PROPOSED SYLLABUS FOR PhD ENTRANCE EXAMINATION

Centre For Theoretical Physics
Jamia Millia Islamia

1. Classical Mechanics

Lagrangian Formulation of Mechanics : Generalized coordinates, Langrange's equations of motion, properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi integrals and energy conservation, Concept of symmetry, invariance under Galilean transformation, velocity dependent potential.

Hamiltonian Formulation of Mechanics : Hamilton's function and Hamilton's equation of motion, configuration space, phase-space and state space,

Variational Principle: Variational principle, Euler's equation, applications of variational principle, shortest distance problem, brachistochrone, Geodesics of a Sphere.

Rotational Motion: Rotating frames of reference, inertial forces in rotating frames, Larmour precision, electromagnetic analogy of inertial forces, effects of Coriolis force, Focoult's pendulum

Hamilton-Jacobi Theory : Action-angle variables - integrable and non-integrable systems - Liouville's theorem .

2. Mathematical Methods in Physics:

Complex Analysis : Analytical functions, Cauchy-Riemann conditions, Line integrals, Cauchy's theorem, Cauchy integral formula, Derivatives of analytical functions, Power Series, Taylor's theorem, Laurent's theorem, Calculus of residues, revaluation of real definite integrals.

Linear spaces and operators : Vector spaces and subspaces, Linear dependence and independence, Basis and Dimensions, linear operators, Inverses, Matrix representation, Similarity transformations, Eigenvalues and eigenvectors, Inner product, Orthogonality, Introduction only to Gramm-Schmidt orthogonalization procedure, Self adjoint and Unitary transformations, Eigenvalues & eigenvectors of termitian & Unitary transformations, Diagonalization.

Special Function : Legendre Hermite, Laguerre function – Generating function, Recurrence relations and their differential equations Orthogonality properties, Bessels's function of first kind, Spherical Bessel function, Associated Legendre function, Spherical harmonics.

Fourier Series and Integral transforms : Fourier Series : Definition, Dirichlet's condition, Convergence, Fourier Integral and Fourier transform, Convolution theorem, Parseral's identity, Applications to the solution of differential equations, Laplace transform and its properties, Applications to the solution of differential equations, Fourier transform & Laplace transform of Dirac Delta function.

3. CLASSICAL ELECTROMAGNETISM

Electrostatics and Magnetostatics : Mathematical preliminaries - boundary value problems using Green function techniques - special techniques for calculating potentials – electrostatics of dielectric media - magnetic vector potential and the gauge problem - Biot-Savart law - magnetic dipole moment and the Larmor precession

Maxwell Electrodynamics : Motion of charges in external fields - electromagnetic waves in vacuum and propagation through continuous media - gauge transformations - Lorentz covariant formulation of electrodynamics - energy-momentum of electromagnetic field and Poynting's theorem - Lagrangian and Hamiltonian formulation of electrodynamics

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4. STATISTICAL MECHANICS

Statistical Description of System of Particles : Specification of the state of the system, Macroscopic and Microscopic states, Phase space, Statistical ensemble, Postulate of equal a priori probability, Probability calculations, Behaviour of density of states, Liouville's theorem(Classical), Quasi-static processes.

Statistical Thermodynamics : Equilibrium conditions and constraints, Distribution of energy between systems in equilibrium, Approach to thermal equilibrium, Temperature, Heat reservoir, Sharpness of the probability distribution, Dependence of the density of states on the external parameters, Equilibrium between interacting systems

5. QUANTUM MECHANICS

Free Particle: The Schrodinger equation, Hamiltonian, commutation relations, Wave functions, probability interpretation, currents, measurement, plane waves, normalization, boundary conditions, discrete space and regularization, delta function, wave packets, group velocity, postulates of quantum mechanics, bra-ket notation, Fourier transform, vector space - matrices, Hermitian and unitary matrices, tensor product, projection operator - Schr odinger and Heisenberg pictures, evolution operator.

Spin-1/2 System : Stern-Gerlach experiment, illustrating quantum mechanics, atom in a magnetic field, dynamics of two level systems.

Perturbation Theory : Time-independent (degenerate and non-degenerate) perturbation theory - time-dependent perturbation theory, sinusoidal perturbations, Fermi golden rule - scattering Theory

Relativistic Quantum Mechanics: Dirac equation and Klein-Gordon equation