

B.Sc. Physics Syllabus

Program Outcomes (POs)

PO No.	Program Outcome
PO1	Demonstrate foundational knowledge in physics and apply it to solve scientific and engineering problems.
PO2	Apply mathematical, computational, and analytical techniques to model physical phenomena.
PO3	Design, conduct, and analyze experiments, interpreting data accurately.
PO4	Develop problem-solving, critical thinking, and logical reasoning skills in theoretical and experimental physics.
PO5	Communicate scientific ideas and results effectively in written, oral, and graphical formats.
PO6	Work collaboratively in teams and demonstrate leadership and project management skills.
PO7	Exhibit professional ethics, scientific temper, and awareness of contemporary issues in science and technology.
PO8	Pursue lifelong learning and be prepared for higher studies, research, or professional careers in physics and related fields.

B.Sc. I Physics – Program Specific Outcomes (PSOs)

PSO1: Fundamental Physics Knowledge

- Understand and apply the basic principles of classical mechanics, thermodynamics, waves, oscillations, optics, and electromagnetism.
- Develop the ability to relate physical concepts to real-world phenomena.

PSO2: Mathematical and Analytical Skills

- Apply mathematical methods and analytical techniques to solve quantitative physics problems.
- Use mathematical modeling to analyze physical systems.

PSO3: Laboratory and Experimental Skills

- Perform experiments with accuracy and precision using standard laboratory equipment.
- Analyze experimental data and interpret results in terms of physical laws and concepts.

PSO4: Scientific Reasoning and Problem Solving

- Develop logical reasoning and critical thinking skills to solve theoretical and practical problems in physics.
- Connect concepts across different areas of physics to address complex phenomena.

PSO5: Communication and Teamwork

- Communicate scientific ideas effectively through written reports and presentations.
- Work collaboratively in laboratory and project-based settings.

PSO6: Foundation for Advanced Studies

- Build a strong conceptual and analytical foundation for higher-level courses in physics and related disciplines, including quantum mechanics, electronics, and materials science.

Course Structure

Part I	
Paper I	Mechanics and Special Theory of Relativity
Paper II	Thermal Physics
Paper III	Electrical Circuit and Basic Semiconductor Electronics
Practical	

Part II	
Paper I	Optics
Paper II	Oscillation, Waves and Electromagnetism
Paper III	Atomic and Nuclear Physics
Practical	

Part III	
Paper I	QUANTUM MECHANICS
Paper II	STATISTICAL MECHANICS AND SOLID STATE PHYSICS
Paper III	BASIC DIGITAL ELECTRONICS AND PHOTONIC DEVICES
Paper IV	ELECTROMAGNETIC THEORY, LASER, HOLOGRAPHY AND OPTICAL, INSTRUMENTS
Practical	

B.Sc. Part I: Course Details

Title: Mechanics and Special Theory of Relativity

Course Objectives

The course aims to:

1. Provide a strong foundation in classical mechanics, vector calculus, and rotational dynamics.
2. Develop the ability to analyze systems of particles and rigid bodies using conservation laws.
3. Introduce students to the principles of fluid mechanics and mechanics of deformable bodies.
4. Explain the limitations of Newtonian mechanics and introduce the framework of special relativity.
5. Build problem-solving skills essential for advanced physics courses.

Course Learning Outcomes (COs)

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

CO Code	Course Outcome
CO1	Apply vector calculus to physical systems and distinguish between inertial and non-inertial frames.
CO2	Analyze systems of particles, apply conservation laws, and study rigid body motion in 2D and 3D.
CO3	Solve problems involving central forces and explain orbital motion using Kepler's laws.
CO4	Understand stress, strain, and elasticity in materials; calculate elastic constants and internal energy.
CO5	Describe fluid motion, apply Bernoulli's and Poiseuille's equations, and measure viscosity.
CO6	Explain and apply the postulates and consequences of special relativity to physical phenomena.

Mapping of CO-POs-PSOs

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	3	2	–	–	–	2	2	2	2	3	–	2	2
CO2	3	3	2	3	2	–	–	–	2	2	3	2	3	2	2	3
CO3	3	3	2	3	–	–	–	–	2	2	3	3	3	–	3	3
CO4	3	2	2	2	2	–	–	–	2	2	2	2	3	3	2	2
CO5	3	2	2	3	3	–	–	–	2	3	3	2	3	3	3	2
CO6	3	3	3	3	–	2	2	–	3	2	3	3	3	–	3	3

Mapping Scale:

- 3 = High
- 2 = Medium
- 1 = Low
- – = No significant mapping

Course Content (Unit-wise Breakdown)

Unit 1: Fundamentals of Mechanics and Vector Calculus

- Vectors: Gradient, divergence, and curl
- Line, surface, and volume integrals
- Frames of reference: Inertial vs non-inertial
- Galilean transformations, pseudo forces, centrifugal and Coriolis forces
- Equivalence principle, inertial and gravitational mass

Unit 2: System of Particles and Rigid Body Dynamics

- Centre of mass, linear momentum, angular momentum
- Motion in 2D and 3D, Moment of inertia and its tensor

- Conservation laws (linear and angular momentum, energy)
- Central and conservative forces, potential energy
- Gravitational potential and field of spherical bodies

Unit 3: Central Force Motion

- Two-particle system, reduced mass, lab and CM coordinates
- Motion in an inverse square force field
- Derivation and application of **Kepler's laws**

Unit 4: Mechanics of Deformable Bodies

- Stress and strain in isotropic media
- Elastic moduli (Young's modulus, bulk modulus, shear modulus), relations among them
- Torsion of a cylinder, bending of beams
- Internal energy of a deformed body

Unit 5: Fluid Mechanics

- Ideal fluids: Continuity equation, Euler's equation
- Streamline and turbulent flows, Bernoulli's theorem
- Viscous fluids, Poiseuille's law
- Measurement of viscosity using rotating cylinder method

Unit 6: Special Theory of Relativity

- Michelson–Morley experiment and its implications
- Einstein's postulates, Lorentz transformations
- Time dilation, length contraction, simultaneity
- Relativistic addition of velocities, relativistic momentum and energy
- Mass-energy equivalence, Doppler shift, and aberration of light

Recommended Textbooks

1. **D. S. Mathur**, *Mechanics*, S. Chand & Co.
2. **H.C. Verma**, *Concepts of Physics Vol. I*, Bharati Bhawan

3. **Sears and Zemansky**, *University Physics*, Pearson
4. **J.C. Upadhyaya**, *Classical Mechanics*, Himalaya Publishing
5. **N.K. Bajaj**, *The Special Theory of Relativity*, Tata McGraw Hill

Paper II: Thermal Physics

Course Objectives

This course aims to:

1. Introduce fundamental concepts of thermodynamics and establish a link with kinetic theory.
2. Explain the laws of thermodynamics and their application to thermal systems and phase transitions.
3. Discuss entropy and thermodynamic potentials with emphasis on their physical significance.
4. Develop understanding of heat conduction, black body radiation, and classical and quantum laws of radiation.
5. Analyze real-world physical systems using thermodynamic principles and relate them to microscopic behavior.

Course Learning Outcomes (COs)

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

CO	Course Outcome
CO1	Define thermodynamic systems, variables, equilibrium, and apply the Zeroth and First Laws of Thermodynamics.
CO2	Analyze Carnot's cycle, understand entropy, the Second Law of Thermodynamics, and apply thermodynamic potentials and Maxwell's relations.
CO3	Explain phase transitions using Clausius-Clapeyron and Ehrenfest equations.
CO4	Apply kinetic theory to derive Maxwell-Boltzmann velocity distribution and transport phenomena.

CO5	Solve problems involving heat conduction using Fourier's law for steady and periodic flows.
CO6	Understand thermal radiation and derive laws such as Stefan-Boltzmann, Wien's displacement law, and Planck's law.

Mapping of CO-POs-PSOs

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	2	2	—	—	—	2	2	2	2	3	—	2	2
CO2	3	3	2	3	2	—	1	—	2	2	3	3	3	—	3	3
CO3	3	2	2	2	—	—	—	—	2	2	2	2	3	—	2	2
CO4	3	3	3	3	2	—	—	—	2	2	3	3	3	—	3	3
CO5	3	2	2	3	3	—	—	—	2	2	3	2	3	2	2	2
CO6	3	3	3	3	—	2	1	—	2	2	3	3	3	—	3	3

Course Content (Unit-wise Breakdown)

◆ Unit 1: Basic Concepts in Thermodynamics

- Thermodynamic systems and variables (macroscopic vs. microscopic)
- Thermodynamic equilibrium, state, and Zeroth law
- Heat and work (path dependence)
- Thermal processes: isothermal, adiabatic, isobaric, isochoric
- First law of thermodynamics, internal energy, Joule's law
- Applications: heat engines and internal energy relations

◆ Unit 2: Second Law of Thermodynamics and Entropy

- Carnot cycle, Carnot engine and refrigerator
- Reversible vs irreversible processes, Carnot's theorem
- Thermodynamic temperature scale
- Clausius theorem and inequality
- Entropy: definition, calculation in various processes
- Physical meaning and role in natural processes
- Thermodynamic potentials: Helmholtz, Gibbs, Enthalpy, Internal energy
- Maxwell's equations and their applications
- Joule-Thomson effect and inversion temperature

◆ Unit 3: Phase Transitions

- Clausius-Clapeyron equation
- First- and second-order phase transitions
- Ehrenfest equations

◆ Unit 4: Kinetic Theory of Gases

- Assumptions of kinetic theory
- Maxwell-Boltzmann distribution
- Average, r.m.s., and most probable speeds
- Mean free path
- Transport phenomena: viscosity, thermal conductivity, diffusion

◆ Unit 5: Heat Conduction

- Fourier's law for 1D heat conduction
- Steady-state and periodic (sinusoidal) heat flow solutions

◆ Unit 6: Radiation

- Radiation as EM waves

- Emission and absorption: black-body concept
- Kirchhoff's law, hollow enclosure model
- Stefan-Boltzmann law, solar constant
- Temperature of black and non-black bodies
- Black-body spectrum: Rayleigh-Jeans law, Wien's laws, Planck's law
- Adiabatic expansion of radiation

Recommended Textbooks

1. **D.S. Mathur**, *Heat and Thermodynamics*, S. Chand
2. **M.W. Zemansky & R.H. Dittman**, *Heat and Thermodynamics*, McGraw-Hill
3. **Sears & Zemansky**, *University Physics*, Pearson
4. **S.C. Garg, R.M. Bansal**, *Thermal Physics*, Tata McGraw-Hill
5. **H.C. Verma**, *Concepts of Physics Vol. II*, Bharati Bhawan
6. **F.W. Sears**, *Kinetic Theory of Gases*, Addison-Wesley

Paper-III Electrical Circuits and Basic Semiconductor Electronics

Course Objectives

- Understand the fundamental concepts of electrical circuits including DC and AC circuit analysis.
- Learn key theorems such as Thevenin's and Norton's for simplifying circuits.
- Analyze transient and steady-state responses in RLC circuits.
- Study and apply AC bridges for precise measurements.
- Understand semiconductor basics, P-N junctions, and characteristics of diodes and transistors.
- Study amplifier configurations, oscillator circuits, and basics of modulation.
- Learn working principles and applications of CRO.

Course Outcomes (COs)

CO	Course Outcome
CO1	Analyze DC and AC electrical circuits using Kirchhoff's laws, Thevenin's and Norton's theorems.
CO2	Understand transient response in RLC circuits and perform related calculations.
CO3	Apply AC bridge methods for precision measurement of inductance and capacitance.
CO4	Explain semiconductor conduction mechanisms, intrinsic and extrinsic semiconductors.
CO5	Describe P-N junction behavior, diode characteristics, and Zener diode voltage regulation.
CO6	Understand BJT operation, amplifier configurations, and design of oscillators.
CO7	Explain basic modulation techniques and AM circuits.
CO8	Understand the working and applications of the CRO.

CO–PO–PSO Mapping Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	3	2	–	–	–	2	2	3	2	3	–	2	2
CO2	3	3	2	3	2	–	–	–	2	2	3	2	3	–	2	2
CO3	3	2	2	3	3	–	–	–	2	2	3	2	3	2	2	2
CO4	3	3	3	2	2	–	–	–	2	2	3	3	3	–	3	3
CO5	3	3	2	2	2	–	–	–	2	2	3	3	3	–	3	3
CO6	3	3	2	3	2	–	–	–	2	2	3	3	3	–	3	3
CO7	3	3	2	2	2	–	–	–	2	2	3	2	3	–	3	3
CO8	3	2	2	2	2	–	–	–	2	2	3	2	3	–	2	2

Unit-wise Course Content

Unit 1: Electrical Circuits – Basics and DC Analysis

- Introduction to circuit parameters: Resistance (R), Inductance (L), Capacitance (C)
- Kirchhoff's Current Law (KCL) and Voltage Law (KVL)
- Solution of circuits using determinant method and matrix method
- Application of methods to T, π , and bridge circuits
- Thevenin's and Norton's Theorems – statement and applications
- Maximum power transfer theorem
- Steady state vs transient behavior in circuits
- Growth and decay of current in inductive circuits
- Charging and discharging of capacitors through resistors, and through series RL circuits
- Ballistic galvanometer – Charge (Qs), current (Cs), measurement of capacitance and high resistance by leakage method

Unit 2: AC Circuits and Resonance

- AC analysis: Phasor diagrams and vector treatment

- Complex impedance and admittance in LR, CR, and LCR circuits (series and parallel)
- Voltage-current relationships and vector diagrams
- Power consumed in AC circuits
- Resonance in series and parallel circuits
- Quality factor (Q) of a coil
- Transformer: principle and equivalent circuit

Unit 3: AC Bridges

- Concept of AC bridges and their uses
- Balance conditions and sensitivity of AC bridges
- Maxwell's bridge for inductance measurement
- Schering's bridge for capacitance measurement

Unit 4: Basics of Semiconductor Electronics

- Conductors, insulators, and semiconductors
- Charge carriers in semiconductors: Electrons and holes
- Intrinsic and extrinsic semiconductors
- Concepts of conductivity and mobility
- Conduction mechanisms: Drift and diffusion currents

Unit 5: P-N Junction and Diodes

- Formation of P-N junction: Built-in potential and depletion region
- Diode equation and characteristics
- Forward and reverse resistance of diode
- Zener diode: characteristics and voltage regulation applications
- Filtering circuits: RC and LC filters

Unit 6: Bipolar Junction Transistor (BJT)

- Structure and working of NPN and PNP transistors
- Characteristics in Common Base (CB) and Common Emitter (CE) configurations
- Hybrid parameters (h-parameters): α , β , and their interrelationship
- Load line analysis
- Small signal hybrid equivalent circuit of BJT
- CE amplifier and mid-frequency response
- Practical amplifier circuits

Unit 7: Oscillators and Feedback

- Principles of feedback in amplifiers
- Barkhausen criteria for sustained oscillations
- Qualitative discussion on collector tuned oscillators
- Hartley and Colpitts oscillator circuits

Unit 8: Modulation Techniques

- Need for modulation in communication
- Types of modulation: Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (PM)
- Frequency spectrum and power in AM wave
- Typical AM circuit
- Linear diode detector

Unit 9: Cathode Ray Oscilloscope (CRO)

- Working principle of cathode ray tube (CRT)
- Block diagram and major components of CRO

Recommended Textbooks

1. **Vinod Prakash** – *Electric Circuits and Basic Semiconductor Devices (as requested)*
2. **Robert L. Boylestad & Louis Nashelsky**, -*Electronic Devices and Circuit Theory*

3. *M. Nahvi & J. Edminister, -Schaum's Outline of Electric Circuits*
4. *V.K. Mehta & Rohit Mehta-Principles of Electronics*

B.Sc. Part II: Course Details

Paper-I Optics

Course Objectives:

This course aims to:

1. Introduce the fundamental concepts of geometric optics and wave optics.
2. Explain interference, diffraction, and polarization of light using analytical and graphical methods.
3. Introduce basic optical instruments and techniques, including lasers and interferometers.
4. Develop practical understanding of resolving power, coherence, and optical activity.

Course Outcomes (COs)

CO	Course Outcome
CO1	Understand geometrical optics concepts including cardinal points and optical combinations.
CO2	Explain the nature of light and apply the theory of interference to practical setups.
CO3	Understand diffraction phenomena and compute resolving power of optical instruments.
CO4	Describe the principles and types of lasers and interferometers.
CO5	Understand and analyze polarization of light and optical activity phenomena.
CO6	Use wave theory to interpret and solve problems involving coherence, diffraction, and interference.

CO–PO–PSO Mapping Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	2	2	–	–	–	2	2	2	2	3	–	2	2
CO2	3	3	3	3	3	–	–	–	2	2	3	2	3	–	3	3
CO3	3	3	3	3	2	–	–	–	2	2	3	3	3	–	3	3
CO4	3	2	2	2	2	–	–	–	2	2	3	2	3	–	2	2

CO5	3	3	2	3	2	–	–	–	2	2	3	3	3	–	3	3
CO6	3	3	3	3	2	–	–	–	3	2	3	3	3	–	3	3

Unit-wise Course Content:

Unit 1: Geometrical Optics

- Cardinal points of coaxial optical systems
- Combination of thin lenses and eyepieces
- Aplanatic points
- Optical instruments: magnifying power and focal adjustments

Unit 2: Nature of Light and Interference

- Wave and photon nature of light
- Complex representation of waves
- Conditions for interference: coherence, visibility
- Michelson interferometer and its applications
- Thin film interference, Newton's Rings
- Multiple reflections and Fabry-Perot etalon
- Temporal and spatial coherence
- Stellar interferometer

Unit 3: Lasers and Stimulated Emission

- Stimulated and spontaneous emission
- Basic principles of laser action
- Ruby and He-Ne lasers – construction, working, applications

Unit 4: Diffraction

- Fresnel diffraction: half-period zones, Cornu's spiral
- Diffraction at edges, slits, and circular apertures
- Zone plates and their imaging properties
- Fraunhofer diffraction: single and double slits
- Diffraction grating: theory, principal maxima width
- Rayleigh's criterion, resolving power of optical instruments
- Concave grating and mounting

Unit 5: Polarization

- Polarised, unpolarised, and partially polarised light
- Polarization by reflection and double refraction
- Huygen's theory, Polaroids
- Wave plates: half-wave, quarter-wave
- Elliptical and circular polarization
- Babinet compensator and Nicol prism
- Analysis of elliptically polarized light
- Optical activity, Fresnel's theory of optical rotation
- Specific rotation, Biquartz and Laurent's polarimeters

Recommended Textbooks

1. **Ajoy Ghatak** – *Optics*
2. **E. Hecht** – *Optics* (Pearson)
3. **Subrahmanyam, Brijlal & Avadhanulu** – *A Textbook of Optics*
4. **N. Subrahmanyam & Lal** – *Waves and Oscillations* (for coherence and interference)
5. **Ghatak & Thyagarajan** – *Lasers: Fundamentals and Applications*
6. **Born & Wolf** – *Principles of Optics* (for advanced reference)

Paper II : Oscillation, Waves and Electromagnetism

Course Objectives:

- To develop an understanding of simple harmonic, damped, and forced oscillations and their real-world applications.
- To study wave propagation in strings and fluids and explore standing waves, energy transfer, and acoustic impedance.
- To understand the fundamentals of electrostatics, magnetostatics, and time-varying fields.
- To derive and interpret Maxwell's equations and electromagnetic wave propagation in free space.

Course Outcomes (COs)

CO	Course Outcome
CO1	Understand and analyze simple, damped, and forced harmonic oscillations and waveforms using Fourier series.
CO2	Explain wave propagation in strings and fluids; apply concepts of impedance and energy transfer.
CO3	Understand the generation, detection, and applications of ultrasonic waves.
CO4	Analyze electrostatics in free space and dielectrics using Gauss's law and electrostatic energy.
CO5	Understand current density, Ohm's law, and magnetostatic field concepts.
CO6	Apply Faraday's law and concept of displacement current to time-varying fields and inductance.
CO7	Derive and apply Maxwell's equations; explain properties of electromagnetic waves in free space.

CO–PO–PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	3	2	–	–	–	2	2	3	2	3	–	3	2
CO2	3	3	2	3	3	–	–	–	2	2	3	3	3	–	3	2
CO3	3	2	2	2	2	–	–	–	2	2	3	2	3	–	2	2
CO4	3	3	3	3	3	–	–	–	2	2	3	3	3	–	3	3

CO5	3	3	2	2	2	—	—	—	2	2	3	3	3	—	3	3
CO6	3	3	2	3	3	—	—	—	2	2	3	3	3	—	3	3
CO7	3	3	3	3	3	—	—	—	2	2	3	3	3	—	3	3

Unit-wise Course Content

Unit 1: Oscillations

- Simple Harmonic Motion (SHM): Definition, equation of motion, energy
- Damped motion: Damping coefficient, underdamped, overdamped, critically damped systems
- Forced oscillations and resonance
- Fourier series: Basics and decomposition of square, sawtooth, and rectified sine waves

Unit 2: Wave Motion in Non-dispersive Media

- Wave equation and progressive wave solution
- Wave motion in strings and fluids
- Particle and wave velocity
- Specific acoustic impedance and energy density
- Intensity of energy transfer
- Reflection and transmission of waves at a boundary
- Standing waves, natural modes of oscillation

Unit 3: Ultrasonics

- Generation and detection of ultrasonic waves
- Measurement of velocity in liquids
- Applications: SONAR, medical imaging, material testing

Unit 4: Electrostatics in Free Space

- Coulomb's law and electric field for simple charge distributions

- Gauss's law (integral and differential form)
- Electric dipole in external field
- Electrostatic potential and its irrotational nature

Unit 5: Electrostatics in Dielectrics

- Polarization and bound charges
- Displacement field **D**
- Gauss's law in dielectrics
- Electrostatic energy as a field integral
- Applications: parallel plate capacitor, charged sphere

Unit 6: Electric Current

- Current density vector
- Continuity equation
- Ohm's law (point and integral form)
- Joule's law

Unit 7: Magnetostatics

- Biot–Savart law and Ampère's law
- Magnetic force on charges and currents
- Magnetic field due to wire, circular loop, and solenoid
- Vector potential and its evaluation
- Divergence and curl of **B**
- Magnetic moment and distant field of current loop
- Magnetization, magnetic materials, field **H**, magnetization current

Unit 8: Time-Varying Fields

- Displacement current and Maxwell's correction

- Faraday's law (integral and differential form)
- Self and mutual inductance
- Magnetic energy in coupled circuits
- Energy stored in solenoid

Unit 9: Electromagnetic Waves in Free Space

- Maxwell's equations in free space
- Plane electromagnetic waves: solution and characteristics
- Electric and magnetic fields in plane waves

Recommended Textbooks

1. **D.V. Halliday, R. Resnick, J. Walker** – *Fundamentals of Physics*
2. **H.J. Pain** – *The Physics of Vibrations and Waves*
3. **David J. Griffiths** – *Introduction to Electrodynamics*
4. **M.N. O. Sadiku** – *Elements of Electromagnetics*
5. **B.L. Theraja** – *Electrical Technology (for Ultrasonics and Applications)*
6. **J.C. Upadhyay** – *Classical Electrodynamics*

Paper III : Atomic and Nuclear Physics

Course Objectives:

- Understand the development of atomic models and quantum numbers.
- Explore magnetic properties of materials using classical and quantum models.
- Introduce basic concepts of quantum mechanics and its applications to potential problems.
- Learn the fundamentals of nuclear structure, radioactivity, nuclear reactions, and elementary particles.

Course Outcomes (COs)

CO	Course Outcome
CO1	Explain atomic structure and electron configurations using quantum numbers and experimental results.
CO2	Understand magnetic properties of materials based on classical and quantum theories.
CO3	Apply quantum concepts like wave-particle duality, uncertainty, and Schrödinger equation to physical problems.
CO4	Analyze nuclear structure, reactions, and radioactive decay processes.
CO5	Understand the structure of atomic nucleus and applications of nuclear physics.
CO6	Identify and classify elementary particles and apply conservation laws in nuclear and particle interactions.

CO–PO–PSO Mapping Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	3	2	–	–	–	2	2	3	2	3	–	3	2
CO2	3	2	2	2	2	–	–	–	2	2	2	2	3	–	2	2
CO3	3	3	3	3	3	–	–	–	3	2	3	3	3	–	3	3
CO4	3	3	3	2	3	–	–	–	2	2	3	3	3	–	3	3
CO5	3	3	3	2	2	–	–	–	2	2	3	3	3	–	3	3
CO6	3	3	3	3	3	–	–	–								

Unit-wise Course Content

Unit 1: Atomic Physics

- Bohr and Bohr-Sommerfeld atomic models
- Spectra of hydrogen and hydrogen-like atoms
- Ionization potential, Critical potential
- Franck-Hertz experiment
- X-rays: Continuous and characteristic, Moseley's law, Bragg's law
- Vector atom model, space quantization, orbital and spin angular momenta
- Magnetic moment, Bohr magneton, Larmor precession
- Stern-Gerlach experiment
- Quantum numbers, Pauli exclusion principle
- Electronic configuration of atoms

Unit 2: Magnetic Properties of Materials

- Diamagnetism and Larmor's theory
- Paramagnetism: Langevin's theory
- Curie and Curie-Weiss laws
- Ferromagnetism and antiferromagnetism: qualitative discussion

Unit 3: Quantum Concepts

- Particle nature of radiation: Photoelectric and Compton effects
- Wave nature of matter: De Broglie waves
- Davisson-Germer experiment
- Wave packets, phase and group velocity
- Heisenberg uncertainty principle (applications)
- Schrödinger's wave equation (1D): Concept of probability and amplitude
- Applications: Potential step, barrier, and quantum tunneling

Unit 4: Nuclear Physics

- Radioactivity: Laws of disintegration, radioactive series
- Radiation detection: GM counter, bubble chamber, scintillation counter
- Nuclear reactions: Kinematics, artificial transmutation
- Discovery of neutron, tracers, transuranic elements
- Cyclotron: working and applications
- Nucleus structure: Binding energy, liquid drop model, semi-empirical mass formula
- Alpha and beta decay, neutrino hypothesis
- Magic numbers and shell model
- Exchange forces and Yukawa theory (qualitative)
- Nuclear fission and fusion, nuclear reactors
- Thermonuclear energy

Unit 5: Elementary Particles

- Classification of particles: Leptons, mesons, baryons
- Quantum numbers: Charge, spin, parity, strangeness, isospin
- Conservation laws in particle physics

Recommended Textbooks

1. **H.S. Mani & G.K. Mehta** – *Introduction to Modern Physics*
2. **Arthur Beiser** – *Concepts of Modern Physics*
3. **E. Hecht** – *Physics: Atomic and Nuclear Physics*
4. **S.N. Ghoshal** – *Nuclear Physics*
5. **Resnick & Halliday** – *Fundamentals of Physics*
6. **Kenneth S. Krane** – *Modern Physics*
7. **D.J. Griffiths** – *Introduction to Elementary Particles*

B.Sc. III: Course Details

Paper – I QUANTUM MECHANICS

Course Objectives

- Introduce the need for quantum mechanics and develop the formalism using wave functions and operators.
- Solve Schrödinger's equation for basic systems like harmonic oscillator and hydrogen atom.
- Understand the mathematical tools of quantum theory including Hermitian operators, commutators, and eigenvalue problems.
- Explore the concept of angular momentum, spin, perturbation theory, and identical particles

Course Outcomes (COs)

CO	Course Outcome
CO1	Understand the foundational postulates of quantum mechanics and the role of the wave function.
CO2	Apply operator formalism to solve eigenvalue problems in quantum mechanics.
CO3	Analyze tunneling, harmonic oscillator, and particle-in-a-box problems using Schrödinger equation.
CO4	Understand angular momentum algebra and apply it to the hydrogen atom.
CO5	Explain spin, spin-orbit coupling, helium atom structure, and the behavior of identical particles in quantum systems.

CO–PO–PSO Mapping Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	3	2	–	–	–	2	2	3	2	3	–	3	2
CO2	3	3	3	3	3	–	–	–	3	2	3	3	3	–	3	3
CO3	3	3	3	3	3	–	–	–	3	2	3	3	3	–	3	3
CO4	3	3	3	2	3	–	–	–	2	2	3	3	3	–	3	3
CO5	3	3	3	2	2	–	–	–	2	2	3	3	3	–	3	3

Unit-wise Course Content

Unit 1: Fundamentals of Quantum Mechanics

- Need for Quantum Mechanics
- Schrödinger Equation (time-dependent and time-independent)
- Interpretation of wave function
- Observables and operators
- Hermitian and parity operators
- Commutation relations
- Eigenvalues and eigenfunctions
- Orthonormality and completeness
- Dirac delta function

Unit 2: Quantum Measurement and Formalism

- Quantum measurement theory
- Non-commutability and uncertainty
- Expectation values
- Ehrenfest's Theorem
- Separation of variables in time-dependent Schrödinger equation
- Density of states

Unit 3: Applications of Schrödinger Equation

- One-dimensional potential barriers and tunneling
- Square well potential and step potential
- Quantum tunneling
- Harmonic oscillator: solution, Hermite polynomials, zero-point energy
- Correspondence with classical mechanics

Unit 4: Angular Momentum and Hydrogen Atom

- Angular momentum operators: L^2 , L_z , ladder operators
- Commutation relations and eigenvalue problems

- Spherically symmetric potentials
- Complete solution of hydrogen atom
- Energy levels and hydrogen spectrum

Unit 5: Spin and Many-Particle Systems

- Elementary concept of spin
- Pauli spin matrices and spin wave functions
- Total angular momentum $J=L+S$
- Spin-orbit coupling
- Ground and excited states of helium atom
- Exchange degeneracy
- Lamb shift (qualitative idea)
- Identical particles
- Symmetric and antisymmetric wave functions
- Pauli Exclusion Principle

Recommended Textbooks

1. **David J. Griffiths** – *Introduction to Quantum Mechanics*
2. **L.I. Schiff** – *Quantum Mechanics*
3. **P.M. Mathews & K. Venkatesan** – *A Textbook of Quantum Mechanics*
4. **S.N. Ghoshal** – *Atomic and Nuclear Physics*
5. **J.J. Sakurai** – *Modern Quantum Mechanics*
6. **Ajoy Ghatak & S. Lokanathan** – *Quantum Mechanics: Theory and Applications*

Paper – II STATISTICAL MECHANICS AND SOLID STATE PHYSICS

Course Objectives

- To develop a foundational understanding of classical and quantum statistical mechanics.
- To derive thermodynamic quantities using partition functions and statistical ensembles.
- To explore the microscopic origins of macroscopic properties of solids.
- To understand crystal structures, lattice dynamics, and the electronic properties of solids.
- To apply quantum statistics to real-world physical systems such as blackbody radiation and electron gases.

Course Outcomes (COs)

CO	Course Outcome
CO1	Apply principles of classical mechanics to describe statistical systems using phase space formalism.
CO2	Use statistical ensembles to derive thermodynamic properties of classical and quantum gases.
CO3	Distinguish between classical, Bose-Einstein, and Fermi-Dirac statistics and apply to physical systems.
CO4	Understand and interpret crystal structures, Miller indices, and reciprocal lattices.
CO5	Analyze lattice vibrations and thermal properties using models like Einstein and Debye.
CO6	Describe electron behavior in solids using band theory and understand electrical and thermal properties of conductors and semiconductors.

CO–PO–PSO Mapping Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	2	–	–	–	2	2	3	2	3	–	3	2
CO2	3	3	3	3	3	–	–	–	3	2	3	3	3	–	3	3
CO3	3	3	3	3	3	–	–	–	3	2	3	3	3	–	3	3
CO4	3	2	2	2	2	–	–	–	2	2	2	2	3	–	2	2
CO5	3	3	3	3	2	–	–	–	2	2	3	3	3	–	3	3
CO6	3	3	3	3	3	–	–	–								

Unit-wise Course Content

Unit 1: Classical and Quantum Statistical Mechanics

- Lagrangian and Hamiltonian mechanics (elementary concepts)
- Hamilton's equations of motion
- Microscopic vs. macroscopic systems
- Phase space and division into cells
- Liouville's theorem and consequences
- Statistical ensembles: microcanonical, canonical, grand canonical
- Equilibrium and fluctuations
- Probability distributions and thermal, mechanical, and diffusive equilibrium
- Entropy and probability
- Entropy of a perfect gas using microcanonical ensemble
- Gibbs paradox

Unit 2: Quantum Statistics and Applications

- Postulates of quantum statistical mechanics
- Partition functions and thermodynamic functions
- Entropy of monoatomic gas via canonical and grand canonical ensembles
- Principle of equipartition of energy
- Maxwell's velocity distribution
- Bose-Einstein and Fermi-Dirac statistics
- Applications:
 - Black-body radiation (Planck distribution)
 - Electronic specific heat (free electron gas)

Unit 3: Crystallography and Crystal Structures

- Crystalline, amorphous, and glassy states
- Lattice vectors and crystal lattices

- Primitive cell, unit cell, and Miller indices
- Interplanar spacing
- Bravais lattices
- Structures: s.c., b.c.c., f.c.c., diamond, h.c.p.
- Reciprocal lattice for s.c., b.c.c., f.c.c.
- Brillouin zones and diffraction conditions
- Bragg's law

Unit 4: Lattice Dynamics and Elastic Properties

- Interatomic forces and classification of solids
- Van der Waals interaction, repulsive forces
- Equilibrium lattice constant
- Compressibility, bulk modulus
- Lattice energy and Madelung constant
- Cohesive energy
- Generalized Hooke's law
- Elastic constants of cubic crystals
- Monoatomic linear chain vibrations
- Dispersion relation, group velocity
- Diatomic linear chain: acoustic and optical modes
- Lattice specific heat: Einstein and Debye models

Unit 5: Electron Theory and Band Structure

- Free electron gas in 1D: energy levels and density of states
- Fermi energy and distribution
- Electrical conductivity and Hall effect
- Band theory of solids

- Kronig–Penney model
- Energy bands and gaps
- Density of states in bands
- Metals, semiconductors, insulators
- Intrinsic semiconductors: Fermi level variation with temperature
- Effective mass of electrons

Recommended Textbooks

1. **R.K. Pathria & Paul D. Beale** – *Statistical Mechanics*
2. **F. Reif** – *Fundamentals of Statistical and Thermal Physics*
3. **C. Kittel** – *Introduction to Solid State Physics*
4. **M.A. Wahab** – *Solid State Physics*
5. **S.O. Pillai** – *Solid State Physics*
6. **Ashcroft and Mermin** – *Solid State Physics*
7. **S. Lokanathan & R.S. Gambhir** – *Statistical and Thermal Physics*

Paper – III BASIC DIGITAL ELECTRONICS AND PHOTONIC DEVICES

Course Objectives

- To understand the operational characteristics of diodes, BJTs, FETs, and MOSFETs.
- To analyze switching behavior and speed of semiconductor devices.
- To introduce logic gates, Boolean algebra, and combinational logic circuits.
- To explain semiconductor photonic devices and their applications.
- To introduce integrated circuit fabrication and digital logic families.

Course Outcomes (COs)

CO	Course Outcome
CO1	Understand characteristics and switching behavior of semiconductor diodes and BJTs.
CO2	Analyze the structure and operation of FETs, MOSFETs, and Schottky devices.
CO3	Apply Boolean algebra and Karnaugh maps to simplify digital logic expressions.
CO4	Construct and analyze combinational logic circuits like adders and subtractors.
CO5	Describe fabrication techniques of ICs and working principles of semiconductor-based photonic devices.

CO–PO–PSO Mapping Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	3	–	–	–	2	2	2	2	3	–	2	2
CO2	3	3	3	3	3	–	–	–	2	2	3	2	3	–	3	2
CO3	3	3	3	3	3	–	–	–	3	2	3	3	3	–	3	3
CO4	3	3	3	2	3	–	–	–	3	2	3	3	3	–	3	3
CO5	3	3	3	2	2	–	–	–								

Unit-wise Course Content

Unit 1: Semiconductor Diodes and BJTs

- Review of characteristics of a semiconductor diode
- Cut-in voltage, storage and transition capacitances

- Diode switching speed, storage and transition times
- Bipolar Junction Transistor (BJT) as a switch
- Ebers-Moll model: Analytic expression
- Saturation properties: Normal, inverse, emitter follower mode
- Comparison of BJT configurations

Unit 2: Advanced Diodes and Transistors

- Metal-semiconductor junctions
- Schottky diode: principle, characteristics, advantages
- Schottky transistor: applications
- Field Effect Transistor (FET): principle, practical structure
- MOSFET: Enhancement and depletion modes
- The MOS switch and digital logic applications

Unit 3: Logic Gates and Boolean Algebra

- Logic gates: AND, OR, NOT, NOR, NAND, XOR
- Truth tables and logic symbols
- Venn diagram representations
- Binary number system
- Boolean algebra: identities and simplification
- Karnaugh maps: simplification of Boolean expressions

Unit 4: Logic Families and Digital Circuits

- RTL (Resistor Transistor Logic): NOR gates, pull-up resistors, fanout, I/O characteristics, rise time
- RTL XOR gate
- DTL (Diode Transistor Logic): fanout, I/O characteristics
- TTL (Transistor-Transistor Logic): active pull-up, I/O characteristics

- Comparison of logic families: RTL, DTL, TTL

Unit 5: Combinational Circuits and Photonic Devices

- Combinational logic:
 - Half adder, full adder (parallel and serial)
 - Half and full subtractor
 - BCD adder
- Integrated Circuits (ICs):
 - Fabrication techniques
 - LSI and MSI
 - Metal-semiconductor contact
- Photonic Devices:
 - Photoelectric effect in semiconductors
 - Photoresistors and photoconductors
 - LEDs and visible displays
 - Photodiode, phototransistor
 - Solar cell and its characteristics

Recommended Textbooks

1. **Millman & Halkias** – *Integrated Electronics*
2. **R.S. Sedha** – *Applied Electronics*
3. **Morris Mano** – *Digital Logic and Computer Design*
4. **B.L. Theraja** – *Basic Electronics*
5. **Albert Malvino & David Bates** – *Electronic Principles*
6. **Vinod Prakash** – *Electric Circuits and Basic Semiconductor Devices (as requested)*
7. **S. Salivahanan** – *Electronic Devices and Circuits*
8. **Boylestad & Nashelsky** – *Electronic Devices and Circuit Theory*

Paper – IV ELECTROMAGNETIC THEORY, LASER, HOLOGRAPHY AND OPTICAL INSTRUMENTS

Course Objectives

- To deepen students' understanding of electromagnetic theory beyond Maxwell's equations—field energy, momentum, stress tensor, wave propagation in media, dispersion, and boundary phenomena.
- To build competence in advanced optics topics like lasers, holography, interference, and high-resolution spectroscopy.
- To develop the ability to apply theory to real-world optical and electromagnetic systems.

Course Outcomes (COs)

CO	Upon completing this course, a student will be able to...
CO1	Compute electrostatic potentials for complex charge distributions using multipole expansions and solve Laplace's equation in various coordinate systems.
CO2	Apply Poynting's theorem and Maxwell's stress tensor to evaluate energy, momentum, and forces in electromagnetic systems.
CO3	Analyze propagation of electromagnetic waves in different media, understand dispersion, reflection, polarization and skin effect.
CO4	Understand the physics of lasers: stimulated emission, gain, threshold, and laser light properties.
CO5	Explain the recording and reconstruction principles of holography and interpret different types of holograms.
CO6	Use advanced optical instruments such as Fabry–Pérot etalons and spectrographs and compute their resolving power and performance.

CO–PO–PSO Mapping Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	3	2	–	–	–	2	2	3	2	3	–	3	2
CO2	3	3	3	3	3	–	–	–	2	2	3	3	3	–	3	3
CO3	3	3	3	3	2	–	–	–	3	2	3	3	3	–	3	3
CO4	3	2	2	2	2	–	–	–	2	2	3	2	3	–	2	2
CO5	3	2	2	2	2	–	–	–	2	2	3	2	3	–	2	2
CO6	3	2	2	2	2	–	–	–	2	2	3	2	3	–	2	2

Unit-Wise Course Content

Unit 1: Electrostatics & Potential Theory

- Electrostatic potential due to arbitrary charge distributions
- Multipole expansion and interaction with external fields
- Solving **Laplace's equation** via separation of variables (Cartesian, spherical, and polar coordinates)

Unit 2: Energy, Momentum & Fields

- Poynting's theorem: energy conservation in electromagnetic fields
- Conservation of momentum: forces on charges + fields
- Maxwell's stress tensor and its physical interpretation

Unit 3: Electromagnetic Waves in Media

- Plane-wave solutions to Maxwell's equations in free space and non-conducting dielectrics
- Polarization of EM waves
- Wave propagation in conducting media (metals) and plasmas
- Basic theory of dispersion
- Boundary conditions at interfaces: Fresnel's formulas, total internal reflection, metallic reflection, skin depth

Unit 4: Laser Physics

- Stimulated vs spontaneous emission
- Einstein's coefficients and their relationships
- Population inversion and threshold conditions for lasing
- Characteristics of laser light (coherence, monochromaticity, directionality, temporal properties)
- Light amplification in inverted media

Unit 5: Holography

- Principles of holography: recording and reconstruction
- Types of holograms: thick (volume) hologram, multiplex hologram, white-light reflection holograms

- Conditions for viewing, contrast, and resolution

Unit 6: Optical Instruments & Interferometry

- Multiple-beam interferometry: Fabry–Pérot interferometer/etalon (resolving power, wavelength measurement)
- Resolving power of (Lummer–Gehrcke) plate
- Grating and prism spectrographs: for visible, IR, and UV ranges
- Application of dispersion and resolution in optical instrumentation

Recommended Textbooks & References

1. *Classical Electrodynamics* by John David Jackson
2. *Introduction to Electrodynamics* by David J. Griffiths
3. *Lasers: Theory and Practice* by K. Thyagarajan & Ajoy Ghatak
4. *Optics* by Eugene Hecht
5. *Fundamentals of Photonics* by Bahaa E. A. Saleh & Malvin Carl Teich
6. *Principles of Optics* by Max Born & Emil Wolf