Raja N.L. Khan Women's College (Autonomous)

Gope Palace, Paschim Medinipur - 721102, West Bengal

National Education Policy (NEP) 2024-25

Syllabus

Physics (UG)

Academic Session: 2024-25

Undergraduate Program

Raja N.L. Khan Women's College

An Autonomous Institution under Vidyasagar University

Accredited by NAAC with 'A' Grade

Programme: CERTIFICATE COURSE IN BASIC PHYSICS

Subject: Physics (Major) Semester-I, Paper-Theory

Course Code: PHSHMJ101T
Course Title: Mechanics

Course Outcomes

1. Understanding of Vector Algebra and Vector Calculus.
2. Study of gravitational field and potential and understanding of Kepler's laws of planetary motion and application.
3. Understanding of different frames of references and conservation laws.
4. Understand the dynamics of rigid body and concept of moment of inertia. Study of moment of inertia of different bodies and its applications.
5. Study the properties of matter, response of the classical systems to external forces and their elastic deformation and its applications.
6. Comprehend the dynamics of Fluid and concept of viscosity and surface tension along with its applications.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Vectors: Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. .	4
Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.	5
Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.	7
Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.	5
Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum.	5
Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts.	7
Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.	5
Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, σ, η by Searles method	7

Reference Books:

1. A Hand Book of Degree Physics – Dasgupta.
2. Classical Mechanics – Maity & Raychoudhuri.
3. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000.
4. Classical Mechanics – J C Upadhyay.

Programme: CERTIFICATE COURSE IN BASIC PHYSICS

Subject: Physics (Major) Semester-I, Paper-Practical

Course Code: PHSHMJ101P

Course Title: Mechanics

Course Outcomes

1. Develop an in-depth understanding of fundamental mechanical concepts such as motion, force, energy, momentum, and rotational dynamics through experimental practices.

2. Gain proficiency in handling scientific instruments, including vernier calipers, micrometers, and other mechanical apparatus, to measure and analyze physical quantities accurately.

3. Enhance skills in recording, analyzing, and interpreting experimental data with precision to verify theoretical principles.

4. Apply concepts of mechanics to solve real-world problems, understanding their relevance to fields like engineering, materials science, and environmental systems.

5. Learn to identify and evaluate sources of error in experiments, improving scientific rigor and accuracy.

6. Develop collaborative and communication skills by working in groups to conduct experiments, share findings, and present results effectively.

7. Foster critical thinking abilities by designing, conducting, and troubleshooting experiments in mechanics.

8. Build a strong practical foundation for advanced studies and research in physics and related interdisciplinary fields.

Mechanics LAB:

1. To determine the Moment of Inertia of a Flywheel.
2. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
3. To determine the Young's Modulus by method of flexure.
4. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
5. To determine the value of g using Bar Pendulum.
6. To determine the value of g using Kater's Pendulum.
7. To study the Motion of Spring and calculate (a) Spring constant, (b) g

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Reference Books:

1. Advanced Practical Physics Vol-1 by B.Ghosh and K G Mazumder.
2. An Advanced Course in Practical Physics by D. Chattopadhyay and P. C. Rakshit.

Programme: CERTIFICATE COURSE IN BASIC PHYSICS

Subject: Physics (Major) Semester-II, Paper-Theory

Course Code: PHSHMJ201T
Course Title: ELECTRICITY AND MAGNETISM

Course Outcomes

1. Demonstrate Gauss law, Coulomb's law for the electric field, and apply it to systems of point charges as well as line, surface, and volume distributions of charges.
2. Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
3. Apply Gauss's law of electrostatics to solve a variety of problems.
4. Describe the magnetic field produced by magnetic dipoles and electric currents.
5. Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electric and magnetic fields.
6. Describe how magnetism is produced and list examples where its effects are observed.
7. Apply Kirchhoff's rules to analyze AC circuits consisting of parallel and/or series combinations of voltage sources and resistors and to describe the graphical relationship of resistance, capacitor and inductor.
8. 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 Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3

- **Total number of Lectures: 45**

Topic	No. of Lectures
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.	20
Magnetism: Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field.Magnetic vector potential.Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro- magnetic materials.	10
Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz'slaw, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.	6
Maxwell's equations and Electromagnetic wave propagation: Equation ofcontinuity 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.	9

Reference Books:

1. A Hand Book of Degree Physics – Dasgupta.

2. Electricity and Magnetism – B.Ghosh.

3. Snatak Padhartya Vidya – Jana , Bera, Pal.

Programme: CERTIFICATE COURSE IN BASIC PHYSICS

Subject: Physics (Major) Semester-II, Paper-Practical

Course Code: PHSHMJ201P

Course Title: ELECTRICITY AND MAGNETISM

Course Outcomes

1. Demonstrate proficiency in setting up and conducting experiments related to electricity and magnetism, including the use of essential laboratory equipment.
2. Implement concepts from electrostatics, magnetostatics, and electromagnetism to solve practical problems and verify theoretical results through experimentation.
3. Accurately measure electric potentials, field strengths, magnetic fields, and currents using instruments like voltmeters, ammeters, galvanometers, and electromagnets.
4. Analyze and interpret experimental data, apply error analysis, and draw conclusions based on experimental observations.
5. Investigate electromagnetic phenomena such as induction, the behavior of capacitors, resistors, and inductors in circuits, and the interaction between electric and magnetic fields.
6. Carry out advanced experiments on electromagnetic waves, mutual inductance, and resonance phenomena, understanding their theoretical implications.

Mechanics LAB:

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer: (i) Measurement of charge and current sensitivity (ii) Measurement of CDR (iii) Determine a high resistance by Leakage Method (iv) To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitance using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine $\frac{d\vec{B}}{dx}$).
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor.
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.

Reference Books:

1. Advanced Practical Physics for students, B.L.Flint& H.T.Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4 th Edition, reprinted 1985, Heinemann Educational Publishers.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-III, Paper-Theory

Course Code: PHSHMJ301T
Course Title: Mathematical Physics-I

Course Outcomes

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

1. **Understand and Apply Complex Analysis:** Analyze and solve physics problems using complex variables, including the evaluation of integrals and the application of residue theorem in physical contexts.

2. **Master Linear Algebra Techniques:** Solve systems of linear equations, perform matrix operations, and apply eigenvalues and eigenvectors to quantum mechanics and other physical systems.

3. **Develop Proficiency in Fourier Series:** Expand periodic functions into Fourier series and use them to solve boundary value problems in heat conduction and wave propagation.

4. **Utilize Fourier Transforms:** Apply Fourier transforms for signal analysis, solving differential equations, and understanding phenomena in optics, quantum mechanics, and electrical circuits.

5. **Solve Differential Equations:** Formulate and solve ordinary and partial differential equations, modeling physical systems such as oscillations, fluid flow, and electromagnetic waves.

6. **Integrate Mathematical Tools in Physics:** Employ a combination of these mathematical methods to analyze and interpret complex physical systems, fostering a deeper understanding of the underlying principles.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Unit-I	
Complex Analysis: Brief Revision of Complex Numbers and their GraphicalRepresentation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables.Analyticity and Cauchy-Riemann Conditions.Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable.Cauchy's Inequality.Cauchy's Integral formula.Simply and multiply connected region.Laurent and Taylor's expansion.Residues and Residue Theorem. Application in solving Definite Integrals	25
Unit-II	
Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, DirichletConditions (Statement only).Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients.Complex representation of Fourier series.Expansion of functions with arbitrary period.Expansion of non-periodic functions over an interval.Even and odd functions and their Fourier expansions.Application.Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.	10
Unit-III	
Matrices: Definition, different types of matrices, Unitary Matrix, Hermitian matrices, Eigen values and eigen vector of a matrix.	5
Unit-IV	
Some Special Integrals: Beta and Gamma Functions and Relation between them.Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).	5

Reference Books:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.

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

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

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

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

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-III, Paper-Practical

Course Code: PHSHMJ301P
Course Title: Computational Mathematical Physics-I

Course Outcomes

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

1. **Apply Python Programming in Mathematical Physics:** Develop Python scripts to solve problems involving complex variables, linear algebra, Fourier series, Fourier transforms, and differential equations.

2. **Solve Complex Variable Problems:** Use Python libraries to evaluate integrals, analyze singularities, and solve problems involving analytic functions and residues.

3. **Implement Linear Algebra Techniques:** Perform matrix operations, compute eigenvalues and eigenvectors, and solve systems of linear equations using Python's numerical libraries such as NumPy.

4. **Analyze Periodic Functions with Fourier Series:** Use Python to compute and visualize Fourier series for solving physical problems in heat conduction and wave mechanics.

5. **Explore Fourier Transforms Computationally:** Apply discrete and fast Fourier transforms to analyze signals and solve differential equations relevant to physics.

6. **Model and Solve Differential Equations:** Employ Python to solve ordinary and partial differential equations for modeling physical systems such as oscillations, fluid flow, and electromagnetic fields.

7. **Plot Graphs in 2D and 3D:** Use the Matplotlib package to create clear, insightful 2D and 3D visualizations of physical and mathematical results.

Course Details

- **Credits:** 01
- **Total No. of Lectures (in hours per week):** 2

Lab Experiment List

Unit 1

Handling of Complex Numbers: Syntax for creating complex numbers in Python, accessing real and imaginary parts, calculating the modulus and conjugate of a complex number, complex number arithmetic, plotting of complex numbers as ordered pairs of real numbers in a plane, conversion from Cartesian to polar representation. Recommended List of Programs:

1. Determine the nth roots of a complex number and represent it in Cartesian and polar form..
2. Transformation of complex numbers as 2-D vectors e.g. translation, scaling, rotation, reflection.
3. Visualization of mappings of some elementary complex functions w = f(z) from z-plane to w-plane.

Unit 2

Introduction to plotting graphs with Matplotlib Basic $2D\&3D$ graph plotting.

Unit 3

1. **Statistical Calculations :** mean, median and standard deviation for a set of discrete data points
2. **Interpolation:** Newton-Gregory forward & backward formula.
3. **Numerical differentiation:** Forward and Backward difference formula.
4. **Numerical Integration:**By trapezoidal rule. , By Simpson's $\frac{1}{3}$ rd rule.

5. **Integration by stochastic method:** Monte Carlo random dot method.
6. **Solution of ODE First order Differential equation:**Euler Method.

Reference Books:

1. Learning Scientific Programming with Python. C. Hill, 2016, Chambridge.
2. A Friendly Introduction to Numerical Analysis. B. Bradie, 2007, Pearson.
3. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
4. Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.
5. Numpy beginners guide, Idris Alba, 2015, Packt Publishing.
6. Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-III, Paper-Theory

Course Code: PHSHMJ302T
Course Title: WAVE & OPTICS

Course Outcomes

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

1. **Understand the Principle of Superposition:** Analyze the superposition of collinear harmonic oscillations to understand the formation of beats and the mathematical representation of resultant waveforms.
2. **Explore Wave Interference:** Explain and apply the conditions for constructive and destructive interference in wave phenomena and solve related problems.
3. **Analyze Interferometric Techniques:** Understand the working principles of interferometers like Michelson and Fabry-Pérot, and apply these to measure wavelength, refractive index, and small displacements.
4. **Examine Diffraction Phenomena:** Distinguish between Fresnel and Fraunhofer diffraction, analyze diffraction patterns from single slits, double slits, and gratings, and apply the concepts to optical instruments.
5. **Apply Mathematical Tools to Wave Optics:** Use mathematical techniques to solve problems related to wave superposition, interference, and diffraction.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Unit-I	
Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.	10
Unit-II	
Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. Characteristics of Laser light. **Interference:** Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.	5 10
Unit-III	
Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.	10
Unit-IV	
Diffraction: Kirchhoff's Integral Theorem and Fresnel-Kirchhoff's Integral formula (Statement and Qualitative discussion on consequences only). Fraunhofer diffraction: Single slit, rectangular aperture. Resolving Power of an optical instrument – Rayleigh's criteria. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.	10

Reference Books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Vibrations and Waves. A.P. French, 2003, CBS.
3. Vibrations & Waves. G.C. King, 2009, Wiley.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-III, Paper-Practical

Course Code: PHSHMJ302P
Course Title: WAVE & OPTICS (PRACTICALS)

Course Outcomes

1. **Conduct Melde's Experiment:** Demonstrate resonance in a vibrating string and calculate the frequency of a tuning fork by studying transverse and longitudinal waves.

2. **Determine Wavelength Using Newton's Rings:** Perform Newton's rings experiment to measure the wavelength of sodium light and understand the principle of interference in thin films.

3. **Measure Wavelength Using Fresnel Biprism:** Use Fresnel's biprism to determine the wavelength of sodium light, applying the concept of interference from coherent sources.

4. **Utilize Michelson's Interferometer:** Determine the wavelength of a sodium source using Michelson's interferometer and explore the practical application of optical interference in precise measurements.

5. **Understand Schuster's Focusing Technique:** Familiarize with Schuster's focusing method to accurately align optical components and measure the angle of a prism.

6. **Determine Refractive Index of Prism Material:** Measure the refractive index of the material of a prism using sodium light and understand its importance in optical system design.

Mechanics LAB:

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify $\lambda^2 \sim T$ law.
2. **Familiarization with: Schuster's focusing**; determination of angle of prism.
3. To determine refractive index of the Material of a prism using sodium source.
4. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
5. To determine wavelength of sodium light using Newton's Rings.
6. To determine wavelength of sodium light using Fresnel Biprism.
7. To determine the wavelength of sodium source using Michelson's interferometer.

Reference Books:

1. Advanced Practical Physics for students, B.L.Flint& H.T.Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4 th Edition, reprinted 1985, Heinemann Educational Publishers.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-IV, Paper-Theory

Course Code: PHSHMJ401T
Course Title: MATHEMATICAL PHYSICS-II

Course Outcomes

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

1. **Solve Differential Equations Using Frobenius Method:** Apply the Frobenius method to solve second-order linear differential equations near singular points, essential for modeling physical systems.

2. **Understand and Utilize Special Functions:** Analyze and employ special functions such as Bessel, Legendre, and Hermite functions to solve problems in quantum mechanics, electromagnetism, and wave theory.

3. **Apply Integral Transforms:** Use Laplace and Fourier transforms to simplify and solve differential equations, boundary value problems, and other mathematical models in physics.

4. **Comprehend Linear Vector Spaces (LVS):** Understand the structure of linear vector spaces, including basis, dimension, and linear independence, and apply these concepts in quantum mechanics and advanced physics problems.

5. **Employ Vector Analysis:** Analyze physical problems using vector calculus, including operations like divergence, curl, and gradient, to model electromagnetic fields and fluid dynamics.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3

- **Total number of Lectures: 45**

Topic	No. of Lectures
Unit-I	
Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral.	5
Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre and Hermite Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials.	10
Unit-II	
Integrals Transforms: Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric,Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples.	10
Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.	10
Unit-III	
Linear Vector Space (LVS) Idea of LVS with 2-d and 3-d cartesian vectors. Introduction to bra and ket vectors. Definition of LVS with examples : 2-d , 3-d vectors, complex numbers, sinusoidal waveforms. Dual space. Inner product, Norm (defined in terms of inner product), Cauchy-Schwarz inequality, metric space. Linear independence and dependence of vectors. Completeness of a set of vectors. Dimension and basis. Orthogonality. Gram-Schmidt method for orthogonalization.	5
Unit-IV	
Introduction to Tensor analysis Definition of cartesian tensors in 3 dimensions. Transformation properties. Contraction of tensors in 3 dimensions.	5

Reference Books:

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

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

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

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

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

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

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-IV, Paper-Practical

Course Code: PHSHMJ401P
Course Title: COMPUTATIONAL MATHEMATICAL PHYSICS-II (PRACTICALS)

Course Outcomes

1. **Solve First-Order Differential Equations Using Python:** Implement numerical methods to solve first-order differential equations and visualize their solutions using Python's Matplotlib library, enhancing their understanding of dynamic systems.

2. **Solve Second-Order Differential Equations Using Python:**Apply Python programming to solve second-order differential equations and graphically analyze the solutions using Matplotlib, demonstrating their applications in oscillatory systems and wave mechanics.

3. **Implement Runge-Kutta Method for Second-Order Differential Equations:** Use the Runge-Kutta numerical method to solve second-order differential equations with high accuracy, showcasing its utility in physical system modeling.

4. **Visualize Solutions with Matplotlib:** Develop clear and informative 2D plots of solutions, interpreting the results effectively to understand the behavior of physical systems modeled by differential equations.

5. **Integrate Computational and Analytical Skills:** Combine numerical methods, Python programming, and visualization techniques to solve complex differential equations in advanced mathematical physics.

Mechanics LAB:

1. Solve the coupled first order differential equations:

   $\frac{\mathrm{d}x}{\mathrm{d}t} = y + x - \frac{x^3}{3}$, $\frac{\mathrm{d}y}{\mathrm{d}t} = -x.$

   for four initial conditions: $x(0) = 0, y(0) = -1, -2, -3, -4.$

   Plot x vs y for each of the four initial conditions on the same screen for $0 \leq t \leq 15$.

2. The ordinary differential equation describing the motion of a pendulum is

   $\vartheta'' = -\sin(\vartheta).$

   The pendulum is released from rest at an angular displacement α i.e.

   $\vartheta(0) = \alpha, \vartheta'(0) = 0.$

   Use the RK4 method to solve the equation for $\alpha = 0.1, 0.5$ and 1.0 and plot ϑ as a function of time in the range $0 \leq t \leq 8\pi$. Also, plot the analytic solution valid in the small ϑ $(\sin\vartheta \approx \vartheta)$.

3. Solve the differential equation:

   $x^2 \frac{\mathrm{d}^2x}{\mathrm{d}x^2} - 4x(x+1)\frac{\mathrm{d}x}{\mathrm{d}t} + 2(1+x)y = x^3$

   with the boundary conditions: at $x = 1, y = \frac{1}{2}e^2, \frac{\mathrm{d}y}{\mathrm{d}x} = \left(-\frac{3}{2}\right)e^2 - 0.5,$

   in the range $1 \leq x \leq 3$. Plot y and $\frac{\mathrm{d}y}{\mathrm{d}x}$ against x in the given range. Both should appear on the same graph.

Reference Books:

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

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

3. Elementary Numerical Analysis, K. E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

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

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

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-IV, Paper-Theory

Course Code: PHSHMJ402T
Course Title: THERMAL PHYSICS

Course Outcomes

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

1. **Understand Kinetic Theory of Gases:** Analyze the behavior of gases using the kinetic theory, derive expressions for pressure and temperature, and comprehend concepts like mean free path and distribution of molecular velocities.

2. **Apply Integral Transforms in Thermal Physics:** Utilize Fourier and Laplace transforms to solve heat conduction problems and model thermodynamic systems mathematically.

3. **Comprehend the Zeroth and First Laws of Thermodynamics:** Explain thermal equilibrium and temperature scales using the zeroth law and apply the first law to analyze energy conservation in physical processes.

4. **Explore the Second Law of Thermodynamics:** Understand entropy and irreversibility, and explain heat engines, refrigerators, and the Carnot cycle based on the second law.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Unit-I	
Kinetic Theory of Gases	
Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.	4
Molecular Collisions: Mean Free Path. Collision Probability. Transport Phenomenon in Ideal Gases.	2
Real Gases: Behavior of Real Gases: The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.	5
Unit-II	
Introduction to Thermodynamics	
Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.	5
Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.	7
Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy Changes in Reversible and Irreversible Processes.	5
Unit-III	
Thermodynamic Potentials: Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation.	5
Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Tds Equations, (3) Energy equations, (4) Change of Temperature during Adiabatic Process.	5

Reference Books:

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

2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press.

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

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

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-IV, Paper-Practical

Course Code: PHSHM402P
Course Title: THERMAL PHYSICS (PRACTICAL)

Course Outcomes

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

1. **Determine the Mechanical Equivalent of Heat (J):** Measure the mechanical equivalent of heat using Callender and Barne's constant flow method, enhancing their understanding of the relationship between mechanical work and heat energy.

2. **Measure Thermal Conductivity of Copper:** Determine the coefficient of thermal conductivity of a good conductor (copper) using Searle's apparatus, applying principles of heat transfer and material properties.

3. **Evaluate Thermal Conductivity of a Bad Conductor:** Use Lee and Charlton's disc method to determine the thermal conductivity of a poor conductor, gaining insights into heat flow through insulating materials.

4. **Study Thermo-Emf in Thermocouples:** Investigate the variation of thermoelectric emf with the temperature difference between two junctions of a thermocouple, demonstrating principles of thermoelectricity and temperature measurement.

5. **Develop Practical Skills in Thermal Measurements:**Enhance skills in using thermal measurement instruments, analyzing experimental data, and interpreting results for practical applications.

6. **Apply Thermal Physics Concepts to Real-World Problems:** Link theoretical principles of thermal conductivity, heat transfer, and thermoelectricity to experimental observations and engineering applications.

Course Details

- **Credits:** 01
- **Total No. of Lectures (in hours per week):** 2

Lab Experiment List

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-IV, Paper-Theory

Course Code: PHSHMJ403T

Course Title: Analog systems and applications (Electronics -I)

Course Outcomes

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

1. **Understand Semiconductor Diodes:** Explain the characteristics, working principles, and applications of semiconductor diodes, including their role in rectification, voltage regulation, and signal modulation.
2. **Analyze Two-Terminal Devices:** Study the properties and uses of two-terminal devices such as Zener diodes, light-emitting diodes (LEDs), and photodiodes, and demonstrate their applications in electronic circuits.
3. **Understand Bipolar Junction Transistors (BJTs):** Explain the construction, operation, and characteristics of BJTs in different configurations (CE, CB, CC) and their applications in switching and amplification.
4. **Design and Analyze Amplifiers:** Design and analyze single-stage amplifiers, studying their gain, input/output impedance, and frequency response for signal amplification.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. **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, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode. **Bipolar Junction transistors:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.	7 4 5
Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. **Feedback in Amplifiers:** Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.	8 2 4
Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. **Applications of Op-Amps:** (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator and Integrator, (5) Log amplifier, (6) Zero crossing detector, (7) Wein bridge oscillator. **Conversion:** Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation).	5 7 3

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning.
4. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-IV, Paper-Practical

Course Code: PHSHM403P

Course Title: Analog systems and applications (Electronics -I-PRACTICAL)

Course Outcomes

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

1. **Analyze Zener Diode Characteristics:** Study the V-I characteristics of a Zener diode and demonstrate its application as a voltage regulator for maintaining constant voltage in electronic circuits.

2. **Perform DC Voltage Addition Using Op-Amps:** Implement and analyze the addition of two DC voltages using an operational amplifier in both inverting and non-inverting modes, showcasing its functionality as a basic arithmetic circuit.

3. **Design Precision Differential Amplifiers:** Design and test a precision differential amplifier using an op-amp, adhering to given input-output specifications, for applications in signal comparison and noise rejection.

4. **Investigate Op-Amp as an Integrator:** Explore the working of an operational amplifier as an integrator and demonstrate its application in waveform generation and signal processing.

5. **Investigate Op-Amp as a Differentiator:** Study the behavior of an operational amplifier as a differentiator and its utility in edge detection and high-frequency signal analysis.

6. **Design a Wien Bridge Oscillator:** Design and implement a Wien bridge oscillator using an op-amp to generate sinusoidal waveforms at a specified frequency.

Course Details

- **Credits:** 01
- **Total No. of Lectures (in hours per week):** 2

Lab Experiment List

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
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 design a Wien bridge oscillator for given frequency using an op-amp.
5. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain.
6. To add two dc voltages using Op-amp in inverting and non-inverting mode.
7. To design a precision Differential amplifier of given I/O specification using Opamp.
8. To investigate the use of an op-amp as an Integrator.
9. To investigate the use of an op-amp as a Differentiator.
10. To design a digital to analog converter (DAC) of given specifications.
11. To study the analog to digital convertor (ADC) IC.
12. To design inverting amplifier using Op-amp (741,351) and study its frequency response.
13. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-V, Paper-Theory

Course Code: PHSHMJ501T
Course Title: MODERN PHYSICS

Course Outcomes

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

1. **Understand Quantum Phenomena:** Explain the photoelectric effect and Compton scattering, highlighting their significance in the development of quantum theory.
2. **Analyze Matter Waves:** Understand the concept of De Broglie wavelength and matter waves and verify them experimentally using the Davisson-Germer experiment.
3. **Describe Wave-Particle Duality:** Explain the wave description of particles using wave packets and understand the implications of wave-particle duality in modern physics.
4. **Apply the Schrödinger Equation:** Solve the Schrödinger equation for non-relativistic particles in simple potential systems, gaining insight into the behavior of quantum systems.
5. **Use Quantum Operators:** Understand and apply momentum and energy operators in quantum mechanics and explore stationary states for systems like the infinite potential well.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Radiation and its nature: Black body Radiation, Planck's quantum hypothesis, Planck's constant (derivation of Planck formula is not required). Photoelectric effect and Compton scattering — light as a collection of photons. Davisson-Germer experiment. Bohr-Sommerfeld quantization of the form $\oint p\mathrm{d}q = nh$. De Broglie wavelength and matter waves. Wave-particle duality. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Probability interpretation: Normalized wave functions as probability amplitudes. Two-slit experiment with photons and electrons. Linear superposition principle as a consequence. Position measurement, γ-ray microscope thought experiment. Heisenberg uncertainty principle (Statement with illustrations). Impossibility of a trajectory of a particle	15
Basics of Quantum Mechanics: Quantum measurements- Deterministic vs probabilistic view points. Description of a particle using wave packets. Spread of the Gaussian wave-packet for a free particle in one dimension. Fourier transforms and momentum space wave function. Position Momentum uncertainty. Simultaneous measurements: Compatible and incompatible observables and their relation to commutativity.	10
Schrödinger Equation: Schrödinger equation as a first principle. Probabilistic interpretation of wave function and equation of continuity (in 1-dimension). Time evolution of wave function . Stationary states. Time independent Schrödinger equation as an eigenvalue equation.	8
Application to one dimensional systems: General discussion of bound states in an arbitrary potential: continuity of wave function, boundary conditions on wave functions and emergence of discrete energy levels. Particle in an infinitely rigid box: energy eigenvalues and eigenfunctions, normalization. Quantum mechanical tunnelling across a step potential and rectangular potential barrier, calculation of reflection and transmission probabilities. α-decay as an example. Application to one dimensional square well potential of finite depth (for bound states only).	12
Quantum mechanics of simple harmonic oscillator: Setting up the eigenvalue equation for the Hamiltonian. Energy levels and energy eigenfunctions in terms of Hermite polynomials (Solution to Hermite differential equation may be assumed). Ground state, zero-point energy and uncertainty principle.	5

Reference Books:

1. Feynman Lectures Vol.3, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education.

2. Basic Quantum Mechanics, A.K.Ghatak , 2004, Macmillan.

3. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Resnick and Eisberg, 2014, Wiley.

4. Introduction to Quantum Mechanics, David J. Griffiths, 2018, Cambridge University Press.

5. Quantum Physics, Stephen Gasiorowicz, 2007, John Wiley & Sons, Inc.

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

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

8. Schaum's outline, Theory and Problems of Modern Physics, R. Gautreau and W. Savin, 2nd Edn, 2020, Tata McGraw-Hill Publishing Co. Ltd.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-V, Paper-Practical

Course Code: PHSHMJ501P
Course Title: MODERN PHYSICS(PRACTICAL)

Course Outcomes

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

1. **Measure Planck's Constant:** Determine Planck's constant by analyzing black body radiation using a photo-detector, connecting experimental results with the quantization of energy.

2. **Analyze the Hydrogen Spectrum:** Measure the wavelength of the H-alpha emission line of the hydrogen atom, verifying the energy levels predicted by the Bohr model.

3. **Demonstrate Quantum Tunneling:** Explore the tunneling effect in a tunnel diode by studying its I-V characteristics, providing practical evidence for quantum mechanical phenomena.

4. **Determine Wavelength of a Laser Source:** Use single-slit diffraction to measure the wavelength of a laser source, applying the principles of wave optics and interference.

5. **Measure the Charge of an Electron:** Set up the Millikan oil drop experiment to determine the charge of an electron, verifying the quantization of electric charge.

Course Details

- **Credits:** 01
- **Total No. of Lectures (in hours per week):** 2

Lab Experiment List

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 photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
8. To setup the Millikan oil drop apparatus and determine the charge of an electron.
9. To show the tunneling effect in tunnel diode using I-V characteristics.
10. To determine the wavelength of laser source using diffraction of single slit.
11. To determine the wavelength of laser source using diffraction of double slits.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-V, Paper-Theory

Course Code: PHSHMJ502T
Course Title: DIGITAL SYSTEMS AND APPLICATIONS (ELECTRONICS II)

Course Outcomes

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

1. **Understand Integrated Circuits:** Explain the fundamentals of integrated circuits (ICs), their design principles, and their applications in digital systems.
2. **Apply Boolean Algebra:** Utilize Boolean algebra to simplify and design logical circuits, gaining proficiency in logic minimization techniques.
3. **Design and Analyze Multiplexers and De-Multiplexers:** Understand the working of multiplexers and de-multiplexers and apply them in data selection and routing applications.
4. **Implement Decoders and Encoders:** Design and analyze decoders and encoders for data conversion and signal processing in digital systems.
5. **Understand Flip-Flops and Sequential Logic:** Explain the operation of flip-flops, including SR, JK, D, and T types, and their role in building sequential logic circuits like counters and memory units.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Integrated Circuits (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.	2
Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.	5
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.	8
Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.	5
Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.	5
Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip- Flop. M/S JK Flip-Flop.	5
Timers: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.	3
Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).	5
Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.	5

Reference Books:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw Hill.
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning.
5. Logic circuit design, Shimon P. Vingron, 2012, Springer.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-V, Paper-Practical

Course Code: PHSHMJ502P
Course Title: DIGITAL SYSTEMS AND APPLICATIONS (ELECTRONICS II)(PRACTICAL)

Course Outcomes

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

1. **Test Basic Electronic Components:** Use a multimeter to test diodes and transistors, ensuring a fundamental understanding of their functionality and behavior in circuits.

2. **Design Combinational Logic Systems:** Develop a combinational logic system based on a given truth table, applying principles of Boolean algebra and logic gate integration.

3. **Implement Arithmetic Circuits:** Design and implement circuits such as Half Adders, Full Adders, and 4-bit Binary Adders to perform binary arithmetic operations, demonstrating foundational skills in digital computation.

4. **Construct Sequential Circuits:** Build a 4-bit counter using D-type or JK Flip-Flop ICs, and analyze the timing diagram to understand sequential circuit behavior.

5. **Develop Circuit Design Skills:** Gain hands-on experience in constructing, testing, and troubleshooting digital circuits using ICs and basic components.

Course Details

- **Credits:** 01
- **Total No. of Lectures (in hours per week):** 2

Lab Experiment List

1. To test a Diode and Transistor using a Multimeter.
2. To design a switch (NOT gate) using a transistor.
3. To verify and design AND, OR, NOT and XOR gates using NAND gates.
4. To design a combinational logic system for a specified Truth Table.
5. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
6. Half Adder, Full Adder and 4-bit binary Adder.
7. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
8. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
9. To build JK Master-slave flip-flop using Flip-Flop ICs.
10. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
11. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
12. To design an astable multivibrator of given specifications using 555 Timer.
13. To design a monostable multivibrator of given specifications using 555 Timer.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.

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

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

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-V, Paper-Theory

Course Code: PHSHMJ503T
Course Title: CLASSICAL MECHANICS

Course Outcomes

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

1. **Understand Fundamental Principles** Comprehend the foundational principles of classical mechanics, including Newtonian mechanics, and their extension to Lagrangian and Hamiltonian frameworks.
2. **Apply Lagrangian Mechanics:** Formulate and solve problems using the Lagrangian approach, emphasizing generalized coordinates, constraints, and variational principles.
3. **Utilize Hamiltonian Formalism:** Analyze physical systems using Hamiltonian mechanics, focusing on phase space, canonical transformations, and conservation laws.
4. **Master Rigid Body Dynamics:** Solve problems related to the motion of rigid bodies, including rotation, angular momentum, and moment of inertia tensor.
5. **Develop Problem-Solving Skills:** Apply advanced analytical methods to classical mechanics problems, fostering a deeper understanding of system dynamics.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Lagrangian Mechanics: Constraints and their classifications with examples, Inconvenience of Newtonian formulation in practice, The principle of virtual work, D Alambert's principle, Generalized coordinates and momenta, Lagrangian function, Lagrange's equations of motion, Advantages of Lagrangian formulation over Newtonian one, Cyclic Coordinates, Hamilton's variational principle, Applications of Lagrangian formulation to simple systems.	12
Hamiltonian Formulation: Hamiltonian function and its physical significance, Hamilton's canonical equations of motion, Advantages of Hamiton's formalism over the Lagrangian formulation, Conservation of Energy, Applications of Hamilton's equations to simple systems, Poisson brackets, Canonical transformations, Generating functions.	10
Rigid Body Dynamics: Generalized coordinates of rigid body, body and space reference systems, Angular momentum and moment of inertia tensor of simple rigid body (cube, sphere, cylinder), Principle axes and principle moments of inertia, Kinetic energy of a rigid body, Euler equations of motion of rigid body.	8
Small Oscillations and Normal Modes: Equilibrium and stability, Potential energy expansion around equilibrium, Linearization and small displacement approximation, Lagrange's equations for small oscillations,Coupled oscillators and matrix representation, Eigenvalues, eigenvectors, and normal modes, Normal coordinates and mode analysis, Applications: coupled pendulums, molecular vibrations	5
Special Theory of Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction & twin paradox. Four-vectors:space-like, time-like & light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four- vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle. The Electromagnetic field tensor and its transformation under Lorentz transformations: relation to known transformation properties of E and B. Electric and magnetic fields due to a uniformly moving charge. Equation of motion of charged particle & Maxwell's equations in tensor form. Motion of charged particles in external electric and magnetic fields.	10

Reference Books:

1. Introduction to Classical Mechanics With Problems and Solutions , D. Morin, Cambridge University Press.
2. Classical Mechanics, A course of Lectures, A.K. Raychaudhuri, 1983, Oxford University Press.

3. Classical Mechanics , N.C. Rana and P. Joag, 2017, McGraw Hill Education.

4. Classical Mechanics, Goldstein, Poole and Safko, 2011, Pearson Education.

5. Introduction to Special Relativity , J.H. Smith, 2003, Dover Publications Inc .

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) **Semester-V, Paper-Practical**

Course Code: PHSHMJ503P
Course Title: CLASSICAL MECHANICS(PRACTICAL)

Course Outcomes

This course focuses on applying computational techniques to classical mechanics problems using Python and its powerful library Matplotlib. Students will explore theoretical concepts while gaining hands-on coding skills to simulate and visualize mechanical systems. Students will:

- Develop Python programs to solve complex classical mechanics problems.
- Simulate and visualize dynamic systems to enhance physical understanding.
- Gain proficiency in Python libraries such as NumPy, SciPy, and Matplotlib.
- Build transferable computational skills for advanced topics like quantum mechanics and computational physics.

Course Details

- **Credits:** 01
- **Total No. of Lectures (in hours per week):** 2

Lab Experiment List

1. **Lagrangian Mechanics:**

   - Formulation of the Lagrangian for single and multi-particle systems.
   - Python implementation of Euler-Lagrange equations.
   - Simulation of systems like the simple pendulum and double pendulum.
   - Visualization of trajectories in configuration space using Matplotlib.

2. **Hamiltonian Formulation:**

   - Transition from Lagrangian to Hamiltonian mechanics.
   - Numerical integration of Hamilton's equations using Python.
   - Phase-space analysis for systems like the harmonic oscillator and chaotic systems.
   - Generation of phase portraits with Matplotlib.

3. **Rigid Body Dynamics:**

   - Rotational motion of rigid bodies and analysis of torque-free systems.
   - Moment of inertia tensor computation.
   - Simulation of gyroscopic motion and precession.
   - 3D visualization of rigid body motion using Python libraries like Matplotlib and mpl_toolkits.mplot3d.

4. **Small Oscillations and Normal Modes:**

   - Analysis of coupled oscillators and derivation of normal modes.
   - Computational solution of eigenvalue problems.
   - Animation of coupled oscillations and visualization of mode shapes.

5. **Special Theory of Relativity:**

- Lorentz transformations and relativistic mechanics.
- Python scripts for relativistic collision problems and time dilation simulations.
- Graphical representation of relativistic effects using Matplotlib.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-V, Paper-Theory

Course Code: PHSHMJ504T
Course Title: ELECTROMAGNETIC THEORY

Course Outcomes

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

1. **Understand Maxwell's Equations** Comprehend the physical significance of Maxwell's equations and their role in describing electromagnetic phenomena.
2. **Analyze Electromagnetic Wave Propagation in Unbounded Media:** Explore the generation and propagation of electromagnetic waves in free space, focusing on wave solutions and energy transport.
3. **Investigate EM Waves in Bounded Media:** Understand the behavior of electromagnetic waves in dielectrics, conductors, and at interfaces, including reflection and refraction.
4. **Examine Wave Polarization:** Analyze different types of wave polarization, including linear, circular, and elliptical, and their implications in wave propagation.
5. **Explore Rotatory Polarization:** Understand optical rotation phenomena in materials and its application in devices like polarimeters.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Maxwell Equations: Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Mo mentum Density and Angular Momentum Density.	10
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.	10
EM Wave in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence)	10
Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates:Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light.	10
Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.	3
Wave Guides: Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations.Phase and group velocity of guided waves. Field energy and Power transmission.	4

Reference Books:

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

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

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

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

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

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-V, Paper-Practical

Course Code: PHSHMJ504P
Course Title: ELECTROMAGNETIC THEORY(PRACTICAL)

Course Outcomes

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

1. **Verify the Law of Malus:** Experimentally confirm Malus's law for plane-polarized light and understand the relationship between intensity and polarization angle.

2. **Determine Specific Rotation Using a Polarimeter:** Measure the specific rotation of sugar solutions, gaining practical experience with optical rotation and polarimetry techniques.

3. **Verify Stefan's Law and Determine Stefan's Constant:** Experimentally verify Stefan's law of blackbody radiation and calculate Stefan's constant using thermal radiation measurements.

4. **Determine the Boltzmann Constant:** Use the V-I characteristics of a PN junction diode to calculate the Boltzmann constant, understanding its significance in thermodynamics and semiconductor physics.

5. **Develop Experimental and Analytical Skills:** Perform precise measurements, analyze data critically, and interpret results effectively in the context of electromagnetic and thermal phenomena.

Course Details

- **Credits:** 01
- **Total No. of Lectures (in hours per week):** 2

Lab Experiment List

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To verify the Stefan‘s law of radiation and to determine Stefan’s constant.
4. To determine the Boltzmann constant using V-I characteristics of PN junction diode.
5. To analyze elliptically polarized Light by using a Babinet’s compensator.
6. To study the reflection, refraction of microwaves.
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-VI, Paper-Theory

Course Code: PHSHMJ601T
Course Title: QUANTUM MECHANICS - I

Course Outcomes

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

1. **Understand the Schrödinger Equation :** Derive and solve the time-dependent and time-independent Schrödinger equations for various physical systems.
2. **Analyze Bound States in Arbitrary Potentials:** Discuss the general properties of bound states in one-dimensional and three-dimensional potentials, emphasizing physical interpretation.
3. **Apply Quantum Theory to Hydrogen-like Atoms:** Solve the Schrödinger equation for hydrogen-like atoms and understand quantum numbers, energy levels, and orbital shapes.
4. **Examine the Effect of External Fields:** Analyze the behavior of atoms in electric (Stark effect) and magnetic fields (Zeeman effect), and understand their physical significance.
5. **Explore Many-Electron Atoms:** Study the quantum mechanics of many-electron atoms, including spin, the Pauli exclusion principle, and approximation methods such as Hartree-Fock.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions;Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation val- ues of position and momentum. Wave Function of a Free Particle.	6
Time independent Schrodinger equation: Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.	8
General discussion of bound states in an arbitrary potential: continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.	7
Quantum theory of hydrogen-like atoms: Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells.	8
Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.	6
Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).	3
Many electron atoms: Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms- L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).	7

Reference Books:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed.,2010, McGraw Hill.
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-VI, Paper-Practical

Course Code: PHSHMJ601P
Course Title: QUANTUM MECHANICS(PRACTICAL)

Course Outcomes

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

1. **Solve the Time-dependent Schrödinger Equation** Numerically solve the time-dependent Schrödinger equation for simple systems and simulate wave packet propagation.

2. **Solve the Time-independent Schrödinger Equation:** Implement solutions to the time-independent Schrödinger equation for various potentials (e.g., infinite well, harmonic oscillator) and visualize wavefunctions and energy levels.

3. **Analyze Bound States in Arbitrary Potentials:** Investigate bound states in different potential profiles using numerical methods such as the finite difference method and visualize energy spectra and wavefunctions.

Course Details

- **Credits:** 01
- **Total No. of Lectures (in hours per week):** 2

Lab Experiment List

Use PYTHON programming language for solving the following problems based on Quantum Mechanics like-

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:
   $\frac{\mathrm{d}^2 y}{\mathrm{d}r^2} = A\left(r\right) u\left(r\right), A\left(r\right) = \frac{2m}{\hbar}[V(r) - E]$ where, $V\left(r\right) = -\frac{e^2}{r}$
   Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is $\approx$ 13.6 eV. Take $e = 3.795\left(eVA\right)^{\frac{1}{2}}$, $\hbar c = 1973\left(eV\mathring{A}\right)$ and $m = 0.511 \times 10^6 eV/c^2$

2. Solve the s-wave radial Schrodinger equation for an atom:
   $\frac{\mathrm{d}^2 y}{\mathrm{d}r^2} = A\left(r\right) u\left(r\right), A\left(r\right) = \frac{2m}{\hbar}[V(r) - E]$
   where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential,
   $V\left(r\right) = -\frac{e^2}{r} exp\left(-\frac{r}{a}\right)$
   Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take, $e = 3.795\left(eV\mathring{A}\right)^{\frac{1}{2}}$, $m = 0.511 \times 10^6 eV/c^2$ and $a = 3\mathring{A}, 5\mathring{A}, 7\mathring{A}$. In these units $\hbar c = 1973(eV\mathring{A})$. The ground state energy is expected to be above -12 eV in all three cases.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-VI, Paper-Theory

Course Code: PHSHMJ602T
Course Title: Solid State Physics

Course Outcomes

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

1. **Understand Crystal Structure :** Analyze and describe the properties of crystalline materials, including unit cells, lattice structures, and symmetry operations. Apply concepts such as Miller indices and Bragg's law in the determination of crystal planes and diffraction patterns.

2. **Apply Drude's Theory:** Explain the classical model of electrical conduction in metals based on the Drude model. Derive expressions for electrical conductivity, resistivity, and discuss the limitations of Drude's approach in explaining real material behaviors.

3. **Analyze Dielectric Properties of Materials:** Understand the behavior of dielectric materials in electric fields.Evaluate polarization, permittivity, and susceptibility in dielectric materials, and discuss applications like capacitors and piezoelectric effects.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Crystal structure Solids: amorphous and crystalline materials. Lattice translation vectors. Lattice with a basis; central and non-central elements. Unit cell. Miller indices. Reciprocal lattice. Types of lattices. Brillouin zones. Diffraction of X-rays by crystals. Laue and Bragg's laws and their equivalence. Atomic and geometrical structure factor. Basic idea of crystal indexing: examples with SC, BCC, FCC structure.	10
Elementary lattice dynamics: Lattice vibrations and phonons: linear monatomic and diatomic chains. Acoustical and optical phonons. Qualitative description of the phonon spectrum in solids.	3
Drude's theory: Free electron gas in metals, effective mass, drift current, mobility and conductivity, Hall effect in metals. Thermal conductivity. Lorentz number, limitation of Drude's theory.	5
Dielectric properties of materials: Polarization. Local electric field at an atom. Depolarization field. Electric susceptibility. Polarizability. Clausius-Mosotti equation. Classical theory of electric polarizability. Normal and anomalous dispersion. Cauchy and Sellmeier relations. Langevin-Debye equation. Complex dielectric constant.	10
Elementary band theory: Kronig-Penney model. Band gap. Effective mass and effective mass tensor. Conductor, semiconductor (P and N type) and insulator. Conductivity of semiconductor, mobility, Hall effect. Measurement of conductivity (4 probe method) and Hall coefficient	8
Magnetic properties of matter : Dia, para, ferri and ferromagnetic materials. Classical Langevin theory of dia- and paramagnetic domains. Quantum mechanical treatment of paramagnetism (using partition function). Curie's law, Weiss's theory of ferromagnetism and ferromagnetic domains. B-H curve and hysteresis. Calculation of energy loss in B-H loop.	10
Superconductivity: Experimental results. Critical temperature. Critical magnetic field. Meissner effect. Type I and type II superconductors, London equation and penetration depth. Isotope effect.	5

Reference Books:

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

2. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer Solid State Physics, Rita John, 2014, McGraw Hill.

3. Elementary Solid State Physics, M. Ali Omar, 1999, Pearson India.

4. The Oxford Solid State Basics, S.H. Simon, 2017, Oxford University Press.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-VI, Paper-Practical

Course Code: PHSHMJ602P
Course Title: SOLID STATE PHYSICS(PRACTICAL)

Course Outcomes

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

1. **Measurement of Susceptibility of Paramagnetic Solution (Quincke's Tube Method):** Determine the magnetic susceptibility of a paramagnetic solution using the Quincke's tube method. Analyze experimental data to calculate susceptibility and interpret the results.

2. **Measurement of Magnetic Susceptibility of Solids:** Use appropriate techniques to measure the magnetic susceptibility of solid materials. Apply the principles of paramagnetism, diamagnetism, and ferromagnetism to analyze the experimental findings.

3. **Draw BH Curve of Fe Using Solenoid & Determine Energy Loss from Hysteresis:** Construct the BH curve of iron using a solenoid and a magnetometer. Determine energy loss from hysteresis by analyzing the loop area and correlate it with material properties.

Course Details

- **Credits:** 01
- **Total No. of Lectures (in hours per week):** 2

Lab Experiment List

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of Solids.
3. To measure the Dielectric Constant of a dielectric Materials with frequency.
4. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
5. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to $150°C$) and to determine its band gap.
6. To determine the Hall coefficient of a semiconductor sample.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-VI, Paper-Theory

Course Code: PHSHMJ603T
Course Title: Nuclear and Particle Physics

Course Outcomes

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

1. **Understand Nuclear Properties and Structure:** Describe the basic properties of nuclei, including mass, charge, binding energy, and stability. Explain nuclear models (liquid drop model, shell model) and their applications in understanding nuclear structure and stability.

2. **Analyze Interaction with and Within the Nucleus:** Discuss the fundamental forces acting within the nucleus, including the strong and weak nuclear forces.Understand nuclear forces, potential models, and the role of the nuclear force in particle interactions and binding.

3. **Study Nuclear Reactions:** Analyze various types of nuclear reactions such as fission, fusion, and scattering.Understand reaction mechanisms, conservation laws, and calculate reaction rates and cross-sections in nuclear processes.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Rutherford scattering: Calculation of differential cross-section.	2
Nuclear properties and structure: Mass, charge, size, B.E, spin and magnetic moment of the nucleus; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle; Isotopes, isobars, isotones. Bainbridge Mass Spectrograph. Nature of nuclear force between nucleons, Stability and binding, N-Z plot. Nuclear models: Liquid Drop model. BetheWeizsäcker semi-empirical mass formula and binding energy. Some applications: explanation of α decay by heavy nuclei, mass parabola, explanation of β decay by mirror nuclei. Nuclear shell model and magic numbers, ground state spin parity, Nordheim's Rule (qualitative discussion on phenomenology with examples).	15
Interaction with and within the nucleus: Radioactivity: α- decay — kinematics, range-energy relationship and Geiger-Nuttall Law; β-decay — energy released, spectrum and Pauli's prediction of neutrino; Energy levels and decay schemes, positron emission and electron capture, selection rules: Fermi and Gamow-Teller transitions. γ-ray emission, nuclear isomerism, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.	10
Nuclear Reactions: Types of reactions, conservation laws, kinematics of reactions, Q-value, reaction rate, reaction cross-section. Concept of compound and direct reaction, Ghoshal's experiment. 23 Resonance reaction, fission and fusion: mass deficit and generation of energy. Reaction characteristics, explanation in terms of liquid drop model, fission products and energy release, spontaneous and induced fission, transuranic elements. Chain reaction and basic principle of nuclear reactors. Nuclear fusion: energetics in terms of liquid drop model. Chain reaction and basic principle of nuclear reactors, slow neutrons interacting with U235, Nuclear Fusion — energetics in terms of liquid drop model (brief qualitative discussions)	10
Particle accelerators and detectors: Linear accelerator, cyclotron, betatron, gas detectors — GM Counters. Semiconductor detectors.	5
Particle physics : Elementary particles and their families, interactions and basic features. Symmetry and conservation laws: energy and momentum, angular momentum, parity, baryon number, lepton number, isospin, hypercharge, and strangeness. Wu's experiment and basic idea of parity violation. Gell-Mann–Nishijima formula. The baryon and meson octet and baryon decuplet diagrams. Quark structure of hadrons. Concept of quark model, color quantum number and gluons (qualitative discussion only).	10

Reference Books:

1. Introductory nuclear Physics by Kenneth S. Krane, 2008, Wiley India.

2. Nuclear and Particle Physics, S. Bhattacharyya, 2020, Universities Press .

3. Introduction to Elementary Particles, D. Griffiths, 2008, John Wiley & Sons.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-VI, Paper-Tutorial

Course Code: PHSHMJ603P
Course Title: Tutorial

Course Details

- **Credits:** 01

Tutorial

Students must be given at least one assignment or a small set of problems. On the basis of regularity of submission and evaluation of assignment by the respective teacher, credits should be awarded to the students.

Programme: FOUR YEAR UNDERGRADUATE PROGRAM IN PHYSICS

Subject: Physics (Major) Semester-VI, Paper-Theory

Course Code: PHSHMJ604T
Course Title: Staistical Mechanics

Course Outcomes

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

1. **Classical Statistics:** Understand and apply the principles of classical statistical mechanics, including the concept of microstates, macrostates, and the distribution of particles in phase space.Derive key thermodynamic quantities such as entropy, temperature, and pressure from statistical principles, using the Maxwell-Boltzmann distribution.

2. **Bose-Einstein Statistics (BE-Statistics):** Explain the statistical behavior of bosons and the concept of Bose-Einstein condensation. Apply Bose-Einstein statistics to systems of indistinguishable particles, such as photons and helium-4, and understand phenomena like blackbody radiation and superfluidity.

3. **Fermi-Dirac Statistics (FD-Statistics):** Understand the behavior of fermions and the Pauli exclusion principle. Apply Fermi-Dirac statistics to systems of fermions, such as electrons in metals, and derive important results like the Fermi energy and Fermi temperature, as well as the concept of electron degeneracy pressure.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Classical Statistics:	
Macrostate and Microstate: Elementary Concept of Ensemble and Ergodic Hypothesis (statement only). Phase space. Microcanonical ensemble, Postulate of equal a priori probability. Boltzmann hypothesis: Entropy and thermodynamic probability	4
Canonical ensemble: Partition function, Thermodynamic properties of an ideal gas. Thermodynamic properties of classical and quantum harmonic oscillator in one dimension using canonical ensemble. Classical entropy expression, Gibbs paradox. Equivalence of microcanonical and canonical ensembles. Sackur-Tetrode equation, Law of equipartition of energy (with proof) and its applications. Thermodynamic functions of a two-energy Level system. Negative temperature. Idea of chemical potential and grand canonical ensemble. Application of ideal gas using grand canonical ensemble	11
Grand Canonical ensemble: System in contact with a particle reservoir; chemical potential; grand canonical partition function and grand potential; fluctuation of internal energy and particle number; Chemical potential of ideal gas; Chemical equilibrium and Saha ionisation equation.	5
Quantum statistical mechanics: Density Matrix; Quantum Liouville theorem; Density matrices for microcanonical, canonical and grand canonical systems; Simple examples of density matrices — one electron in a magnetic field, particle in a box; Identical and indistinguishable particles — B-E and F-D distributions.	10
Ideal quantum gas: . Ideal quantum gas (8). Ideal quantum gas in microcanonical ensemble; grand partition function;statistics of occupation numbers; pressure of a quantum ideal gas. Ideal Bose gas: equation of state; Bose condensation. Ideal Fermi gas: equation of state; statistical properties. Specific heat of Bose and Fermi gases.	10
Phase transition and critical phenomena: Liquid gas and magnetic phase transitions; classification of phase transitions. Critical phenomena - critical exponents, universality and scaling relations. Ising model – exact solution in one dimension by transfer matrix method; Calculation of critical exponents (alpha, beta, gamma and delta) using mean field theory (Weiss) and Landau theory;	10

Reference Books:

1. M. Plischke and B. Bergersen: Equilibrium Statistical Physics.

2. R.K. Pathria: Statistical Mechanics.

Programme: CERTIFICATE COURSE IN BASIC PHYSICS

Subject: Physics, Paper-Theory

Course Code: SEC-I

Course Title: BASIC INSTRUMENTATION SKILLS

Course Outcomes

1. Understand the basic principles, construction, and working of commonly used laboratory instruments.
2. Develop proficiency in handling, calibrating, and maintaining instruments for experimental and industrial purposes.
3. Analyze the functioning of analog and digital measuring devices for precise data acquisition.
4. Gain knowledge of error analysis and the importance of calibration in experimental physics.
5. Acquire skills in assembling and troubleshooting basic circuits for instrumentation applications.
6. Apply knowledge of instrumentation in practical scenarios, including environmental and industrial monitoring.
7. Learn to interpret technical manuals and datasheets for instrumentation tools effectively.
8. Explore the interdisciplinary applications of basic instrumentation in fields like medical physics, engineering, and environmental science.
9. Foster a hands-on approach and critical thinking for experimental setups using instrumentation skills.
10. Develop an understanding of safety protocols and ethical considerations while working with instruments.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. **Multimeter:** Principles of measurementof dc voltage and dc current, ac voltage, ac current and resistance. Specifications of amultimeter and their significance.	4
Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles ofvoltage, measurement (block diagram only). Specifications of an electronic Voltmeter/Multimeter and their significance.	4
AC millivoltmeter: Type of AC millivoltmeters, Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.	3
Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls.Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period.Specialfeatures of dual trace, introduction to digital oscilloscope, probes. Digital storageOscilloscope: Block diagram and principle of working.	5 3
Digital Instruments: Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital Voltmeter.	3
Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time- base stability, accuracy and resolution.	3

Suggested Reading

1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
3. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

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Hands on training of the following Instruments:

Total number of lectures : 20

1. Measurement of different circuit component using multimeter.
2. Use of a bread borad.
3. Use of function generator.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Use of AC millivoltmeter.

Programme: CERTIFICATE COURSE IN BASIC PHYSICS

Subject: Physics, Paper-Theory

Course Code: SEC-II
Course Title: INTRODUCTION AND BASICS PYTHON PROGRAMMING

Course Outcomes

This course is to get exposure with various aspects of instruments and their usage through hands-on mode.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Introduction and Overview: Computer architecture and organization, memory and Input/output devices	2
Basics of scientific computing: Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.	4
Graphics and visualization with Python: Introduction to plotting using Python (matplotlib). Scatter plots. Density plots. 3D graphics. Animation	4
Introduction to programming in python: Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object oriented programming, random number generation, user-defined functions.	8
Applications of Python Programming: Sum and average of a list of numbers, sorting, binary search, finding prime numbers, area of a circle, volume of a sphere, value of π, sum of series, factorial, Fibonacci series.	5
Introduction to Numerical computation using numpy and scipy: Introduction to the python numpy module. Arrays in numpy, array operations, array item selection, slicing, shaping arrays. Basic linear algebra using the linalg sub module.	5
Application of Numpy and Scipy: Matrix multiplication, solution of transcendental equation, solution of a set of	5

Suggested Reading

1. Introduction to Numerical Analysis, S.S. Sastry, 5thEdn. , 2012, PHI Learning Pvt.Ltd.

2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn. , 2007, Cambridge University Press.

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

Hands on training of the following Instruments:

Total number of lectures : 20

Hands on training on the "INTRODUCTION AND BASICS PYTHON PROGRAMMING" relevant with the theory topic.

Programme: CERTIFICATE COURSE IN BASIC PHYSICS

Subject: Physics, Paper-Theory

Course Code: SEC-III

Course Title: SCIENTIFIC WRITING SKILLS (LATEX)

Course Details

- **Credits:** 04
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

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1. Introduction to LATEX: The difference between WYSIWYG and WYSIWYM. Preparing a basic LATEX file. Compiling LATEX file.
2. Document classes: Different type of document classes, e.g., article, report, book and beamer.
3. Page Layout: Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation.
4. List structures: Itemize, enumerate, description etc.
5. Representation of mathematical equations: Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line-surface-volume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc.
6. Customization of fonts: Bold fonts, emphasize, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny, etc.
7. Writing tables: Creating tables with different alignments, placement of horizontal, vertical lines.

8. Figures: Changing and placing the figures, alignments Packages: amsmath, amssymb, graphics, graphicx, Geometry, algorithms, color, Hyperref etc. Use of Different LATEX commands and environments, Changing the type style, symbols from other languages. Special characters.

Note: Software required: LATEX in Linux and Mik-TEX in Windows. Preferred editor Kile/ Emacs/ TEX Studio in Linux and TEX Studio in Windows.

Suggested Reading

1. LATEX- A Document Preparation System , Leslie Lamport , 1994, Addison-Wesley.
2. Walking with LATEX, Suman Bandopadhyaya, Techno World.
3. LATEX Tutorials A PRIMER, Indian TEXuser group, E. Krishnan.

Programme: CERTIFICATE COURSE IN BASIC PHYSICS

Subject: Physics (Minor) Semester-I, Paper-Theory

Course Code: PHSHMI101T

Course Title: Mechanics

Course Outcomes

1. Understanding of Vector Algebra and Vector Calculus.
2. Study of gravitational field and potential and understanding of Kepler's laws of planetary motion and application.
3. Understanding of different frames of references and conservation laws.
4. Understand the dynamics of rigid body and concept of moment of inertia. Study of moment of inertia of different bodies and its applications.
5. Study the properties of matter, response of the classical systems to external forces and their elastic deformation and its applications.
6. Comprehend the dynamics of Fluid and concept of viscosity and surface tension along with its applications.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Vectors: Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. .	4
Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.	5
Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.	7
Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.	5
Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum.	5
Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts.	7
Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.	5
Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, σ, η by Searles method	7

Reference Books:

1. A Hand Book of Degree Physics – Dasgupta.
2. Classical Mechanics – Maity & Raychoudhuri.
3. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000.
4. Classical Mechanics – J C Upadhyay.

Programme: CERTIFICATE COURSE IN BASIC PHYSICS

Subject: Physics (Minor) Semester-I, Paper-Practical

Course Code: PHSHMI101P

Course Title: Mechanics

Course Outcomes

1. Develop an in-depth understanding of fundamental mechanical concepts such as motion, force, energy, momentum, and rotational dynamics through experimental practices.

2. Gain proficiency in handling scientific instruments, including vernier calipers, micrometers, and other mechanical apparatus, to measure and analyze physical quantities accurately.

3. Enhance skills in recording, analyzing, and interpreting experimental data with precision to verify theoretical principles.

4. Apply concepts of mechanics to solve real-world problems, understanding their relevance to fields like engineering, materials science, and environmental systems.

5. Learn to identify and evaluate sources of error in experiments, improving scientific rigor and accuracy.

6. Develop collaborative and communication skills by working in groups to conduct experiments, share findings, and present results effectively.

7. Foster critical thinking abilities by designing, conducting, and troubleshooting experiments in mechanics.

8. Build a strong practical foundation for advanced studies and research in physics and related interdisciplinary fields.

Mechanics LAB:

(a) To determine the Moment of Inertia of a Flywheel.

(b) To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).

(c) To determine the Young's Modulus by method of flexure.

(d) To determine the Modulus of Rigidity of a Wire by Maxwell's needle.

(e) To determine the value of g using Bar Pendulum.

(f) To determine the value of g using Kater's Pendulum.

(g) To study the Motion of Spring and calculate (a) Spring constant, (b) g

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Reference Books:

(a) Advanced Practical Physics Vol-1 by B.Ghosh and K G Mazumder.

(b) An Advanced Course in Practical Physics by D. Chattopadhyay and P. C. Rakshit.

Programme: PHYSICS (MINOR-2)

Subject: Physics (Minor) , Paper-Theory

Course Code: PHSHMI201T

Course Title: ELECTRICITY AND MAGNETISM

Course Outcomes

(a) Grasp the fundamental principles of electrostatics, magnetostatics, and electromagnetism, including electric fields, magnetic fields, and their interactions.

(b) Use vector calculus and differential equations to solve problems related to electric and magnetic fields in various configurations, including Coulomb's law, Gauss's law, Ampère's law, and Faraday's law.

(c) Calculate electric potentials, field intensities, magnetic flux, and forces on charges and currents in static and dynamic fields.

(d) Understand the concept of electromagnetic waves, their propagation, and their applications in communication and energy transmission.

(e) Recognize the relevance of electricity and magnetism in modern technological applications, such as electrical circuits, motors, transformers, and communication devices.

(f) Perform experiments to observe the effects of electric and magnetic fields, including measurements and analysis of results.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Vector Analysis: Scalar and Vector product, gradient, divergence, Curl and theirsignificance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only) .	12
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	22
Magnetism: Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field.Magnetic vector potential.Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferromagnetic materials	10
Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz'slaw, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.	6
Maxwell's equations and Electromagnetic wave propagation: Angular velocity and angular momentum. Torque. Conservation of angular momentum.	10

Reference Books:

(a) Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.

(b) Electricity & Magnetism, J.H. Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

(c) Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.

(d) University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Programme: PHYSICS (MINOR-2)

Subject: Physics (Minor-2) , Paper-Practical

Course Code: PHSHMI201P

Course Title: ELECTRICITY AND MAGNETISM

Course Outcomes

(a) Demonstrate proficiency in setting up and conducting experiments related to electricity and magnetism, including the use of essential laboratory equipment.

(b) Implement concepts from electrostatics, magnetostatics, and electromagnetism to solve practical problems and verify theoretical results through experimentation.

(c) Accurately measure electric potentials, field strengths, magnetic fields, and currents using instruments like voltmeters, ammeters, galvanometers, and electromagnets.

(d) Analyze and interpret experimental data, apply error analysis, and draw conclusions based on experimental observations.

(e) Investigate electromagnetic phenomena such as induction, the behavior of capacitors, resistors, and inductors in circuits, and the interaction between electric and magnetic fields.

(f) Carry out advanced experiments on electromagnetic waves, mutual inductance, and resonance phenomena, understanding their theoretical implications.

(g) Enhance problem-solving abilities by dealing with practical challenges in setting up experiments, collecting data, and troubleshooting experimental setups.

(h) Cultivate a scientific mindset, encouraging curiosity, precision, and a deeper understanding of how electromagnetic principles govern the physical world.

ELECTRICITY AND MAGNETISM LAB:

(a) To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.

(b) Ballistic Galvanometer: (i) Measurement of charge and current sensitivity (ii) Measurement of CDR (iii) Determine a high resistance by Leakage Method (iv) To determine Self Inductance of a Coil by Rayleigh's Method.

(c) To compare capacitances using De'Sauty's bridge.

(d) Measurement of field strength B and its variation in a Solenoid (Determine dB/dx).

(e) To study the Characteristics of a Series RC Circuit.

(f) To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor.

(g) To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.

Reference Books:

(a) Advanced Practical Physics for students, B.L.FlintH.T.Worsnop, 1971, Asia Publishing House.

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

Programme: PHYSICS (MINOR-3)

Subject: Physics (Minor) , Paper-Theory

Course Code: PHSHMI301T

Course Title: WAVES AND OPTICS

Course Outcomes

(a) Grasp the fundamental concepts of mechanical and electromagnetic waves, including wave properties such as frequency, wavelength, amplitude, and speed.

(b) Demonstrate an understanding of wave behavior such as interference, diffraction, and polarization, and apply these principles to solve related problems.

(c) Explain the wave nature of light, including its propagation, reflection, refraction, and the application of Snell's law.

(d) Apply the principles of interference and diffraction to phenomena like Young's double-slit experiment, diffraction gratings, and optical devices.

(e) Analyze the working of optical instruments such as microscopes, telescopes, and spectrometers, and understand their uses in scientific and technological applications.

(f) Understand the concept of light polarization and its practical applications, such as polarizing filters and optical fibers.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3
- **Total number of Lectures: 45**

Topic	No. of Lectures
Superposition of Two Collinear Harmonic oscillations: Linearity & SuperpositionPrinciple. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats)	4
Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.	2
Waves Motion- General: Transverse waves on a string. Travelling and standingwaves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.	7
Fluids: Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of liquid with temperature- lubrication.	6
Sound: 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 auditorium.	6
Wave Optics: : Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.	3
Interference: Interference: Division of amplitude and division of wavefront. Young'sDouble Slit experiment.Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedgeshaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.	10
Michelson's Interferometer: (1) Idea of form of fringes (no theory needed), (2)Determination of wavelength, (3) Wavelength difference, (4) Refractive index, and (5) Visibility of fringes	3
Diffraction: Fraunhofer diffraction- Single slit; Double Slit. Multiple slits andDiffraction 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
Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.	5

Reference Books:

(a) Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill

(b) Principles of Optics, B.K. Mathur, 1995, Gopal Printing.

(c) Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications.

(d) University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986.Addison-Wesley.

Programme: PHYSICS (MINOR-3)

Subject: Physics (Minor-3) , Paper-Practical

Course Code: PHSHMI201P

Course Title: WAVE & OPTICS

Course Outcomes

(a) Perform Wave Experiments: Conduct experiments to observe and analyze wave phenomena such as interference, diffraction, and polarization in various media.

(b) Measure Optical Quantities: Accurately measure optical parameters like refractive index, focal length, and the wavelength of light using instruments such as spectrometers, microscopes, and diffraction gratings.

(c) Investigate Interference and Diffraction: Set up and analyze interference patterns, such as those observed in Young's double-slit experiment, and understand diffraction effects using single-slit or multiple-slit setups.

(d) Examine Polarization: Perform experiments to observe and understand the polarization of light using polarizers and analyzers, and study phenomena like Brewster's angle.

(e) Analyze Optical Instruments: Use optical instruments like telescopes, microscopes, and spectrometers, and understand their calibration, operation, and applications in practical scenarios.

(f) Data Analysis and Error Estimation: Collect and analyze experimental data, apply error analysis, and accurately interpret results to validate theoretical predictions.

(g) Apply Wave Theory to Practical Problems: Develop problem-solving skills by applying theoretical concepts of waves and optics to real-world experimental situations.

(h) Enhance Scientific Inquiry: Foster scientific curiosity and precision in conducting optical experiments, leading to a deeper understanding of light and wave phenomena.

WAVES AND OPTICS (PRACTICALS):

(a) To investigate the motion of coupled oscillators.

(b) To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda^2 \sim T$ Law.

(c) To study Lissajous Figures

(d) Familiarization with Schuster‘s focussing; determination of angle of prism.

(e) To determine the Refractive Index of the Material of a Prism using Sodium Light.

(f) To determine Dispersive Power of the Material of a Prism using Mercury Light.

(g) To determine the value of Cauchy Constants.

(h) To determine the Resolving Power of a Prism.

(i) To determine wavelength of sodium light using Fresnel Biprism.

(j) To determine wavelength of sodium light using Newton's Rings.

(k) To determine the wavelength of Laser light using Diffraction of Single Slit.

Reference Books:

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

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

Programme: PHYSICS (MINOR-4)

Subject: Physics (Minor) , Paper-Theory

Course Code: PHSHMI401T

Course Title: ELEMENTS OF MODERN PHYSICS

Course Outcomes

(a) Understand Key Concepts in Modern Physics: Grasp fundamental principles in modern physics, including special relativity, quantum mechanics, and atomic theory.

(b) Explore Quantum Mechanics: Learn the basics of quantum mechanics, including wave-particle duality, the Schrödinger equation, and the concept of wavefunctions, and apply them to systems like the hydrogen atom.

(c) Analyze Atomic and Molecular Structure: Understand atomic models, including Bohr's model and quantum mechanical models, and explore molecular structures using principles of quantum chemistry.

(d) Study Nuclear Physics: Understand nuclear models, radioactivity, nuclear reactions, and the basics of fission and fusion processes.

(e) xamine Solid State Physics: Develop a foundational understanding of the behavior of solids, including concepts like crystal structures, semiconductors, and band theory.

(f) Relate to Modern Technological Applications: Recognize the role of modern physics in technological advancements, such as lasers, semiconductors, and quantum computing.

Course Details

- **Credits:** 03
- **Total No. of Lectures (in hours per week):** 3

- **Total number of Lectures: 45**

Topic	**No. of Lectures**
Planck's quantum, Planck's constant and light as a collection of photons; Photoelectric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.	8
Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra.	4
Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.	4
Two slit interference experiment with photons, atoms & 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 wave function, probabilities and normalization; Probability and probability current densities in one dimension.	11
One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier.	12
Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.	6
Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission.	11
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.	4

Reference Books:

(a) Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill

(b) Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson,2009, PHI Learning

(c) Six Ideas that Shaped Physics:Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill.

(d) Quantum Physics, Berkeley Physics,Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.

Programme: PHYSICS (MINOR-4)

Subject: Physics (Minor-4) , Paper-Practical

Course Code: PHSHMI401P

Course Title: ELEMENTS OF MODERN PHYSICS

Course Outcomes

(a) Conduct Experiments in Modern Physics: Perform laboratory experiments to observe and verify principles from modern physics, including experiments related to the photoelectric effect, atomic spectra, and X-ray diffraction.

(b) Apply Quantum Mechanics in Experiments: Conduct experiments to observe quantum phenomena, such as determining Planck's constant and understanding the behavior of electrons in magnetic fields (e.g., using the Stern-Gerlach experiment).

(c) Measure Atomic and Nuclear Properties: Measure and analyze properties of atoms and nuclei, such as determining the energy levels in atoms or the decay rate of radioactive materials.

(d) Investigate Relativity Effects: Set up experiments to understand the implications of special relativity, including determining time dilation or relativistic mass increase in controlled setups.

(e) Use Advanced Laboratory Instruments: Gain practical skills in using instruments such as spectrometers, oscilloscopes, and Geiger counters for precise measurements of physical quantities.

(f) Analyze Data and Interpret Results: Collect experimental data, perform error analysis, and interpret results to validate theoretical concepts in modern physics.

(g) Enhance Problem-Solving Skills: Develop problem-solving skills by analyzing experimental results, troubleshooting setups, and applying theoretical knowledge to practical situations.

ELEMENTS OF MODERN PHYSICS (PRACTICALS):

(a) To determine value of Boltzmann constant using V-I characteristic of PN diode.

(b) To determine work function of material of filament of directly heated vacuum diode.

(c) To determine the ionization potential of mercury.

(d) To determine value of Planck's constant using LEDs of at least 4 different colours.

(e) To determine the wavelength of H-alpha emission line of Hydrogen atom.

(f) To determine the absorption lines in the rotational spectrum of Iodine vapour.

(g) To study the diffraction patterns of single and double slits using laser and measure its intensity variation using Photosensor & compare with incoherent source – Na.

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

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

(j) To setup the Millikan oil drop apparatus and determine the charge of an electron.

Reference Books:

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

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