DEPARTMENT OF PHYSICS

The Department provides a two-years program of studies leads to the degree of Master of Science (M.Sc.) in Physics. The minimum requirements needed is 30 credit hours distributed as follows:

1) 15 credit hours for compulsory courses.
2) 9 credit hours for elective courses.
3) 6 credit hours for a dissertation.

(1) Compulsory Courses

Code	Course Title	Credits
4511	Classical Mechanics	3
4512	Mathematical Physics	3
4513	Quantum Mechanics	3
4521	Classical Electrodynamics	3
4522	Statistical Mechanics	3
4523	Computational Methods in Physics	2

(2) Elective Courses

Nuclear Group		
Code	**Course Title**	**Credits**
4531	Advanced Nuclear Physics	3
4532	Advanced Lab. I	3
	(Electronics)	2
	(Nuclear)	1
4540	Special Topics	2
Solid State		
4533	Solid State Physics	3
4534	Advanced Lab II	3
	(Electronics)	2
	(Solid)	1
	Special Topics	2
Theoretical Group		
4531		3
4535	Quantum Field Theory	3
4540	Special Topics	
Biophysics Group		
4536	Radiation Biophysics	3

4532	Advanced Lab I	3
	Electronics	2
	Nuclear	1

(3) Optional Courses

Code	Course Title	Credits
4599	Thesis	6

Description of Courses

4511 Classical Mechanics(3Credits)

Review of the mechanics of a system of particles in the configuration space, constraints Hamilton's principle, Lagrange's equations of motion and their simple applications, conservation theorem and symmetry properties.

Review of kinematics and dynamics of the rigid body motion, the Euler angles, Euler's theorem on the motion of a rigid body, finite and infintesimal rotation, the coriolis force, the inertia tensor, it's eigenvalues and the principal axis transtormation, the symmetrical top with one point fixed.

Phase space description of mechanics, the hamilton equations of motion and their derivation from the variational principle, cyclic co-ordinates and the conservation theorem, the principle of least action.

Special relativity in classical mechanics, the lorentz transformation in real four dimensional spaces, force and energe equations, the lagrangian and hamiltonian formulations of relativistic mechanics, covariant formulations.

Canonical transformations and their examples, poisson brackets and other canonical invariants, infinitesimal canonical transformations, and conservation theorem in poisson bracket formulation. Liouville's theorem.

The Hamilton-Jacob equations for Hamilton's principal and characteristic functions, their examples and separation of variables, Action-angle variables, The Kepler problem in action-angle variables.

Theory of small oscillations, the eigenvalues equations and the principal axis transformation, Frequencies of free vibration and normal co-ordinates, Free vibrations of a linear tri-atomic molecule, Forced vibrations.

Introduction to Lagrangian and Hamiltonian formulations for continuos systems and fields.

4512 Mathematical Physics(3 Credits)

Partial differential equation classifications and methods of solution, Separation of variables.

Ordinary differential equation, singularities, Parity and linear dependence, Series solution and its limitation, Generating second solution using Wronskian.

Sturm Liouville theory and eigenvalue problems, Generalized Green's identity and adjoint boundary conditions.

Classical orthogonal polynomials, Generalized Rodrigue's formula, Classification of polynomials, Recurrence relation and normalization integral.

Fourier series and orthogonal functions, Complex Fourier series, Fourier transforms, Integral transform, method of solving differential equation using integral transform.

Special functions, Gamma, Beta and Dirac Delta functions, Bessel, Hypergeometric and confluent Hypergeometric functions, Functions related to Hypergeometric and confluent Hypergeometric functions.

Green's functions method in one, two and three dimensions. Expansion of Green's function in polar co-ordinate.

Function of complex variable, Residue theorem and its application in evaluating the integrals.

4513 Quantum Mechanics (3Credits)

General formalism, Linear vector space, Operators, Dirac's bra and ket notations.

Approximation methods in quantum mechanics and their applications, Stationary state perturbation theory, Variational methods, W. K. B. approximation, Time dependent perturbation theory, Transition probabilities, Fermi Gordon rule.

Kinematics of scattering process, Scattering by finite range spherically symmetric potentials, Partial wave analysis, Phase shift, Green's function formulation, The optical theorem, Resonant scattering and Berit-Wigner formulas, Scattering of identical particles, Coulomb scattering, The Born's approximation and it's applications.

Symmetry in quantum mechanics, spatial rotation, inversion and time reversal, Symmetry properites and conservation laws, Symmetry and degeneracy, Commutation relation for generators of infinitesimal rotations, Coupling of angular momentum. Clebsch-Gordon coefficients. Irreducible tensor operators and Wigner Eckart theorem, Permutation symmetry, Construction of symmetric and antisvmmetricwavefunctions.

4521 Classical Electrodynamics (3 Credits)

Brief review of electrostatics, Differential equations of electrostatics, Boundary value problems in electrostatics, Method of images, Green's function method in two and three dimensions, Green's function in cylindrical as well as spherical polar co-ordinates.

Multipole expansion of electrostatic field, Electric multipole moment, dielectrics, Boundary value problems in magnetostatics.

Magnetostatics, Differential equation of magnetostatics, Vector potential, magnetic moments, Boundary value problems in magnetostatics.

Time varying fields, Maxwell equation's, Vector and scalar potentials, Gauge transformations and Lorentzend Coulomb gauge, Solution of wave equation by Green's function method, Poynting theorem and conservationlaws, Maxwell stress tensor, Transformation properties of electromagnetic fields, Magnetic monopole radiation, Dirac quantization condition.

Fields and radiation of a localised oscillating source, Electric dipole radiation, Magnetic dipole radiation, Electric quadropole radiation, Radiation by a moving charge, LienardWiechart potential and fields for a point charge.

Spherical wave solution of a scalar wave equation, Multipole expansion of electromagnetic field, Angular distribution of multipole radiation, Multiple radiation in atomic and nuclear systems, Radiation from a linear center fed antenna.

Dynamics of relativistic particles and electromagnetic field, Lagrangian and Hamiltonian of electromagnetic fields, Canonical and symmetric stress tensors, Conservation laws, Solution of a wave equation in covariant Green's function.

4522 Statistical Mechanics(2 Credits)

Assemblies, Phase space, Average properties of an assembly, Classical and quantum assemblies.

Maxwell Bolzman statistics, Distribution over energies, Velocities and momenta, Weight of configuration, Most probable configuration. Sharpness of configuration, Rcmperature Maxwell-Boltzman distribution.

Application of Maxwell-Boltzman statistics. Average properties of systems, classical perfect gas, Mean and most probable velocities, The

Doppler brooding of spectral line, Equibartition of energy, Heat capacities of gases, The Einstein diffusion equation.

Bose-Finstein statistics. B. E. distribution B. E. gas, Black body radiation.

Ferni-Dirac statistics, F. D. distribution, F. D. gas, The electron gas, Paramagnetism, Theromionic emission.

Temperature and entropy, Free energy, Max weight for classical perfect gas, The Boltzman partition function, The classical partition function, Gibbs paradox. The semi-classical perfect gas. Components of partition function.

Canomical ensemble, The constant temperature ensemble, Properties of the canonical ensemble, Total partition function, The quantum mechanical density operator.

The grand canonical ensemble, The grand partition function, The chemical potential in equilibrium state.

4523 Computational Methods in Physics (2 Credits)

Fundamentals of a programming language. Basic operations with complex numbers, Error's and double precision, Numerical methods, Solution of non-linear algebraic and transcendental equations.

Polynomials and zeros of polynomials, Matrix method and linear equations (eigenvalue problem), Numerical integration, Simpson's method, Solution of ordinary differential equations, Interpolation, Numerical differentiation.

Statistical distributions. Binomial distributions, Gaussian and Poisson distributions, Systematic and random errors precision accuracy. Programming of errors. Last-square method, Test of the goodness of fits, Monte Carlo methods.

4531 Nuclear Physics(3 Credits)

Basic nuclear properties and their measurements, Size, Charge, Angular momentum, Parity, Electronic and magnetic moments, Mass and binding energy, Fission and fusion.

Nuclear force, Nuclenon-nucleon interaction. Deuteron problem, Nucleon-nucleon scattering, Effective range theory, Singlet and triplet scattering lengths, Spin and charge independence of nuclear forces, Nucleontwo body problem with isospin, Generalised Pauli exclusion principle, Two body exchange forces, Most general form of nuclear two body interaction.

Nuclear models, Shell model, Nilsson model, Collective model, Vibrations and rotations, Liquid drop model and fission, Semi-empirical mass formula.

Nuclear reactions, basic kinematics, compound nucleus and direct reactions (stripping and pick up), Optical potential, Resonance and Breit Wigner formula, Heavy ion reactions.

Radioactive decay of nuclei, theories $\propto$, β, and γ decay, Weak interactions, Allowed and forbidden transitions, Fermi and GT transitions, Multiplicity, and the selection rules for gamma transitions, Life-times, Mixing and banching ratios, Weisskpof estimates.

4532 Advanced Lab I(3 Credits)

Eight electronics experiments to designed by the department. Four nuclear physics experiments to be designed by the department.

4533 Solid State physics(3 Credits)

Reciprocal lattice and its proerties, Periodic functions, Brillouin zones. Lattice dynamics in 3-D (classical approach), Natural co-ordinates and transfer to quantum mechanics, Modes of vibrations, Force constant, Quantum mechanical approach to study specific heat (non-interpolation formulation), Debye specific heat for longitudinal and transverse waves, Experimental study of phonon spectrum.

Electrons in periodic potential, Bloch's theorem, Nearly free electron model (theory of perturbation), Band structure, Fermi surface, The tight binding approximation (for S, P, D, … electrons), Wannier functions, Cellular method agumental and orthogonal plane waves.

Dynamics of electron without relaxation, Electron wave packet, Holes, electron dynamics with magnetic field, Cyclotron orbitals, Hall effect in strong magnetic field.

Mechanics of relaxation, Boltzman equation, Relaxation time approximation and it's calculation, Impurity scattering, Matthieson rule, Wiedmann Franz law.

Solution of Boltzman equation with electric and magnetic fields, Effective mass tensor, Electrical conductivity, Thermal conductivity, Thermo electric effects, magnetoresistivity, Hall effect, Magnetoresistance for electric wave.

Optical properties, Dispersion and absorption, Optical modes in ionic crystal.

4534 Advanced Lab (II) (3 Credits)

Eight electronics experiments to be designed by the department.

Four Solid State physics experiments to be designed by the department.

4535 Quantum Field Theory(3 Credits)

Review of Lagrangian and Hamiltonian functions for continuous systems and fields. Quantum equation of motion, Harmonic oscillators in terms of creation and annihilation operator, Generalization of quantum equation of motion.

Quantization of free (nonrelativistic) electromagnetic field, interaction of radiation with matter, Emission and absorption of light by an atom, Scattering of light by free electron.

Second quantization, Quantization of Schrodinger field for bosons and fermions, Interaction of quantized field, Bremsstrahlung. Klein Gordon and Dirac equations, Covariant relativistic formulations. Solution of Dirac equation for free particle and for hydrogen atom.

Quantum electrodynamics, quantization of Dirac field and relativistic E. M. field, Compton scattering, Pan production and annihilation. The problem ofinfinities in quantum electrodynamics, Renormalization of mass of electron, The lamb shift, anomalous magnetic moment of the electron.

4536 Radiation Biophysics I(3 Credits)

Interaction of ionizing radiation: types and sources, radiation fields, Interaction of ionizing radiation with matter: photons, charged particles and neutrons, Energy transfere processes: Stopping power, Linear energy transfere (LET), restricted LET and other radiation quality parameters. Radiation Chemistry: initial physical events, radiolvsis of water, Action of radiation on aqueous solutions, Biological effects of ionizing radiation. Dosimetry of ionizing radiation, quantities, units and definitions, micro-dosemetry and nanodosemetry. Detection of ionizing radiation. Principles of radiation protection.

4540 Special Topic(2 Credits)

A thesis related subject, this to be chosen by the supervisor and endorsed by the department. The course description should be decided and taught by the project supervisor.

4599 Project(6 Credits)