## Syllabus for Ph.D. Entrance in Physics

**Section 1: Mathematical Physics**

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Cayley-Hamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Fourier series, Fourier and Laplace transforms. elements of complex analysis: Cauchy Riemann conditions, Cauchy's theorems, singularities, residue theorem and applications.

**Section 2: Classical Mechanics**

Newton's laws. Dynamical systems, Central force motions. Kepler's problem. Two body Collisions - scattering in laboratory and Centre of mass frames. Motion of rigid body. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Special theory of relativity, Lorentz transformations, relativistic kinematics and mass–energy equivalence.

**Section 3: Electromagnetic Theory**

Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance. Electromagnetic waves in free space.

**Section 4: Quantum Mechanics**

Postulates of quantum mechanics; uncertainty principle; Schrodinger equation; one-, two- and three-dimensional potential problems; particle in a box, transmission through one dimensional potential barriers, harmonic oscillator, linear vectors and operators in Hilbert space; angular momentum and spin; addition of angular momenta; time independent and dependent perturbation theory; elementary scattering theory.

**Section 5: Thermodynamics and Statistical Physics**

Laws of thermodynamics and their consequences. Phase space, micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Principle of detailed balance. Blackbody radiation and Planck's distribution law.

**Section 6: Solid State Physics**

Bravais lattices. Reciprocal lattice. Bonding of solids. Free electron theory and electronic specific heat. Drude model of electrical and thermal conductivity. Hall effect. Electron motion

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in a periodic potential, band theory of solids: metals, insulators and semiconductors. elements of superconductivity: Type-I and Type II superconductors, Meissner effect, London equation. Nano-structured materials and their properties.

**Section 7: Electronics**

Multivibrators. Semiconductor devices: diodes, Bipolar Junction Transistors, Field Effect Transistors; operational amplifiers: negative feedback circuits, active filters and oscillators; regulated power supplies; basic digital logic circuits, sequential circuits, flip-flops, counters, registers, A/D and D/A conversion. Microprocessor, Opto-electronic Devices.

**Section 8: Nuclear and Particle Physics**

Deutron Problem. Nuclear radii and charge distributions, nuclear binding energy, Nuclear models, liquid drop model: semi-empirical mass formula, Fermi gas model of nucleus, nuclear shell model; nuclear force and two nucleon problem; alpha decay, beta-decay, electromagnetic transitions in nuclei; Rutherford scattering, nuclear reactions, conservation laws; fission and fusion; particle accelerators and detectors; Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance.

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**BOTANY SYLLABUS**
**Ph. D. Entrance**

**UNIT I: DIVERSITY OF CRYPTOGAMS**

General introduction, brief history and classification, reproduction, life cycle pattern of algae and fungi. Bryophyta: General characters, Classification, life cycle pattern and economic importance, Pteridophyta: General characters, Classification, reproduction and life cycle.

**UNIT II: DIVERSITY OF PHANEROGAMS**

Gymnosperms: General characters, classification, reproduction and life cycle, Angiosperms: General characters, taxonomic ranks, types of classification (artificial, natural and phylogenetic) salient features of Bentham & Hooker's system of classification with merits and demerits, binomial nomenclature. Codes of nomenclature, ICBN and its preamble and major rules.

**UNIT III: CELL BIOLOGY AND GENETICS**

Cell, cell organelles, structure and their functions, Cell division- Process and significance of Mitosis and Meiosis, Cell cycle. Mendelian Genetics: Laws of inheritance, Monohybrid cross, Dihybrid cross, Back cross and Test cross, Gene interaction and epistasis, Sex linked inheritance, Chromosomal Aberrations

**UNIT IV: MORPHOLOGY AND MORPHOGENESIS OF ANGIOSPERMS**

Angiospermic flower and its different parts, their phylogeny. Principles of Taxonomy– Taxonomic structure, hierarchy, concept of species and development. Systematic position of some selected families on the basis of phylogeny and their economic importance.

**UNIT V: HISTOLOGY AND ANATOMY**

Meristem, Simple Tissues, Complex Tissues, Secretary Tissues, Root, stem and leaf anatomy of dicotyledons and monocotyledons, Secondary and Anomalous secondary growth in dicot and monocot root and stem

**UNIT VI: PLANT EMBRYOLOGY**

History of plant embryology, development and structure of microsporangium, development and structure of male gametophyte, pollen physiology. Development and structure of ovule/megasporangium, development and structure of female gametophytes. Pollination, fertilization, self-incompatibility, development of endosperm, embryo and seed. Polyembryony and apomixis, parthenocarpy and parthenogenesis. In vitro culture of embryo, embryo rescue after wide hybridization and its application, anther and pollen, somatic hybridization, endosperm culture and production of triploids.

**UNIT VII: ECOLOGY**

Ecology – Definition and Scope, Structure of ecosystem (Abiotic and Biotic), Types of ecosystem, Ecological pyramids and energy flow, Food chain and Food web, Morphological and anatomical adaptations of plants to water stress conditions-Hydrophytes, Xerophytes and ,

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halophytes, Pollution: Causes and effects of water, soil and air pollution and their control measures.

**UNIT VIII: ECONOMIC BOTANY**

Botanical name, family, method of cultivation and economic importance of Cereals, Pulses, Fiber yielding plants, Oil yielding plants, Timber yielding plants and Medicinal plants (Aloe, Ocimum, Adathoda, Withania). Sources of forest products and cultivation- tannins and dyes, gums and resins, rubber and latex and paper pulp. Study of important fumigatories, masticatories and beverages such as tobacco, nut, tea, coffee and cocoa. Brief account of non-traditional economic plants- jojoba and guayale. Utilization of byproducts of crops– cotton stalks, paddy husks and coconut fibers.

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## M.Sc. (Mathematics) Entrance Examination Syllabus

**Algebra**: Groups, subgroups, Abelian groups, non-abelian groups, cyclic groups, permutation groups; Normal subgroups, Lagrange's Theorem for finite groups, group homomorphism and quotient groups, Rings, Subrings, Ideal, prime ideal. maximal ideals; Fields, quotient field.

**Linear Algebra:** Vector spaces, Linear dependence and Independence of vectors, basis, dimension, linear transformations, matrix representation with respect to an ordered basis, Range space and null space, rank-nullity theorem; Rank and inverse of a matrix, determinant, solutions of systems of linear equations, consistency conditions. Eigenvalues and eigenvectors. Cayley-Hamilton theorem. Symmetric, Skewsymmetric, Hermitian, Skew-Hermitian, Orthogonal and Unitary matrices.

**Real Analysis**: Sequences and series of real numbers. Convergent and divergent sequences, bounded and monotone sequences, Convergence criteria for sequences of real numbers, Cauchy sequences, absolute and conditional convergence; Tests of convergence for series of positive terms-comparison test, ratio test, root test, Leibnitz test for convergence of alternating series. Functions of one variable: limit, continuity, differentiation, Rolle's Theorem, Cauchy's Taylor's theorem. Interior points, limit points, open sets, closed sets, bounded sets, connected sets, compact sets; completeness of R, Power series (of real variable) including Taylor's and Maclaurin's, domain of convergence, term-wise differentiation and integration of power series. Functions of two real variable: limit, continuity, partial derivatives, differentiability, maxima and minima. Method of Lagrange multipliers. Homogeneous functions including Euler's theorem.

**Complex Analysis**: Functions of a complex Variable, Differentiability and analyticity, Cauchy Riemann Equations, Power series as an analytic function, properties of line integrals, Goursat Theorem, Cauchy theorem, consequence of simply connectivity, index of a closed curves. Cauchy's integral formula, Morera's theorem, Liouville's theorem, Fundamental theorem of Algebra, Harmonic functions.

**Integral Calculus**: Integration as the inverse process of differentiation, definite integrals and their properties, Fundamental theorem of integral calculus. Double and triple integrals, change of order of integration. Calculating surface areas and volumes using double integrals and applications. Calculating volumes using triple integrals and applications.

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**Differential Equations**: Ordinary differential equations of the first order of the form $y'=f(x,y)$. Bernoulli's equation, exact differential equations, integrating factor, Orthogonal trajectories, Homogeneous differential equations-separable solutions, Linear differential equations of second and higher order with constant coefficients, method of variation of parameters. Cauchy-Euler equation.

**Vector Calculus**: Scalar and vector fields, gradient, divergence, curl and Laplacian. Scalar line integrals and vector line integrals, scalar surface integrals and vector surface integrals, Green's, Stokes and Gauss theorems and their applications.

**Linear Programming:** Convex sets, extreme points, convex hull, hyper plane & polyhedral Sets, convex function and concave functions, Concept of basis, basic feasible solutions, Formulation of Linear Programming Problem (LPP), Graphical Method of LPP, Simplex Method.

**Laplace Transforms:** Existence theorem for Laplace transforms, Linearity of the Laplace transforms, Shifting theorems, Laplace transforms of derivatives and integrals, Differentiation and integration of Laplace transforms, Convolution theorem, Inverse Laplace transforms, convolution theorem, Inverse Laplace transforms of derivatives and integrals, solution of ordinary differential equations using Laplace transform.

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## Ph.D. (Mathematics) Entrance Examination Syllabus

**Analysis:** Elementary set theory, finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, supremum, infimum. Sequences and series, convergence, limsup, liminf. Bolzano Weierstrass theorem, Heine Borel theorem. Continuity, uniform continuity, differentiability, mean value theorem. Sequences and series of functions, uniform convergence. Riemann sums and Riemann integral, Improper Integrals. Monotonic functions, types of discontinuity, functions of bounded variation, Lebesgue measure, Lebesgue integral. Functions of several variables, directional derivative, partial derivative, derivative as a linear transformation, inverse and implicit function theorems.
Metric spaces, compactness, connectedness. Normed linear Spaces. Spaces of continuous functions as examples.

**Linear Algebra:** Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations. Algebra of matrices, rank and determinant of matrices, linear equations. Eigenvalues and eigenvectors, Cayley-Hamilton theorem. Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms. Inner product spaces, orthonormal basis. Quadratic forms, reduction and classification of quadratic forms.

**Complex Analysis:** Algebra of complex numbers, the complex plane, polynomials, power series, transcendental functions such as exponential, trigonometric and hyperbolic functions. Analytic functions, Cauchy-Riemann equations. Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Maximum modulus principle, Schwarz lemma, Open mapping theorem. Taylor series, Laurent series, calculus of residues. Conformal mappings, Mobius transformations.

**Algebra:** Permutations, combinations, pigeon-hole principle, inclusion-exclusion principle, derangements. Fundamental theorem of arithmetic, divisibility in Z, congruences, Chinese Remainder Theorem, Euler's Ø- function, primitive roots. Groups, subgroups, normal subgroups, quotient groups, homomorphisms, cyclic groups, permutation groups, Cayley's theorem, class equations, Sylow theorems. Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domain, principal ideal domain, Euclidean domain. Polynomial rings and irreducibility criteria. Fields, finite fields, field extensions, Galois Theory.

**Topology**: basis, dense sets, subspace and product topology, separation axioms, connectedness and compactness.

**Ordinary Differential Equations (ODEs):** Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs. General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function.

**Partial Differential Equations (PDEs):** Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs. Classification of second order PDEs, General solution of higher order PDEs with constant coefficients, Method of separation of variables for Laplace, Heat and Wave equations.

**Numerical Analysis:** Numerical solutions of algebraic equations, Method of iteration and Newton-Raphson method, Rate of convergence, Solution of systems of linear algebraic equations using Gauss elimination and Gauss-Seidel methods, Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration, Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

**Calculus of Variations:** Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations.

**Linear Integral Equations:** Linear integral equation of the first and second kind of Fredholm and Volterra type, Solutions with separable kernels. Characteristic numbers and eigenfunctions, resolvent kernel.

**Classical Mechanics:** Generalized coordinates, Lagrange's equations, Hamilton's canonical equations, Hamilton's principle and principle of least action, Two-dimensional motion of rigid bodies. Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations.

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