M. Sc. PHYSICS

Choice Based Credit System (Semester Pattern)

Program Outcomes (POs)

- PO 1 -Courses offered in the Physical Sciences/ Pure Sciences give students a capacity of demonstrating comprehensive knowledge and general understanding of the fundamental principles of the physical and chemical processes around them.
- PO 2 - Students will demonstrate an understanding of the analytical methods required to interpret and analyze results and draw conclusions as supported by their data.
- PO 3 - Students will demonstrate proficiency in the acquisition of data using a variety of laboratory instruments and in the analysis and interpretation of such data
- PO 4 - Students will become proficient in handling relevant scientific instruments and have a understanding of the principles of working.
- PO 5 - Students can formally communicate the results of investigations using both oral and written communication skills.
- PO 6 - Students also obtain the knowledge, skills, and motivation necessary to lifelong learning and problem solving attitude.

Program Specific Outcomes (PSO) – M.Sc. Physics

After completion of course, the student will be to:

- PSO 1 - Get exposure to the fundamental concepts of Physics for with exposure to advanced concepts in various topics in Physics

- PSO 2 - Get acclimatized to the latest developments in the specific areas of Physics.
- PSO 3 -Develop new experiments, analysing the data to make reports for presentation.
- PSO 4 - Using numerical techniques to assess errors in experiments and refining the experimental data.
- PSO 5 - On completion of M.Sc. (Physics) programme, the students will have a scope to join as Project Associate in any Major Research Project and progress in Research and Development. He/She can also pursue a doctoral programme, Ph. D. Students can pursue work as Data Scientist.
- PSO 6 - Pursue a career in Computer Programmer and Software development using the knowledge acquired in studying various subjects.

Course Outcomes (COs) - M.Sc. Physics Semester - I

Paper 1 Mathematical Physics

- CO1 - This course initiates students for development of Mathematical Concepts introducing him/her to Curvilinear co-ordinate Systems, and ideas about gradient
- CO2 - The course introduces a student to solution of differential equations, Vector spaces.
- CO3 -The students learn about the mathematical concepts related to different functions as used for the linear differential equations.
- CO4 - Students learn about various vector spaces, *Hermite Polynomials*, Bessel's Functions, Lagurre Polynomials and Integral & Differential forms.

2. Complex Analysis and Numerical Methods

- CO1 - Solve complex algebra, Analytical functions, and roots of non linear functions.
- CO2 - Calculus of Residues, solving all types of equations by numerical computation using computers.
- CO3 - Students learn about Singularities- Poles, Branch Points, Calculus of Residues-Residues Theorem, Cauchy, Principle value, Pole Expansion of Meromorphic Functions.
- CO4 - Roots of nonlinear equations
- CO5 -Bisection method, false position method, iteration method, Newton- Raphson method, secant method and Finite differences.
- CO6 - Numerical integration, trapezoid rule, Simpson's 1/3 rule, Simpson's 3/8th rule, Linear least squares.

3. Electronics:

- CO1 - Students will learn about Basic and conceptual knowledge of Semiconductor discrete devices, Bipola devices (JFET, MOSFET, SCR, (UJT).
- CO2 - Students will learn about Opto-electronic devices like Photodiode, solar cell, LED, LCD and Photo transistor.
- CO3 - Students will learn about introduction to knowledge of transistor as a switch OR, AND NOT and Gates, Multivibrators, counters and convertors and semiconductor memories.

4. Electrodynamics — I

- CO1 - Students will learn about electric and magnetic fields; electric current, electric density.
- CO2 - Students will learn about Electromagnetic phenomena, matrix representation of electromagnetic phenomena, concept of magnetic field and its theoretical representation.
- CO3 - Students will learn about Coloumb's law, Electric field, Charge distribution, Dirac delta function, Field lines, Gauss's law and applications.
- CO4 - Students will learn about Differential form of Gauss's law, Electric potential, Poisson and Laplace's equations, Electrostatic potential energy. Semester — II

1. **Quantum Mechanics — I**

    - CO1 - Students will learn about time dependent and time-independent Schrodinger equation, continuity equation, wavepacket, admissible wave functions, stationary states. Ehrenfest's theorem, momentum eigen functions in the coordinate representation, box normalization and Dirac delta function.
    - CO2 - The students will learn about linear vector spaces, inner or scalar product, Schwarz inequality, state vectors, general formalism of operator mechanics vector, operator algebra, commutation relations, eigen values and eigen vectors, hermitian operators degeneracy, orthogonality eigenvectors of Hermitian operators, noncommutativity of two operators and uncertainty in the simultaneous measurements of the corresponding dynamical variables.

- CO3 - Solution of Schrodinger equation for simple problems, 1-D Square well, step and barrier potentials, 1-D harmonic oscillator, zero point energy. harmonic oscillator problem by operator method.
- CO4 - Clebsch Gordon Equations, addition of Angular Momenta.

2. **Statistical Physics**

- CO1 - Students will learn about Fundamentals of classical statistical mechanics, microstate and macrostate, distribution function, Liouville's theorem, Gibbs Paradox, ensembles (microcanonical, canonical and grand-canonical).
- CO2 - Students will learn about Fundamentals of quantum statistical mechanics, BE and FD Statistics, Symmetry of wave functions, Boltzmann limit of Bosons and Fermions, Ideal Bose system: Bose-Einstein condensation.
- CO3 - Students will learn about Weak and strong degeneracy, Fermi function, Fermi energy, behaviour of ideal Fermi gas at absolute zero and below Fermi temperature, Fermionic Condensation, Free electrons in metals as fermions, Electronic specific heat.
- CO4 - Students will learn about Phase transition: Phase transition of first and second order, Landau theory of phase transition, Ising model, Order parameter, Critical exponents, Scaling hypothesis, Random walk, Brownian motion.

3. **Classical Mechanics**

- CO1- Students will learn about survey of elementary principles of mechanics of a particle, Dynamical systems, Phase space

dynamics, stability analysis, constraints & their classifications,

- CO2- Students will learn about Conservation theorems and symmetry properties, Hamiltonian formalism, Hamiltons equations, Routh's procedure for cyclic coordinates, conservation laws
- CO3 - Students will learn about Central force motion, reduction to one body problem, equations of motions and first integrals, classification of orbits for inverse square central forces. Two body collisions, Rutherford scattering in laboratory and centre-of-mass frames;
- CO4 - Students will learn about rigid body dynamics, Euler's angles, Euler's theorem, moment of inertia tensor, eigen values and principal axis transformation, non-inertial frames and Pseudo forces, Periodic motion.

4. Electrodynamics - II

- CO1 - Students will learn about Scalar waves: Plane waves, spherical waves, phase and group velocities and wave packets Vector waves: Electromagnetic plane waves, harmonic plane waves, elliptic linear and circular polarization,
- CO2- Students will learn about Symmetries of Maxwell equations: Lorentz transformations, Covariance of electrodynamics, Lorentz gauge condition
- CO3- Students will learn about Motion of a charge in EM fields: Lorentz force, motion in uniform, static, electric and magnetic fields and combined static EM fields.
- CO4 - Students will learn about Wave guides: fields on the surface and within a hollow metallic conductor, TE, TM, TEM

modes in a rectangular and cylindrical wave guide, Resonant Cavities, Dielectric waveguides.

Semester - III

1. Quantum Mechanics-II

- CO1 - This course initiates a student for development of knowledge in Time independent perturbation theory, first order perturbation theory applied to non-degenerate states, second order perturbation extension to degenerate state.
- CO2 - This course initiates a students for development of knowledge in Time dependent perturbation theory, transition rate, Fermi Golden rule, constant perturbation harmonic in time, radiative transitions, absorption and induced emission, Atomic radiation, dipole approximation, Einstein's atomic radiation, Einstein's A and b coefficients and their calculations.
- CO3 - Students will be able to learn about system of identical particles, exchange and transposition operators, totally symmetric and antisymmetric wave function and their expressions
- CO4 - Students will learn about Scattering theory, scattering cross-section in laboratory and centre of mass system, Scattering by a central potential,
- CO5 - This topic gives information to the students in the field of the Klein- Gordon equation and initial difficulties in interpreting its solutions, Dirac's relativistic equation, Dirac's matrices, explanation of the spin of the electron, equation for an electron in an electromagnetic Field.

2. Solid State Physics and Spectroscopy

- CO1 - This course initiates students for development of knowledge Order in Solids-Crystal classes and system, 2d and 3d lattices, Space groups, Concept of point group, bonding of common crystal structure; reciprocal lattice, diffraction and structure factor, Miller and Bravais indices etc.
- CO2 - This course initiates students for development of knowledge of Bonding, diffraction and structure factor in solids, short and long range order in liquids and solids, liquid crystals, quasicrystals and glasses.
- CO3 - This course initiates students for development of knowledge in Cystal Vacancies, Point defects, line defects and stacking faults, Burgers vector And Burger circuit, presence of dislocation, dislocation motion, perfect and imperfect dislocations, slip planes and slip directions, dislocation reactions.
- CO4 - Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Some features of one-electron and two electron atoms, Relativistic corrections for energy levels of hydrogen atom.
- CO5 - Types of molecules, Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Morse potential energy curve, Molecules as vibrating rotator.

3. Materials Science — I (Core Elective)

- CO1 - This course initiates students for development of knowledge in Equilibrium and kinetics: Stability and metastability, Basic thermo dynamic functions, Statistical nature of entropy, Kinetics of thermally activated process.

- CO2 - Phase diagrams: The phase rule, free energy composition diagram, correlation between free energy and phase diagram, calculation of phase boundaries, thermodynamics of solutions, single component system (water), two component system containing two phases and three phases, Binary phase diagrams having intermediate phases, Binary phase diagrams with eutectic system.
- CO3 - Students will learn the details of Phase transformations: Time scale for phase changes, peritectic reaction, eutectoid and eutectic transformations, order disorder transformation, transformation diagrams, dendritic structure in alloys.
- CO4 - Students learn the phenomena of Diffusion in solids: Fick's laws and their solutions, the Kirkendall effect, mechanism of diffusion, temperature dependence of diffusion co-efficient, self diffusion, interstitial diffusion, the Snoek effect in diffusion, diffusion in ionic crystals, diffusion path other than the crystal lattice.
- CO5 - Students will be able to learn details about Solid state energy devices: Fundamental of Solar cells, Primary and secondary solid state cells, advantages of lithium batteries, ion intercalation compounds for secondary cell.

4. Nano Science and Nano Technology (Subject Centric Course-Elective)

- CO1 - This course initiates students for development of knowledge in : Introduction to Nanoscience: Introduction to quantum physics, electron as waves, wave mechanics, Schrödinger equation and particle in a box, Free electron theory

(qualitative idea) and its features, Idea of band structure, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, dots etc.

- CO2 - This topic initiates students for development of knowledge in: Nanomaterials Synthesis: Physical methods: High energy ball milling, Physical vapour deposition, various methods in deposition of nano materials. Synthesis of metal & semiconductor nanoparticles by colloidal route, Langmuir-Blodgett method, Microemulsions, Sol-gel method, Chemical bath deposition, Wet chemical method.
- CO3 - X-ray diffraction, UV-VIS spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy, Transmission Electron Microscopy, Scanning Electron Microscopy,
- CO4 - Students will learn advanced techniques like Scanning Tunnelling Microscopy, Atomic Force Microscopy, Vibration Sample Magnetometer.
- CO5 - Students will learn about special Nanomaterials and their Properties: Special Nanomaterials: Carbon nanotubes, Porous silicon, Aerogels, Core shell structures. Self assembled nanomaterials. Properties of nanomaterials: Mechanical, Thermal, Electrical, Optical, Magnetic, Structural properties.

Semester - IV

1. Nuclear Physics & Particle Physics (Core Course):

- CO1 - Students will be able to learn about Basic nuclear properties; size, radii, shape, and charge distribution, spin, parity,

mass, binding energy, semi- empirical mass formula, liquid drop model, nuclear stability, laws of radioactive decay and various scattering phenomena.

- CO2 - Students will learn Nature of nuclear force, elements of deuteron problem, n-n scattering, charge independence and charge symmetry of nuclear forces. Elementary properties of alpha-, beta-, and gamma-, decay of nuclei, their classification, characteristics and selection rules. Elementary theories of alpha-, beta-, and gamma-, decay. Nuclear reactions- conservation laws, mechanism, and cross section.
- CO3 - Interaction of charged particles and electromagnetic radiation with matter. Principles of nuclear radiation detectors: G-M counter, proportional counter, Na(Tl) scintillation detector, semiconductor detectors.
- CO4 - Classification of elementary particles, strong, weak and electromagnetic interaction. Gellmann-Nishijima formula Properties of hadrons, baryons, mesons, leptons, and quarks- their quantum numbers, charge, mass, spin, parity, iso-spin, strangeness etc.

2. **Solid State Physics (Core Course):**

- CO1 - Students will be able to learn about Bloch theorem, the Kronig- Penney model, construction of Brillouin zones, extended and reduced zone schemes, effective mass of an electron, tight binding approximation. Fermi surface.
- CO2 - Students will be able to learn about Energy of atomic motions, adiabatic principle, harmonic approximation, cyclic boundary condition. Lattice vibrations of linear monoatomic and

diatomic chains. Dispersion relations, acoustic and optical phonons.

- CO3 - Student will be able to learn about electrons moving in one and three dimensional potential wells, quantum state and degeneracy, density of states, electrical and thermal conductivity of metals, relaxation time and mean free path, the electrical resistivity of metals, thermonic emission. effect, thermoelectric power.
- CO4 - Superconductivity, Type I and II super conductors, Meissner effect, isotope effect, London equation, coherence length, elements of B. C. S. theory, tunnelling DC and AC Josephson effect, Ginzberg-Landau Theory macroscopic quantum interference.

3. Materials Science II (Core Elective):

- CO1 - Students will be able to learn about Elasticity, model of elastic response, inelasticity, viscoelasticity, stress-strain curves, concept of various mechanical properties such as hardness, yield strength, toughness, ductility, yield toughness, ductility, brittleness, stiffness etc.
- CO2 - Students can explore advanced concepts in Spin glass, magnetic bubbles, domain walls, magnetic multi-layers, magnenites, GMR and CMR, DMS materials. Photonic band gap materials.
- CO3 - Students will learn about Concept of equilibrium and non-equilibrium processing and their importance in materials science.

- CO4 - Physical method — Bottom up: cluster beam evaporation, Ion beam deposition, Gas evaporation, Chemical method — Hydrothermal, combustion, bath deposition with capping techniques and top down.
- CO5 - Students will learn Processing of materials: Metallic and non metallic, Ceramics and other materials. Only basic elements of powder technologies, compaction, sintering calcination, vitrification reactions, with different example, phenomenon of particle coalescence, porosity. Quenching: concept, glass formation.

4. **Experimental Techniques in Physics (Subject Centric Course):**

- CO1 - Students will be able to learn about Different types of radiations (X-rays, UV-VIS, IR, microwaves and nuclear) and their sources Detectors: gamma-rays, X-rays, UV-VIS, IR, microwaves and nuclear detectors.
- CO2 - X-ray Diffraction — Production of X-rays, Types (continuous and characteristics), Bragg's diffraction condition, principle, instrumentation (with filters) and working, Techniques used for XRD — Laue's method, Rotating crystal method, Powder (DebyeScherrer) method etc.
- CO3 - Students will learn about Derivation of Scherrer formula for size determination Neutron Diffraction: Principle, Instrumentation and Working Thermal analysis: Principle, Instrumentation and Working.
- CO4 - Students will learn new facts about Optical Microscopy: Principle, Instrumentation and Working of optical microscope. Electron Microscopy: Principle, Instrumentation and Working of

Scanning Electron Microscope (SEM), Field Emission Scanning Electron Microscope (FESEM).

- CO5 - Students will be able to learn Spectroscopic characterization (principle, instrumentation and working): Infra-Red (IR), Fourier Transform Infra- Red (FTIR), Ultraviolet-Visible (UV-VIS), Diffused Reflectance Spectroscopy (DRS), X-ray Absorption (XPS), Electron Spin Resonance

PROJECT

- CO1 - Plan and develop experimental project work from basics to advance version.
- CO2 - Use of concepts in Physics to practical understanding of the problems.
- CO3 - Use the advanced techniques to explore different phenomena in materials in the different phases and structures.
- CO4 - Students will submit a project report at the end of the 4th semester which has a comprehensive study, factual information about the data acquired various visits to advanced laboratories for experimental analysis and scope for further research.
- CO5 - Students will write a research paper based on their experimental finding for presentation in different conferences.