DEPARTMENT OF PHYSICS
C. M. Dubey Post Graduate College, Bilaspur (C.G.)

Learning Outcomes in M.Sc. (Previous & Final) PHYSICS Programme:

- **PROGRAMME OUTCOMES (POs):**

The student who will be completing Post Graduation with the Degree M.Sc. PHYSICS should be able to

PO1. Science knowledge: Knowledge of basic science fundamentals

PO2. Problem analysis: Develop analytical skills to identify, formulate, analyze complex mechanisms using first principles basic sciences.

PO3. Development of solutions: Design solutions for complex chemical process problems and evolve procedures that meet the specified needs with appropriate consideration for the public health and safety and environmental considerations.

PO4. Critical review of solutions: Use of research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern analytical tool usage: Select, and apply appropriate techniques, resources, and modern analytical tools

PO6. The scientist and society: Apply reasoning through the contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional chemical practice.

PO7. Environment and sustainability: Understand the impact of the chemical processes in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the chemistry practice

PO9. Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex scientific activities with the science community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the scientific and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

- **PROGRAMME SPECIFIC OUTCOMES (PSOs):**

PSO1: Students will demonstrate knowledge of mathematical physics, quantum mechanics, electrodynamics, statistical physics, and be able to apply this knowledge to analyze a variety of physical phenomena and related subjects.

PSO2: Students will acquire experimental skills which enable them to take precise measurements in physics labs and analyze the measurements to draw valid conclusions. In addition, students will exhibit skills in solving problems numerically using computer programming, plotting tools, and related software.

PSO3: Students will show enhanced oral and written scientific communication skills and be able to think critically and work independently as well as in a team and play beneficial role in the society as a person with better scientific outlook.

❖ COURSE OUTCOMES (COs):

M.Sc. (Previous) PHYSICS

PAPER – I: MATHEMATICAL PHYSICS & CLASSICAL MECHANICS

❖ Broad contents of the course:

1. Vector Spaces, Matrices and Eigen Value Problems.

2. Tensor Algebra: Contravariant, covariant tensors, Christophell's symbol, Covariant differentiation.

3. Differential equation: second order linear ordinary differential equations with variable coefficient.

3. Special Functions: Legendre's, Laguerre's, Bessel's, and Hermite's Differential Equation.

4. D'Alembert's Principle, Lagrangian formulation and it's applications.

5. Variational Principle and Calculus of Variation.

6. Hamiltonian formulation of mechanics and it's applications.

7. Principle of least action.

8. Canonical Transformation, Hamilton-Jacobi Theory.

9. Poisson's Brackets and Lagrange's Brackets.

❖ Course Learning Outcomes:

After going through the course, the student should be able to

CO1. Generalize the concept of real/complex vector space to an arbitrary finite dimensional vector space.

CO2. Investigate the properties of vector spaces and sub-spaces using Linear Transformation.

CO3. Learn some basic properties tensors, their symmetric and antisymmetric nature, the Cartesian tensors, the general tensors, contravariant, covariant, and mixed tensors and their transformation properties under coordinate transformations, physical examples of tensors such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor etc.

CO4. Solve ordinary differential equations with variable coefficient.

CO5. Get an idea of Power series method to solve differential equations.

CO6. Learn about the special functions, such as the Hermite polynomial, the Legendre polynomial, the Laguerre polynomial and Bessel functions and their differential equations and their applications in various physical problems such as in quantum mechanics.

CO7. Conceptualize the basic conservation laws in physics and of phase portrait.

CO8. Understand and apply the Lagrangian formalism to simple dynamical systems.

CO9. Apply Hamilton's equations and solve problems in dynamical systems.

CO10. Transform the phase-space coordinate system preserving the form of Hamilton's equation.

CO11. Apply the properties of Poisson's bracket and canonical transformations for solving simple systems.

M.Sc. (Previous) PHYSICS

PAPER – II: QUANTUM MECHANICS ATOMIC AND MOLECULAR PHYSICS

❖ **Broad contents of the course:**

1. Introduction to Quantum mechanics: Uncertainty principle, Schroedinger Equation and it's application to One dimensional problems (Potential well and barrier, Harmonic oscillator)

2. Bra and Ket notation, Commutation Relations, Angular momentum, Pauli's Matrices.

3. Spherically Symmetric Potential: H-atom problem.

4. Time-independent perturbation theory and application to Zeeman Effect, Stark Effect.

5. Variational Principle: application to He, H- atom and SHO; WKB Method.

6. Time dependent Perturbation Theory, Fermi's Golden rule; Harmonic Perturbation.

7. Transition Probabilities: Absorption and Emission phenomena; Selection Rule for electric dipole transitions.

8. Identical particles: Symmetric and Anti symmetric wave function.

9. Spectra of hydrogen and hydrogen like atoms. Sommerfeld's elliptic orbit, Relativistic corrections.

10. Pauli's Vector atom model, four quantum numbers, Spectral terms, L-S and J-J coupling.

11. Normal and Anomalous Zeeman effect.

12. Types of molecules: Energy levels, Selection rules, Spectra: Rotational energy and spectra of diatomic molecules as rigid rotor and non-rigid rotor.

❖ Course Learning Outcomes:

After going through the course, the student should be able to

CO1. Explain microscopic phenomena, quantum theory formulation- introduced through Schrodinger equation after an exposition of inadequacies of classical mechanics.

CO2. Have the interpretation of wave function of quantum particle and probabilistic nature of its location and subtler points of quantum phenomena are exposed to the student.

CO3. Understand the behavior of quantum particle encountering a barrier or potential and familiarize the mathematical background viz. Hilbert space, Bra-Ket notation, matrix method etc. in which the basic and applied quantum mechanics are framed.

CO4. Comprehend the basic concepts of angular momentum and improve problem solving skills using commutation algebra.

CO5. Solve non-relativistic hydrogen atom, for its spectrum and eigenfunctions.

CO6. Gain knowledge of approximation methods for stationary and non-degenerate states of a system and apply them to solve quantum mechanical problems like Harmonic Oscillator, Zeeman Effect, Stark Effect etc.

CO7. Acquire knowledge and calculate the minimum energy state of a quantum system.

CO8. Have a clear concept about the propagation of a particle(wave) in a quasi-classical condition and deal with the problems related to slowly varying potentials.

CO9. Solve and calculate the probability of a transition from lower state to higher one for a quantum system where the perturbation depends on time, harmonic in nature.

CO10. Comprehend the concepts of absorption and emission phenomena.

CO11. Identify basic difference between the identical particles and their corresponding wave functions.

CO12. Understand the relativistic behavior of quantum particles and their dynamics.

CO13. Apply the concept of Bohr's Model in analyzing the spectra of H and H-like atoms.

CO14. Explain the key properties of many electron atoms.

CO15. Demonstrate the quantization of space and spin using Vector-atom model.

CO16. Discuss the relativistic corrections for the energy levels of the hydrogen atom and their effect on optical spectra.

CO17. Acquire knowledge about the observed dependence of atomic spectral lines on externally applied magnetic field.

CO18. Classify different types of molecules and their corresponding energy levels, spectrum, and selection rules for valid transitions viz. rotational, vibrational etc.

M.Sc. (Previous) PHYSICS

PAPER – III: ELECTRODYNAMICS, PLASMA PHYSICS & STATISTICAL MECHANICS

❖ Broad contents of the course:

1. Maxwell's equations, Gauge Transformations: Lorentz gauge and Coulomb gauge.
2. Wave equations in terms of Scalar and Vector Potentials.
3. Poynting's Theorem for system of particles and EM field.
4. Concept of four vector and Covariant formulation of Electrodynamics.
5. Retarded Potential, Lienard-Wiechart potentials, the electromagnetic field of a uniformly moving point charge, Radiation from an accelerated charge at low velocity.
6. Radiation from different Charge and Current distribution.
7. Townsend's ionization theory, Elementary concept of plasma, Hydro-magnetic equations, plasma oscillations and wave motion, probes for plasma measurement.
8. Connection between statistics and thermodynamics, entropy of mixing and Gibb's paradox.
9. Concept of Phase Space, Microstate and Macrostate.
10. Postulates and Hypothesis: Boltzmann Entropy relationship.
11. Ensemble average and Time average.
12. Thermodynamics in different types of Ensembles.
13. Indistinguishability of Particles: MB, BE and FD statistics, applications to Ideal gas, Blackbody radiation and free electron in metals.

❖ Course Learning Outcomes:

After going through the course, the student should be able to

CO1. Achieve an understanding of the Maxwell's equations, role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media.

CO2. Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum, and angular momentum density.

CO3. Analyze the phenomena of wave propagation in the unbounded, bounded, vacuum, dielectric, guided and unguided media.

CO4. Recapitulate and learn Lorentz transformations on space-time and other four vectors, four-vector notations, space-time invariant length, length contraction, time dilation, mass-energy relation.

CO5. Review the retarded potentials, potentials due to a moving charge, Lienard-Wiechert potentials, electric and magnetic fields due to a moving charge, power radiated, Larmor's formula and its relativistic generalization.

CO6. Understand and use of the mathematical models for plasma.

CO7. Distinguish the dynamics of plasma and neutral fluid media.

CO8. Knowledge of formulating and modifying the basic dynamical fluid equations to account for dynamics of plasma.

CO9. Describe the propagation of waves in plasma.

CO10. Comprehend and articulate the connection as well as dichotomy between classical statistical mechanics and quantum statistical mechanics.

CO11. Get an idea about the entropy of mixing and Gibbs paradox.

CO12. Understand the concepts of microstate, macrostate, ensemble, phase space, thermodynamic probability, and partition function.

CO13. Demonstrate the combinatoric studies of particles with their distinguishably or indistinguishably nature and conditions which lead to the three different distribution laws e.g., Maxwell-Boltzmann distribution, Bose-Einstein distribution and Fermi-Dirac distribution laws of particles and their derivation.

CO14. Conceptualize ensembles and relations between partition function and thermo dynamical potentials.

CO15. Calculate the macroscopic properties of degenerate photon gas using BE distribution law, understand Bose-Einstein condensation law and liquid Helium. Bose derivation of Plank's law

CO16. Understand the concept of Fermi energy and Fermi level, calculate the macroscopic properties of completely and strongly degenerate Fermi gas, electronic contribution to specific heat of metals.

CO17. Apply F-D statistical distribution law to derive thermodynamic functions of a degenerate Fermi gas, electron gas in metals and their properties.

M.Sc. (Previous) PHYSICS

PAPER – IV: ELECTRONICS

❖ Broad contents of the course:

1. Biasing, working and characteristics of BJT and Concept of Feedback.
2. Principle of Oscillator: Phase Shift, Wein Bridge Oscillator.
3. Differential Amplifier: DC analysis and AC analysis.
4. Operational Amplifier: Open and Closed loop Gain, CMRR.
5. Op-Amp as Inverting, Non-inverting, function generator, UJT and SCR.
6. Basic logic gates and operations: Universal building block, K-Map, SOP and POS expressions.
7. Flip-flops and timing diagrams: RS, JK, JK Master-slave
8. Microwave devices: Tunnel Diode, Gunn Diode, Backward diode and IMPATT diode.
9. Radiative and non-radiative transitions.
10. LEDs: Visible and Infrared LEDs, Diode Laser.
11. LASER: Population Inversion

❖ Course Learning Outcomes:

After going through the course, the student should be able to

CO1. Analyze the different biasing and equivalent circuits, coupled amplifiers and feedback in amplifiers and oscillators.

CO2. Explain basic working of an oscillator including its different components and to employ the same to study different wave forms and to measure voltage, current, frequency and phase.

CO3. Understand the basics and working of Op-Amp and it's wide applications as devices and hence their efficiencies.

CO4. Analyze sequential systems by choosing Flip-Flop as a building block.

CO5. Construct both combinational circuits and sequential circuits by employing NAND as building blocks and demonstrate Adders, Subtractors, Shift Registers, and multivibrators.

CO6. Understand and implement the function of a counter.

CO7. Characterize Tunnel Diode, Gunn diode, Backward diode etc. and their working principle.

CO8. Gain knowledge about transitions in visible and infra-red regions.

CO9. Learn about semiconductor light emitting diodes (LEDs) and LASERs, and the important rules for their analysis, planning, design, and implementation.

CO10. Apply knowledge through challenging homework problem sets to cement understanding of the material and prepare for their career.

CO11. Choose suitable semiconductor materials for light emitting devices.

- **<u>COURSE OUTCOMES (COs):</u>**

M.Sc. (Final) PHYSICS

PAPER – I: CONDENSED MATTER PHYSICS & NUCLEAR PHYSICS

- **Broad contents of the course:**

1. Crystal Structures: Unit cells, Direct lattice. 2D and 3D Bravais lattice,
2. Miller indices, Closed Packed Structures.
3. Bragg's Law and Laue's Equation, Reciprocal Lattice and Brillouin Zone.
4. Defects in Crystals: Point defects, Vacancies and Dislocations.
5. Band theory of Solids: Bloch theorem, Kroning-Penny model.
6. Superconductivity: Critical Temperature, Meissner Effect, Thermodynamics of superconducting transitions.
7. Ferromagnetism: Weiss theory, Curie-Weiss law, Heisenberg model and molecular field theory.
8. Nuclear Forces: Meson theory, spin dependance, Yukawa interaction.
9. Nuclear Reactions: Compound Nucleus, Partial wave analysis, Breit-Wigner one level formula resonance scattering.
10. Nuclear Models: Liquid drop model, Shell model and Collective model.
11. β decay: β spectrum, neutrino hypothesis, Fermi's theory of β decay.
12. Elementary Particles: Classification, Conservation laws, Invariance under parity, Symmetry [SU (2), SU (3)], Quark theory.

- **Course Learning Outcomes:**

After going through the course, the student should be able to

CO1. Have a brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays by crystalline materials.

CO2. Reveal various structural imperfections as well as to discover their formation mechanism and to understand their effects on the properties of solid materials.

CO3. Comprehend the understanding on the basic approaches to the formation of electronic Band structure of materials and the Fermi surfaces.

CO4. Understand the band structure effects that arise from differently shaped potentials.

CO5. Obtain simple numeric solutions for the eigen values and eigenstates for any confining one-dimensional potential.

CO6. Understand the different theories of superconductivity and its applications

CO7. Explain type I and type II superconductivity on the basis of thermodynamic calculations of Gibbs' free energy for a superconductor.

CO8. Show how the London equations and Maxwell's equations lead to the prediction of the Meissner effect.

CO9. Acquire complete knowledge on the classical and quantum theories of the different types of magnetism and elucidate the exchange interaction and domain theories of ferromagnetism.

CO10. Calculate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in theory of beta decay.

CO11. Have knowledge on the basic aspects of nuclear reactions, the Q-value of such reaction and its derivation from conservation laws, The reaction cross-sections, the types of nuclear reactions, direct and compound nuclear reactions.

CO12. Have a clear concept about different Nuclear Models.

CO13. Gain knowledge on the basic aspects of particle Physics – the fundamental interactions, elementary and composite particles.

❖ **COURSE OUTCOMES (COs):**

M.Sc. (Final) PHYSICS

PAPER – II: OPTIONAL (A)

NUMERICAL METHODS AND PROGRAMMING

❖ **Broad contents of the course:**

1. Solution of simultaneous linear equations using Gaussian Elimination Method.
2. Solution of Algebraic and Transcendental equations: Bisection, Newton-Raphson and False-Position Method.

3. Approximate Methods for Eigen value and Eigen Vector: Power and Jacobi Method.

4. Calculus of Finite Differences and Interpolation; Numerical differentiation and Integration.

5. Numerical solution of ordinary difference equation: Euler and Runge method, predictor and corrector methods.

6. Elementary idea of solution of partial differential equation.

7. Problem analysis and Flow Chart.

8. Structure of a simple C-program, Variables, Constants

9. Logical Operators and Arithmetic Operators.

10. Decision making statements and the concept of Loops in C-programming.

11. Functions, Arrays and Strings.

- ❖ **Course Learning Outcomes:**

After going through the course, the student should be able to

CO2. Solve system of linear equations through constructing upper and lower triangular matrix by applying the method of Gaussian Elimination.

CO3. Implement the concept of pivoting.

CO4. Deal with different Algebraic and Transcendental equations through Bisection, Newton-Raphson and False-Position Method and hence comparative study of convergence will be done.

CO5. Distinguish between exact methods and approximate methods.

CO6. Solve mathematical problems using approximate methods viz. Power method and Jacobi Method.

CO7. Learn the fundamentals of the C programming languages and their applications in solving simple physical problems involving interpolations, differentiations, integrations, differential equations as well as finding the roots of equations.

M.Sc. (Final) PHYSICS

PAPER – III: SPECIAL PAPER (A)

ELECTRONICS - I

- ❖ **Broad contents of the course:**

1. Noise and it's types, Equivalent noise generators and comparison of BJT's and FET's signal to noise ratios.

2. Noise factor of amplifier in cascade, loosy network; Narrowband Band Pass noise.

3. Signal analysis: Trigonometric and complex exponential Fourier series, Complex Fourier spectrum, Fourier transforms involving impulse function.

4. Linear systems: energy signals and power signals, Parseval's theorem, Frequency shifting theorem.

5. Amplitude modulation: Frequency spectrum, power, SSB modulation.

6. Frequency modulation: Frequency spectrum; Phase modulation.

7. Pulse modulation systems: PAM- modulation, demodulation PTM, generation of PTM signals, PWM and PPM circuits, PWM and PPM demodulation circuits, PCM, PCM systems, inter signal interference, eye patterns, bandwidth of PCM systems.

8. Data transmission: ASK, FSK, PSK, probability error, optimum filter, matched filter.

❖ Course Learning Outcomes:

After going through the course, the student should be able to

CO1. Knowledge of random probability, random variables, random signals.

CO2. Analysis of noise and its impact on different modulation technology.

CO3. Learn the fundamentals of signals and linear time invariant systems used in communication system.

CO4. Analyze and resolve the signals in frequency domain using Fourier series, Fourier Transform and determine and sketch the amplitude and frequency spectrum of various signals.

CO5. Distinguish between different modulation techniques and compare their superiority.

CO6. Explain the conventional digital communication system.

CO7. Apply the knowledge of signals and system and evaluate the performance of digital communication system.

M.Sc. (Final) PHYSICS

PAPER – IV: SPECIAL PAPER (B)

ELECTRONICS - II

❖ **Broad contents of the course:**

1. Evolution of Microprocessor, Microprocessor Architecture.
2. Memory: Semiconductor memories, Magnetic Memories.
3. Basic concept of high level and assembly languages.
4. Intel 8085: ALU, Timing and Control Unit, Registers, Data and Address Bus, Pin Configuration.
5. Instruction Cycle, Machine Cycle: Time Diagram
6. Addressing Modes, Instruction set of 8085.
7. Assembly Language Programs.
8. Microprocessor Based Analog to Digital Converter ADC 800, Digital to Analog Converter DAC 808.
9. Microprocessor Applications.

❖ **Course Learning Outcomes:**

After going through the course, the student should be able to

CO1. Explain the embedded systems including its generic architecture, design and classifications, embedded processors, and microcontrollers.

CO2. Conceptualize the organization of intel microprocessor 8085, its architecture, pin diagram, timing diagram, instruction set and programming in assembly language.

CO3. Discuss the organization of Intel 8085 microcontroller, its architecture, instruction set, programming and its memory organization, timing diagram.

CO4. Solve input/output operations and manipulation for arithmetic and logical operations.

CO5. Handle programming with and without interrupt service request.

CO6. Understand and implement microprocessor and assembly language programming with special reference to Intel μP 8085.

CO7. Deal with microprocessor-based Analog to Digital Converter, Digital to Analog Converter.

CO8. Use the concept and programming techniques to microprocessor-based applications.