Detailed Syllabus of 3rd Semester Minor Courses

Course Title: Thermal Physics
Course Code: MIN PHY 3.1
Nature of Course: Minor I
Total credits: 4 (Theory-3, practical-1)
Total marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objective: The aim of the course is to To equip students with a critical understanding of thermodynamic principles, enabling them to analyze statistical interpretations of thermodynamic laws and comprehend key thermodynamic properties and potentials.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Basic Laws and First Law of Thermodynamics	Thermodynamic Equilibrium, Zeroth Law of Thermodynamics and Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy and First Law for various processes, Applications of First Law: Relation between CPC_PCP and CVC_VCV Work done in isothermal and adiabatic processes	9	9	9
Unit 2: Second Law of Thermodynamics and Entropy	Reversible and Irreversible processes, Heat Engines, Carnot's Cycle and Efficiency, Refrigerators and Coefficient of Performance, Second Law: Kelvin-Planck and Clausius Statements, their equivalence, Carnot's Theorem, Thermodynamic Scale of Temperature, Concept of Entropy, Clausius Theorem and Inequality, Entropy in reversible and irreversible processes, Entropy of a perfect gas and entropy of the universe.	9	9	9
Unit 3: Thermodynamic Potentials and Phase Transitions	Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Definitions, Properties and Significance, Magnetic Work and Adiabatic Demagnetization. First and Second Order Phase Transitions (with examples), Temperature–Entropy diagram for Carnot's Cycle, Third Law of Thermodynamics, Unattainability of Absolute Zero.	9	9	9
Unit 4: Maxwell's Relations and Applications	Derivation of Maxwell's Relations, Applications: Clausius-Clapeyron Equation, Calculation of CP−CV, TdS Equations, Joule-Kelvin Coefficient for Ideal and Van der Waals gases, Energy Equations	9	9	9

Unit 5: Kinetic Theory of Gases and Real Gases	Maxwell-Boltzmann Distribution and Experimental Verification, Doppler Broadening, Stern's Experiment, Mean, RMS and Most Probable Speeds, Degrees of Freedom and Law of Equipartition (qualitative), Behaviour of Real Gases, Virial Equation, Andrew's Experiment on CO_2, Van der Waals Equation, Critical Constants, P-V Diagrams, Continuity of States, Joule's and Joule-Thomson Experiments, Joule-Thomson Effect for Real and Van der Waals Gases.	9	9	9
Total		**45**	**45**	**45**

General Lab Practical: (Minimum five experiments are to be performed in classes)

One experiment is to be performed in the Examination

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 study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its two Junctions.
6. To record and analyze the cooling temperature of a hot body as a function of time using thermocouple.
7. To determine Stefan's Constant by electric bulb method.

Course outcomes: After completing this course the students will be able to

CO1: Understand and apply the zeroth and first laws of thermodynamics to different thermodynamic systems and processes.

CO2: Evaluate the implications of the second and third laws of thermodynamics, including entropy changes in reversible and irreversible processes.

CO3: Analyze thermodynamic potentials and their applications in physical and magnetic systems, including phase transitions.

CO4: Derive and utilize Maxwell's relations and related equations to study energy changes and properties of thermodynamic systems.

CO5: Interpret kinetic theory and real gas behavior, including molecular velocity distributions and deviations from ideal gas laws.

Suggested Readings

1. Worsnop, B. L., & Flint, H. T. (1923). *Advanced Practical Physics for Students*. Asia Publishing House.
2. Nelson, M., & Ogborn, J. M. (1985). *Advanced Level Physics Practicals* (4th ed.). Heinemann Educational Publishers.
3. Prakash, I., & Ramakrishna. (2011). *A Textbook of Practical Physics* (11th ed.). Kitab Mahal.
4. Panigrahi, S., & Mallick, B. (2015). *Engineering Practical Physics*. Cengage Learning India Pvt. Ltd.
5. Squires, G. L. (2001). *Practical Physics* (4th ed.). Cambridge University Press.

Course Title: Mathematical Physics
Course Code: MIN PHY 3.2
Nature of Course: Minor II
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc.) =20

Course objective: The objective of this course is to familiarize students with advanced mathematical methods required in undergraduate physics. The course introduces series solutions of differential equations, special functions, matrix methods, partial differential equations, and Fourier series, which are extensively used in quantum mechanics, electrodynamics, statistical mechanics, solid-state physics, and other branches of physics.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Vector Algebra	Vector algebra, scalar and vector product with illustration from physics, vector triple products. Vector calculus: scalar field and vector field with examples, space curve, differentiation of a vector with respect to a scalar, gradient of a scalar, divergence and curl of a vector with examples from physics.	12	12	12
Unit 2: Integrals	Ordinary integration of vectors, Line integral, surface integral and volume integral, Gauss's theorem, Stoke's theorem and Green's theorem and their applications.	10	10	10
Unit 3: Coordinate systems	Curvilinear coordinate system, coordinate line and coordinate surface, unit normal vectors and unit tangent vectors, scale factor, orthogonal curvilinear coordinates, cylindrical polar coordinates and spherical polar coordinate systems.	11	11	11
Unit 4: Differential equation	**First-order differential equations**: Separable, homogeneous, exact, and linear equations with illustrative physical examples (e.g., radioactive decay, RC circuits). **Second-order linear differential equations** with constant coefficients: Homogeneous and non-homogeneous cases, method of undetermined coefficients and variation of parameters. **Applications in physics:** Simple harmonic oscillator, damped and driven harmonic motion, LC circuits. **Brief introduction to partial differential equations (PDEs)**: Classification (elliptic, parabolic, hyperbolic), with examples like heat equation, wave equation, and Laplace's equation.	15	15	15
Unit 5: Tensor Analysis	**Introduction to tensors**: Scalars, vectors, and tensors; transformation properties under rotation and general coordinate transformations. Rank of a tensor, symmetric and antisymmetric tensors. Metric tensor, Kronecker delta, Levi-Civita symbol.	12	12	12
Total		**60**	**60**	**60**

Course Outcomes: On successful completion of this course students will be able to
CO1: Understand and apply vector algebra and vector calculus to analyze physical phenomena such as fields, forces, and fluid flow.
CO2: Perform and interpret line, surface, and volume integrals, and apply Gauss's, Stokes', and Green's theorems to physical problems.
CO3: Use curvilinear coordinate systems (cylindrical and spherical) and compute scale factors, tangent and normal vectors in orthogonal systems.
CO4: Solve ordinary and basic partial differential equations and relate them to physical systems like oscillations and wave propagation.
CO5: Grasp the basics of tensor algebra and apply tensor concepts in mechanics and field theory, including stress and electromagnetic tensors.

Suggested Readings:

1. Spiegel, M. R. (1968). *Vector Analysis*. Schaum's Outline Series, McGraw-Hill.
2. Gupta, A. B., & Ghosh, D. (1993). *Atomic & Nuclear Physics*. Pragati Prakashan.
3. Arfken, G. B., Weber, H. J., & Harris, F. E. (2013). *Mathematical Methods for Physicists* (7th ed.). Elsevier Academic Press.
4. Riley, K. F., Hobson, M. P., & Bence, S. J. (2010). *Mathematical Methods for Physics and Engineering* (3rd ed.). Cambridge University Press.
5. Mathews, J. & Walker, R. L. (1970). *Mathematical Methods of Physics* (2nd ed.). Benjamin-Cummings.
6. Simmons, G. F. (1972). *Differential Equations with Applications and Historical Notes* (2nd ed.). McGraw-Hill.
7. Chatterjee, A. W. (2005). *Tensor Calculus*. University Press.

Detailed Syllabus of 4th Semester Minor Courses

Course Title: Electricity and Magnetism
Course Code: MIN PHY 4.1
Nature of Course: Minor I
Credits: 4 (Theory-3, practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The objective of this course is to provide a comprehensive understanding of vector calculus and its application to electrostatics, magnetism, electromagnetic induction, and Maxwell's equations, enabling students to analyze and solve fundamental problems in classical electromagnetism and electromagnetic wave propagation.

Course Outlines

Units	Content	L	M	Hours
Unit 1: 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. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.	15	15	15
Unit 2: Magnetism	Magnetostatics: Biot-Savart's law, and its applications to – (i) straight conductor, (ii) circular coil and (iii) solenoid carrying current. Divergence and curl of a 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.	10	10	10
Unit 3: 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.	8	8	8

Unit 4: Maxwell's Equations and EM Wave	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, polarization.	12	12	12
Total		**45**	**45**	**45**

General Lab Practical:
Minimum five experiments are to be performed in classes
(One experiment is to be performed in examination)

1. To study the function of Multimeter and use it for measuring
   (a) Resistances, (b) AC and DC Voltages, (c) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De' Sauty's bridge.
6. Measurement of field strength **B** and its variation in a solenoid (determine dB/dx).
7. To determine self-inductance of a coil by Anderson's bridge.
8. To study response curve of a Series or Parallel LCR circuit and determine
   (a) Resonant frequency (b) Band width (c) Quality factor Q

Course Outcomes: Upon completion of this course, students are expected to
CO1: Understand and apply vector algebra, differential operators, and vector theorems to physical problems.
CO2: Analyze electrostatic fields and potentials for various charge distributions and dielectric media.
CO3: Explain magnetostatics concepts including Biot-Savart law, Ampere's law, and magnetic properties of materials.
CO4: Describe electromagnetic induction phenomena including self and mutual inductance and energy stored in magnetic fields.
CO5: Comprehend Maxwell's equations, electromagnetic wave propagation, and associated energy and polarization concepts.

Suggested Readings:

1. Griffiths, D. J. (2013). *Introduction to Electrodynamics* (4th ed.). Pearson.
2. Sadiku, M. N. O. (2014). *Elements of Electromagnetics* (6th ed.). Oxford University Press.
3. Hayt, W. H., & Buck, J. A. (2012). *Engineering Electromagnetics* (8th ed.). McGraw-Hill.
4. Balanis, C. A. (2012). *Advanced Engineering Electromagnetics* (2nd ed.). Wiley.
5. Jackson, J. D. (1999). *Classical Electrodynamics* (3rd ed.). Wiley

Course Title: Quantum Mechanics
Course Code: MIN PHY 4.2
Nature of Course: Minor II
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc.) =20

Course Objective: The objective of the course is to provide a fundamental understanding of the physical principles governing the properties of solids, focusing on crystal structure, bonding, lattice dynamics, electronic properties, and magnetic and dielectric behavior of materials.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Origin of Quantum Mechanics	Failure of classical physics. Blackbody radiation. Photoelectric effect. Compton effect. Wave-particle duality. de Broglie hypothesis. Davisson–Germer experiment. Heisenberg uncertainty principle and its applications. Wave packet (qualitative idea).	12	12	12
Unit 2: Wave Function and Schrödinger Equation	Wave function and its physical interpretation. Probability density and normalization. Expectation values. Operators, eigenvalues and eigenfunctions. Time-dependent and time-independent Schrödinger equations. Boundary conditions.	12	12	12
Unit 3: One-Dimensional Quantum Systems	Particle in a one-dimensional infinite potential well. Energy eigenvalues and eigenfunctions. Probability density. Finite potential well (qualitative treatment). Quantum tunnelling and its applications. Step potential (qualitative discussion).	12	12	12
Unit 4: Harmonic Oscillator and Hydrogen Atom	One-dimensional harmonic oscillator. Zero-point energy. Hydrogen atom (qualitative treatment). Quantum numbers. Atomic orbitals. Degeneracy of energy levels.	12	12	12
Unit 5: Angular Momentum and Applications	Orbital angular momentum. Angular momentum operators. Eigenvalues and eigenfunctions of angular momentum. Space quantization. Spin angular momentum (introductory). Applications of quantum mechanics in semiconductors, lasers, electron microscopy, nanotechnology, quantum dots, and quantum computing (introductory).	12	12	12
Total		**60**	**60**	**60**

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

CO1: Explain the limitations of classical physics and describe the origin and fundamental principles of quantum mechanics.
CO2: Interpret the physical meaning of the wave function and apply the Schrödinger equation to solve simple quantum mechanical problems.
CO3: Analyze elementary quantum systems such as the particle in a box, finite potential well, harmonic oscillator, and hydrogen atom.
CO4: Apply the concepts of operators, eigenvalues, angular momentum, quantum numbers, and electron spin in understanding microscopic systems.
CO5: Explain the role of quantum mechanics in modern science and technology, including semiconductors, lasers, nanotechnology, and quantum computing.

Suggested Readings:

1. Griffiths, D. J., & Schroeter, D. F. (2018). *Introduction to Quantum Mechanics* (3rd ed.). Cambridge University Press.
2. Eisberg, R., & Resnick, R. (1985). *Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles* (2nd ed.). John Wiley & Sons.
3. Ghatak, A., & Lokanathan, S. (2019). *Quantum Mechanics: Theory and Applications* (6th ed.). Macmillan India.
4. Mathews, P. M., & Venkatesan, K. (2017). *A Textbook of Quantum Mechanics* (2nd ed.). McGraw-Hill Education.
5. Zettili, N. (2009). *Quantum Mechanics: Concepts and Applications* (2nd ed.). John Wiley & Sons.
6. Beiser, A. (2003). *Concepts of Modern Physics* (6th ed.). McGraw-Hill Education.
7. Liboff, R. L. (2003). *Introductory Quantum Mechanics* (4th ed.). Addison-Wesley..

Detailed Syllabus of 5th Semester Minor Courses

Course Title: Nuclear Physics and Electronics -I
Course Code: MIN PHY 5.1
Nature of Course: Minor I
Credits: 4
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of this course is to offer the students the knowledge of general properties of nucleus, radioactivity, particle accelerator and detector etc.

Course Outlines

Units	Content	L	M	Hours
Unit 1: General Properties of Nuclei	Constituents of a nucleus. Mass, volume, density, radius, charge of a nucleus. Atomic mass unit (amu). Mass-defect, binding energy, packing fraction, average binding energy, binding energy curve and its significance. Nuclear reactions, fission and fusion reactions. Q value of a nuclear reaction. Endothermic and exothermic reactions.	12	10	12
Unit 2: Radioactivity	Types of radioactive decay. Soddy–Fazan's displacement law. Radioactive decay law. Half-life and mean life of a radioelement. Radioactive dating. Unit of radioactivity. Activity of radioactive sources. Radioisotopes, their production and uses. Alpha (α) decay. Range of an α particle. Geiger Nuttall law, (b) -decay: energy kinematics for -decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.	15	12	15
Unit 3: Accelerators and detectors	Need of particle accelerators. Linear accelerator – construction and working principle. Nuclear detectors. Ionization chamber- construction and working principle.	7	8	7
Unit 4: Semi-conductors	P and N type semiconductors, P-N junction diodes, unbiased and biased P-N junctions, depletion layer, barrier potential, diode characteristics, photo-diode, Zenter diode and their uses, LED and their uses	7	8	7
Unit 5: Rectifiers	Rectifier: half wave and full wave rectifier. Efficiency of rectification, ripple factor, shunt capacitor filter.	6	6	6

Unit 6: Transistors	Transistors. Different configurations and characteristics of transistors. Alpha and beta of a transistor and their relations. Transistor as amplifier. DC load line and Q-point of a transistor, Biasing and stability factors of a circuit. h parameter and its equivalent circuit. Classification of amplifiers: Class A, B and C.	13	12	13
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand nuclear properties, binding energy concepts, and nuclear reactions including fission, fusion, and Q-value.
CO2: Explain types of radioactive decay, laws of radioactivity, and applications of radioisotopes.
CO3: Describe α, β, and γ decay mechanisms along with related laws and concepts like neutrino hypothesis and internal conversion.
CO4: Understand the working of particle accelerators and nuclear detectors such as ionization chambers.
CO5: Analyze semiconductor devices, rectifiers, and transistors, including their configurations, biasing, amplifier classes, and applications.

Suggested readings:

1. Millman, J., & Halkias, C. C. (1991). *Integrated Electronics*. Tata McGraw-Hill.
2. Beiser, A. (2002). *Concepts of Modern Physics*. Tata McGraw-Hill.
3. Lilley, J. (2001). *Nuclear Physics: Principles and Applications*. Wiley.
4. Boylestad, R. L., & Nashelsky, L. (2009). *Electronic Devices and Circuit Theory*. Pearson Education.
5. Enge, H. A. (1986). *Introduction to Nuclear Physics*. Addison-Wesley.
6. Theraja, B. L. (2006). *Basic Electronics*. S. Chand & Company.
7. Neamen, D. A. (2012). *Semiconductor Physics and Devices*. McGraw-Hill Education.
1. M. P. (2011). *Essential Mathematical Methods*. Cambridge University Press.

Course Title: Electromagnetic Theory
Course Code: MIN PHY 5.2
Nature of Course: Minor II
Credits: 4
Total Marks: 100

Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objectives of this course are to offer the students the knowledge of Maxwell's equations, propagation of EM waves in different media, production and detection of different types of polarized EM waves, general information as waveguides and fiber optics.

Units	Content	L	M	Hours
Unit 1: Maxwell's equations	Deduction of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector.	8	8	8
Unit 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.	16	16	16
Unit 3: EM Wave Propagation in bounded Media	Boundary conditions at a plane interface between two media. Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients.	11	11	11
Unit 4: Polarization of Electromagnetic Waves	Uniaxial and Biaxial Crystals. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Mathematical treatment for the production of different type of polarized light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. 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.	18	18	18

Unit 5: Optical Fibres	Definitions of various optical fibers. Numerical Aperture. Step and Graded Indices. Concept of Single and Multiple Mode fibers and their uses.	7	7	7
Total		**60**	**60**	**60**

Detailed Syllabus of 6th Semester Minor Courses

Course Title: Atomic Physics and Solid state Physics
Course Code: MIN PHY 6.1
Nature of Course: Minor I
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course Objective: The objective of the course is to offer the students to acquire the knowledge of positive rays, Bohr's theory of hydrogen atom, vector atom model, X-rays etc. of atomic physics; and the main features of crystal lattices and phonons, understand the elementary lattice dynamics and its influence on the properties of materials, explain the dielectric ferroelectric and magnetic properties of solid.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Positive rays	Positive rays: analysis of positive rays. Properties of positive rays. Production of positive rays. Aston and Bainbridge mass spectrographs.	6	6	6
Unit 2: Bohr's theory	Bohr's theory of hydrogen atom. Energy level diagram. Ritz combination principle. Excitation potential, critical potential and ionization potential. Fine structures of the spectral lines. Sommerfield's extension of the Bohr's theory (qualitative only).	10	10	10
Unit 3: Vector atom model	Vector atom model. Bohr magneton, spinning electron. Quantum numbers. Pauli's exclusion principle, source of radiation in external fields – normal Zeeman effect.	8	8	8
Unit 4: X-rays and matter wave	Origin and production of X-rays. Continuous and characteristic X-rays. Moseley's law, diffraction of X-rays by crystals, Bragg's law, Compton effect. Frank and Hertz experiment, matter wave, Davisson and Germar experiment.	10	10	10
Unit 5: Crystal Structure	Amorphous and Crystalline Materials. Lattice Translation Vectors. Symmetry operations, 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.	10	10	10
Unit 6: Elementary Lattice Dynamics	Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids.	8	8	8

Unit 7: Magnetic Properties of Matter	Dia, Para, Ferri, and Ferromagnetic Materials. Classical Langevin Theory of Dia and Paramagnetic Domains. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Hysteresis and B-H Curve.	8	8	8
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand the fundamental concepts of positive rays, Bohr's hydrogen atom theory, and the vector atom model.
CO2: Explain the nature and properties of X-rays and their applications.
CO3: Describe the structure and characteristics of crystal lattices and phonons in solids.
CO4: Analyze elementary lattice dynamics and their impact on material properties.
CO5: Explain the dielectric, ferroelectric, and magnetic properties of solids and the behavior of electrons in solids.

Suggested Readings:

1. White, H. E. (1934). *Introduction to Atomic Spectra*. Tata McGraw-Hill.
2. Kumar, R. (1990). *Atomic and Molecular Spectra*.
3. Beiser, A. (1987). *Concepts of Modern Physics*. McGraw-Hill.
4. Rajam, J. B. (2007). *Atomic Physics*. S. Chand & Co.
5. Kittel, C. (2004). *Introduction to Solid State Physics* (8th ed.). Wiley India Pvt. Ltd.
6. Ghatak, A. K., & Kothari, L. S. (1970). *Lattice Dynamics*. Tata McGraw-Hill.
7. Dekker, A. J. (1966). *Solid State Physics*. Macmillan.
8. Ashcroft, N. W., & Mermin, N. D. (1976). *Solid State Physics*. Saunders College.
9. Pillai, S. O. (2005). *Solid State Physics*. New Age International Publishers.

Course Title: Elements of Modern Physics
Course Code: MIN PHY- 6.2
Nature of Course: Minor II
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objectives: The objective of the course is to introduce students to the foundational principles of quantum mechanics and nuclear physics, exploring wave-particle duality, nuclear structure and decay, detection techniques, nuclear energy processes, and the fundamentals of laser physics.

Units	Content	L	M	Hours
Unit 1: Quantum Theory	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.	6	6	6
Unit 2: Uncertainty and Wave-Particle Duality	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.	9	9	9
Unit 3: Structure of the Atomic Nucleus	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. Atomic Mass Unit. Mass defect and binding energy Nuclear forces, Nature of nuclear forces, N–Z graph, liquid drop model: semi-empirical mass formula and binding energy, nuclear shell model (qualitative discussions) and magic numbers.	12	12	12
Unit 4: Radioactivity	Stability curve and stability of nuclei, Law of radioactive decay, Law of successive disintegration, Secular equilibrium, Transient equilibrium. Fine structure of alpha energy spectrum. Beta decay energy released, continuous beta 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.	10	10	10

Unit 5: Nuclear Reactions	Nuclear Reactions, Energy consideration in Nuclear Reaction, Q-value of nuclear reaction, Mass deficit in nuclear reaction, Einstein's mass-energy equivalence principle and generation of nuclear 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).	11	11	11
Unit 6: Laser and Holography	Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Characteristics of LASER. Three-Level and Four-Level Lasers. Basic lasing. Ruby Laser and He-Ne Laser. Principle of Holography, Recording and Reconstruction Method, Theory of Holography as Interference between two Plane Waves, Point Source Holograms.	12	12	12
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of the course students will be able to
CO1: Explain the quantum theory of light, photoelectric effect, and matter waves using key experiments and wave-packet concepts.
CO2: Apply Heisenberg's uncertainty principle to physical scenarios and understand its implications on particle behavior and measurement.
CO3: Describe the structure of the atomic nucleus, calculate binding energies, and interpret nuclear models qualitatively.
CO4: Analyze radioactive decay processes and characterize alpha, beta, and gamma emissions and their properties.
CO5: Identify nuclear radiation detection techniques and explain the working principles of gas-filled detectors.
CO6: Evaluate nuclear reactions in terms of Q-values and energy generation through fission and fusion processes.
CO7: Understand the principles of laser operation, including population inversion, stimulated emission, and construction of common lasers.

Suggested Readings:

1. Krane, K. S. (1983). *Introduction to Modern Physics*. Wiley.
2. Beiser, A. (2003). *Concepts of Modern Physics* (6th ed.). McGraw-Hill.
3. Lilley, J. (2001). *Nuclear Physics: Principles and Applications*. Wiley.
4. Bransden, B. H., & Joachain, C. J. (2000). *Quantum Mechanics* (2nd ed.). Pearson.
5. Silfvast, W. T. (2004). *Laser Fundamentals* (2nd ed.). Cambridge University Press.