Islamic University of Science and Technology, Awantipora-192122

Department of Physics

Syllabus for Ph. D. Admission Exam

Part A: Research Methodology Maximum Marks: 35

UNIT I

Steps of Scientific Thinking, Research, Definition of Research, Characteristics of Research, Nature of Research, Importance of Research, Types of Research, Basic Research, Applied Research, Difference between Action Research and Fundamental Research, Identification of a Problem, Criteria for selection of a Problem, Defining a Problem, Statement of a Problem, The Research Proposal, Criteria for evaluating Research Proposal, Characteristics of a good Researcher, Review of Literature (Meaning, Need, Objectives, Importance, Sources), The Criteria for Good Measurement; Error analysis; Types of errors and Error propagation.

UNIT II

Scientific Writing: Goals and Objectives; Structure of documents; importance of clear title, abstract or summary, Introduction, Methods, Results and Discussion, Illustrations and aids; Numbers and statistics, Tables and Figures; Language and grammar; writing proposals; making presentations; Formatting documents; Drafts and revisions; Editing; Writing popular science / journal article; Science fiction.

UNIT III

Computers, Interpreters and Operating system, Basic knowledge of computers and software, General awareness of computer hardware (CPU, Input/output and auxiliary storage devices, primary and secondary memory), Basic knowledge of software and programming languages (FORTRAN, C, C++), Types of programming languages, General awareness of popular commercial software packages and other scientific application packages (Mathmatica, MATLAB).

UNIT IV

Numerical Analysis: The solution of Numerical algebraic and transcendental equations; convergence of solutions; Interpolation; Finite differences; Newton's formula for interpolation; Numerical differentiation; Newton's forward and backward formulas to get derivatives; Numerical Integration: Trapezoidal, Simpson 1/3 and 3/8 rule. Numerical solution of ODEs: Euler's Method, Modified Euler's Method, Runge Kutta methods: Second and Fourth order.

Part B: Subject Specific **Maximum Marks: 35**

UNIT I

Complex Calculus; Analytic functions, Cauchy-Riemann relations; Cauchy's theorem, Taylor and Laurent expansions; Singularities; Calculus of Residues, Fourier series and transform; Laplace transform and its properties; Differential equations (second order partial equations) and the methods of solutions; Special functions (Bessel, Legendre, Laguerre, Spherical Harmonics, Hermite); Tensor Analysis: Covariance and contravariance, symmetric and anti-symmetric tensors, symmetric and skew symmetric tensors, The quotient rule, Kronecker Delta and Levi Civita tensor; Green's Functions in One Dimension: Calculation of Green's Functions for simple differential operators, Green's Function for the Laplacian, Green's Functions for Second order Linear Differential Operators (SOLDOs), Adjoint and Self Adjoint Operators, Self-Adjoint SOLDOs; Probability: Definition, Properties, Permutations and Combinations, Random Variable, Discrete Probability Distributions, Covariance and Correlations, Conditional Probability Distribution, Normal, Binomial and Poison distributions.

UNIT II

Wave particle duality, The Schrodinger's equation, Operators. Statistical interpretation, Probability and Current Densities, Ehrenfest theorem; 1D problems (Box, Step and Barrier), Linear harmonic oscillator

Dirac delta function and its properties; simple harmonic oscillator problem by operator method; Hilbert space, Dirac's bra-ket notation; Postulates of quantum mechanics, Eigen functions and Eigen values, Pictures, Heisenberg's equation of motion; Angular Momentum; Ladder operators L_+ and L_- ; Angular momentum as a generator of infinitesimal rotations, Eigen values of J^2 and J_z; Addition of angular momenta, Computation of Clebsch-Gordon coefficients in simple cases; Hydrogen atom; Perturbation theory (Time independent and dependent); WKB approximation, The Fermi golden rule, Semi-classical theory of radiation; Scattering theory; Born approximation, Scattering by a spherically symmetric potential; Screened coulomb potential, Method of partial waves; Optical theorem; Systems of identical particles and exchange degeneracy; Slater determinant; Density operator and density matrix; Klein Gordan and Dirac equations.

UNIT III

Calculus of variations; The Lagrangian Formalism; Generalised coordinates; D'Alembert's principle and Lagrangian equations; Hamilton's Principle; Symmetry properties of space and time and Conservation Theorems; The Central Force Problem: Reduction to the equivalent one-body problem, First Integrals; Kepler's problem; classification of orbits; The Virial Theorem; Noether's Theorem; Physical significance of the Hamiltonian function; Hamiltonian formulation of Relativistic Mechanics; The Principle of Least Action; Poisson brackets (PB); The Hamilton-Jacobi equation;

Liouville's theorem; The Euler Angles; Euler's Theorem; The inertia tensor; Small Oscillations; Special theory of relativity; Statistical Basis of Thermodynamics; Physical significance of the number Ω (N, V, E); Ensemble Theory; Partition Function; Calculations of various Statistical Quantities; Density matrix; System of Indistinguishable Particles, Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics; Electron gas in metals; Phase Transitions. Electrostatics and Magnetostatics; Maxwell's equations; Scalar and vector potentials, gauge transformations, Coulomb and Lorentz Gauge, Maxwell's equations in terms of potentials. Energy and momentum in electrodynamics; Minkowski space; Transformation of electric and magnetic fields under Lorentz transformations, Covariant form of Maxwell's equation, Lorentz force on a relativistic charged particle; Lagrangian and Hamiltonian for a relativistic charge particle in external electromagnetic fields.

UNIT IV

Simple theory of two nucleon system –Deuteron problem, Weizsacker's semi-empirical mass formula and its applications; Shell model; Kinds of nuclear reactions, Kinematics of nuclear reactions; Compound reaction mechanism, nuclear fission and fusion, laws of successive disintegration; Alpha Decay: Gamow's Theory, Beta Decay: Fermi's theory of beta decay, selection rules; Basic interactions and their mediating quanta, particles' families; Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.), conservation rules; Gellmann-Nishijima Relation. Quark model; CPT theorem, Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction; Laboratory and Centre-of-mass systems; Quark-Gluon Plasma and phase diagram.