COURSE OBJECTIVES AND LEARNING OUTCOMES OF ¾ YEARS UNDER GRADUATE CURRICULUM IN PHYSICS

NISTARINI COLLEGE, PURULIA

AFFILIATED TO

SIDHO – KANHO – BIRSHA UNIVERSITY, PURULIA

Requisite of the course: **Mathematics** as Minor
Marks in the final (end semester) examination: 15 Marks for 01 Credit for both Theory and Practical.
Duration of Final Examination: 3 Hours.

Semester I

Mechanics and Properties of Matter (*6 Credits*)

Course Objective: The objective of this course is to provide students with a comprehensive understanding of mechanics and properties of matter. Through theoretical concepts, problem-solving exercises, and practical applications, students will develop a strong foundation in Mechanics and Properties of Matter, enabling them to analyse and interpret complex physical phenomena related to motion, forces, and material behaviour of real world.

Learning Outcome: By achieving the course objectives, students will be well-prepared to solve complex problems in classical mechanics, understand the fundamental properties of materials, and interpret various physical phenomena, providing a solid foundation for further studies in physics, engineering, and related fields.

Theory (*4 Credits*)

Vector Differentiation
Directional derivatives and normal derivatives, Gradient of a scalar field and its geometrical interpretation, Divergence and curl of a vector field with their physical significances, Del and Laplacian operators, Vector identities. **(6 Lectures)**

Fundamentals of Dynamics
Reference frames. Inertial frames; Review of Newton's Laws of Motion. Equation of motion of a particle, 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. Motion of Centre of Mass, Principle of conservation of momentum with applications. **(6 Lectures)**

Work and Energy
Work and Energy, Work 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 and potential energy. Work done by non-conservative forces. Law of conservation of energy. **(4 Lectures)**

Collisions
Collisions, Centre of mass frame and Laboratory frames, Elastic and inelastic collisions between particles. Elastic collision in two-dimensional case, coefficient of restitution. **(3 Lectures)**

Rotational Dynamics
Angular momenta 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, rod, lamina, ring, disc, spherical shell, solid sphere. Kinetic energy of rotation, rolling along a slope, Application to compound pendulum. Motion involving both translation and rotation. **(10 Lectures)**

Gravitational 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). **(8 Lectures)**

Non-Inertial Systems:

Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force and its effect on *g*. Coriolis force and its applications. Geophysical effects of coriolis force, Components of velocity and acceleration in Cylindrical and Spherical coordinate systems. **(6 Lectures)**

Elasticity

Elastic constants, Relation between elastic constants. Twisting torque on a cylinder or wire. Bending of beam, bending moment, Cantilever: shear force and torque, Cantilever loaded at any distance from the fixed end, Beam supported at both end and loaded at the centre, shape of Girders/ rail tracks. **(7 Lectures)**

Fluid Motion

Kinematics of moving fluids: equation of continuity, Poiseuille's equation for flow of a liquid through a capillary tube, Euler's equation, Bernoulli's theorem and its applications. **(4 Lectures)**

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.

(6 Lectures)

Laboratory Practical (*2 Credits***)**

List of Practical (Any six)

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the Moment of Inertia of a Cylinder.
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
5. To determine the Young's Modulus of a Wire by Flexural/ Optical Lever Method.
6. To determine the value of g using Kater's Pendulum.
7. To determine the Modulus of Rigidity of a Wire by Maxwell's needle/dynamical method
8. To determine the elastic Constants of a wire by Searle's method.
9. To study the Motion of Spring and calculate, (a) Spring constant, (b) g and (c) Modulus of rigidity and (d) unknown mass.

Reading References

Theory

1) An Introduction to Mechanics, D Kleppner and R J Kolenkow, McGraw Hill.
2) Physics, R Resnick, J Halliday and D Walker, 8th Edition, Wiley.
3) Mechanics, Berkeley Physics, Vol.1, C. Kittel, W. Knight, et. al. Tata McGraw Hill.
4) Introduction to Classical Mechanics, D Morin, Cambridge University Press.
5) Mechanics and Properties of Matter, A B Gupta, 5th Edition, Books and Allied Pvt Ltd.
6) Mechanics, D S Mathur and P S Hemne, S. Chand and Company Pvt Ltd.
7) Theory and Problems of Theoretical Mechanics, M R Spiegel, McGraw Hill.

8) A Treatise on General Properties of Matter, Sengupta and Chatterjee, NCBA.
9) Properties of Matter, Brij Lal and N Subrahmanyam, S. Chand and Company Pvt Ltd.
10) The Physics of Waves and Oscillations, N K Bajaj, Tata McGraw Hill.
11) Vibrations and Waves, A P French, CBS Publishers.

Practical

1) Advanced Practical Physics for Students, B L Flint and H T Worsnop, Asia Publishing House
2) An Advanced Course in Practical Physics, D Chattopadhyay and P C Rakshit, NCBA
3) Advanced Level Physics Practicals, M Nelson and J M. Ogborn, 4th Edition, Heinemann Educational Publishers
4) A Text Book of Practical Physics, I Prakash, R Krishna and A K Jha, Kitab Mahal
5) Laboratory Manual of Physics, Vol 1, M Jana, Books and Allied Pvt Ltd

Semester II

Electricity and Magnetism (*6 Credits*)

Course Objective: The objective of this course is to provide students with a comprehensive understanding of electricity and magnetism, covering vector integration, electric fields, electric potential, dielectric properties of matter, magnetic fields, magnetic properties of matter, electromagnetic induction, and electrical circuits. Through theoretical concepts, practical experiments, and problem-solving exercises, students will develop a strong foundation in the fundamental principles of electricity and magnetism. The course aims to equip students with the knowledge and skills necessary to analyze, predict, and apply electromagnetic phenomena in various engineering, scientific, and technological contexts of their surroundings.

Learning Outcome: On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence: Knowledge: The student has acquired detailed knowledge of electromagnetism (electric and magnetic force and field, induction) and preliminary knowledge of electromagnetic waves. Skills: The student can solve problems with moderate mathematical complexity related to electric and magnetic force and field, electric charge, electric potential, current, voltage and resistance, capacitors. They will be expert in application of Gauss law, Faradays law, Lenz law. General competence: Enhanced ability to handle force at a distance phenomenon.

Theory (*4 Credits*)

Vector Integration
Ordinary integrals of vectors. Multiple integrals, 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). **(10 Lectures)**

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. **(5 Lectures)**

Conservative nature of electrostatic field. Electrostatic potential. Laplace's and Poisson equations. The Uniqueness theorem (statement only). Potential and electric field of a dipole. Force and torque on a dipole. Multipole expansion. **(5 Lectures)**

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. Method of images and its application to: (1) Plane infinite sheet and (2) Sphere. **(10 Lectures)**

Dielectric Properties of Matter
Electric field in matter. Polarization of 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. **(6 Lectures)**

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). **(4 Lectures)**

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 Lectures)**

Magnetic Properties of Matter

Magnetization vector (*M*). Magnetic Intensity (*H*). Magnetic Susceptibility and permeability. Relation between *B*, *H*, and *M*. Ferromagnetism. B-H curve, hysteresis and its applications. **(3 Lectures)**

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 Lectures)**

Electrical Circuits

AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. LC and CR circuits, Series LCR circuit: (1) Resonance, (2) Power dissipation and (3) Quality Factor, and (4) Band width. Parallel LCR circuit. **(5 Lectures)**

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. **(3 Lectures)**

Laboratory Practical (*2 Credits*)

General topic to be covered

Use a Multimeter for measuring

a) Resistances
b) AC and DC Voltages
c) DC Current
d) Capacitances
e) Checking electrical fuses.

List of Practical (Any six)

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To determine the resistance of a galvanometer by half deflection method.
5. Measurement of field strength *B* and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self-inductance of a coil by Anderson's bridge.
9. To study response curve of a Series LCR circuit and determine its
   a) Resonant frequency
   b) Impedance at resonance
   c) Quality factor *Q*
   d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its
   a) Anti- resonant frequency

b) Quality factor *Q*.

Reading References

Theory

1) Electricity and Magnetism, E M Purcell and D J Morin, 3rd Edition, McGraw-Hill
2) Introduction to Electrodynamics, D J Griffiths, 4th Edition, Cambridge University Press
3) Classical Electromagnetism, H C Verma, Bharati Bhawan
4) Elements of Electromagnetics, M N O Sadiku, Oxford University Press.
5) Electricity, Magnetism and Electromagnetic Theory, S Mahajan and S R Choudhury, Tata McGraw Hill
6) Electricity and Magnetism, J H Fewkes and J Yarwood. Vol. I, Oxford University Press.
7) Feynman Lectures, Vol. 2, R P Feynman, R B Leighton, and M Sands, Pearson.
8) Foundations of Electricity and Magnetism, B Ghosh, 5th Edition, Books and Allied Pvt Ltd

Practical

1) Advanced Practical Physics for Students, B L Flint and H T Worsnop, Asia Publishing House
2) An Advanced Course in Practical Physics, D Chattopadhyay and P C Rakshit, NCBA
3) Advanced level Physics Practicals, M Nelson and J M Ogborn, 4th Edition, Heinemann Educational Publishers
4) Engineering Practical Physics, S Panigrahi and B Mallick, Cengage Learning.
5) Laboratory Manual of Physics, Vol 2, M Jana, Books and Allied Pvt Ltd

Semester III

Waves and Optics (*6 Credits*)

Course Objective: The objective of this course is to familiarize undergraduate students with the principles of electricity and magnetism, providing a comprehensive understanding of their correlation. Students will learn about electric and magnetic fields, Gauss's Law, Ampere's Circuital Law, and Faraday's Law. Through theoretical concepts and practical applications, students will develop problem-solving skills and gain proficiency in analyzing electrical and magnetic phenomena. They will apply mathematical tools to solve complex electromagnetic problems, enhancing their quantitative abilities. By the end of the course, students will be equipped to comprehend and apply electromagnetism in various engineering, physics, and technological contexts, preparing them for advanced studies and careers in related fields.

Learning Outcome: By the end of this course, undergrad students will: a. Demonstrate a comprehensive understanding of electricity and magnetism principles, including electric and magnetic fields, Gauss's Law, Ampere's Circuital Law, and Faraday's Law. b. Develop problem-solving skills and apply mathematical tools to analyse and predict electrical and magnetic phenomena in various scenarios. c. Gain practical experience through laboratory experiments, enhancing their ability to conduct and interpret electrical and magnetic measurements. d. Apply electromagnetism knowledge to engineering, physics, and technological applications, fostering critical thinking and analytical abilities. e. Be prepared for advanced studies and careers in industry, physics, and related fields, equipped with a strong foundation in electromagnetism.

Theory (*4 Credits*)

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. Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(5 Lectures)**

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 Lectures)**

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. **(6 Lectures)**

Wave Optics
Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **(2 Lectures)**

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. 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. **(14 Lectures)**

Diffraction

Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. 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. **(14 Lectures)**

Polarization of Electromagnetic Waves

Transverse nature of light waves. Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. 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. Analysis of Polarized Light. **(8 Lectures)**

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Specific rotation. Laurent's half-shade polarimeter. **(4 Lectures)**

Holography

Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. Uses of holograms. **(3 Lectures)**

Laboratory Practical (*2 Credits*)

List of Practicals (Any six)

1. To study Lissajous Figures.
2. To investigate the motion of coupled oscillators.
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 unknown wavelength from the μ-λ curve using He-source.
6. To determine the wavelength of sodium source using Michelson's interferometer.
7. To determine wavelength of sodium light using Fresnel Biprism.
8. To determine wavelength of sodium light using Newton's Rings.
9. To determine wavelength of (1) Na-source and (2) spectral lines of Hg-source using plane diffraction grating.
10. To determine dispersive power and resolving power of a plane diffraction grating.
11. To determine the specific rotation of sugar solution using polarimeter.

Reading References

Theory

1. Waves: Berkeley Physics Course, Vol. 3, F Crawford, Tata McGraw Hill.
2. The Physics of Waves and Oscillations, N K Bajaj, Tata McGraw Hill.
3. Vibrations and Waves, A P French, CBS Publishers.
4. Oscillations and Waves, S Garg, S K Ghosh, S Gupta, Prentice Hall of India
5. Principles of Optics, M Born and E Wolf, Pergamon Press.
6. Fundamentals of Optics, F A Jenkins and H E White, McGraw Hill

7. Optics, A Ghatak, McGraw Hill
8. Optics, E Hecht, Pearson Education
9. Modern Optics, A B Gupta, Books and Allied Pvt Ltd
10. A Textbook on Optics, N Subrahamanyam, Brij Lal, and M N Avadhanulu, S Chand and Co Pvt Ltd
11. A Text Book of Light, B Ghosh and K G Mazumdar, 2nd Edition, Shreedhar Prakashani

Practical

1. Advanced Practical Physics for Students, B L Flint and H T Worsnop, Asia Publishing House
2. Advanced practical physics, B Ghosh and K G Mazumdar, Shreedhar Publishers
3. Advanced Level Physics Practicals, M Nelson and J M Ogborn, 4th Edition, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for Udergraduate Classes, D P Khandelwal, Vani Pub.
5. An Advanced Course in Practical Physics, D Chattopadhyay and P C Rakshit, NCBA
6. Laboratory Manual of Physics, Vol 1, M Jana, Books and Allied Pvt Ltd

Semester-IV

1. Thermal Physics (*6 credits*)

Course Objective: This course aims to provide students with a comprehensive understanding of the principles and concepts of thermal physics. Students will learn about thermodynamic laws, temperature, heat, and work. They will analyse the behavior of gases, phase transitions, and thermal properties of materials. The course will cover topics such as heat conduction in material, heat engines, entropy, and the kinetic theory of gases. Students will apply these principles to solve practical problems in engineering and everyday life. By the end of the course, students will be equipped to analyse and interpret thermal phenomena and appreciate their relevance in various scientific and technological applications.

Learning Outcome: By the end of this course, students will: a. Demonstrate a comprehensive understanding of the fundamental principles of thermal physics, including thermodynamic laws and heat transfer mechanisms. b. Analyse and predict the behaviour of gases, liquids, and solids under varying temperature and pressure conditions. c. Comprehend the concepts of heat engines, refrigerators, and their practical applications in engineering and technology. d. Apply statistical mechanics and the kinetic theory of gases to interpret the macroscopic properties of matter at the molecular level. e. Evaluate and solve complex problems related to heat conduction, convection, and radiation in various physical scenarios. f. Develop practical skills in conducting thermal experiments and data analysis, reinforcing theoretical concepts and enhancing problem-solving abilities. g. Recognize the significance of thermal physics in various disciplines and its relevance to real-world applications in energy, environment, and technology.

Theory (*4 Credits*)

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. **(5 Lectures)**

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. **(4 Lectures)**

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. **(8 Lectures)**

Heat conduction in solid
Variable and steady state of heat flow, thermal conductivity, thermal receptivity, thermometric conductivity, thermal conductivity of a composite. Fourier equation of heat conduction in one dimension. Steady state solution and application to Ingen Hausz's experiments, extension to three dimensions for

spherical and cylindrical heat flow. Lee's method. Cylindrical shell method. Statement of Wiedmann-Franz's Law. **(4 Lectures)**

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 C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. **(8 Lectures)**

Second Law of Thermodynamics

Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, second 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. **(10 Lectures)**

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. **(7 Lectures)**

Thermodynamic Potentials

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Gibbs free energy and spontaneity of a process. Surface Films and Variation of Surface Tension with Temperature, Magnetic Work. Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius-Clapeyron Equation and Ehrenfest equations. **(7 Lectures)**

Maxwell's Thermodynamic Relations

Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. **(7 Lectures)**

Laboratory Practical (*2 credits***)**

List of Practical (Any six)

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 andCharlton'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.

Reading References

Theory

1. Heat and Thermodynamics, M W Zemansky, R Dittman, McGraw Hill.
2. Concepts in Thermal Physics, S J Blundell and K M Blundell, 2nd Edition, Oxford University Press.
3. An Introduction to Thermal Physics, D. V. Schroeder, Oxford University Press.
4. Thermal Physics, S. Garg, R. Bansal and S K Ghosh, 2nd Edition, Tata McGraw Hill.
5. The Kinetic Theory of Gases, L B Loeb, Radha Publication House
6. Thermal Physics, A B Gupta and H P Roy, Books and Allied Pvt Ltd
7. Thermodynamics, Kinetic Theory, Statistical Thermodynamics, F W Sears and G L Salinger, Narosa.
8. Thermal Physics, C Kittel and H Kroemer, W H Freeman Publisher.
9. Thermodynamics and an Introduction to Thermostatistics, H. B. Callen, Wiley.

Practical

1. Advanced Practical Physics for Students, B L Flint and H T Worsnop, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash and R Krishna, Kitab Mahal
3. Advanced PracticalPphysics, B Ghosh and K G Mazumdar, Shreedhar Prakashani
4. An Advanced Course in Practical Physics: D Chattopadhyay and P C Rakshit, NCBA
5. Laboratory Manual of Physics, Vol 1, M Jana, Books and Allied Pvt Ltd

2. Electronics-I (Analog and Digital Electronics) (*6 Credits*)

Course Objective: This course will enable students to • Learn basic semiconductor physics and two terminal devices and its application. • Understand construction and characteristics of JFETs and MOSFETs and differentiate with BJT. • Demonstrate and Analyze Operational Amplifier circuits and their applications • Describe, Illustrate and Analyze Combinational Logic circuits, Simplification of Algebraic Equations using Karnaugh Maps and Quine McClusky Techniques. • Describe and Design Decoders, Encoders, Digital multiplexers, Adders and Subtractors, Binary comparators, Latches and Master-Slave Flip-Flops.

Learning Outcome: Upon completion of the Course, the students will be able to: a. Know the characteristics and utilization of various electronics components. b. Design and analyze electronic circuits for real world applications. In addition, students will also be able to design, analyze, and implement digital circuits. They will understand logic gates, Boolean algebra, and combinational and sequential circuits, gaining practical skills in building digital systems for various applications.

Theory (*4 Credits*)

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. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and

Reverse Biased 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. (**11 Lectures**)

<u>Bipolar Junction transistors and amplifier:</u>

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.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. (**12 Lectures**)

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 and Anti-log amplifier, (7) Zero crossing detector. Non-linear – (1) inverting and non-inverting comparators, (2) Schmidt triggers. **(9 Lectures)**

<u>Field Effect transistors</u>

Classification of various types of FETs, construction of JFET, drains characteristics, biasing, operating region, pinch-off voltage. MOSFET: construction of enhancement and depletion type, principle of operation and characteristics. Elementary ideas of CMOS and NMOS. (**6 Lectures**)

<u>Digital Circuits</u>

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbersand their conversion to other system. 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. **(5 Lectures)**

<u>Boolean algebra</u>

De Morgan's Theorems. Boolean Laws. 1's and 2's complement, binary number addition, subtraction and multiplication, Binary Subtraction using 2's Complement, Simplification of Logic Circuit using Boolean Algebra. Fundamental Products, SOP and POS form. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

(**6 Lectures**)

Data processing circuits

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

(**5 Lectures**)

Sequential Circuits

SR, JK, D- and T- 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. Excitation table, Timing diagram for different FF.

(**6 Lectures**)

Laboratory Practical (*2 Credits***)**

List of Practical (Any six)

1. To study V-I characteristics of PN junction diode, Light emitting diode, and Zener diode.
2. To design the circuit for Frequency response of a CE amplifier

3. To design a bridge rectifier circuit for full wave rectification and calculation of rectification efficiency, ripple factor.
4. To design an inverting, non-inverting amplifier using Op-amp (741) for dc voltage of given gain
5. To design adder, subtractor, Integrator using Op-amp.
6. To design a switch (NOT gate) using a transistor.
7. To verify and design AND, OR, NOT and XOR gates using NAND gates.
8. To design a combinational logic system for a specified Truth Table.
9. Half Adder, Full Adder and 4-bit binary Adder.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.

Reading References

Theory

1. Semiconductor Physics and Devices, S M Sze, Wiley
2. Modern Semiconductor Devices for Integrated Circuits, C C Hu, Pearson
3. Integrated Electronics, J Millman, C Halkias, and C Parikh, Tata McGraw Hill
4. Electronic devices and circuit Theory, R L Bolysted and LNashelsky, Pearson
5. Electronics: Fundamentals and Applications, J. D. Ryder, Prentice Hall.
6. Electronic Principles, A P Malvino and D J Bates, McGraw Hill
7. Digital Fundamentals, T L Floyd, Pearson
8. Digital Electronics, R P Jain, Tat McGraw Hill
9. Digital Principles and Applications, A P Malvino, D P Leach and G Saha, Tata McGraw Hill
10. Digital Electronics G K Kharate, Oxford University Press.
11. Electronics Fundamental and Application, D. Chattopadhyay and P.C. Rakshit, New Age
12. Fundamental Principles of Electronics, B Ghosh, Books and Allied Pvt Ltd

Practical

1. Modern Digital Electronics, R.P. Jain, 4th Edition, Tata McGraw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, Mc-GrawHill.
3. Opamps for everyone, Mancini, Newnes Pub.