**COURSE OUTCOMES (PG)**

**M. Sc (Physics)**

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| **S No** | **Class & Semester** | **Course & Course Code** | **COs** | **Course Outcomes** |
| 1 | M. Sc. I-Sem | Classical Mechanics &PHY6101T | CO 1 | Utilize D’Alembert’s principle and generalized coordinates to systematically derive and apply Lagrange’s equations for analyzing complex mechanical systems. |
| CO2 | Develop equations of motion using Poisson brackets and analyze the significance of infinitesimal contact transformations and symmetry generators in mechanical systems. |
| CO3 | Employ the Hamilton-Jacobi formalism to solve equations for advanced mechanical systems and investigate their practical applications in physics and engineering. |
| CO4 | Explore the force-free motion of a rigid body, understanding its theoretical foundation and relevance in advanced mechanics and real-world scenarios. |
| CO5 | Investigate the effects of velocity-dependent potentials in the Lagrangian formulation and assess their implications for the dynamics of mechanical systems. |
| 2 | Quantum Mechanics & PHY6102T | CO 1 | Analyze linear operators, eigenvalues and eigenkets, including their role in the quantum mechanical framework. |
| CO2 | Apply advanced approximation methods such as the variational method, time-dependent perturbation theory (non-degenerate and degenerate) and the WKB approximation to determine energy states. |
| CO3 | Develop a strong understanding of Hilbert spaces, wave functions, and quantum mechanical principles such as bases, dimension, subspaces, dual spaces and inner product spaces, employing Dirac notation to analyze orthonormality, completeness and matrix representations. |
| CO4 | Analyze time evolution in quantum systems, solve eigenvalue problems in various scenarios such as particles in a box, harmonic oscillators and the hydrogen atom. |
| CO5 | Explore the theory of angular momentum, including matrix representations, eigenstates, spherical harmonics and Clebsch-Gordon coefficients. |
| 3 | Classical Electrodynamics-I & PHY6103T | CO 1 | Students will demonstrate proficiency in solving electrostatic problems, including applications of Gauss's law and Laplace's equations. |
| CO2 | Students will apply methods like the method of images and Green's functions to solve boundary value problems in electrostatics and electrodynamics. |
| CO3 | Students will comprehend and utilize Maxwell’s equations to describe electromagnetic fields in various materials and interfaces. |
| CO4 | Students will analyze and predict wave behavior at interfaces, in waveguides, and under various boundary conditions. |
| CO5 | Students will understand the dynamics of charged particles in fields, calculate radiation from moving charges, and use tensor formalism for relativistic electromagnetism. |
| 4 | Numerical Methods & Computer Fundamental & PHY6105T | CO 1 | Define and explain the sources of errors in numerical analysis, including round-off errors, truncation errors, and the importance of error analysis in numerical computations. |
| CO2 | Apply direct and iterative methods (e.g., Gauss-Elimination, Jacobi, Gauss-Seidel) to solve linear systems. |
| CO3 | Use and apply various interpolation methods, such as linear interpolation, iterated interpolation, inverse interpolation, Hermite interpolation, and spline interpolation, to estimate values and construct approximation functions from discrete data sets. |
| CO4 | Implement numerical methods such as Bisection, Newton’s, modified Newton’s, and Iteration methods to solve nonlinear equations. Students will apply these methods to problems with both real and complex roots, analyzing the convergence and stability of the methods used. |
| CO5 | Analyze and solve problems involving higher-order equations and multi-dimensional integration, understanding the underlying principles of stability and accuracy. |
| 5 | M. Sc. & II-Sem | Research Methodology & PHY6201T | CO 1 | Explain the characteristics, objectives, and importance of research and differentiate between scientific and non-scientific methods. |
| CO2 | Classify and apply different types of research methods and designs suited to specific research problems. |
| CO3 | Construct well-defined hypotheses and select appropriate sampling methods for their research studies |
| CO4 | Capable of designing structured research frameworks and accurately identifying and formulating research problems. |
| CO5 | Distinguish between primary and secondary data, collect data systematically, and process it for meaningful analysis. |
| 6 | Electronics & PHY6202T | CO 1 | Explain the working principles of p-n junction diodes, analyze their I-V characteristics, and evaluate the role of clipper and clamper circuits in signal processing. |
| CO2 | Examine the operation of JFET, MOSFET, and BJT as amplifiers, and determine stability factors and biasing techniques for FET and BJT circuits. |
| CO3 | Demonstrate practical knowledge of Op-Amp behavior in feedback systems and design analog circuits using Op-Amps for various applications. |
| CO4 | Develop combinational circuits using Boolean algebra and Karnaugh maps, and implement logical functions with multiplexers, decoders, and adders. |
| CO5 | Analyze sequential logic circuits, including flip-flops, counters, and shift registers, and comprehend the principles of digital-to-analog (D/A) and analog-to-digital (A/D) conversion systems. |
| 7 | Atomic and Molecular Physics & PHY6203T | CO 1 | Explain the basic principles behind the Normal and Anomalous Zeeman Effects, Paschen-Back Effect and Stark Effect in atomic systems and recognize their impact on spectral line splitting. |
| CO2 | Examine the relativistic corrections to energy levels, fine structure and magnetic dipole interactions in hydrogen-like atoms. |
| CO3 | Critically assess and apply the principles of Molecular Photoelectron Spectroscopy, NMR, ESR and resonance spectroscopy to the electronic spectra of diatomic and polyatomic molecules. Discuss the significance of Frank-Condon’s principle in electronic transitions and how it relates to experimental data. |
| CO4 | Demonstrate the ability to classify and analyze the spectra of one- and two-electron systems, understanding singlet, doublet, and triplet emission characters, and apply the concepts to understand the rotational, vibrational, and Raman spectra, including their relationship to molecular symmetry. |
| CO5 | Define and describe the energy spectrum, including the probability distribution of radial and angular wave functions for hydrogen-like atoms, and qualitatively explain the effect of spin on the hydrogen atom's energy levels. |
| 8 | Mathematical Physics & PHY6206T | CO 1 | Define coordinate transformations in N-dimensional space, including contravariant and covariant tensors, Jacobians, and pseudo-tensors. They will also be able to use these concepts in examples like the change in density and angular momentum. |
| CO2 | Compute Fourier and inverse Fourier transforms, apply them to simple examples like finite wave trains, and understand their use in solving problems such as the wave equation and diffraction theory. |
| CO3 | Apply algebraic and differential tensor operations to real-world physical scenarios, such as using stress and strain tensors, Hooke's law in tensor form, and understanding the covariance of Maxwell’s equations. |
| CO4 | Compute Laplace transforms and apply them to solve linear differential equations with constant and variable coefficients, including partial differential equations. They will also be able to apply the convolution theorem in relevant physical systems. |
| CO5 | **Analyze the irreducible representations of crystallographic point groups and apply this understanding to problems in materials science and solid-state physics.** |
| 9 | M. Sc. & III-Sem | Advance Quantum Mechanics & PHY301 | CO 1 | Explain the kinetic model of gases and deduce relationships like Boyle’s law while interpreting temperature and molecular behavior. |
| CO2 | Demonstrate the ability to apply the Van der Waals equation to analyze the behavior of real gases and interpret experimental P-V curves and critical constants. |
| CO3 | Calculate mean free paths, molecular diameters, and transport coefficients, and understand the interrelationship between transport phenomena in gases. |
| CO4 | Analyze thermodynamic systems using the first and second laws of thermodynamics, including reversible and irreversible processes, Carnot cycles, and entropy changes. |
| CO5 | Apply blackbody radiation laws, such as Planck's law and Wien's displacement law, to explain thermal radiation phenomena and the specific heat behavior of gases at low temperatures. |
| 10 | Statistical and Solid State Physics & PHY302 | CO 1 | Explain the concepts of statistical distributions, phase space, density of states, and Liouville’s theorem. |
| CO2 | Derive equations of state, specific heat, and entropy of a perfect gas using the microcanonical ensemble. |
| CO3 | Determine translational, rotational and vibrational contributions to the partition function of an ideal diatomic gas, and calculate specific heat for ortho- and para-hydrogen. |
| CO4 | Analyze phenomena like Bose-Einstein condensation, Planck’s formula, and liquid He4​ as a boson system. |
| CO5 | Utilize Fermi-Dirac statistics to study thermal conductivity, electrical conduction, and specific heat in metals. |
| 11 | Nuclear Physics-I & PHY303 | CO 1 | Explain the general nature of nuclear forces, including charge independence, spin dependence, and the central, non-central, and velocity-dependent potentials. |
| CO2 | Analyze the ground and excited states of deuteron, calculate its magnetic dipole and electric quadrupole moments, and evaluate the implications of non-central forces. |
| CO3 | Apply partial wave analysis to neutron-proton and proton-proton scattering at low energy, interpret scattering lengths, and discuss the implications of exchange forces and effective range theories. |
| CO4 | Describe the processes of absorption, photoelectric effect, Compton scattering, pair production, and energy loss due to ionization and Bremsstrahlung, along with their energy dependencies. |
| CO5 | Gain proficiency in the working principles and applications of nuclear detectors such as gas-filled counters, scintillation counters, Cerenkov counters, and solid-state detectors, as well as in analyzing data using advanced measurement techniques. |
| 12 | Electronics & Communication-I & PHY304 | CO 1 | Compute the electromagnetic field distribution in rectangular waveguides for TE and TM modes and determine phase velocity and group velocity. |
| CO2 | Utilize the scattering matrix method to analyze microwave components such as tees and hybrid junctions for efficient signal transmission. |
| CO3 | Describe the working principles, operational characteristics, and noise properties of solid-state microwave devices used in modern communication systems. |
| CO4 | Explain the construction, operation, and efficiency of microwave tubes, including two-cavity Klystrons, Reflex Klystrons, Magnetrons, and Traveling Wave Tubes, for high-power microwave applications. |
| CO5 | Conduct microwave measurement techniques for power, frequency, attenuation, VSWR, and return loss, and utilize Smith charts for impedance matching and analysis. |
| 13 | Nanotechnology-I & PHY305 | CO 1 | Explain the fundamentals of nanotechnology, including the classification of nanostructures and the behavior of materials at the nanoscale. |
| CO2 | Identify and classify nanostructures based on their dimensional properties (0D, 1D, 2D) and characterize their mechanical, electrical and optical properties in relation to their size and structure. |
| CO3 | Explain how reducing the size of materials to the nanoscale impacts their properties, including changes to system energy, structure, and electronic conduction. |
| CO4 | Compare and contrast different methods for synthesizing nanostructures, such as chemical, physical, and hybrid techniques (e.g., sol-gel, ball milling, spray pyrolysis, CVD, etc.), and assess their advantages, limitations, and potential applications. |
| CO5 | Identify the challenges related to controlling size, morphology, and aggregation during the synthesis of nanomaterials, and propose strategies to overcome these challenges. |
| 14 | M. Sc. IV Sem | Introduction of Quantum Field Theory & PHY401 | CO 1 | Demonstrate a foundational understanding of scalar and vector fields in classical physics and their significance in field theory. |
| CO2 | Formulate and solve field equations using the Lagrangian formalism and the Euler-Lagrange equation in classical field theory. |
| CO3 | Apply the second quantization formalism to identical bosons, including real and complex Klein-Gordon fields, and analyze their physical implications. |
| CO4 | Explain the principles of electromagnetic interactions and gauge invariance and their role in field theories. |
| CO5 | Utilize the S-matrix formalism to analyze significant scattering processes such as Compton scattering, Bhabha scattering and Møller scattering. |
| 15 | Solid State Physics-II & PHY402 | CO 1 | Analyze concepts of optical phonons, dielectric constants and experimental techniques such as inelastic neutron scattering, the Mössbauer effect and Debye-Waller factor. |
| CO2 | Examine interactions of electrons and phonons with photons, including direct and indirect transitions. |
| CO3 | Define photoconductivity, photoluminescence, and the role of point, line, planar, and bulk defects such as F-centers in alkali halides. |
| CO4 | Explore Nuclear Magnetic Resonance (NMR), including Bloch equations, conditions for resonance, and experimental observations. |
| CO5 | Interpret key phenomena such as the Meissner effect, heat capacity, isotope effect, flux quantization and ultrasonic attenuation. |
| 16 | Nuclear Physics-II & PHY403 | CO 1 | Explain the assumptions, justifications and features of the nuclear shell model, including spin-orbit coupling, magic numbers, single-particle wave functions and predictions for ground state parity, angular momentum, and transition probabilities. |
| CO2 | Describe the cooperative modes of nuclear motion through the collective model Hamiltonian, including spherical and deformed nuclei, collective spectra, electromagnetic transitions and Nilsson's model for single-particle states. |
| CO3 | Illustrate the mechanisms of gamma decay and beta decay, including reduced transition probabilities, selection rules, weak interaction characteristics and parity violation, with experimental validations and theoretical frameworks like Fermi and Gamow-Teller transitions. |
| CO4 | Examine the theories of nuclear reactions, including compound nucleus formation, resonance scattering, statistical theories and specific nuclear reaction mechanisms such as stripping and pick-up reactions, using models like PWBA. |
| CO5 | Integrate theoretical concepts such as transition probabilities, collective spectra and nuclear reactions to analyze and compare with experimental data, ensuring alignment with phenomena like nuclear isomerism and deformation effects. |
| 17 | Electronics and Communication-II & PHY404 | CO 1 | Evaluate the characteristics, operations, and applications of different power semiconductor devices such as SCRs, TRIACs, MOSFETs, and IGBTs. |
| CO2 | Examine and assess the performance of single-phase and three-phase controlled rectifiers, commutation circuits, and cycloconverters in power electronics applications. |
| CO3 | Explain the principles of microwave propagation in ferrite materials and accurately calculate the communication range for microwave and satellite systems. |
| CO4 | Apply signal operations such as time and frequency shifting, scaling, and correlation to enhance signal processing performance. |
| CO5 | Explain and implement various modulation and demodulation techniques, including amplitude modulation (DSBSC, SSB, VSB) and angle modulation (wide-band FM), for effective communication system design. |
| 18 | Nanotechnology-II & PHY405 | CO 1 | Explain the basic principles and classification of nanotechnology, including nanoscale architecture, the free electron model, energy bands, crystalline solids and the effects of nanometer length scale on material properties. |
| CO2 | Classify different types of nanodimensional materials (0D, 1D, 2D structures) and analyze the size effects on surface energy, lattice parameters and phonon density of states. |
| CO3 | Describe various general methods for the synthesis of nanostructures, such as precipitative, reactive, hydrothermal/solvothermal methods and evaluate their suitability for scaling and potential applications. |
| CO4 | Physical and chemical methods for the synthesis of nanostructured materials, including thermal evaporation, PLD, sputtering, sol-gel processes and CVD, with a focus on their underlying principles and applications. |
| CO5 | Explain the specific features of nanoscale growth, including nucleation, growth control, stability, aggregation and post-condensation effects and apply these concepts to predict the morphology of nanoparticles. |