MADHABDEV UNIVERSITY

DEPARTMENT OF PHYSICS

SYLLABUS: FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUGP) IN PHYSICS (MINOR)

Under National Education Policy - NEP 2020

Approved in the meeting of the Board of Studies of the Department of Physics on: July 11, 2026

FYUGP (MINOR) SYLLABUS (UNDER NEP-2020) OF THE DEPARTMENT OF PHYSICS MADHABDEV UNIVERSITY

Approved in the meeting of the Board of Studies of the Department of Physics held on July 11, 2026

<u>Members Present</u>

Sl. no.	Name of the member
1.	**Dr. Limpon Bora** Academic Registrar, Madhabdev University
2.	**Dr. Arindam Phukan** (HoD i/c) Chairperson Dept. of Physics, Madhabdev University
3.	**Dr. Lakhinath Borah** Member, Dept. of Physics, Madhabdev University
4.	**Dr. Sudipta Hazarika** Member, Dept. of Physics, Madhabdev University
5.	**Dr. Dhruba Jyoti Gogoi** Member, Dept. of Physics, Madhabdev University
6.	**Prof. Mrinal Kumar Das** External member HoD, Dept. of Physics, Tezpur University
7.	**Prof. Upamanyu Das** External member Dept. of Physics, Bhattadev University

Comprehensive Program Learning Outcomes and Academic Framework

Academic Framework (NEP-2020 Guidelines)

The Four-Year Undergraduate Programme (FYUGP) in Physics (Minor) at Madhabdev University is structured in strict accordance with the National Education Policy (NEP) 2020. The curriculum is designed to provide a holistic, progressive education spanning eight semesters, seamlessly integrating classical foundations, modern physics, mathematical applications, practical laboratory skills, and the rich heritage of Indian Knowledge Systems (IKS).

Each course carries a weightage of **4 Credits**, comprising a total of 60 contact hours. The evaluation framework for theory papers maintains a standard distribution of **100 Marks** (70 Marks for the End-Semester Examination and 30 Marks for In-Semester Assessment).

Program Structure Overview: Comprehensive Program Learning Outcomes (PLOs)

Semester	**Paper Code**	**Course Title**	**Course Type**	**Credits**
I	PHYN 101	Physics I (Mechanics, Properties of Matter, Math, IKS)	Theory	4
II	PHYN 201	Physics II (Electricity, Magnetism, Circuits)	Theory	4
III	PHYN 301	Thermal Physics and Statistical Mechanics	Theory	4
IV	PHYN 401	Lab-I (Mechanics, E&M, Thermal Physics)	Practical	4
V	PHYN 501	Waves and Optics	Theory	4

VI	PHYN 601	Elements of Modern Physics	Theory	4
VII	PHYN 701	Solid State Physics and Electronics	Theory	4
VIII	PHYN 801	Lab-II (Waves, Modern Physics, Electronics)	Practical	4

Upon successful completion of the 4-year FYUGP Minor in Physics, students will have acquired a robust theoretical foundation and practical proficiency across multiple domains of physics. The overarching learning outcomes are categorized as follows:

1. Mastery of Classical and Thermal Physics

- Apply Newtonian mechanics, conservation laws, and Kepler's laws to solve complex mechanical and central force problems.
- Evaluate macroscopic properties of matter, including rigid body dynamics, elasticity, fluid mechanics, and viscosity.
- Analyze physical systems using the laws of thermodynamics, thermodynamic potentials, kinetic theory of gases, and the principles of classical and quantum statistical mechanics.

2. Proficiency in Electromagnetism and Optics

- Formulate and solve problems involving electric and magnetic fields, dielectric properties, and magnetic properties of matter.
- Understand the origin and implications of Maxwell's equations and electromagnetic induction.
- Explain and mathematically model wave mechanics, harmonic oscillations, and physical optics, including phenomena like interference, diffraction, and polarization.

3. Grasp of Modern and Condensed Matter Physics

- Bridge the gap between classical and quantum mechanics by applying the Schrödinger equation, Heisenberg's uncertainty principle, and concepts of wave-particle duality.
- Analyze nuclear structures, radioactive decay, fission, fusion, and the foundational principles of laser physics.
- Understand condensed matter concepts, including X-ray crystallography, energy band theory, and the theoretical underpinnings of superconductivity.

4. Competence in Electronics and Network Analysis

- Apply network theorems (Thevenin, Norton, Superposition) to AC/DC circuits and electrical machines.
- Understand the physics of semiconductor devices, including PN junction diodes, Zener diodes, and bipolar junction transistors (BJT).

- Design and analyze digital electronics, including Boolean algebra, logic gates, and integrated circuits (ICs).

5. Advanced Laboratory and Experimental Skills

- Acquire hands-on expertise in executing precision measurements across mechanics, thermal physics, electricity, and magnetism (Lab-I).
- Develop advanced experimental techniques in optics, quantum physics, LASER applications, and both analog and digital circuit design (Lab-II).
- Identify random errors, handle sophisticated scientific instrumentation, and validate theoretical physics models through empirical data.

6. Mathematical Fluency and Historical Awareness

- Utilize advanced mathematical tools, including vector calculus, differential operators, and integral theorems in multiple coordinate systems, to formulate physical theories.
- Recognize the historical evolution of physical concepts through the lens of Indian Knowledge Systems (IKS), appreciating ancient mathematical and physical formulations (e.g., Vaisheshika Sutra, Aryabhatiya) and the monumental 20th-century contributions of Indian physicists to modern science.

Semester-I

Course Type: Minor Course
Paper Name: Physics I
Paper code: PHYN 101
Credits: 4 (Theory)
Marks Distribution: 70 (End-Semester) + 30 (In-Semester) = 100 (Total)
Total Contact Hours: 60

Course Objectives

To establish a strong foundation in classical mechanics, the macroscopic properties of matter, vector calculus, and to introduce both the historical roots of Indian Knowledge Systems (IKS) and the monumental contributions of Indian scientists to modern physics.

Course Outcomes (COs)

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

1. Apply Newton's laws, conservation principles, and Kepler's laws to solve two-body problems and analyze central force motions.
2. Evaluate the macroscopic properties of matter, including the dynamics of rigid rotating bodies, elasticity, surface tension, and fluid viscosity.
3. Utilize vector calculus, differential operators, and integral theorems to formulate and solve physics problems in multiple coordinate systems.
4. Describe the evolution of physical concepts through ancient Indian Knowledge Systems and recognize the foundational contributions of Indian physicists to modern quantum and astrophysics.

Course Content (End-Semester Marks: 70)

Unit I: Newtonian Mechanics, Gravitation, and Relativity (26 Lectures | 33 Marks)

Newtonian Mechanics: Concept of frame of references (Inertial and non-inertial). Review of Newton’s laws of motion. Galilean Transformation and Galilean invariance. Two-body problem, reduction of two-body problem to one-body problem. Centre of mass, angular momentum and torque, angular momentum of a system of particles about their Centre-of mass, principle of conservation of angular momentum, Impulse.

Force, Work and Energy: Conservative and Non-conservative force, Work-Energy Theorem, Work done in conservative field, conservative force as potential gradient. Elastic and Inelastic collisions. Laboratory and Centre-of-mass reference frames.

Gravitation: Central force, Motion of a particle under central force field. Gravitational field and potential, calculation of gravitational field and potential due to spherical shell and solid sphere. Kepler’s laws, satellites in a circular orbit and applications. Geosynchronous orbits, Weightlessness. Basic idea of Global Positioning System (GPS).

Special Theory of Relativity: Michelson-Morley experiment and its outcomes. Postulates of special theory of relativity, Lorentz Transformation, Length contraction, Time dilation, variation of mass with velocity, Mass-Energy Equivalence, Relativistic addition of velocities.

Unit II: Properties of Matter (14 Lectures | 16 Marks)

Rigid Body Dynamics: Equation of motion of rotating rigid bodies, moment of inertia, theorems of Moment of Inertia. Calculation of M.I of a circular lamina, a solid cylinder, a hollow sphere and a solid sphere. Kinetic Energy of Rotation, Motion involving both translation and rotation. Theory of compound pendulum and determination of ‘g’.

Elasticity: Hooke’s law, Stress-Strain diagram. Young modulus, Bulk modulus and Modulus of Rigidity, Poisson’s ratio, relation between elastic constants. Bending of beam, the cantilever. Work done in stretching and work done in twisting a wire. Twisting a couple on a cylinder.

Fluid Mechanics: Surface Tension and Surface Energy, angle of contact, rise of liquid in a capillary tube. Viscosity: Streamline flow, turbulent flow, equation of continuity, determination of coefficient of viscosity by Poiseuille’s method, Stoke’s method.

Unit III: Mathematical Physics (14 Lectures | 17 Marks)

Vector Calculus: Elements of vector calculus, Properties of vector under rotation, Scalar and Vector fields.

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

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

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

Unit IV: Indian Knowledge Systems (IKS) and Contributions to Modern Physics (6 Lectures | 4 Marks)

Ancient Foundations: Maharishi Kanada’s *Vaisheshika Sutra*: concepts of *Anu* and *Paramanu* (atomism), and the categorization of motion (*Karma*). Relative motion in the *Aryabhatiya*. Early formulations of gravitation: Brahmagupta's concept of *Gurutvakarshana* and Bhaskaracharya's description of Earth's attractive force. Brief overview of the Kerala School (Madhava of Sangamagrama) and infinite series.

Contributions to Modern Physics: Foundational impact of Indian scientists in the 20th century: Satyendra Nath Bose (Bose-Einstein statistics and Bosons), C.V. Raman (Raman scattering/effect), Meghnad Saha (Thermal ionization equation in astrophysics), Homi J. Bhabha (Cosmic rays and Bhabha scattering), and Subrahmanyan Chandrasekhar (Chandrasekhar limit for white dwarfs).

Reference books:

- Mechanics D.S. Mathur, S. Chand & Co

- Elements of Properties of Matter, D.S.Mathur, S. Chand & Co
- Properties of Matter, Brijlal and Subramaniam.
- Mechanics (In SI Units): Berkeley Physics Course Vol 1 Charles Kittel, Walter Knight, et al Tata McGrawHill 2007
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
- Mathematical Physics, Dass and Verma.S. Chand & Co

Expected learner outcome: This course will

1. Introduce the students to the basic concepts of mechanics.
2. Enable students to get a vast idea of conservation laws and its correlation with nature and symmetry.
3. Enable the students to understand different properties of matter with realization.
4. Develop analytical skills to solve vector algebra with application to physics.
5. Develop knowledge of special relativity to understand relativistic formulation of modern theories.

Semester: II

Course Type: Minor Course
Paper Title: Physics II
Paper code: PHYN 201
Credits: 4 (Theory)
Marks Distribution: 70 (End-Semester) + 30 (In-Semester) = 100 (Total)
Total Contact Hours: 60

Course Objectives: The course will enable the student to

1. To have a detailed knowledge about electric and magnetic fields.
2. To have an idea about formulation and application of dielectric properties of matter.
3. To acquire a clear understanding of magnetic properties of matter.
4. To understand the origin of the Maxwell equations.
5. Apply various network theorems such as Superposition, Thevenin, Norton, Reciprocity, Maximum Power Transfer, etc. and their applications in electronics, electrical circuit analysis, and electrical machines.

Course Contents:

Unit-I: Electric Field and Electric Potential: (22 marks)

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

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

Electrostatic energy of system of charges.Electrostatic energy of a charged sphere.Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors.Parallel-plate capacitor.Capacitance of an isolated conductor.Method of Images and its application to (1) Plane Infinite Sheet and (2) Sphere. **(20 L)**

Unit-II: Dielectric Properties of Matter: (12 marks)

Electric Field in matter. Polarisation, Polarisation Charges. Electrical Susceptibility and DielectricConstant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics. **(10 L)**

Unit-III: Magnetic Field and Magnetic Properties of Matter: (16 marks)

Magnetic force between current elements and definition of Magnetic Field B.Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1)Solenoid and (2) Toroid. Properties of **B:** curl and divergence. 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. Magnetization vector

(M). Magnetic Intensity**(H).** Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism**. B-H** curve and hysteresis. **(15 L)**

Unit-IV: Electromagnetic Induction: (5 marks)

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 L)**

Unit-V: Electrical Circuits: (15 marks)

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

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. Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR. **(10 L)**

Recommended readings:

- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012,Tata McGraw
- Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
- Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
- Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
- Electricity and Magnetism, J.H.Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press

Expected learner outcome: This course will

1. Students will have a theoretical as well as practical knowledge about different electrical and magnetic properties of matter.
2. Develop the basic theoretical knowledge as well as experimental skills of the students on electrical networking.
3. Train the students to handle and repair instruments based on electric and magnetic field effects.

Semester III

Course Type: Minor Course
Paper Title: Thermal Physics and Statistical Mechanics
Paper code: PHYN-301
Credits: 4 (Theory)
Marks Distribution: 70 (End-Semester) + 30 (In-Semester) = 100 (Total)
Total Contact Hours: 60

Course Objectives: The course will enable the student to

1. To understand the fundamental laws of thermodynamics and their applications to various thermodynamical processes.
2. To comprehend thermodynamic potentials and apply Maxwell's relations to physical phenomena.
3. To study the kinetic theory of gases and understand transport phenomena such as viscosity, conduction, and diffusion.
4. To explore the theory of blackbody radiation and derive foundational laws like Planck's and Wien's.
5. To grasp the core concepts of statistical mechanics, including both classical and quantum statistics.

Course Contents:

Unit-I: Laws of Thermodynamics: (26 marks)
Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. (22 L)

Unit-II: Thermodynamic Potentials: (12 marks)
Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations. (10 L)

Unit-III: Kinetic Theory of Gases: (12 marks)
Derivation of Maxwell's law of distribution of velocities and its experimental verification, mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono- atomic and diatomic gases. (10 L)

Unit-IV: Theory of Radiation: (7 marks)
Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan-Boltzmann law and Wien's displacement law from Planck's law. (6 L)

Unit-V: Statistical Mechanics: (13 marks)

Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics. (12 L)

Recommended readings:

Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
Heat and Thermodynamics, M.W. Zemasky and R. Dittman, 1981, McGraw Hill
Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W. Sears and G.L. Salinger. 1988, Narosa
University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications

Expected learner outcome: This course will

1. Students will have a theoretical understanding of thermodynamic laws, thermodynamic potentials, and statistical methods.
2. Develop the basic theoretical knowledge of the students regarding the kinetic theory of gases, transport phenomena, and the theory of radiation.
3. Train the students to apply classical and quantum statistical distribution laws to physical systems like electron and photon gases.

Semester-IV

Paper name: Lab-I

Paper code: PHYN-401Credit-4

Group A: Mechanics

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 height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
10. To determine the elastic Constants of a wire by Searle's method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.

Group B: Electricity & Magnetism

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To 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 verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self-inductance of a coil by Anderson's bridge.
10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by Absolute method.

Group C: Thermal Physics
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.

Recommended readings:

- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal,1985, Vani Pub.
- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

Semester-V

Course Type: Minor Course
Paper Title: Waves and Optics
Paper code: PHYN-501
Credits: 4 (Theory)
Marks Distribution: 70 (End-Semester) + 30 (In-Semester) = 100 (Total)
Total Contact Hours: 60

Course Objectives: The course will enable the student to

1. To understand the principle of superposition, harmonic oscillations, and the formation of Lissajous figures.
2. To comprehend the general principles of wave motion, including phase velocity, group velocity, and normal modes.
3. To study the physics of sound, including resonance, Fourier's theorem, and the acoustics of buildings.
4. To explore the fundamental concepts of wave optics and the detailed phenomena of interference in various setups.
5. To analyze both Fraunhofer and Fresnel diffraction patterns and understand the polarization of light waves.

Course Contents:

Unit-I: Superposition Harmonic oscillations: (7 marks)
Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. (6 L)

Unit-II: Waves Motion- General: (8 marks)
Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity. (7 L)

Unit-III: Sound: (12 marks)
Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.
(10 L)

Unit-IV: Wave Optics: (3 marks)
Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.
(3 L)

Unit-V: Interference: (18 marks)
Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index. Michelson's Interferometer: Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes. (15 L)

Unit-VI: Diffraction: (16 marks)
Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. (14 L)

Unit-VII: Polarization: (6 marks)
Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. (5 L)

Recommended readings:
Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
Principles of Optics, B.K. Mathur, 1995, Gopal Printing
Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications
University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986.

Expected learner outcome: This course will

1. Equip students with a comprehensive understanding of wave mechanics, superposition, and the physical properties of sound and acoustics.
2. Develop a strong theoretical foundation in physical optics, enabling students to explain complex phenomena like interference, diffraction, and polarization.
3. Train students to apply these principles to understand and analyze standard optical instruments and experimental setups, such as interferometers and diffraction gratings.

Semester-VI

Course Type: Minor Course
Paper Title: Elements of Modern Physics
Paper code: PHYN-601
Credits: 4 (Theory)
Marks Distribution: 70 (End-Semester) + 30 (In-Semester) = 100 (Total)
Total Contact Hours: 60

Course Objectives: The course will enable the student to

1. To introduce the foundational concepts of quantum theory, including blackbody radiation, the photoelectric effect, and matter waves.
2. To explore wave-particle duality, the Heisenberg uncertainty principle, and the foundational aspects of the Schrodinger equation.
3. To build a comprehensive understanding of nuclear structure, nuclear models, and the nature of nuclear forces.
4. To analyze the phenomena of radioactivity, nuclear fission, and fusion, including their energy generation mechanisms.
5. To comprehend the fundamental principles of lasers, including population inversion, spontaneous emission, and specific laser systems.

Course Contents:

Unit-I: Basics of Quantum Theory: (12 marks)
Planck’s quantum theory, Planck’s constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.
(10 L)

Unit-II: Wave-particle duality: (18 marks)
Wave-particle duality, Heisenberg uncertainty principle, estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.
Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and

normalization; Probability and probability current densities in one dimension.
(15 L)

Unit-III: Nuclear Physics: (35 marks)
Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.
Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.
Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). (30 L)

Unit-IV: Lasers: (5 marks)
Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.
(5 L)

Recommended Readings:
Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan

Additional recommended readings:
Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co
Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.

Expected learner outcome: This course will

1. Equip students with a firm grasp of the fundamental principles of modern physics, bridging the conceptual gap between classical and quantum mechanics.
2. Develop the ability to mathematically and conceptually analyze physical systems using the Schrodinger equation and uncertainty principles.
3. Provide a thorough understanding of nuclear properties, radioactive processes, and laser physics, laying the groundwork for advanced studies in applied and theoretical physics.

Semester-VII

Paper Name: Solid State Physics and Electronics (minor)
Paper Code: PHYN-701
Credit: 4

Course Objectives

At the completion of the course, a student will be able to:

1. Understand the basics of crystals and X-Ray crystallography and Reciprocal lattice concepts.
2. Band theory and its use to distinguish among conductors, insulators and semiconductors.
3. To learn about superconductivity and related topics.
4. Semiconductors and Transistors and their characteristics.
5. Introductory idea of Digital electronics, Boolean algebra, Gates and about IC's.

Unit-I: Crystal Structure

[6 Marks | 5 Lectures]

Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis, Unit Cell, Miller Indices, Types of Lattices, Diffraction of X-rays by Crystals, Bragg's Law. Concept of Reciprocal Lattice and Brillouin Zone.

Unit-II: Elementary Band Theory

[12 Marks | 10 Lectures]

Free electron theory and its limitations, Kronig Penny model, Band Gap, Conductor, Semiconductor and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient.

Unit-III: Superconductivity

[5 Marks | 5 Lectures]

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

Unit-IV: Semiconductor Devices

[23 Marks | 20 Lectures]

- **Semiconductor Basics:** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity, Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode, Current Flow Mechanism in Forward and Reverse Biased Diode.
- **Two-terminal Devices and their Applications:** (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter.
- (2) Zener Diode and Voltage Regulation.
- (3) Tunneling Diode.
- **Transistors:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β, Relations between α and β.

Unit-V: Digital Circuits

[24 Marks | 20 Lectures]

- **Logic Gates & Number Systems:** Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.
- **Boolean Algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.
- **Integrated Circuits (ICs):** Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital ICs.

Recommended Readings

- *Introduction to Solid State Physics*, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd
- *Solid State Physics*, M.A. Wahab, 2011, Narosa Publications
- *Elementary Solid-State Physics*, 1/e M. Ali Omar, 1999, Pearson India
- *Elements of Solid-State Physics*, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
- *Solid State Electronic Devices*, B.G. Streetman & S.K. Banerjee, 6th Edn., 2009, PHI Learning
- *Electronic Devices & Circuits*, S. Salivahanan & N.S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- *Semiconductor Devices: Physics and Technology*, S.M. Sze, 2nd Ed., 2002, Wiley India
- *Fundamentals of Digital Circuits*, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
- *Digital Circuits and Systems*, Venugopal, 2011, Tata McGraw Hill.
- *Digital Electronics*, G K Kharate, 2010, Oxford University Press

Expected Learner Outcome

The course will enable the students to get some basic ideas of Solid State Physics and Electronics, in the first part, the physics of Condensed Matter Physics, where X-Ray Crystallography, Band Theory, Hall Effect and Super conductivity are incorporated and in the later part the students may expect to learn all about Semi conducting devices like Diodes, Transistors and its uses as Amplifiers etc and IC's.

Semester-VIII

Paper Name: Lab-II (minor)
Paper Code: PHYN-801
Credit: 4

Course Objective

This is a Lab paper, so a student may be expected to learn some underlying physical phenomena by hands-on experience in the fields of Waves and Optics (Group A), in the field of modern physics (Group B) and in electronics (Group C).

Group-A: Wave and Optics

2. To investigate the motion of coupled oscillators.
3. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ^2– T Law.
4. To study Lissajous Figures.
5. Familiarization with Schuster`s focussing; determination of angle of prism.
6. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
7. To determine the Refractive Index of the Material of a Prism using Sodium Light.
8. To determine Dispersive Power of the Material of a Prism using Mercury Light.
9. To determine the value of Cauchy Constants.
10. To determine the Resolving Power of a Prism.
11. To determine wavelength of sodium light using Fresnel Biprism.
12. To determine wavelength of sodium light using Newton's Rings.
13. To determine the wavelength of Laser light using Diffraction/Interference of Single Slit.
14. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating.
15. To determine the Resolving Power of a Plane Diffraction Grating.
16. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

Group-B: Elements of Modern Physics

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photoelectrons versus frequency of light.
3. To determine the Planck's constant using LEDs of at least 4 different colours.
4. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
5. To set up the Millikan oil drop apparatus and determine the charge of an electron.
6. To show the tunneling effect in tunnel diodes using I-V characteristics.
7. To determine the wavelength of a laser source using diffraction of a single slit.
8. To determine the wavelength of a laser source using diffraction of double slits.
9. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.

Group-C: Electronics

1. To study V-I characteristics of PN junction diodes, and Light emitting diodes.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
5. To verify and design AND, OR, NOT and XOR gates using NAND gates.
6. To design a combinational logic system for a specified Truth Table.
7. To convert a Boolean expression into a logic circuit and design it using a logic gate IC.

Recommended Readings

- *Advanced Practical Physics for students*, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- *Advanced level Physics Practicals*, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- *A Text Book of Practical Physics*, I. Prakash & Ramakrishna, 11th Ed., 2011, KitabMahal
- *Elements of Solid-State Physics*, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.
- *Modern Digital Electronics*, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.

Expected Learner Outcome

After performing a good number of practicals of this paper the student will acquire a sound experimental knowledge in the fields of Sound and Optics, in Quantum Physics and LASER and also in the fields of both analog and digital electronics.