 2	10	25 15	50	4		4

SHPHS/503/ DSE-1	AdvancedMathematicalPhysics(DSE T1) Or ClassicalDynamics(DSET2)	6	10	40	50	5	1	
SHPHS /504/DSE-2	NuclearandParticlePhysics(DSE T3) Or AstronomyandAstrophysics(DSE T4)	6	10	40	50	5	1	
Totalin Semester – V		**24**	**40**	**160**	**200**	**20**		**8**

Semester-VI

Course Code	**CourseTitle**	**Credit**	**Marks**			**No.ofHours**		
			I.A.	**ESE**	**Total**	**Lec.**	**Tu.**	**Pr.**
SHPHS/601/C -13	Electromagnetic Theory (T13)ElectromagneticTheoryLab (P13)	4 2	10	25 15	50	4		4
SHPHS/602/C -14	StatisticalMechanics(T14) StatisticalMechanicsLab(P14)	4 2	10	25 15	50	4		4
SHPHS/603/D SE-3	PhysicsofEarth(DSET5)Or BiologicalPhysics(DSE T6)	6	10	40	50	5	1	
SHPHS/604/DS E-4	NanoMaterialsandApplications(DSE T7)&(DSEP7) Or Communication Electronics(DSE T8) &(DSEP8)	4+ 2	10	25 15	50	4		4
Totalin Semester –VI		**24**	**40**	**160**	**200**	**18**		**12**

SH= Science Honours, PHS = Physics, ACSHP= Arts Commerce Science Honours Pass, C= Core Course, AECC= Ability Enhancement Compulsory Course, SEC= Skill Enhancement Course, GE= Generic Elective, DSE= Discipline Specific Elective, IA= Internal Assessment, ESE= End-Semester Examination, Lec.=Lecture, Tu.= Tutorial, and Prc.=Practical

CBCS SYLLABUS FOR THREE YEARS UNDER GRADUATE COURSE IN PHYSICS HONOURS(SANTALI VERNACULAR)

Core T1 – Mathematical Physics (4 Credits)

1. Calculus

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.

2. 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).

3. Orthogonal Curvilinear Coordinates

Orthogonal Curvilinear Coordinates. Unit vectors in curvilinear coordinate system. Arc length and volume element.Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

4. Fourier Series

Periodic function, Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.

5. Frobenius Method and Special Functions

Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues 1Formula, 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 o (x) and J 1 (x)) and Orthogonality.

6. Some Special Integrals

Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

6. Partial Differential Equations

Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

Reference Books

► Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.

► An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning

► Differential Equations, George F. Simmons, 2007, McGraw Hill.

► Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.

► Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book

► Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning

► Mathematical Physics, Goswami, 1st edition, Cengage Learning

► Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press

► Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.

► Essential Mathematical Methods, K.F.Riley&M.P.Hobson, 2011, Cambridge Univ. Press

► Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.

Core P1 – Mathematical Physics Lab (2 credits)

1. Introduction and Overview

Computer architecture and organization, memory and Input/output devices

2. Basics of scientific computing

Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and

Repetition, single and double precision arithmetic, underflow & overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods

3. Errors and error Analysis

Truncation and round off errors, Absolute and relative errors, Floating point computations.

4. Introduction to plotting graphs with Gnuplot

Basic 2D and 3D graph plotting - plotting functions and data files, fitting data using gnuplot's fit function, polar and parametric plots, modifying the appearance of graphs, Surface and contour plots, exporting plots.

5. Curve fitting, Least square fit, Goodness of fit, standard deviation

2Ohms law to calculate R, Hooke's law to calculate spring constant

Reference Books

► Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.

► A first course in Numerical Methods, U.M. Ascher& C. Greif, 2012, PHI Learning.

► Elementary Numerical Analysis, K.E. Atkinson, 3 rdEdn . , 2007, Wiley India Edition.

► Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.

► An Introduction to computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press

► Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd

Course Learning Outcome(T1 and P1)

●Revise the knowledge of calculus, vectors, vector calculus, probability and probability distributions. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.

- Learn the curvilinear coordinates which have applications in problems with spherical and cylindrical symmetries.
- Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.
- Learn about the special functions, such as the Hermite polynomial, the Legendre polynomial, the Laguerre polynomial and Bessel functions and their differential equations and their applications in various physical problems such as in quantum mechanics which they will learn in future courses in detail.
- Learn the beta, gamma and the error functions and their applications in doing integrations.

Skills To be Learned:

- Training in calculus will prepare the student to solve various mathematical problems.
- Training in mathematical tools like calculus, integration, series solution approach , special function will prepare the student to solve ODE, PDE's which model physical phenomena.
- He / she shall develop an understanding of how to model a given physical phenomena such as pendulum motion, rocket motion, stretched string, etc., into set of ODE's, PDE's and solve them.
- These skills will help in understanding the behavior of the modeled system

Core T2 – Mechanics (4 Credits)

1. Fundamentals of Dynamics

Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable- mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

2. Work and Energy

Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Qualitative study of one dimensional motion from potential energy curves. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

3. Rotational Dynamics

Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

4. Fluid Motion

Motion of ideal fluids. Streamlines and streamline flow. The continuity equation. Euler's equation for an incompressible fluid. Steady flow. Bernoulli's theorem and its applications.Toricelli's expression for the velocity of efflux of a liquid. Venturimeter. Kinematics of Moving Fluids,Poiseuille's Equation for Flow of a Liquid through Capillary

5. Elasticity

Stress and strain. Hooke's law. Elastic moduli and their interrelationship. Strain-energy in a stretched wire. Strain-energy associated with a pure strain. Torsion of a wire. Torsional oscillations. Loaded beams. Bending moment. Stresses induced by bending. The cantilever. Beam supported at its two ends and carrying a load at any point of the beam.

6. Gravitation and Central Force Motion

Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere.

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).

7. Non-Inertial Systems

Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

8. Special Theory of Relativity

Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.

Reference Books

► An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.

► Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.

► Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.

► Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.

► Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education

► Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Additional Books for Reference

► Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000

University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley

► Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning

► Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Core P2 – Mechanics Lab (2 Credits)

General topic

1. Measurements of length (or diameter) using verniercaliper, screw gauge and travelling microscope.

2. To study the random error in observations.

List of practical (Any five of the following experiments should be done)

1. To study the Motion of Spring and calculate, (a) Spring constant, (b) g and (c) Modulus of rigidity.

2. To determination of the Young's modulus of a material in the form of a bar by the method of flexure.

3. To determine the coefficient of viscosity of water by capillary flow method (Poiseuille's method).

4. Determination of the coefficient of viscosity of highly viscous liquid by Stoke's method.

5. To determine the value of g using Bar Pendulum.

6. To determine the value of g using Kater's Pendulum.

7. To determine the height of a building using a Sextant.

48. To determine the Moment of Inertia of a Flywheel.

Reference Books

► Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Edn, 2011, KitabMahal

► Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

Course learning outcome:(T2 and P2)

After going through the course, the student should be able to

●Understand laws of motion and their application to various dynamical situations, notion of inertial frames and concept of Galilean invariance. He / she will learn the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.

●Understand the analogy between translational and rotational dynamics, and application of both motions simultaneously in analyzing rolling with slipping.

●Write the expression for the moment of inertia about the given axis of symmetry for different uniform mass distributions.

●Understand the phenomena of collisions and idea about center of mass and laboratory frames and their correlation.

●Understand the principles of elasticity through the study of Young Modulus and modulus of rigidity.

●Understand simple principles of fluid flow and the equations governing fluid dynamics.

●Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of Gravitation.

●Explain the phenomena of simple harmonic motion and the properties of systems executing such motions.

●Describe how fictitious forces arise in a non-inertial frame, e.g., why a person sitting in a merry-go-round experiences an outward pull.

●Describe special relativistic effects and their effects on the mass and energy of a moving object.

●appreciate the nuances of Special Theory of Relativity (STR)

●In the laboratory course, the student shall perform experiments related to mechanics (compound pendulum), rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity) and fluid dynamics (verification of Stokes law, Searle method) etc.

Skills to be learned

●Learn basics of the kinematics and dynamics linear and rotational motion.

●Learn the concepts of elastic in constant of solids and viscosity of fluids.

●Develop skills to understand and solve the equations of Newtonian Gravity and central force problem.

●Acquire basic knowledge of oscillation.

●Learn about inertial and non-inertial systems and essentials of special theory of relativity.

Core T3 - Electricity and Magnetism (4 Credits)

1. Electric Field and Electric Potential

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Uniqueness theorem (statement). Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

2. Dielectric Properties of Matter

Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and

Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics.

3. Magnetic Field

Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole).

Ampere's Circuital Law and its application to (1) infinite straight wire, (2) Infinite planar surface current, and (3) Solenoid. Properties of B: curl and divergence. Axial vector property of B and its consequences. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.

4. Electromagnetic Induction

Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current

5. 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.

6. Electrical Circuits

5AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit

7. Network theorems

Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits

Note: For the sake of brevity, details of ballistic galvanometer may be omitted from the theory course. Some part of the theory may be needed for the experiments, but this can be covered as part of Practical.

Reference Books

► Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw

► Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education

► Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

► Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education

► Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.

► Electricity and Magnetism, J.H.Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

Core P3 – Electricity and Magnetism Lab (2 Credits)

General topic

Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.

List of Practical (Any five of the following experiments should be done)

1. To verify the Thevenin, Norton and Maximum power transfer theorems.

2. To determine self-inductance of a coil by Anderson's bridge.

3. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency,

(b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.

4. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor Q.

5. Determination of the ECE of copper.

6. Determination of the boiling point of a suitable liquid using a platinum resistance thermometer.

7. Determination of a ballistic galvanometer constant by capacitor charging and discharging method.

8. Construction of one Ohm coil.

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal

6► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.

► A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

Course learning outcome(T3 and P3)

After going through the course, the student should be able to

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

●Explain and differentiate the vector (electric fields, Coulomb’s law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.

●Apply Gauss's law of electrostatics to solve a variety of problems.

●Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.

●Demonstrate a working understanding of capacitors.

●Describe the magnetic field produced by magnetic dipoles and electric currents.

●Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electric and magnetic fields.

●Understand the dielectric properties, magnetic properties of materials and the phenomena of electromagnetic induction.

●Describe how magnetism is produced and list examples where its effects are observed.

●Apply Kirchhoff's rules to analyze AC circuits consisting of parallel and/or series combinations of voltage sources and resistors and to describe the graphical relationship of resistance, capacitor and inductor.

●Apply various network theorems such as Superposition, Thevenin, Norton, Reciprocity, Maximum Power Transfer, etc. and their applications in electronics, electrical circuit analysis, and electrical machines.

●In the laboratory course the student will get an opportunity to verify various laws in electricity and magnetism such as Lenz's law, Faraday's law and learn about the construction, working of various measuring instruments.

●Should be able to verify of various circuit laws, network theorems elaborated above, using simple electric circuits.

Skills to be learned

- This course will help in understanding basic concepts of electricity and magnetism and their applications.
- Basic course in electrostatics will equips the student with required prerequisites to understand electrodynamics phenomena.

Core T4 - Waves and Optics (4 Credits)

1. Oscillations

SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

2. Superposition of Collinear Harmonic oscillations

Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. Superposition of two perpendicular Harmonic Oscillations. Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

3. Wave Motion

Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation.

Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves

4. Superposition of Two Harmonic Waves

Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.

5. Wave Optics

Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

6. Interference

Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

7. Interferometer

Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.

8. Diffraction and Holography

7Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

Reference Books

► Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

► Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill

► Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.

► Optics, AjoyGhatak, 2008, Tata McGraw Hill

► The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

► The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

► Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

Core P4 – Wave and Optics Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. To investigate the motion of coupled oscillators.

2. To study Lissajous Figures.

3. Familiarization with: Schuster`s focusing; determination of angle of prism.

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 wavelength of sodium light using Fresnel Biprism.

7. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.

8. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books

► Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

► Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill

► Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.

► Optics, AjoyGhatak, 2008, Tata McGraw Hill

► The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

► The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

► Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

Course learning outcome(T4 and P4)

This course will enable the student to

●Recognize and use a mathematical oscillator equation and wave equation, and derive these equations for certain systems.

●Apply basic knowledge of principles and theories about the behaviour of light and the physical environment to conduct experiments.

●Understand the principle of superposition of waves, so thus describe the formation of standing waves.

●Explain several phenomena we can observe in everyday life that can be explained as wave phenomena.

●Use the principles of wave motion and superposition to explain the Physics of polarisation, interference and diffraction.

●Understand the working of selected optical instruments like biprism, interferometer, diffraction grating, and holograms.

●In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment, Fresnel Biprism etc. Resolving power of optical equipment can be learnt firsthand.

●The motion of coupled oscillators, study of Lissajous figures and behaviour of transverse, longitudinal waves can be learnt in this laboratory course.

Skills to be learned

●He / she shall develop an understanding of various aspects of harmonic oscillations and waves specially.

(i) Superposition of collinear and perpendicular harmonic oscillations

(ii) Various types of mechanical waves and their superposition.

●This course in basics of optics will enable the student to understand various optical phenomena, principles, workings and applications optical instruments.

Core T5 - Mathematical Physics-II (4 Credits)

1. Complex numbers

Polar form. Argand diagram. Geometrical interpretation of algebraic operations on complex numbers. Functions of a complex variable. Single- and multivalued functions. Analytic functions. Cauchy-Riemann equations.

2. Complex line integrals

Cauchy's integral theorem (no proof is required) for simply connected regions. Simple consequences of Cauchy's theorem. Cauchy's integral formula. Jordan's Lemma. The Taylor and Laurent expansions (statement only). Singular points. Removable singularity. Poles. Essential singularity. Residue at a pole of order m. Cauchy's residue theorem. Evaluation of simple integrals with the help of residue theorem.

3. Matrix algebra

Transpose of a matrix, Hermitian, orthogonal and unitary matrices. Matrix for rotation in two and three dimensions. The inverse of a matrix. Solution of a system of linear equations by matrix method. Eigenvalues and eigenvectors of a matrix. Properties of eigenvectors and eigenvalues of Hermitian and unitary matrices. Matrix representations of Linear operators. Similarity transformation.

4. 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.

5. 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.

6. Variational calculus in Physics

Functionals. Basic ideas of functionals. Extremization of action as a basic principle in mechanics. Lagrangianfomulation. Euler's equations of motion for simple systems: harmonics oscillators, simple pendulum, spherical pendulum, coupled oscillators. Cyclic coordinates. Symmetries and conservation laws. Legendre transformations and the Hamiltonian formulation of mechanics. Canonical equations of motion. Applications to simple systems.

Reference Books

► Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.

► Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.

► Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.

► Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.

► Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press

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

► Mathematical Physics, P. K. Chattopadhyay, 2014, New Academic Science.

Core P5 – Mathematical Physics II Lab (2 Credits)

1. Introduction to programming in python:

Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object oriented programming.

2. Introduction to Computer Programming

Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search, Random number generation, Area of circle, area of square, volume of sphere, value of pi (π).

3. Introduction to Numerical Computation

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods, Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation, Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method, Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods.

Reference books

► Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.

► Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.

► Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.

► Effective Computation in Physics- Field guide to research with Python, A. Scopatz and K.D. Huff, 2015, O'Rielly

► A first course in Numerical Methods, U.M. Ascher& C. Greif, 2012, PHI Learning.

► Elementary Numerical Analysis, K.E. Atkinson, 3 rdEdn . , 2007, Wiley India Edition.

► Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover

Pub.

► An Introduction to computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press

► Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt.Ltd

Course learning outcome(T5 and P5):

● Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.

● Learn about the special functions, such as the Hermite polynomial, the Legendre polynomial, the Laguerre polynomial and Bessel functions and their differential equations and their applications in various physical problems such as in quantum mechanics which they will learn in future courses in detail.

● Learn the beta, gamma and the error functions and their applications in doing integrations.

● Know about the basic theory of errors, their analysis, estimation with examples of simple experiments in Physics.

● Acquire knowledge of methods to solve partial differential equations with the examples of important partial differential equations in Physics.

● In the laboratory course, learn the basics of the Scilab software, their utility, advantages and disadvantages.

● Apply the Scilab software in curve fittings, in solving system of linear equations, generating and plotting special functions such as Legendre polynomial and Bessel functions, solving first and second order ordinary and partial differential equations.

Skills to be learned

● He / she shall develop an understanding of various aspects of harmonic oscillations and waves specially.

(i) Superposition of collinear and perpendicular harmonic oscillations

(ii) Various types of mechanical waves and their superposition.

● This course in basics of optics will enable the student to understand various optical phenomena, principles, workings and applications optical instruments.

Core T6 - Thermal Physics (4 Credits)

1. Introduction toThermodynamics

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

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 10engine & 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 of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

2. Thermodynamic Potentials

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb’s Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, ClausiusClapeyron Equation and Ehrenfest equations

3. Maxwell’s Thermodynamic Relations

Derivations and applications of Maxwell’s Relations, Maxwell’s Relations:(1) ClausiusClapeyron 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.

4. Kinetic Theory of Gases

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern’s Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. Molecular Collisions.

Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

5. 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. Joule- Thomson Cooling.

Reference Books

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

► Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill

► Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.

► Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.

11► Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press

► Thermodynamics and an introduction to thermostatistics, H. B. Callen, 1985, Wiley.

► Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications

Core P6 – Thermal Physics Lab (2 Credits)

List of Practical (Any fiveof the following experiments should be done)

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

► Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers●

► A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

Course learning outcome:

●Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations.

●Learn about Maxwell's thermodynamic relations.

Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzman distribution law, equitation of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.

●Learn about the real gas equations, Van der Waal equation of state, the Joule-Thompson effect.

●In the laboratory course, the students are expected to do some basic experiments in thermal Physics, viz., determinations of Stefan's constant, coefficient of thermal conductivity, temperature coefficient of resistant, variation of thermo-emf of a thermocouple with temperature difference at its two junctions and calibration of a thermocouple.

Skills to be learned

●This basic course in thermodynamics will enable the student to understand various thermo dynamical concepts, principles.

Core T7 - Digital Systems and Applications (4 Credits)

1. Integrated Circuits

Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.

2. Digital Circuits

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

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 multivibrator 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).

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.

Reference Books

► Digital Principles and Applications, A.P. Malvino, D. P. Leach and Saha, 7th Ed., 2011, Tata McGraw

► Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.

► Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.

► Digital Electronics G K Kharate ,2010, Oxford University Press

► Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning

► Logic circuit design, Shimon P. Vingron, 2012, Springer.

► Digital Electronics, SubrataGhoshal, 2012, Cengage Learning.

► Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill

► Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

Core P7 – Digital Systems and Applications Lab (2 Credits)

General topic

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.

2. To test a Diode and Transistor using a Multimeter.

List of Practical (Any five of the following experiments should be done)

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.

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 design an astablemultivibrator of given specifications using 555 Timer.

9. To design a monostablemultivibrator of given specifications using 555 Timer.

Reference Books

13► Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.

► Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

Course learning outcome(T7 and P7)

As the successful completion of the course the student is expected to be conversant with the following.

●Basic working of an oscilloscope including its different components and to employ the same to study different wave forms and to measure voltage, current, frequency and phase.

●Secure first-hand idea of different components including both active and passive components to gain a insight into circuits using discrete components and also to learn about integrated circuits.

●About analog systems and digital systems and their differences, fundamental logic gates, combinational as well as sequential and number systems.

●Synthesis of Boolean functions, simplification and construction of digital circuits by employing Boolean algebra.

●Sequential systems by choosing FlipFlop as a building bock- construct multivibrators, counters to provide a basic idea about memory including RAM,ROM and also about memory organization.

●Microprocessor and assembly language programming with special reference to IntelµP 8085.

●In the laboratory he is expected to construct both combinational circuits and sequential circuits by employing NAND as building blocks and demonstrate Adders, Subtractors, Shift Registers, and multivibrators using 555 ICs. He is also expected to use µP 8085 to demonstrate the same simple programme using assembly language and execute the programme using a µP kit.

Skills to be learned

- ●Acquire skills to understanding the functioning and operation of CRO to measure physical quantities in electrical and electronic circuits.
- ●Learn the basics of IC and digital circuits, and difference between analog and digital circuits. Various logic GATES and their realization using diodes and transmitters.
- ●Learn fundamental of Bolean algebra and their role in constructing digital circuits.
- ● Learn about combinatorial and sequential systems by building block circuits to construct multivibrators and counters.
- ●Understand basics of microprocessor and assembly language programming with Examples

Core T8 - Mathematical Physics III (4 Credits)

1. Linear Vector Spaces

Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.

Inner products. Gram-Schmidt orthogonalization. Orthogonal and unitary transformations and their matrix representations.

2. Integrals Transforms

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of

Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations

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. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

3. Eigen-values and Eigenvectors

Cayley- Hamiliton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix.

Reference Books

► Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press

Core P8 – Mathematical Physics III Lab (2 Credits)

List of Practical (Any five of the followings should be done)

1.Solve differential equations

$dy/dx=e^{-x}$ with y=0 or x=0

$dy/dx+e^{-x}=x^2$

$d^2y/dt^2+2dy/dt=-y$

$d^2y/dt^2+e^{-t}dy/dt=-y$

2. Dirac Delta Function: Evaluate for $1/\sqrt{2\prod\sigma^2}\int e^{-(x-2)2/2\sigma^{\wedge}2}(x+3)dx$ σ=1, 0.1, .01 and show it tends to 5.

3. Fourier Series: Program to sum , Evaluate the Fourier coefficients of a given periodic function (square wave).

4. Frobenius method and Special functions:

Show recursion relation

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.

7. Evaluation of trigonometric functions e.g. sin θ, Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate 1/(x 2 +2) numerically and check with computer integration

8. Compute the nth roots of unity for n = 2, 3, and 4.

9. Find the two square roots of −5+12j.

10. Integral transform: FFT of $e\text{-}x^{\wedge 2}$

Reference Books

► Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press

► Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications

► Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

► A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

Cousse learning outcome(T8 and P8)

●Learn about the Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems. They are also expected to learn the Laplace transform, the inverse Laplace transforms, their properties and their applications in solving physical problems.

●In the laboratory course, the students should apply their C++/Scilab programming language to solve the following problems:

(i)Solution first- and second- order ordinary differential equations with appropriate boundary conditions

Skills to be learned

●Knowledge of various mathematical tools like complex analysis, integral transform will equip the student with reference to solve a given ODE, PDE.

●These skills will help in understanding the behavior of the modeled systems.

Core T9 - Elements of Modern Physics (4 Credits)

1. Unit 1

Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.

2. Unit 2

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction.

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

3. Unit 3

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier.

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.

4. Unit 4

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.

Reference Books

► Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.

► Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill

► Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.

► Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.

► Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill

► Quantum Mechanics: Theory & Applications, A.K.Ghatak&S.Lokanathan, 2004, Macmillan

Additional Books for Reference

► Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.

► Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.

► Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.

► Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.

► Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

Core P9 –Modern Physics Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

161. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light

2. To determine work function of material of filament of directly heated vacuum diode.

3. To determine the wavelength of H-alpha emission line of Hydrogen atom.

4. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

5. To setup the Millikan oil drop apparatus and determine the charge of an electron.

6. To determine the wavelength of laser source using diffraction of single slit.

7. To determine the wavelength of laser source using diffraction of double slits.

8. To determine the Boltzmann constant using I-V characteristics of PN junction diode

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Edn, 2011,Kitab Mahal

Course learning outcome(T9 and P9)

●Understand the theory of quantum measurements, wave packets and uncertainty principle

●Understanding the properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.

●Ability to calculate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in theory of beta decay.

●Understand fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.

● Understand various interactions of electromagnetic radiation with matter. Electron positron pair creation.

● Understand the spontaneous and stimulated emission of radiation, optical pumping and population inversion. Three level and four level lasers. Ruby laser and He-Ne laser in details. Basic lasing.

●In the laboratory course, the students will get opportunity to perform the following experiments

● Measurement of Planck's constant by more than one method.

●Verification of the photoelectric effect and determination of the work Function of a metal.

●Determination of the charge of electron and e/m of electron.

● Determine the wavelength of Laser sources by single and Double slit experiments

●Determine the wavelength and angular spread of He-Ne Laser using plane diffraction grating.

●Verification of the law of the Radioactive decay and determine the mean life time of a Radioactive Source, Study the absorption of the electrons from Beta decay. Study of the electron spectrum in Radioactive Beta decays of nuclei.

●Plan and Execute 2-3 group projects in the field of Atomic, Molecular and Nuclear Physics in collaboration with other institutions, if, possible where advanced facilities are available.

Skills to be learned

●Comprehend the failure of classical physics and need for quantum physics.

●Grasp the basic foundation of various experiments establishing the quantum physics by doing the experiments in laboratory and interpreting them.

●Formulate the basic theoretical problems in one, two and three dimensional physics and solve them.

●Learning to apply the basic skills developed in quantum physics to various problems in

(i) Nuclear Physics

(ii) Atomic Physics

(iii)Laser Physics

●Learn to apply basic quantum physics to Ruby Laser, He-Ne Laser

Core T10 - Analog Systems and Applications (4 Credits)

1. Semiconductor Diodes

P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode.

2. Two-terminal Devices and their Applications

Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.

3.Bipolar Junction transistors

n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

4.Field Effect transistors

Field effect transistor – JEET and its IV characteristics, pinch-off voltage, applications. MOSFET – structure, classification of MOSFETs, enhancement and depletion types, typical applications; structure, I-V characteristics .

5.Amplifiers

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider

Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. Frequency response of a CE amplifier.

Coupled Amplifier: Two stage RC-coupled amplifier .

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 oscillator, determination of Frequency. 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: Linear - (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. Non-linear – (1) inverting and non-inverting comparators, (2) Schmidt triggers.

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

Reference Books

► Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.

► Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.

► Solid State Electronic Devices, B.G.Streetman &S.K.Banerjee, 6th Edn.,2009, PHI Learning

► Electronic Devices & circuits, S.Salivahanan& N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw

Hill

► OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall

► Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.

► Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer

► Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India

► Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning

► Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

3.20 Core P10 – Analog Systems and Applications Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. To study the characteristics of a Bipolar Junction Transistor in CE configuration and designing 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 design a Wien bridge oscillator for given frequency using an op-amp.
4. To design a digital to analog converter (DAC) of given specifications.
5. To design inverting amplifier andnon-inverting using Op-amp (741,351) for dc voltage of given gain.
6. To design inverting amplifier and non-inverting amplifier using Op-amp (741,351) and study its frequency response
7. To study the zero-crossing detector and comparator
8. To investigate the use of an op-amp as adderin inverting and non-inverting mode, Differentiator and Integrator.

Reference Books

18► Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

► OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.

► Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

► Electronic Devices & circuit Theory, R.L. Boylestad& L.D. Nashelsky, 2009, Pearson

Course learning outcome:

At the end of the course the student is expected to assimilate the following and possesses basic knowledge of the following.

●N- and P- type semiconductors, mobility, drift velocity, fabrication of P-N junctions; forward and reverse biased junctions.

●Application of PN junction for different type of rectifiers and voltage regulators.

● NPN and PNP transistors and basic configurations namely common base, common emitter and common collector, and also about current and voltage gain.

●Biasing and equivalent circuits, coupled amplifiers and feedback in amplifiers and oscillators.

●Operational amplifiers and knowledge about different configurations namely inverting and non-inverting and applications of operational amplifiers in D to A and A to D conversions.

●To characterize various devices namely PN junction diodes, LEDs, Zener diode, solar cells, PNP and NPN transistors. Also construct amplifiers and oscillators using discrete components. Demonstrate inverting and non-inverting amplifiers using op-amps.

Skills to be learned

● Learn basic concepts of semiconductor diodes and their applications to rectifiers.

● Learn about junction transistor and their applications.

●Learn about different types of amplifiers including operational amplifier.

(Op-Amp) and their applications.

●Learn about sinusoidal oscillators of various types and A/D conversion.

Core T11 - Quantum Mechanics and Applications (4 Credits)

1. Schrodinger Equation

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

Time independent Schrodinger equation: Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

2. General discussion of bound states in an arbitrary potential

continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.

3.Quantum theory of hydrogen-like atoms

Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,shells.

4.Atoms in Electric & Magnetic Fields

Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

5.Atoms in External Magnetic Fields

Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).

6. Many electron atoms

Pauli's Exclusion Principle. Symmetric &Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular

19momentum. Vector Model. Spin-orbit coupling in atoms- L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

Reference Books

► A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill

► Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.

► Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.

► Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.

► Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

► Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer

► Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional Books for Reference

► Quantum Mechanics, EugenMerzbacher, 2004, John Wiley and Sons, Inc.

► Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education

► Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

Core P11 – Quantum Mechanics and Applications Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. To determine the ionization potential of mercury.

2. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency

3. Study of Zeeman effect: with external magnetic field; Hyperfine splitting

4. To show the tunneling effect in tunnel diode using I-V characteristics.

5. To determine the quantum efficiency of CCDs.

6. Measurement of Planck's constant using black body radiation and photo-detector.

7. To determine the Planck's constant using LEDs of at least 4 different colours.

8. To determine the absorption lines in the rotational spectrum of Iodine vapour.

Reference Books

► OCTAVE and SCILAB: Scientific &

► Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández.2014 Springer.

Course learning outcome(T11 and P11)

This course will enable the student to get familiar with quantum mechanics formulation.

● After an exposition of inadequacies of classical mechanics in explaining microscopic phenomena, quantum theory formulation is introduced through Schrodinger equation.

● The interpretation of wave function of quantum particle and probabilistic nature of its location and subtler points of quantum phenomena are exposed to the student.

● Through understanding the behavior of quantum particle encountering a i) barrier, ii) potential, the student gets exposed to solving non-relativistic hydrogen atom, for its spectrum and eigenfunctions.

● Study of influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.

●The experiments using Sci-lab will enable the student to appreciate nuances involved in the theory.

● This basic course will form a firm basis to understand quantum many body problems.

● In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical one-dimensional and three dimensional potentials.

Skills to be learned

● This course shall develop an understanding of how to model a given problem such as particle in a box, hydrogen atom, hydrogen atom in electric fields.

●Many electron atoms, L-S and J-J couplings.

● These skills will help in understanding the different Quantum Systems in atomic and nuclear physics.

Core T12 - Solid State Physics (4 Credits)

1. Crystal Structure

Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg’s Law. Atomic and Geometrical Factor.

2. Elementary Lattice Dynamics

Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit’s Law, Einstein and Debye theories of specific heat of solids. T^3law

3.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.

4.Dielectric Properties of Materials

Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. ClausiusMosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.

5.Ferroelectric Properties of Materials

Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

6.Elementary band theory

Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient.

7.Superconductivity

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

Reference Books

► Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt.

Ltd.

► Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India

► Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill

► Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning

► Solid-state Physics, H. Ibach and H. Luth, 2009, Springer

► Solid State Physics, Rita John, 2014, McGraw Hill

► Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India

► Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Core P12 – Solid State Physics Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)

2. To measure the Magnetic susceptibility of Solids.

3. To determine the Coupling Coefficient of a Piezoelectric crystal.

4. To measure the Dielectric Constant of a dielectric Materials with frequency

5. To determine the refractive index of a dielectric layer using SPR

6. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.

217. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method

(room temperature to 150 o C) and to determine its band gap.

8. To determine the Hall coefficient of a semiconductor sample.

9. To determine the complex dielectric constant and plasma frequency of metal using Surface

Plasmon resonance (SPR)

10. To study the PE Hysteresis loop of a Ferroelectric Crystal.

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal

► Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

Course learning outcome:

At the end of the course the student is expected to learn and assimilate the following.

● A brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays by crystalline materials.

●Knowledge of lattice vibrations, phonons and in depth of knowledge of Einstein and Debye theory of specific heat of solids.

●At knowledge of different types of magnetism from diamagnetism to ferromagnetism and hysteresis loops and energy loss.

●Secured an understanding about the dielectric and ferroelectric properties of materials.

●Understanding above the band theory of solids and must be able to differentiate insulators,

●To 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

Skills to be learned

● Learn basics of crystal structure and physics of lattice dynamics

●Learn the physics of different types of material like magnetic materials, dielectric materials, metals and their properties.

● Understand the physics of insulators, semiconductor and conductors with special emphasis on the elementary band theory of semiconductors.

●Comprehend the basic theory of superconductors. Type I and II superconductors, their properties and physical concept of BCS theory.

Core T13 - Electromagnetic Theory (4 Credits)

1.Maxwell Equations

Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density.

2. EM Wave Propagation in Unbounded Media

Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane

EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

3.EM Wave in Bounded Media

Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence)

4.Polarization of Electromagnetic Waves

Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel’s Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light

Rotatory Polarization: Optical Rotation. Biot’s Laws for Rotatory Polarization. Fresnel’s Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel’s theory. Specific rotation. Laurent’s half-shade polarimeter.

Electro-optic and magneto-optic effects: Faraday effect. Verdet’s constant. Kerr effect. Kerr cell as a fast optical shutter. Use of a Kerr cell in the determination of the speed of light.

Pockels effect.

5.Wave guides

Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.

6.Optical Fibres

Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

Reference Books

► Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.

► Optics, E. Hecht, 2016, Pearson.

► Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.

► Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning

► Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill

► Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning

► Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.

► Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

► Electromagnetic Fields & Waves, P.Lorrain&D.Corson, 1970, W.H.Freeman& Co.

► Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.

► Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004,Cambridge University Press

Core P13 – Electromagnetic Theory Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

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 study Polarization and double slit interference in microwaves.
6. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
7. To verify the Stefan`s law of radiation and to determine Stefan's constant.
8. To study dependence of radiation on angle for a simple Dipole antenna.
9. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
10. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
11. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal

► Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Course learning outcome(T13 and P13)

●Achieve an understanding of the Maxwell's equations, role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media.

● Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.

●Analyse the phenomena of wave propagation in the unbounded, bounded, vacuum, dielectric, guided and unguided media.

●Understand the laws of reflection and refraction and to calculate the reflection and transmission coefficients at plane interface in bounded media.

●Understand the linear, circular and elliptical polarisations of em waves. Production as well as detection of waves in laboratory.

● Understand propagation of em waves in anisotropic media, uni-axial and biaxial crystals phase retardation plates and their uses.

●Understand the concept of optical rotation, theories of optical rotation and their experimental rotation, calculation of angle rotation and specific rotation.

● Understand the features of planar optical wave guide and obtain the Electric field components, Eigen value equations, phase and group velocities in a dielectric wave guide.

● Understand the fundamentals of propagation of electromagnetic waves through optical fibres and calculate numerical apertures for step and graded indices and transmission losses.

●In the laboratory course, the student gets an opportunity to perform experiments Demonstrating principles of

● Interference, Refraction and diffraction of light using monochromatic sources of light. Demonstrate interference, Refraction and Diffraction using microwaves.

●Determine the refractive index of glass and liquid using total internal reflection of light.

●Verify the laws of Polarisation for plane polarised light.

●Determine Polarisation of light by Reflection and determine the polarization angle off or air-glass surface

●Determine the wavelength and velocity of Ultrasonic waves in liquids using diffraction.

Skills to be learned

●Comprehend the role of Maxwell’s equation in unifying electricity and magnetism.

● Derive expression for

(i) Energy density

(ii) Momentum density

(iii) Angular momentum density of the electromagnetic field

● Learn the implications of Gauge invariance in EM theory in solving the wave equations and develop the skills to actually solve the wave equation in various media like

(i) Vacuum

(ii) Dielectric medium

(iii) Conducting medium

(iv) Dilute plasma

● Derive and understand associated with the properties, EM wave passing through the interface between two media like

(i) Reflection

(ii) Refraction

(iii) Transmission

(iv) EM waves

●Learn the basic physics associated with the polarization of electromagnetic waves by doing various experiments for:

(i) Plane polarized light

(ii) Circularly polarized light

(iii) Circularly polarized light

●Learn the application of EM theory to

(i) Wave guides of various types

(ii) Optical fibers in theory and experiment

Core T14 – Statistical Mechanics (4 Credits)

1. Classical Statistical Mechanics

Macrostate & Microstate, Elementary Concept of Ensemble, Microcanonical ensemble, Phase Space, Entropy and Thermodynamic Probability, Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, SackurTetrode 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. Grand canonical ensemble and chemical potential.

2. Classical Theory of Radiation

Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe.

3.Quantum Theory of Radiation

Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.

4.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.

5.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.

Reference Books

► Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed.,1996, Oxford University Press.

► Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill

► Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall

24► Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.

► Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

► An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

► Statistical Mechanics – an elementary outline, A. Lahiri, 2008, Universities Press

Core P14 – Statistical Mechanics Lab (2 Credits)

List of Practical (any four of the following experiments should be done)

1. Computational analysis of the behaviour (any three) of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:

a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations

b) Study of transient behavior of the system (approach to equilibrium)

c) Relationship of large N and the arrow of time

d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution

e) Computation and study of mean molecular speed and its dependence on particle mass

f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed

2. single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose- Einstein statistics:

a) volume Cv, depend upon the temperature, total number of particles N and the spectrum of single particle states.

b) Ratios of occupation numbers of various states for the systems considered above

c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.

3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.

4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.

5. Plot the following functions with energy at different temperatures

a) Maxwell-Boltzmann distribution

b) Fermi-Dirac distribution

c) Bose-Einstein distribution

Reference Books

► Elementary Numerical Analysis, K.E.Atkinson, 3 rdEdn . 20 07 , Wiley India Edition

► Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.

► Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987

► Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.

► Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

25► Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.

► Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-33190678964.

Course learning outcome(T14 and P14)

●Understand the concepts of microstate, macrostate, ensemble, phase space, thermodynamic probability and partition function.

●Understand the combinatoric studies of particles with their distinguishably or indistinguishably nature and conditions which lead to the three different distribution laws e.g. Maxwell-Boltzmann distribution, Bose-Einstein distribution and Fermi-Dirac distribution laws of particles and their derivation.

● Comprehend and articulate the connection as well as dichotomy between classical statistical mechanics and quantum statistical mechanics.

● Learn to apply the classical statistical mechanics to derive the law of equipartition of energy and specific heat.

●Understand the Gibbs paradox, equipartition of energy and concept of negative temperature in two level system.

●Learn to derive classical radiation laws of black body radiation. Wiens law, Rayleigh Jeans law, ultraviolet catastrophe. Saha ionization formula.

●Learn to calculate the macroscopic properties of degenerate photon gas using BE distribution law, understand Bose-Einstein condensation law and liquid Helium. Bose derivation of Plank's law

● Understand the concept of Fermi energy and Fermi level, calculate the macroscopic properties of completely and strongly degenerate Fermi gas, electronic contribution to specific heat of metals.

● Understand the application of F-D statistical distribution law to derive thermodynamic functions of a degenerate Fermi gas, electron gas in metals and their properties.

● Calculate electron degeneracy pressure and ability to understand the Chandrasekhar mass limit, stability of white dwarfs against gravitational collapse.

● In the laboratory course, the students gets an opportunity to verify Stefan's Law of radiation and determine Stefan's constant.

●Design and perform some experiments to determine Boltzmann' Constant.

●Use Computer simulations to study:

i.Planck's Black Body radiation Law and compare with the Wien's Law and Raleigh - Jean's Law in appropriate temperature region.

ii. Specific Heat of Solids by comparing, Dulong-Petit, Einstein's and Debye's Laws and study their temperature dependence

●Compare the following distributions as a function of temperature for various energies and the parameters of the distribution functions:

i. Maxwell-Boltzmann distribution

ii. Bose-Einstein distribution

iii. Fermi-Dirac distribution

● Do 3-5 assignments given by the course instructor to apply the methods of Statistical mechanics to simple problems in Solid State Physics and Astrophysics

●Do the regular weekly assignments of at least 2-3 problems given by the course

Skills to be learned

●Learn the basic concepts and definition of physical quantities in classical statistics and classical distribution law.

●Learn the application of classical statistics to theory of radiation.

● Comprehend the failure of classical statistics and need for quantum statistics.

● Learn the application of quantum statistics to derive and understand.

1. Bose Einstein statistics and its applications to radiation.

2. Ferm-Dirac statistic and its applications to quantum systems.

4.Department Specific Electives Subjects Syllabus

4.1 DSE T1 - Advanced Mathematical Physics (6 Credits)

1. Cartesian Tensors

Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti- symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines .

Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.

2. General Tensors

Transformation of Co-ordinates. Minkowski Space. Contravariant& Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.

3.Group Theory

Review of sets, Mapping and Binary Operations, Relation, Types of Relations.

Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel. Some special groups with operators. Matrix Representations: Reducible and Irreducible representations. Schur's lemma. Orthogonality theorems. Character tables and their uses. Application to small vibrations.

4.Advanced Probability Theory:

Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability 26distributions, Expectation and Variance, Special Probability distributions: The binomial distribution, The poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares.

Course learning outcome:

●Learn the basic properties of the linear vector space such as linear dependence and independence of vectors, change of basis, isomorphism and homomorphism, linear transformations and their representation by matrices.

 Learn the basic properties of matrices, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices and their correspondence to physical quantities, e.g, operators in quantum mechanics. They should also learn how to find the eigenvalues and eigenvectors of matrices.

 Learn some basic properties tensors, their symmetric and antisymmetric nature, the Cartesian tensors, the general tensors, contravariant, covariant and mixed tensors and their transformation properties under coordinate transformations, physical examples of tensors such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor etc.

●In the laboratory course, the students are expected to solve the following problems using the Scilab/C++ computer language:

(i) Multiplication of two 3×3 matrices,

(ii) Diagonalization of a matrix,

(iii) Inverse of a matrix,

(iv) Solutions of differential equations satisfied by different orthogonal polynomials and special function,

(v)Determination of wave functions for stationary states as eigenfunctions of Hermitian differential operators and also the energy eigenvalues,

Skills to be learned

●In this course, the students should the learn the skills of doing calculations with the linear vector space, matrices, their eigenvalues and eigenvectors, tensors, real and complex fields, linear and multilinear transformations in various physical situations, e.g., the Lorentz transformations etc.

●They also become efficient in doing calculations with the 'calculus of variation'.

● In the laboratory course, the students should acquire the skills of applying the the C++/ SCILAB/MATLAB/MATHEMATICA software in solving standard physical problems.

DSE T2 - Classical Dynamics (6 Credits)

1. Classical Mechanics of Point Particles

Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities,

Recap of Lagrangian and Hamiltonian mechanics. Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy. Effective potential. The Laplace-Runge-Lenz vector.

2. Small Amplitude Oscillations

Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N -1) - identical springs.

3.Special Theory of Relativity

Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

4.Fluid Dynamics

Fluid, an element of fluid and its velocity, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.

Course learning outcome:

● Revise the knowledge of the Newtonian, the Lagrangian and the Hamiltonian formulations of classical mechanics and their applications in appropriate physical problems.

● Learn about the small oscillation problems.

●Recapitulate and learn the special theory of relativity- postulates of the special theory of relativity, Lorentz transformations on space-time and other four vectors, four-vector notations, space-time invariant length, length contraction, time dilation, mass-energy relation, Doppler effect, light cone and its significance, problems involving energy-momentum conservations.

● Learn the basics of fluid dynamics, streamline and turbulent flow, Reynolds's number, coefficient of viscosity and Poiseuille's equation.

●Review the retarded potentials, potentials due to a moving charge, Lienard Wiechert potentials, electric and magnetic fields due to a moving charge, power radiated, Larmor's formula and its relativistic generalization.

Skills to be learned

Learn to define generalised coordinates, generalised velocities, generalised force and write Lagrangian for mechanical system in terms of generalised coordinates.

- Learn to derive Euler-Lagrange equation of motion and solve them for simple mechanical systems.
- Learn to write Hamiltonian for mechanical systems and derive and solve Hamilton's equation of motion for simple mechanical systems.
- Formulate the problem of small amplitude oscillation and solve them to obtain normal modes of oscillation and their frequencies in simple mechanical systems.
- Develop the basic concepts of special theory of relativity and its applications to dynamical systems of particles.
- Develop the methods of relativistic kinematics of one and two particle system and its application to two particle decay and scattering.
- Develop and understand the basic concepts of fluid dynamics and its applications to simple problems in liquid flow.

DSE T3 - Nuclear and Particle Physics (6 Credits)

1.General Properties of Nuclei

Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

2. Nuclear Models

Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

3. Radioactivity decay

(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α---decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.

4. Nuclear Reactions

Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

5.Interaction of Nuclear Radiation with matter

Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

6.Detector for Nuclear Radiations

Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

7. Particle Accelerators

Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

8.Particle physics

Particle interactions; basic features, types of particles and its families. Symmetries and

Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.

Course learning outcome:

●Learn the ground state properties of a nucleus – the constituents and their properties, mass number and atomic number, relation between the mass number and the radius and the mass number, average density, range of force, saturation property, stability curve, the concepts of packing fraction and binding energy, binding energy per nucleon vs. mass number graph, explanation of fusion and fission from the nature of the binding energy graph.

● Know about the nuclear models and their roles in explaining the ground state properties of the nucleus –(i) the liquid drop model, its justification so far as the nuclear properties are concerned, the semi-empirical mass formula, (ii) the shell model, evidence of shell structure, magic numbers, predictions of ground state spin and parity, theoretical deduction of the shell structure, consistency of the shell structure with the Pauli exclusion principles.

● Learn about the process of radioactivity, the radioactive decay law, the emission of alpha, beta and gamma rays, the properties of the constituents of these rays and the mechanisms of the emissions of these rays, outlines of Gamow's theory of alpha decay and Pauli's theory of beta decay with the neutrino hypothesis, the electron capture, the fine structure of alpha particle spectrum, the Geiger-Nuttall law, the radioactive series.

● Learn the basic aspects of nuclear reactions, the Q-value of such reaction and its derivation from conservation laws, The reaction cross-sections, the types of nuclear reactions, direct and compound nuclear reactions, Rutherford scattering by Coulomb potential.

● Learn some basic aspects of interaction of nuclear radiation with matter- interaction of gamma ray by photoelectric effect, Compton scattering and pair production, energy loss due to ionization, Cerenkov radiation.

● Learn about the detectors of nuclear radiations- the Geiger-Mueller counter, the scintillation counter, the photo-multiplier tube, the solid state and semiconductor detectors.

●The students are expected to learn about the principles and basic constructions of particle accelerators such as the Van-de-Graff generator, cyclotron, betatron and synchrotron. They should know about the accelerator facilities in India.

● Gain knowledge on the basic aspects of particle Physics – the fundamental interactions, elementary and composite particles, the classifications of particles: leptons, hadrons (baryons and mesons), quarks, gauge bosons. The students should know about the quantum numbers of particles: energy, linear momentum, angular momentum, isospin, electric charge, colour charge, strangeness, lepton numbers, baryon number and the conservation laws associated with them.

Skills to be learned

● Skills to describe and explain the properties of nuclei and derive them from various models of nuclear structure.

● To understand, explain and derive the various theoretical formulation of nuclear disintegration like α decay, β decay and □ decays.

● Develop basic understanding of nuclear reactions and decays with help of theoretical formulate and laboratory experiments.

●Skills to develop basic understanding of the interaction of various nuclear radiation with matter in low and high energy ....

● Ability to understand, construct and operate simple detector systems for nuclear radiation and training to work with various types of nuclear accelerators.

●Develop basic knowledge of elementary particles as fundamental constituent of matter, their properties, conservation laws during their interactions with matter.

DSE T4 - Astronomy and Astrophysics (6 Credits)

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. Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of

Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.

2.Astronomical techniques

Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes)

3.Physical principles

Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium.

4.The sun and solar family

The sun (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology). The solar family (Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets.

Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification)

5.The milky way

Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the

Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.

6.Galaxies

Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms

7.Large scale structure & expanding universe

Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).

Reference Books

► Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.

► Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory,4th Edition, Saunders College Publishing.

► The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.

► Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer

► K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, New Delhi,2002.

► BaidyanathBasu, 'An introduction to Astro physics', Second printing, Prentice - Hall of India Private limited, New Delhi, 2001.

► Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication

Course learning outcome:

● Ability to comprehend astronomical scales and understand basic concepts of positional astronomy like astronomical coordinate system and measurement of distances, time and temperature and radius of star.

●Understand basic parameters of stars like brightness, radiant flux, luminosity, magnitude, orbits, spectral classification. H-R diagram

●Understand astronomical techniques, various types of optical telescopes and telescope mountings. Various types of detectors and their use with telescopes.

● Understanding Physics of sun and solar system: photosphere, chromosphere, corona, solar activity. Solar MHD, helioseismology, solar system and its origin. Nebular model. Tidal forces and planetary rings.

● Understanding Physics of stars and sun. Role of gravitation in astroPhysics, Newton vs Einstein, viral theorem and thermodynamic equilibrium. Atomic spectra, stellar spectra. Spectral classification, luminosity classification, temperature dependence.

● Acquire basic knowledge of galaxies and Milky Way. Morphology and classification of galaxies, intrinsic stages of galaxies, galactic halo, milky way, gas and dust in galaxy, spiral arm, rotation of galaxy and dark matter. Star clusters in Milky Way, galactic nucleus and its properties.

● Learn about the large scale structure and expanding universe cosmic distance ladder, distance measurements, cluster of galaxies, Hubble's law.

Skills to be learned

- Skills to learn and operate astronomical instruments to perform observations related to the positional astronomy measurement.
- Conceptualize skills to understand basic parameters for describing the properties of stars and making experimental measurements, their interpretation and role in understanding of astrophysical phenomenon. Study of solar and stellar spectra.
- Learn to describe solar parameters, solar atmosphere, origin of solar system, solar and extra-solar planets, planetary rings.
- Acquire basic knowledge of Milky Way and Galaxies, their properties and structure.
- Skills for understanding basics of large scale structures and expending universe.

DSE T5 – Physics of Earth (6 Credits)

1. The Earth and the Universe

29Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic

planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences.

General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. Energy and particle fluxes incident on the

Earth. The Cosmic Microwave Background.

2. Structure

The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior?

The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.

The Atmosphere: variation of temperature, density and composition with altitude, clouds.

The Cryosphere: Polar caps and ice sheets. Mountain glaciers.

The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms.

3.Dynamical Processes

The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes: types products and distribution.

The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend– air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.

The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones.

Climate: Earth's temperature and greenhouse effect. Paleoclimate and recent climate changes. The Indian monsoon system.

Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state.

4.Evolution

Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent.

Time line of major geological and biological events.

Origin of life on Earth.

Role of the biosphere in shaping the environment.

Future of evolution of the Earth and solar system: Death of the Earth.

5.Disturbing the Earth – Contemporary dilemmas

1. Human population growth.

2. Atmosphere: Greenhouse gas emissions, climate change, air pollution.

3. Hydrosphere: Fresh water depletion.

4. Geosphere: Chemical effluents, nuclear waste.

5. Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

Reference Books

► Planetary Surface Processes, H. Jay Melosh, Cambridge University Press, 2011.

► Consider a Spherical Cow: A course in environmental problem solving, John Harte. University Science Books

► Holme's Principles of Physical Geology. 1992. Chapman & Hall.

► Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

Course learning outcome:

This course will provide an exposure to student

● In the origin of Universe, place of Earth as a third rock revolving around Sun, its satellite Moon and in general evolution of present day Universe.

●overview of the structure and evolution of the Earth as a dynamic planet within our solar system

● Application of physical principles of elasticity and elastic wave propagation to understand modern global seismology as a probe of the Earth's internal structure. The origin of magnetic field, Geodynamics of earthquakes and the description of seismic sources; a simple but fundamental theory of thermal convection; the distinctive rheological behaviour of the upper mantle and its top layer shall be understood.

● Climate and various roles played by water cycle, carbon cycle, nitrogen cycles in maintain steady state of earth shall be explored.

● This will enable the student to understand the contemporary dilemmas (climate change, bio diversity loss, population growth, etc.) disturbing the Earth

●In the tutorial section, through literature survey on the various aspects of health of Earth, project work / seminar presentation, he she will be to appreciate need to 'save' Earth.

Skills to be learned

Knowledge of the place of Earth in this Universe and its formation, structure and its evolution shall enable the student to appreciate the reasons for keeping Earth 'SAFE'

DSE T6 – Biological Physics (6 Credits)

1.Overview

The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic processes and diversity of macroscopic form. Types of cells. Multicellularity. Allometric scaling laws.

2.Molecules of life

Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling.

Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell.

Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally.

3.The complexity of life

At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Complex networks of molecular interactions: metabolic, regulatory and signaling networks. Dynamics of metabolic networks; the stoichiometric matrix. Living systems as complex organizations; systems biology. Models of cellular dynamics. The implausibility of life based on a simplified probability estimate, and the origin of life problem.

At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development.

Brain structure: neurons and neural networks. Brain as an information processing system. Associative memory models. Memories as attractors of the neural network dynamics.

At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems.

4.Evolution

The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

Reference Books

► Physics in Molecular Biology; Kim Sneppen& Giovanni Zocchi (CUP 2005)

► Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004)

► Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)

► An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)

► Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

Course learning outcome:

This course will enable student to

●Acquire mastery of the fundamental principles and applications of various branches of Physics in understanding biological systems.

● Nuggets of thermodynamics and statistical mechanics, electricity and magnetism, will help in understating heat transfer in biomaterials.

● Relevance of chemistry principles and thermodynamics in understanding energy transfer mechanism and protein folding in biological systems.

● He /she will acquire necessary mathematical skills in differential equations, analysis, and linear algebra for simulation studies.

●A basic course in bioPhysics will provide proficiency in basic lab skills, including understanding and using modern instrumentation and computers.

●Get exposure to complexity of life at i) the level of Cell, ii) level of multi cellular organism and iii) at macroscopic system – ecosystem and biosphere

● Student gets exposure to models of evolution.

Skills to be learned

●Basic concepts about biological physics and evolution are learned.

DSE T7 – Nano Materials and Applications (4 Credits)

1.Nanoscale Systems

Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

2.Synthesis of NanostructureMaterials

Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.

3.Characterization

X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy.

4.Optical Properties

Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostructures and nanostructures.

5.Electron Transport

Carrier transport in nanostrucutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects

6.Applications

Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical

32data storage. Magnetic quantum well; magnetic dots -magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

Reference Books

► C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).

► S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)

► K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).

► Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

► M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).

► Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.

► Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

DSE P7 - Nano Materials and Applications Lab (2 Credits)

List of practical (any five experiments should be done)

1. Synthesis of metal nanoparticles by chemical route.

2. Synthesis of semiconductor nanoparticles.

3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.

4. To study the XRD pattern of nanomaterials and estimation of particle size.

5. To study the effect of size on color of nanomaterials.

6. To prepare composite of CNTs with other materials.

7. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.

8. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

Reference Books

► C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).

► S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).

► K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience& Technology (PHI Learning Private Limited).

► Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

Course learning outcome:

At the end of the course the student is expected to possess the concept the following.

● In the Nano systems and its implications in modifying the properties of materials at the nanoscale.

● Concept of Quantum confinement, 3D,2D,1D and 0D nanostructure with examples.

● Different synthesis techniques including top down and bottom up approaches.

●Characterization of nanostructured materials using X-ray diffraction, electron microscopy, Atomic Force Microscopy and Scanning Tunneling Microscopy.

●Optical properties of nanostructured materials, modification of band gap, excitonic confinement.

● Applications of nanostructured materials in making devices namely MEMS, NEMS and other heterostructures for solar cell and LEDs.

● The student will synthesize nanoparticles by different chemical routs and characterize them in the laboratory using the different techniques he has learnt in the theory. He will also carry out thin film preparation and prepare capacitors and evaluate its performance. He also expected to fabricate a PN diode and study its I-V characteristics.

Skills to be learned

● Develop basic understanding of nanostructured materials.

●Learn the synthesis and characterization of nanostructured materials.

● Understanding the optical properties of nanostructured materials and electron transport phenomenon.

● Lean to understand the functioning of various analytical techniques using

(i) X-ray Diffraction

(ii) Atomic Force Microscopy

(iii) Scanning Electron Microscopy

(iv) Scanning Tunneling Microscopy

(v)Transmission Electron Microscopy

● Application of nanoparticles in various fields like:

(i) LED

(ii) Solar Cells

(iii) Single Electron Transform Devices

(iv) Magnetic Data Storage

(v) Micro-electrochemical Systems (MEMS)

(vi) Nano- electrochemical Systems (NEMS)

DSE T8 - Communication Electronics (4 Credits)

1.Electronic communication

Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio.

2.Analog Modulation

Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver

Analog Pulse Modulation

Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

3.Digital Pulse Modulation

Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

4.Introduction to Communication and Navigation systems

Satellite Communication– Introduction, need, Geosynchronous satellite orbits geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink

Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only).

GPS navigation system (qualitative idea only)

DSE P8 – Communication Electronics Lab (2 Credits)

List of Practical (Any five experiments should be done)

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)

Reference Books

► Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.

► Electronic Communication system, Blake, Cengage, 5th edition

Course learning outcome:

At the end of the course the student is expected to have an idea/concept of the following,

●Electromagnetic spectra and different frequency bands.

● Modulation, different types of modulation and about super heterodyne receivers.

● Concept of sampling, sampling theorem and multiplexing.

●Digital transmission, encoding and decoding.

●Satellite communication including uplinking and downlinking.

● Mobile communication/telephony and concepts of cell telephony.

●2G, 3G, 4G and 5G (Quantitative).

●Apply the theory that they have learned in the theory class to gain hands on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.

Skills to be learned

● Learn the skills to understand the basic concepts of communication.

● Learn the techniques of different types of modulation of electromagnetic signals like

(i) Amplitude Modulation

(ii) Frequency Modulation

(iii) Phase Modulation

(iv) Analog Pulse Modulation

(v)Digital Pulse Modulation

- Learn basics of satellite communication.
- Learn concepts and application of mobile telephony system.

Skill Enhancement Course

SEC T1 - Computational Physics (2 Credits)

1.Introduction

Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

2. Scientific Programming

Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

3.Control Statements

Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO- WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

4. Programming

1. Exercises on syntax on usage of FORTRAN

2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.

3. To print out all natural even/ odd numbers between given limits.

4. To find maximum, minimum and range of a given set of numbers.

5. Calculating Euler number using exp(x) series evaluated at x=1

5.Scientific word processing: Introduction to LaTeX

TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

6.Visualization

Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Hands on exercises

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

Reference Books

► Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.

► Computer Programming in Fortran 77”. V. Rajaraman (Publisher: PHI).

► LaTeX–A Document Preparation System”, Leslie Lamport (Second Edition, Addison-Wesley, 1994).

► Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)

► Schaum’s Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.

► Computational Physics: An Introduction, R.C. Verma, et al. New Age International Publishers, New Delhi(1999)

► A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning

► Elementary Numerical Analysis, K.E. Atkinson, 3 rdEdn., 2007, Wiley India Edition

Course learning outcome:

● Learn the importance of computers in solving problems in Physics.

● Learn how to plan for writing the algorithm for solving a problem by drawing the flowchart of simple problems like roots of quadratic equations etc.

● Have a working knowledge about the Linux system, for example, the necessary commands.

● Learn, write and run FORTRAN programs in the Linux system. In particular, they should attempt the following exercises:

(i) Exercises on syntax on usage of FORTRAN.

(ii) Usage of GUI windows, Linux commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.

(iii) To print out all natural even/ odd numbers between given limits.

(iv) To find maximum, minimum and range of a given set of numbers.

● The students should also learn "Scientific Word Processing", particularly, how to use the LaTeX software in writing articles and papers which include mathematical equations and diagrams. Similarly, students should learn the basics of Gnuplot.

● To have hands-on experience on computational tools, students are expected to do the following exercises:

(i) to compile a frequency distribution and evaluate mean, standard deviation etc,

(ii) to evaluate sum of finite series and the area under a curve,

(iii) to find the product of two matrices

(iv) to find a set of prime numbers and Fibonacci series,

(v) to write program to open a file and generate data for plotting using Gnuplot,

(vi) plotting trajectory of a projectile projected horizontally,

(vii) plotting trajectory of a projectile projected making an angle with the horizontal direction,

(viii) creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen, saving it as an eps file and as a pdf file,

(ix) to find the roots of a quadratic equation,

(x)numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization,

(xi) Simulate the motion of a particle in a central force field and plot the output for visualization.

Skills to be learned

● The students should learn the skills for writing a flow chart and then writing the corresponding program for a specific problem using the C/ C ++ /FORTRAN language.

● The student should also acquire the proficiency in effectively using the GUI Windows, the LINUX operating system and also in using the LaTeX software for wring a text file.

SEC T2 – Renewable Energy and Energy Harvesting (2 Credits)

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, biogas generation, geothermal energy tidal energy, Hydroelectricity.

2. Solar energy

36Solar energy, its importance, storage of solar energy, solar pond, non-convective 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 photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

3.Wind Energy harvesting

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

4.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.

5.Geothermal Energy

Geothermal Resources, Geothermal Technologies

6.Hydro Energy

Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

7. Piezoelectric Energy harvesting

Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power

8. Electromagnetic Energy Harvesting

1. Linear generators, physics mathematical models, recent applications
2. Carbon captured technologies, cell, batteries, power consumption
3. Environmental issues and Renewable sources of energy, sustainability.

9. Demonstrations and Experiments

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage using thermoelectric modules.

Reference Books

► Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi

► Solar energy - M P Agarwal - S Chand and Co. Ltd.

► Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.

► Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.

► Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009

► J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

► http://en.wikipedia.org/wiki/Renewable_energy

SEC T3 – Radiation Safety (2 Credits)

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.

2. Interaction of Radiation with matter: Types of Radiation

Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, Interaction of Photons - Photo- electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons- Collision, slowing down and Moderation.

3.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, Thermo luminescent Dosimetry.

4.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 management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.

5.Application of nuclear techniques

Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterization, Food preservation.

Experiments

1. Study the background radiation levels using Radiation meter

2. Characteristics of Geiger Muller (GM) Counter:

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

4. Study of counting statistics using background radiation using GM counter.

5. Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation

in different routine materials by operating GM at operating voltage.

6. Study of absorption of beta particles in Aluminum using GM counter.

7. Detection of α particles using reference source & determining its half-life using spark counter

8. Gamma spectrum of Gas Light mantle (Source of Thorium)

Reference Books

► W.E. Burcham and M. Jobes – Nuclear and Particle Physics – Longman (1995)

► G.F.Knoll, Radiation detection and measurements

► ThermoluninescenseDosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)

► W.J. Meredith and J.B. Massey, "Fundamental Physics of Radiology". John Wright and Sons, UK, 1989.

► J.R. Greening, "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.

► Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001

► A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.

► NCRP, ICRP, ICRU, IAEA, AERB Publications.

► W.R. Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981

Course learning outcome:

●Be aware and understand the hazards of radiation and the safety measures to guard against these hazards.

● Revise or learn the basic aspects of the atomic and nuclear Physics, specially the radiations that originate from the atom and the nucleus.

●Have a comprehensive knowledge about the nature of interaction of matter with radiations like gamma, beta, alpha rays, neutrons etc. and radiation shielding by appropriate materials.

● Know about the units of radiations and their safety limits, the devises to detect and measure radiation, such as the Geiger-Mueller counter and scintillation counter.

● The students are expected to learn 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) its 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.

● Learn about the devices which apply radiations in medical sciences, such as MRI, PET.

●The students are expected to do the following experiments: (i) Study the background radiation levels using Radiation meter ,

● (ii) Characteristics of Geiger Muller (GM) Counter, getting the plateau curve and the operating voltage and the statistical distribution of beta or gamma ray emitted from a radioactive source,

● Determination of gamma ray linear and mass absorption coefficient of a given material, and drawing the mass absorption coefficient vs. energy curve for a given material with a number of gamma ray sources, (v)study of beta ray energy spectrum for a given source.

Skills to be learned

● General concepts of nuclei, nuclear forces and atomic physics are studied.

●Basic knowledge about nuclear radiation types and radiation detectors.

SEC T4 – Weather Forecasting (2 Credits)

1. Introduction to atmosphere

Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics.

2. Measuring the weather

Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws

3.Weather systems

Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

4.Climate and Climate Change

Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate

5.Basics of weather forecasting

Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

Demonstrations and Experiments

1. Study of synoptic charts & weather reports, working principle of weather station.

2. Processing and analysis of weather data

a. To calculate the sunniest time of the year.

b. To study the variation of rainfall amount and intensity by wind direction.

c. To observe the sunniest/driest day of the week.

d. To examine the maximum and minimum temperature throughout the year.

e. To evaluate the relative humidity of the day.

f. To examine the rainfall amount month wise.

3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.

4. Formats and elements in different types of weather forecasts/ warning (both aviation and non-aviation)

Reference Books

► Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books

► The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.

► Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.

► Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.

► Why the weather, Charls Franklin Brooks, 1924, Chpraman& Hall, London.

► Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

Course learning outcome:

●Acquire basic knowledge of the elements of the atmosphere, its composition at various heights, variation of pressure and temperature with height.

● To learn basic techniques to measure temperature and its relation with cyclones and anti-cyclones.

● Knowledge of simple techniques to measure wind speed and its directions, humidity and rainfall. Absorption, emission and scattering of radiations in atmosphere. Radiation laws.

● Knowledge of global wind systems, jet streams, local thunderstorms, tropical cyclones, tornadoes and hurricanes.

●Knowledge of climate and its classification. Understanding various causes of climate change like global warming, air pollution, aerosols, ozone depletion, acid rain.

● Develop skills needed for weather forecasting, mathematical simulations, weather forecasting methods, types of weather forecasting, role of satellite observations in weather forecasting, weather maps etc. Uncertainties in predicting weather based on statistical analysis.

● In the laboratory course, students should be able to learn:

● Principle of the working of a weather Station, Study of Synoptic charts and weather reports.

●Processing and analysis of weather data.

● Exercises in reading of Pressure charts, Surface charts, Wind charts and their analysis.

●Develop ability to do weather forecasts using input data.

●Assign Group Activity to observe and examine:

i.Sunniest and driest day of the week

ii. Keep record of daily Temp, Pressure, rainfall and wind velocity

iii. Prepare regular reports of the above observations and circulate it through the local media for the benefit of local community.

Skills to be learned

●Learn the physical parameters to describe the basic structure of atmosphere and make their measurements.

● Understand the weather system and learn to measure the parameter describing the weather and its changes.

● Learn basic ideas about climate and physical factors affecting climate change.

● Learn basic physics of weather forecasting.

5.5 SEC T5 – Physics Workshop Skill (2 Credits)

1. Introduction

Measuring units: conversion to SI and CGS. Familiarization with meter scale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.

2. Mechanical Skill

Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. 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.

3.Electrical and Electronic Skill

Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay.

4.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.

Reference Books

► A text book in Electrical Technology - B L Theraja – S. Chand and Company.

► Performance and design of AC machines – M.G. Say, ELBS Edn.

► Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.

40► Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732]

► New Engineering Technology, Lawrence Smyth/Liam Hennessy,The Educational Company of Ireland [ISBN: 0861674480]

Course learning outcome:

● After the successful completion of the course the student is expected to acquire skills/ hands on experience / working knowledge on various machine tools, lathes, shapers, drilling machines, cutting tools, welding sets and also in different gear systems, pulleys etc. He /she will also acquire skills in the usage of multimeters, soldering iron, oscilloscopes, power supplies and relays.

Skills to be learned

● Learn to use mechanical tools to make simple measurement of length, height, time, area and volume.

● Obtain hand on experience of workshop practice by doing casting, foundry, machining, welding and learn to use various machine tool like lathe shaper, milling and drilling machines etc. and working with wooden and metal blocks.

● Learn to use various instruments for making electrical and electronics measurements using multimeter, oscilloscopes, power supply, electronic switches and relays

5.6 SEC T6 – Electrical Circuits and Network Skills (2 Credits)

1. Basic Electricity Principles

Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.

2. Understanding Electrical Circuits

Main 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. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

3.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.

4.Generators and Transformers

DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

5.Electric Motors

Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor

6.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

7. Electrical Protection

Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device)

8. 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, split bolts, and solder. Preparation of extension board.

Reference Books

► A text book in Electrical Technology - B L Theraja - S Chand & Co.

► A text book of Electrical Technology - A K Theraja

► Performance and design of AC machines - M G Say ELBS Edn.

Course learning outcome:

● After the completion of the course the student will acquire necessary skills/ hands on experience /working knowledge on multimeters, voltmeters,ammeters, electric circuit elements, dc power sources, ac/dc generators, inductors, capacitors, transformers, single phase and three phase motors, interfacing dc/ac motors to control and measure, relays and basics of electrical wiring.

Skills to be learned

● Skills to understand various types of DC and AC circuits and making electrical drawings with symbols for various systems.

● Skills to understand and operate generators, transformers and electric motors.

● Develop knowledge of solid state devices and their uses.

● Skills to do electrical wiring with assured electrical protection devices.

5.7 SEC T7 - Basic Instrumentation Skills (2 Credits)

1. Basic of Measurement

Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

2. Electronic Voltmeter

Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.

3.Cathode Ray Oscilloscope

Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance.

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

4.Signal Generators and Analysis Instruments

Block diagram, explanation and specifications of low frequency signal generators. Pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

5.Impedance Bridges & Q-Meters

Block diagram of bridge: working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges.

6.Digital Instruments

Principle and working of digital meters. Comparison of analog& digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.

Digital Multimeter

Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution.

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

1. Use of an oscilloscope.

422. CRO as a versatile measuring device.

3. Circuit tracing of Laboratory electronic equipment,

4. Use of Digital multimeter/VTVM for measuring voltages

5. Circuit tracing of Laboratory electronic equipment,

6. Winding a coil / transformer.

7. Study the layout of receiver circuit.

8. Trouble shooting a circuit

9. Balancing of bridges

Laboratory Exercises

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.

2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.

3. To measure Q of a coil and its dependence on frequency, using a Q- meter.

4. Measurement of voltage, frequency, time period and phase angle using CRO.

5. Measurement of time period, frequency, average period using universal counter/ frequency counter.

6. Measurement of rise, fall and delay times using a CRO.

7. Measurement of distortion of a RF signal generator using distortion factor meter.

8. Measurement of R, L and C using a LCR bridge/ universal

Open Ended Experiments

1. Using a Dual Trace Oscilloscope

2. Converting the range of a given measuring instrument (voltmeter, ammeter)

Course learning outcome:

After the successful completion of the course the student is expected to have the necessary working knowledge on accuracy, precision, resolution, range and errors/uncertainty in measurements. He/she will acquire hands on skills in the usage of oscilloscopes, multimeters, multivibrators, rectifiers, amplifiers, oscillators and high voltage probes. He also would have gained knowledge on the working and operations of LCR Bridge, generators, digital meters and counters.

Skills to be learned

● Develop skills to use basic electrical instruments like multimeter, electronic voltmeter, cathode ray, and oscilloscope.

● Acquire efficiency in making signal generators and analysis of obtained signals.

● Learn to understand and use various types of digital instruments.

● Develop knowledge of making measurements with Impedance Bridges and Q meters.

5.8 SEC T8 - Applied Optics (2 Credits)

1. Sources and Detectors

Lasers, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers.

Experiments on Lasers:

1. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.

2. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.

3. To find the polarization angle of laser light using polarizer and analyzer

4. Thermal expansion of quartz using laser

Experiments on Semiconductor Sources and Detectors

1. V-I characteristics of LED

2. Study the characteristics of solid state laser

3. Study the characteristics of LDR

4. Photovoltaic Cell

5. Characteristics of IR sensor

2. Fourier Optics

Concept of Spatial frequency filtering, Fourier transforming property of a thin lens

Experiments on Fourier Optics:

1. Fourier optic and image processing

a. Optical image addition/subtraction

b. Optical image differentiation

c. Fourier optical filtering

d. Construction of an optical 4f system

2. Fourier Transform Spec

Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science.

Experiment:

1. To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation

can also be done.

3. Holography

Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition

Experiments on Holography and interferometry

1. Recording and reconstructing holograms
2. Constructing a Michelson interferometer or a Fabry Perot interferometer
3. Measuring the refractive index of air
4. Constructing a Sagnac interferometer
5. Constructing a Mach-Zehnder interferometer
6. White light Hologram

4. Photonics: Fibre Optics

Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating

Experiments on Photonics: Fibre Optics

1. To measure the numerical aperture of an optical fibre
2. To study the variation of the bending loss in a multimode fibre
3. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern
4. To measure the near field intensity profile of a fibre and study its refractive index profile
5. To determine the power loss at a splice between two multimode fibre

Reference Books

► Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.

44► LASERS: Fundamentals & applications, K.Thyagrajan&A.K.Ghatak, 2010, Tata McGraw

Hill

► Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books

► Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier.

► Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.

► Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.

► Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.

► Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4th Edn., 1996, Cambridge Univ. Press

Course learning outcome:

This course will enable the student to get

● Familiar with optical phenomena and technology.

●Qualitative understanding of basic lasing mechanism, types of Lasers, characteristics of Laser Light, types of Lasers, and its applications in developing LED, Holography.

● The idea of propagation of electromagnetic wave in a nonlinear media – Fibre optics as an example will enable the student to practice thinking in a logical process, which is essential in science.

● Experiments in this course will allow the students to discuss in peer groups to develop their cooperative skills and reinforce their understanding of concepts.

Skills to be learned

This course will help in understanding about the lasers and detectors, Holography, Optical fibre and their applications.

6. Generic Elective

GE T1 – Mechanics, Electrostatics and Sound. (4 Credits)

1.Vector Analysis

Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.

Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

2. Laws of Motion

Frames of reference. Newton’s Laws of motion. Dynamics of a system of particles. Centre of Mass.

3.Momentum and Energy

Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

4.Rotational Motion

Angular velocity and angular momentum. Torque. Conservation of angular momentum.

5.Gravitation

Newton’s Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications.

6.Elasticity

Hooke's law –stress-strain diagram, Elastic moduli- relation between elastic constants, poisson's ratio expression for Poisson's ratio in terms of elastic constants- work done in stretching and work done in twisting a wire – twisting couple on a cylinder –Determination of

Rigidity modulus by static torsion- Torsional pendulum- Determination of Rigidity modulus and moment of inertia by Searles method.

7. Special Theory of Relativity

Postulate of special theory of relativity. Lorentz transformations. Simultaneity and order of events. lorentz contraction. Time dilation, relativistic transformation of velocity, relativistic addition of velocities.

8. Sound

Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). Graphical and APnalytical Methods. Lissajous Figures with equal an unequal frequency and their uses. Damped oscillations. Forced vibrations and resonance.

45Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.

9. Electrostatics

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Parallel plate capacitor completely filled with dielectric.

Reference Books

► University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley

► Mechanics Berkeley Physics, v.1: Charles Kittel, et.al. 2007, Tata McGraw-Hill.

► Physics – Resnick, Halliday& Walker 9/e, 2010, Wiley

► Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

GE P1 – Mechanics and sound Lab (2 Credits)

List of Practical

1. Measurements of length (or diameter) using verniercaliper, screw gauge and travelling microscope.

2. To determine the Moment of Inertia of a Flywheel.

3. To determine the Young's Modulus of a Wire by Optical Lever Method.

4. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.

5. To determine the Elastic Constants of a Wire by Searle's method.

6. To determine g by Kater's Pendulum.

7. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

8. To investigate the motion of coupled oscillators

9. To study Lissajous Figures

10. To determine the Moment of Inertia of cylindrical body about an axis passing through its centre of gravity.

11. Frequency f vs 1/l curve for a sonometer- wire and hence unknown frequency of a tuning fork.

12. To determine the Modulus of Rigidity of a Wire by dynamical method.

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

46► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

► Engineering Practical Physics, S.Panigrahi&B.Mallick, 2015, Cengage Learning India Pvt. Ltd.

► A Text Book of Practical Physics, InduPrakash and Ramakrishna, 11th Edition, 2011, KitabMahal, New Delhi.

GE T2 –Electromagnetism and Thermal Physics (4 Credits)

1. Magnetism

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential.

Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro- magnetic materials.

Electromagnetic Induction

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

2. Maxwell`s equations and Electromagnetic wave propagation

Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves.

3.Kinetic Theory of Gases

Mean free path (zeroth order), Law of equipartion of energy (no derivation) and its applications to specific heat of gases, mono-atomic and diatomic gases.

4.Theory of Radiation

Blackbody radiation, Plank’s distribution law (statement only), Stefan Boltzmann Law and Wien’s displacement law (statement only and graphical explanation)

5.Laws of Thermodynamics

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 CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot’s cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

6.Statistical Mechanics

Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law (Only distribution formula with explanation) comparison of three statistics.

Reference Books

► Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education

► Electricity & Magnetism, J.H. Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press

► Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

► D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings

►Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.

► A Treatise on Heat, MeghnadSaha, and B.N. Srivastava, 1969, Indian Press.

► Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.

► Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill

► Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and

► G.L. Salinger. 1988, Narosa

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

► Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications

GE P2 – Electromagnetism and Thermal Physics Lab (2 Credits)

List of Practical

1. Measurement of Planck's constant using black body radiation.

2. To determine Stefan's Constant.

3. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.

4. To use a Multimeter for measuring

a. Resistances

b. AC and DC Voltages

c. DC Current

d. Checking electrical fuses.

5. Ballistic Galvanometer:

a. Measurement of charge and current sensitivity

b. Measurement of CDR

c. Determine a high resistance by Leakage Method

6. To study the Characteristics of a Series RC Circuit.

7. To study a series LCR circuit LCR circuit and determine its

a. Resonant frequency

b. Quality factor

8. To determine a Low Resistance by Carey Foster's Bridge.

9. To verify the Thevenin and Norton theorems

10. To verify the Maximum Power Transfer Theorems

. 11. Resistance of suspended coil galvanometer by half deflection method and hence the current sensitivity of the galvanometer.

12. Potential difference across a low resistance and hence the current through it with the help

of a meter bridge (without end correction)

13. To determine the coefficient of linear expansion of the material of a rod using Optical Lever Method

Reference Books

► Advanced Practical Physics for students, B.L.Flint&H.T.Worsnop, 1971, Asia Publishing House.

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed.2011, KitabMahal

GE T3 – Physical Optics and Modern Physics (4 Credits)

1.Wave Optics

Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

2. Interference

Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes);

Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

Diffraction

Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate.

3.Polarization

Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

4.Crystal Structure

Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Diffraction of X-rays by Crystals. Bragg's Law.

5.Quantum Mechanics

Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.

Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum& Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle

6.Nuclear Physics

General properties of atomic nucleas. Packing fraction, mass defect, binding energy, systematics of stable nuclei.

Radioactivity. Law of radioactive decay; Mean life and half-life. Transient and secular equilibrium.

Fission and fusion. Mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with U 235 ; Fusion and thermonuclear reactions.

Reference Books

► A Text book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, 2nd Ed., 2010, McGraw Hill

► Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.

► Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.

► Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.

► Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

► Quantum Mechanics for Scientists and Engineers, D.A.B. Miller, 2008, Cambridge University Press

► Quantum Mechanics, EugenMerzbacher, 2004, John Wiley and Sons, Inc

► Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed. 2005, Pearson Education

► Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

► Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).

► Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).

► Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004)

► Introduction to Elementary Particles, D. Griffith, John Wiley & Sons

► Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi

► Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).

► Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).

► Theoretical Nuclear Physics, J.M. Blatt &V.F.Weisskopf (Dover Pub.Inc., 1991)

► Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill

► Principles of Optics, B.K. Mathur, 1995, Gopal Printing

► Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications

► University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley

GEP3 Optics and Modern Physics Lab (2 Credits)

List of Practical

1. Familiarization with Schuster`s focussing; determination of angle of prism.

2. To determine the Refractive Index of the Material of a Prism using Sodium Light.

3. To determine Dispersive Power of the Material of a Prism using Mercury Light

4. To determine the Resolving Power of a Prism.

5. To determine wavelength of sodium light using Newton's Rings

6. To determine the Resolving Power of a Plane Diffraction Grating.

7. To determine value of Boltzmann constant using V-I characteristic of PN diode.

8. To determine work function of material of filament of directly heated vacuum diode.

9. To determine value of Planck's constant using LEDs of at least 4 different colours.

10. Refractive index of water by travelling microscope .

11. Refractive index of the material of a lens by lens mirror method .

5012. Refractive index of the liquid by lens- mirror method.

13. Focal length of a convex lens by combination method and calculation of its power.

GE T4 - Electronics and instrumentation (4 Credits)

1.Elementary band theory

Band Gaps. Conductors, Semiconductors and insulators. P and N type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect (only statement), Hall coefficient.

2.Semiconductor Devices and Amplifiers

Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff& Saturation regions Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q- point. Voltage Divider Bias Circuit for CE Amplifier. H-parameter, Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers.

3.Operational Amplifiers (Black Box approach)

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed- loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator.

4.Digital Electronics

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map

Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.

5.Instrumentations

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation.

Reference Books

► Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.

► Electronic devices & circuits, S. Salivahanan& N.S. Kumar, 2012, Tata Mc-Graw Hill

► Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.

► Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning

51► Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill

► Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.

► Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd.

► OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

GE P4 – Electronics Lab. (2 Credits)

List of Practical

1. To verify and design AND, OR, NOT and XOR gates using NAND gates.

2. To minimize a given logic circuit.

3. Adder-Subtractor using Full Adder I.C.

4. Study of zener diode characteristics and its application as voltage regulator.

5. To study the characteristics of a Transistor in CE configuration.

6. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.

7. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.

8. To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.

9. Band gap measurement of for thermistor.

10. To draw the I-V characteristics of a suitable resistance and that of a junction diode within specified limit on a graph, and hence to find d.c. and a.c. resistance of both the elements at the point of intersection.

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CBCS SYLLABUS FOR THREE YEARS UNDER-GRADUATE COURSE IN PHYSICS (PROGRAMME) (SANTALI VERNACULAR)

(w.e.f. 2021-2022)

T1 – Physics I (4 Credits)

1.Vector Analysis

Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a

parameter. Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-

divergence theorem and Stoke's theorem of vectors (statement only).

2. Laws of Motion

Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of

Mass.

3.Momentum and Energy

Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

4.Rotational Motion

Angular velocity and angular momentum. Torque. Conservation of angular momentum.

5.Gravitation

Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a

plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement

only). Satellite in circular orbit and applications.

6.Elasticity

Hooke's law –stress-strain diagram, Elastic moduli- relation between elastic constants,

poisson's ratio expression for Poisson's ratio in terms of elastic constants- work done in stretching and work done in twisting a wire – twisting couple on a cylinder –Determination of

Rigidity modulus by static torsion- Torsional pendulum- Determination of Rigidity modulus and moment of inertia by Searles method.

7. Special Theory of Relativity

Postulate of special theory of relativity. Lorentz transformations. Simultaneity and order of events. lorentz contraction. Time dilation, relativistic transformation of velocity, relativistic addition of velocities.

8. Sound

Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). Graphical and APnalytical Methods. Lissajous Figures with equal an unequal frequency and their uses. Damped oscillations. Forced vibrations and resonance.

Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.

9. Electrostatics

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Parallel plate capacitor completely filled with dielectric.

Reference Books

► University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley

► Mechanics Berkeley Physics, v.1: Charles Kittel, et.al. 2007, Tata McGraw-Hill.

► Physics – Resnick, Halliday& Walker 9/e, 2010, Wiley

► Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

P1 – Physics I Lab (2 Credits)

List of Practical

1. Measurements of length (or diameter) using verniercaliper, screw gauge and travelling microscope.

2. To determine the Moment of Inertia of a Flywheel.

3. To determine the Young's Modulus of a Wire by Optical Lever Method.

4. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.

5. To determine the Elastic Constants of a Wire by Searle's method.

6. To determine g by Kater's Pendulum.

7. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

8. To investigate the motion of coupled oscillators

9. To study Lissajous Figures

10. To determine the Moment of Inertia of cylindrical body about an axis passing through its centre of gravity.

11. Frequency f vs 1/l curve for a sonometer- wire and hence unknown frequency of a tuning fork.

12. To determine the Modulus of Rigidity of a Wire by dynamical method.

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

54► Engineering Practical Physics, S.Panigrahi&B.Mallick, 2015, Cengage Learning India Pvt. Ltd.

► A Text Book of Practical Physics, InduPrakash and Ramakrishna, 11th Edition, 2011, KitabMahal, New Delhi.

T2 –Physics II (4 Credits)

1.Magnetism

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro- magnetic materials.

Electromagnetic Induction

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

2. Maxwell`s equations and Electromagnetic wave propagation

Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves.

3.Kinetic Theory of Gases

Mean free path (zeroth order), Law of equipartion of energy (no derivation) and its applications to specific heat of gases, mono-atomic and diatomic gases.

4.Theory of Radiation

Blackbody radiation, Plank's distribution law (statement only), Stefan Boltzmann Law and Wien's displacement law (statement only and graphical explanation)

5.Laws of Thermodynamics

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 CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

6.Statistical Mechanics

Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law (Only distribution formula with explanation) comparison of three statistics.

Reference Books

► Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education

► Electricity & Magnetism, J.H. Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press

► Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

► D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings ►

Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.

► A Treatise on Heat, MeghnadSaha, and B.N. Srivastava, 1969, Indian Press.

► Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.

► Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill

► Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and

► G.L. Salinger. 1988, Narosa

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

► Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications

P2 –Physics II Lab (2 Credits)

List of Practical

1. Measurement of Planck's constant using black body radiation.

2. To determine Stefan's Constant.

3. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.

4. To use a Multimeter for measuring

a. Resistances

b. AC and DC Voltages

c. DC Current

d. Checking electrical fuses.

5. Ballistic Galvanometer:

a. Measurement of charge and current sensitivity

b. Measurement of CDR

c. Determine a high resistance by Leakage Method

6. To study the Characteristics of a Series RC Circuit.

7. To study a series LCR circuit LCR circuit and determine its

a. Resonant frequency

b. Quality factor

8. To determine a Low Resistance by Carey Foster's Bridge.

9. To verify the Thevenin and Norton theorems

10. To verify the Maximum Power Transfer Theorems

. 11. Resistance of suspended coil galvanometer by half deflection method and hence the current sensitivity of the galvanometer.

12. Potential difference across a low resistance and hence the current through it with the help of a meter bridge (without end correction)

13. To determine the coefficient of linear expansion of the material of a rod using Optical Lever Method

Reference Books

► Advanced Practical Physics for students, B.L.Flint&H.T.Worsnop, 1971, Asia Publishing

House.

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed.2011, KitabMahal

T3 –Physics.III(4 Credits)

1.Wave Optics

Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

2. Interference

Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes);

Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

Diffraction

Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate.

3.Polarization

Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

4.Crystal Structure

Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Diffraction of X-rays by Crystals. Bragg's

Law.

5.Quantum Mechanics

Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.

Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum & Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle

6.Nuclear Physics

General properties of atomic nucleas. Packing fraction, mass defect, binding energy, systematics of stable nuclei.

Radioactivity. Law of radioactive decay; Mean life and half-life. Transient and secular equilibrium.

Fission and fusion. Mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with U 235 ; Fusion and thermonuclear reactions.

Reference Books

► A Text book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, 2nd Ed., 2010, McGraw Hill

► Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.

► Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.

► Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.

► Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

► Quantum Mechanics for Scientists and Engineers, D.A.B. Miller, 2008, Cambridge University Press

► Quantum Mechanics, EugenMerzbacher, 2004, John Wiley and Sons, Inc

► Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed. 2005, Pearson Education

► Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

► Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).

► Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).

► Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004)

► Introduction to Elementary Particles, D. Griffith, John Wiley & Sons

► Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi

► Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).

► Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).

► Theoretical Nuclear Physics, J.M. Blatt &V.F.Weisskopf (Dover Pub.Inc., 1991)

► Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill

► Principles of Optics, B.K. Mathur, 1995, Gopal Printing

► Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications

► University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley

P3 - Physics Lab III (2 Credits)

List of Practical

1. Familiarization with Schuster`s focussing; determination of angle of prism.
2. To determine the Refractive Index of the Material of a Prism using Sodium Light.
3. To determine Dispersive Power of the Material of a Prism using Mercury Light
4. To determine the Resolving Power of a Prism.
5. To determine wavelength of sodium light using Newton's Rings
6. To determine the Resolving Power of a Plane Diffraction Grating.
7. To determine value of Boltzmann constant using V-I characteristic of PN diode.
8. To determine work function of material of filament of directly heated vacuum diode.
9. To determine value of Planck's constant using LEDs of at least 4 different colours.
10. Refractive index of water by travelling microscope .
11. Refractive index of the material of a lens by lens mirror method .
12. Refractive index of the liquid by lens- mirror method.
13. Focal length of a convex lens by combination method and calculation of its power.

T4 –Physics IV (4 Credits)

1.Elementary band theory

Band Gaps. Conductors, Semiconductors and insulators. P and N type Semiconductors.

Conductivity of Semiconductors, mobility, Hall Effect (only statement), Hall coefficient.

2.Semiconductor Devices and Amplifiers

Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction

Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff& Saturation regions Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q- point. Voltage Divider Bias Circuit for CE Amplifier. H-parameter, Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers.

3.Operational Amplifiers (Black Box approach)

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed- loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator.

4.Digital Electronics

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map

Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.

5.Instrumentations

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers

Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter,

Zener Diode and Voltage Regulation.

Reference Books

► Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.

► Electronic devices & circuits, S. Salivahanan& N.S. Kumar, 2012, Tata Mc-Graw Hill

► Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.

► Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990,

PHI Learning

► Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011,

Tata McGraw Hill

► Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn.,

Oxford University Press.

59► Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt.

Ltd.

► OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

P4 – Physics IV Lab.(2 Credits)

List of Practical

1. To verify and design AND, OR, NOT and XOR gates using NAND gates.

2. To minimize a given logic circuit.

3. Adder-Subtractor using Full Adder I.C.

4. Study of zener diode characteristics and its application as voltage regulator.

5. To study the characteristics of a Transistor in CE configuration.

6. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.

7. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.

8. To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.

9. Band gap measurement of for thermistor.

10.To draw the I-V characteristics of a suitable resistance and that of a junction diode within specified limit on a graph, and hence to find d.c. and a.c. resistance of both the elements at the point of intersection.