Written Test Format and Syllabus

Computer Science and Engineering, School of Electrical Sciences

Ph.D. Admission Test Syllabus

Data structures and Algorithms

Programming in C. Recursion. Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs, Searching, sorting, hashing. Asymptotic worst case time and space complexity. Algorithm design techniques: greedy, dynamic programming and divide-andconquer. Graph traversals, minimum spanning trees, shortest paths

Probability and Discrete Mathematics

Random variables. Uniform, normal, exponential, Poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem. Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Monoids, Groups. Graphs: connectivity, matching, coloring. Combinatorics: counting, recurrence relations, generating functions

Automata Theory

Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and contex-free languages, pumping lemma. Turing machines and undecidability.

Architecture and Digital Design

Boolean algebra. Combinational and sequential circuits. Minimization. Number representations and computer arithmetic (fixed and floating point). Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining, pipeline hazards.

Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

Operating Systems

System calls, processes, threads, inter-process communication, concurrency and synchronization. Deadlock. CPU and I/O scheduling. Memory management and virtual memory. File systems.

Computer Networks

Concept of layering: OSI and TCP/IP Protocol Stacks; Basics of packet, circuit and virtual circuit-switching; Data link layer: framing, error detection, Medium Access Control, Ethernet bridging; Routing protocols: shortest path, flooding, distance vector and link state routing; Fragmentation and IP addressing, IPv4, CIDR notation, ARP, DHCP, ICMP, NAT; Transport layer: flow control and congestion control, UDP, TCP, sockets; Application layer protocols: DNS, SMTP, HTTP, FTP, Email.

Written Test Format and Syllabus

Electronics and Communication Engineering, School of Electrical Sciences

Ph.D. Admission Test Syllabus

Basic Electronic Circuits: Diode circuits: clipping, clamping and rectifiers. BJT and MOSFET amplifiers: biasing, ac coupling, small signal analysis, frequency response. Current mirrors and differential amplifiers. Op-amp circuits: Amplifiers, summers, differentiators, integrators, active filters, Schmitt triggers and oscillators. Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates, arithmetic circuits, code converters, multiplexers, decoders. Sequential circuits: latches and flip-flops, counters, shift-registers, finite state machines.

Signals and Systems: Continuous-time signals: Fourier series and Fourier transform, sampling theorem and applications. Discrete-time signals: DTFT, DFT, z-transform, discrete-time processing of continuous-time signals. LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeroes, frequency response, group delay, phase delay.

Analog and Digital Communication: Analog communications: amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, superheterodyne receivers. Information theory: entropy, mutual information and channel capacity theorem. Digital communications: PCM, DPCM, digital modulation schemes (ASK, PSK, FSK, QAM), bandwidth, inter-symbol interference, MAP, ML detection, matched filter receiver, SNR and BER. Fundamentals of error correction, Hamming codes, CRC.

Probability and Random Processes: Probability and Statistics: Mean, median, mode, standard deviation, combinatorial probability, probability distributions, binomial distribution, Poisson distribution, exponential distribution, normal distribution, joint and conditional probability. Random processes: autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems.

Electromagnetic Theory: Maxwell's equations: differential and integral forms and their interpretation, boundary conditions, wave equation, Poynting vector. Plane waves and properties: reflection and refraction, polarization, phase and group velocity, propagation through various media, skin depth. Transmission lines: equations, characteristic impedance, impedance matching, impedance transformation, S-parameters, Smith chart. Rectangular and circular waveguides, light propagation in optical fibers, dipole and monopole antennas, linear antenna arrays.

Digital Signal Processing: Introduction to DSP, Signals and Systems Characterization, FIR and IIR
: Recursive and Non Recursive, Z -Transform, Discrete Time Signals and Systems in Frequency Domain, Sampling, Quantization, Discrete Fourier Transform, Fast Fourier Transform, Shorttime Fourier Transform, Digital Filter Structure, Analog Filter Design, Digital Filter Design.

Linear Algebra: Vector space, basis, linear dependence and independence, matrix algebra, eigenvalues and eigenvectors, rank, solution of linear equations- existence and uniqueness. Norm and its properties, inner product and its properties, Cauchy Schwarz inequality, eigen value decomposition, positive semidefinite matrices.

Electronic Devices and Circuits: Energy bands in semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors; Carrier transport: diffusion current, drift current, mobility and resistivity, Poisson, and continuity equations. P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photodiode, solar cell; Diode circuits; BJT and MOSFET circuits and amplifiers; current mirrors and differential amplifiers; op-amp circuits; feedback and oscillators.

Digital Logic Design: Binary arithmetic; Combinational circuits: Boolean algebra, minimization of functions; arithmetic circuits, code converters, multiplexers, decoders; Sequential circuits: latches and flip-flops, counters, shift-registers, finite state machines and timing; Data converters and semiconductor memories.

VLSI Design: Fabrication Technology: Basic steps of fabrication of CMOS; MOS transistor characteristics, MOS switch and inverter, Bi-CMOS inverter, latch-up in CMOS inverter, superbuffers, propagation delay models, switching delay in logic circuits; Logic Design: switch logic, gate restoring logic, various logic families and logic gates, PLA; Dynamic and sequential circuits: bi-stable circuit elements, CMOS SR latch, clocked latch and flip-flops; Semiconductor Memories: SRAM, DRAM, non-volatile memories.

Written Test Format and Syllabus

Electrical Engineering, School of Electrical Sciences

Ph.D. Admission Test Syllabus:

Basic Electrical Engineering: DC Networks; Single phase AC Circuits; Three phase AC Circuits; Two Port Network; Theorems; DC Transient

Electric Machine: DC Machines, 1-Ph Transformer

Mathematics: Laplace Transform; Inverse Laplace Transform; Fourier Transform; Ordinary Differential Equation; Linear Differential Equation

Control Systems: Open loop and closed-loop control systems; Transient Response and Steady State Error Analysis; Root Locus Method; Frequency Response Analysis; Compensation Techniques; State Space Analysis

Power Systems: Line Parameters; Performance of Transmission Lines; Overhead Line Insulators; Mechanical Design of Overhead Lines; Corona; Under Ground Cable; Power System Transients; Design of Transmission Lines; Power Circle diagram; Load flow analysis; Load frequency control; Economic Operation of power system; Power system stability

Power Electronics: Power Semiconductor Devices; Rectifiers; AC-AC Phase control; DC-DC Converters; Inverters; Pulse Width Modulation; Power Supply Applications

AC Machine and Drives: Single Phase Induction Motor; Three-Phase induction motor; Synchronous Motor; Synchronous Generator; Auto Transformer; Three Phase Transformer**;** AC Drives; DC Drives**.**

Syllabus for Ph.D. Admission Written Test (Civil Engineering-SIF)

Specialization: Environmental Engineering

Forecasting water demand, Water Sources, Water quality parameters (physical, chemical, and biological) and drinking water standards, Environmental chemistry-basic concepts, Water treatment systems, Physico-chemical processes, Distribution networks.

Components of wastewater flows, Sewerage systems, Wastewater characteristics, Wastewater Treatment (Preliminary, Primary, Secondary, Tertiary), Reaction rates and order, Type of reactors, Biomass growth curve, Suspended growth process, Mass balance analysis for biomass and substrate in activated sludge process (ASP), modifications in conventional ASP, Attached growth process, Trickling filter, Bio-tower, rotating biological contactor, Anaerobic treatment, Up flow sludge blanket reactor, Constructed wetland, Sludge management (Sludge dewatering, Aerobic and anaerobic sludge digestion, disposal), Adsorption, Membrane Filtration.

Municipal Solid Waste: Sources, Composition and Characteristics, Integrated Solid Waste management system: Generation, Storage Segregation, Collection, Reuse and Recycling possibilities, Transfer and Transport, Biological and Thermal/thermos-chemical Conversion technologies, Landfilling.

Air pollution, Sources of air pollution, Types of pollutant, sinks, and transport; Effects on health and environment; Criteria pollutants, ambient and source standards. Dispersion modeling. Particulate and Gaseous Pollutant Monitoring and Control. Concept of Environmental impact assessment (EIA), Practical applications of EIA, EIA methodologies, Environmental management plan.

Specialization: Geotechnical Engineering

Index properties of soil, clay mineralogy, structural arrangement of grains, classification of soil using BIS codes. Effective stress concepts in soils. Permeability, Darcy's law, determination of permeability, laboratory determination (constant head and falling head methods). Factors influencing permeability of soils, seepage, two-dimensional flow, Laplace's equation, introduction to flow nets. Compaction theory, laboratory and field Compaction, factors influencing compaction. Consolidation settlement, Terzaghi's one-dimensional consolidation theory, e-log p relationship, estimation of primary consolidation settlement for NC and OC clays. Shear strength of soils, Mohr-Coulomb failure theory, measurement of drained and undrained shear strength parameters using direct shear & triaxial compression (UU, CU, and CD tests), UCC, and Vane shear tests, pore pressure parameters, factors that influence shear strength of the soil. Soil exploration: Objectives, trial pits, borelogs, SPT, CPT, SCPT, DCPT; Settlement and bearing capacity of shallow footings: spread, mat or raft foundations, Deep foundations : Pile and pile Groups under axial loading. Retaining Structures: Earth Pressure theories (Rankine, Coulomb), Stress distribution, gravity and rigid cantilever walls.

Specialization: Structural Engineering

Single-degree-freedom systems: undamped and damped free vibration; Response to harmonic and periodic excitations;

Analysis of Statically Determinate Structures; Review of shear force and bending moment diagrams in beams and frames; Plane trusses: Deflection of trusses; Deflection of beams and frames; Influence line diagrams and moving loads;

Basics of Limit State Design of RCC Members; Assumptions in the LSM of design; Design of RC Beams for Bending Moment, Shear Force, Bond and Torsion. Axially and eccentrically loaded RC Columns. Design of RCC one-way and two-way slabs.

Stress- Theory of stress, Differential equation of equilibrium, Transformation of plane stresses and Mohr's circle, Stress analysis of axially loaded bar, State of deformation and strain, Generalized Hooke's law- Stress-strain (constitutive) relationship, Plane stress and plain strain problems, Thin-walled pressure vessels, Torsion-solid circular shaft, Bending of symmetric

beam- Shear force and bending moment, Bending stresses, Shear stresses in bending, Shear flow, Analysis of short column and long column.

Fundamental of concrete - constituents, proportioning, mixing, transportation, placing and curing, Properties of fresh and hardened concrete, Quality control in concrete construction, Concrete mix design, Durability of concrete

Specialization: Transportation Engineering

Traffic studies- volume, speed and delay studies, elements of traffic flow theory, peak hour volume and peak hour factor, PCU concept, traffic capacity and LOS, Greenshields' and Greenberg models, fundamental of transportation system planning, basics of Four-step travel demand forecasting.

Elements of geometric design of highways, stopping sight distance, overtaking sight distance, types of overtaking in Indian context, horizontal alignment, transition curves, super elevation, vertical curves.

Characterization of soil and unbound granular materials, Soil Stabilisation, Properties of bitumen, emulsion, and modified binders, Rheology of bitumen, bituminous mix design (Marshall method), Volumetric Properties.

Type of Pavements, philosophy of pavement design, Pavement Composition, factors affecting pavement design (traffic & loading, pavement component materials, Climatic conditions, failure criteria, reliability etc.), Design of flexible and rigid pavements.

Specialization: Water Resources Engineering

Basic properties of water; Determination of hydrostatic forces; Kinematics of flow; Potential flow; Continuity, Energy and Momentum principles; Open channel flow; Uniform and gradually varied flows; Dimensional analysis; Hydraulic similitude and Modelling; Flow in pipes and Pipe networks; Hydraulics machines; Pumps and Turbines.

Concepts of hydrologic cycle; Measurement and analysis of precipitation and runoff; Hydrograph analysis; Floods; Flood routing; Streamflow measurement; Irrigation requirement of crops; Design of canals; Design and drawing of weirs and barrages; cross drainage works; Classification; analysis; design and drawing of Gravity and Earth dams; Design and drawing of spillways and energy dissipators.

PhD Entrance Examination Syllabus for Mechanical Engineering 2023

Design Engineering

Engineering Mechanics: Free-body diagrams and equilibrium; friction and its applications including rolling friction, belt-pulley and brakes. Trusses and frames; virtual work; kinematics and dynamics of particles in plane motion; impulse and momentum (linear and angular) and energy formulations.

Mechanics of Materials: Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; concept of shear centre; deflection of beams; torsion of circular shafts.

Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.

Machine Design: Design for static and dynamic loading; failure theories; fatigue strength and the SN diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs.

Fluids and Thermal Engineering

Fluid Mechanics: Fluid properties; fluid statics, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings; basics of compressible fluid flow.

Thermodynamics: Thermodynamic systems and processes; properties of pure substances, behavior of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.

Applications: Power Engineering: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. I.C. Engines: Air-standard Otto, Diesel and dual cycles. Refrigeration and air conditioning.

Manufacturing Engineering

Engineering Materials: Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.

Casting, Forming and Joining Processes: Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet

(shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

Machining and Machine Tool Operations: Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; principles of non-traditional machining processes; NC/CNC machines and CNC programming.

Operations Research: Linear programming, simplex method, transportation, PERT and CPM.

Mathematics

Linear Algebra: Matrix algebra, systems of linear equations, eigenvalues and eigenvectors.

Calculus: Functions of single variable, limit, continuity and differentiability, indeterminate forms; evaluation of definite and improper integrals; partial derivatives, Taylor series, maxima and minima, Fourier series

Differential equations: First order equations (linear and nonlinear);

Probability and Statistics: Definitions of probability, sampling theorems, conditional probability; mean, median, mode and standard deviation; random variables, binomial, Poisson and normal distributions.

Indian Institute of Technology Bhubaneswar School of Basic Sciences

Syllabus for Ph.D. Admission (Physics)

PART 'A' CORE

Mathematical Methods of Physics

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, CayleyHamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions). Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals. Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem. **Classical Mechanics**

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions -scattering in laboratory and Centre of mass frames. Rigid body dynamics-moment of inertia tensor. Non-inertial frames and pseudo forces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Periodic motion: small oscillations, normal modes. Special theory of relativity-Lorentz transformations, relativistic kinematics and mass–energy equivalence.

Electromagnetic Theory

Electrostatics: 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.

Dielectrics and conductors. Basic Optics, Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Dynamics of charged particles in static and uniform electromagnetic fields.

Quantum Mechanics

Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Time-independent perturbation theory and applications. Variational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, spin-statistics connection.

Thermodynamic and Statistical Physics

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibria. 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.

Electronics and Experimental Methods

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo-and heterojunction devices), device structure, device characteristics, frequency dependence and applications. Opto-electronic devices (solar cells, photo-detectors, LEDs). Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits). A/D and D/A converters. Microprocessor and microcontroller basics. Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting

PART 'B' ADVANCED

Mathematical Methods of Physics

Green's function. Partial differential equations (Laplace, wave and heat equations in two and three dimensions). Elements of computational techniques: root of functions, interpolation, extrapolation, integration by trapezoidal and Simpson's rule, Solution of first order differential equation using Runge-Kutta method. Finite difference methods. Tensors. Introductory group theory: SU(2), O(3).

Classical Mechanics

Dynamical systems, Phase space dynamics, stability analysis.Poisson brackets and canonical transformations. Symmetry, invariance and Noether's theorem. Hamilton-Jacobi theory.

Electromagnetic Theory

Dispersion relations in plasma. Lorentz invariance of Maxwell's equation. Transmission lines and wave guides. Radiation-from moving charges and dipoles and retarded potentials.

Quantum Mechanics

Spin-orbit coupling, fine structure. WKB approximation. Elementary theory of scattering: phase shifts, partial waves, Born approximation. Relativistic quantum mechanics: Klein-Gordon and Dirac equations. Semi-classical theory of radiation.

Thermodynamic and Statistical Physics

First-and second-order phase transitions. Diamagnetism, paramagnetism, and ferromagnetism. Ising model. Bose-Einstein condensation. Diffusion equation. Random walk and Brownian motion. Introduction to nonequilibrium processes.

Electronics and Experimental Methods

Linear and nonlinear curve fitting, chi-square test. Transducers (temperature, pressure/vacuum, magnetic fields, vibration, optical, and particle detectors). Measurement and control. Signal conditioning and recovery. Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding. Fourier transforms, lockin detector, box-car integrator, modulation techniques. High frequency devices (including generators and detectors).

Atomic, Molecular and Optical Physics

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectral lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin

resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. BornOppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers, spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

Condensed Matter Physics

Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasicrystals.

Nuclear and Particle Physics

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model. Nature of the nuclear force, form of nucleonnucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations. Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions. Classification of fundamental forces. 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. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.

Syllabus for PhD entrance (Chemistry)

Chemistry

- Quantum chemistry, Molecular spectroscopy, Chemical and statistical thermodynamics, Electrochemistry, Chemical kinetics, Colloids and surfaces, Solid state chemistry.

- Chemical periodicity, Structure, bonding and reactivity, Chemical applications of group theory, Concepts of acid and bases, Main group elements, Transition metals and coordination compounds, Inner transition elements, Organometallic chemistry, Bioinorganic chemistry, Cages and metal cluster, Nuclear chemistry, Analytical chemistry and characterisation of inorganic compounds.

- IUPAC nomenclature of organic molecules, Principles of stereochemistry, Aromaticity, Organic reactive intermediates, Organics reaction mechanism, Common named reactions and rearrangements, Organic transformations and reagents, Concepts in organic synthesis,

Asymmetric synthesis, Pericyclic reaction, Heterocyclic chemistry, Chemistry of natural products, Structure determination of organic compounds by spectroscopic techniques, Polymer chemistry.

For more details, please refer to the most recent syllabus of the Chemical Sciences for CSIR/UGCNET and GATE.

Syllabus for PhD entrance (Mathematics)

Real Analysis: Real number system and set theory: Completeness property, Archimedian property, Denseness of rationals and irrationals, Countable and uncountable, Cardinality, Zorn's lemma, Axiom of choice. Metric spaces: Open sets, Closed sets, Continuous functions, Completeness, Cantor intersection theorem, Baire category theorem,

Compactness, Totally boundedness, Finite intersection property. Riemann-Stieltjes integral: Definition and existence of the integral, Properties of the integral, Differentiation and integration. Sequence and Series of functions: Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation. Equicontinuity, Ascoli's Theorem, Weierstrass approximation theorem.

Complex Analysis: Polar representation and roots of complex numbers; Spherical representation of extended complex plane; Elementary properties and examples of analytic functions: The exponential, Trigonometric functions, Mobius transformations, Cross ratio; Complex integration: Power series representation of analytic functions, Zeros of analytic functions, Cauchy theorem and integral formula, The index of a point with respect to a closed curve, the general form of Cauchy's theorem; Open Mapping Theorem; Classification of singularities: Residue theorem and applications; The Argument Principle;

The Maximum modulus Principle; Schwarz's lemma; Phragmen-Lindelof theorem.

Algebra: Groups: Binary operation and its properties, Definition of a group, Examples and basic properties, Subgroups, Cyclic groups, Dihedral Groups, Permutation groups, Cayley's theorems. Coset of a subgroup, Lagrange's theorem, Order of a group, Normal subgroups, Quotient group, Homomorphisms, Kernel Image of a homomorphism, Isomorphism theorems, Direct product of groups, Group action on a set, Semi-direct product, Sylow' theorems, Structure of finite abelian groups. Rings: Definition, Examples and basic properties. Zero divisors, Integral domains, Fields. Characteristic of a ring, Quotient field of an integral domain. Subrings, Ideals, Quotient rings, Isomorphism theorems, Ring of polynomials. Prime, Irreducible elements and their properties, UFD, PID and Euclidean domains. Prime ideal, Maximal ideals, Prime avoidance theorem, Chinese remainder theorem. Fields: Field of fractions, Gauss lemma, Fields, field extension, Galois theory.

Linear Algebra: Vector spaces over fields, subspaces, bases and dimension; Systems of linear equations, matrices, rank, Gaussian elimination; Linear transformations, representation of linear transformations by matrices, rank-nullity theorem, duality and transpose; Determinants, Laplace expansions, cofactors, adjoint, Cramer's Rule; Eigenvalues and eigenvectors, characteristic polynomials, minimal polynomials, CayleyHamilton Theorem, triangulation,

diagonalization, rational canonical form, Jordan canonical form; Inner product spaces, Gram-Schmidt orthonormalization, orthogonal projections, linear functionals and adjoints, Hermitian, self-adjoint, unitary and normal operators, Spectral Theorem for normal operators; Rayleigh quotient, Min-Max Principle. Bilinear forms, symmetric and skew-symmetric bilinear forms, real quadratic forms, Sylvester's law of inertia, positive definiteness.

Ordinary and Partial Differential Equations: Ordinary differential equations: first order equations, Picard's theorem (existence and uniqueness of solution to first order ordinary differential equation). Second order differential equations- second order linear differential equations with constant coefficients. Systems of first order differential equations, equations with regular singular points, stability of linear systems. Introduction to power series and power series solutions. Special ordinary differential equations arising in physics and some special functions (e.g. Bessel's functions, Legendre polynomials, Gamma functions) and their orthogonality. Oscillations - Sturm Liouville theory. Mathematical models leading to partial differential equations. First order quasi-linear equations. Nonlinear equations.

Cauchy-Kowalewski's theorem (for first order). Classification of second order equations and method of characteristics. Riemann's method and applications. One dimensional wave equation and D'Alembert's method. Vibration of a membrane. Duhamel's principle. Solutions of equations in bounded domains and uniqueness of solutions. BVPs for

Laplace's and Poisson's equations. Maximum principle and applications. Green's functions and properties. Existence theorem by Perron's method. Heat equation, Maximum principle. Uniqueness of solutions via energy method. Uniqueness of solutions of IVPs for heat conduction equation. Green's function for the heat equation. Finite difference method for the existence and computation of solution of heat conduction equation.

Probability: Probability:-Axiomatic definition, Properties. Conditional probability, Bayes rule and independence of events. Random variables, Distribution function, Probability mass and density functions, Expectation, Moments, Moment generating function, Chebyshev's inequality. Special distributions: Bernoulli, Binomial, Geometric, Negative Binomial, Hypergeometric, Poisson, Uniform, Exponential, Gamma, Normal, Joint distributions, Marginal and conditional distributions, Moments, Independence of random variables, Covariance, Correlation, Functions of random variables, Weak law of large numbers, P. Levy's central limit theorem (i.i.d. finite variance case), Normal and Poisson approximations to binomial.

Syllabus for Ph.D. Admission (Biosciences)

1. CSIR-UGC National Eligibility Test (NET) syllabus link. (https://csirhrdg.res.in/SiteContent/ManagedContent/ContentFiles/20201221135946325lifescience_syllbus.pdf)

2. GATE (Biotechnology) and GATE (Life Sciences) syllabus link. https://gate.iitkgp.ac.in/gate2022/gate_syllabus.html

PHD IN PHILOSOPHY SCHOOL OF HUMANITIES, SOCIAL SCIENCES & MANAGEMENT, IIT BHUBANESWAR

SYLLABUS FOR ENTRANCE EXAMINATION

1. INDIAN PHILOSOPHY & CONTEMPORARY THOUGHT

Vedic & Upanishadic World Views; Nine Systems (Astika & Nastika) of Indian Philosophy, Practical Vedanta of Vivekananda; Concept of Mind & Evolution in Sri Aurobindo; Notion of Self, God & Man in Iqbal; Concept of Philosophy & Subject as Freedom in K.C Bhattacharya; Gandhian notion of Non-violence, Satyagraha & Critique of Modern Civilization; Ambedkar's Varna & the Caste System.

2. WESTERN PHILOSOPHY: CLASSICAL & MODERN

Pre-Socratic Philosophy; Medieval Philosophy - The Sophists & Socrates; Plato – Allegory of the Cave, Education, Knowledge, Theory of Forms; Aristotle – Form & Matter, Theory of Causation; Descartes – Method of Doubt, Mind-Body Relation, Proofs for the existence of God; Spinoza – Substance, Attributes and Modes; Leibneitz – Monadology & the Doctrine of Pre-established Harmony; Locke –Theory of Knowledge, Concept of Substance, Representationalism; Berkeley – Rejection of Locke's Primary & Secondary Qualities, esse est percipii, The Problem of Solipcism; Hume – Impressions & Ideas, Fact & Value, Rejection of Metaphysics, Scepticism, Reason & Passions; Kant – The Critical Philosophy, Copernican Revolution, Forms of Sensibility, Categories of Understanding.

3. EXISTENTIALISM AND PHENOMENOLOGY

Kierkegaard – Truth and Subjectivity; Sartre – Freedom of Choice and Determinism; Neitzsche –Will to Power; Husserl – Husserlian Method & Intentionality; Heidegger – Being and Nothingness, Man as Being in the World, Critique of Technology; Logical Positivism – The Verifiability Theory of Meaning, Rejection of metaphysics, Habermas – Communicative Action, Discourse Theory,

4. TOPICS IN LOGIC

Deductive Logic - Nature of Categorical Propositions, Distribution, Square of Opposition, Aristotelian Syllogism, Moods and Fallacies, Finding the Validity of Aruguments Through Truth Table Method, Shorter Truth Table Method, Venn Diagram, Method of Deduction; Inductive Logic - The meaning of Cause; Induction by Simple Enumeration; Mill's Method of Experimental Inquiry; Mill's Method of Agreement, Method of Difference, Joint Method of Agreement and Difference, Method of Residues, Method of Concomitant Variations; Criticism of Mills Methods, Vindication of Mill's Methods.

5. TOPICS IN ETHICS

Ethics in Theory and Practice: Meta, Normative & Applied; Concept of Duty and Obligation, Freedom and Responsibility, Crime, Theories of Punishment; Issues in Abortion, Euthanasia, Suicide, and Cloning; Gender Studies; Feminism; Care Ethics; Animal Ethics; Environmental Ethics; Sustainable Development; Consumerism; Human Rights; Indigenous Rights.

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Written Examination Syllabus for the PhD admission in Economics

Micro Economics: Theory of Consumer Behaviour (Demand, Supply, Elasticity, Utility); Theory of Production and Costs; Market Structures, competitive and non-competitive equilibria; Efficiency Criteria: Pareto-Optimality, Kaldor –Hicks and Wealth Maximization; Asymmetric Information: Adverse Selection and Moral Hazard

Macro Economics: Determination of output and employment (Classical & Keynesian Approach); National Income Analysis; Consumption Function; Investment Function; Multiplier and Accelerator; Demand and Supply of Money; IS-LM Model Approach; Inflation and Phillips Curve Analysis; Monetary and Fiscal Policy; Rational Expectation Hypothesis; Business Cycles

Basic Econometrics: Linear Regression Models and their properties – BLUE; goodness of fit; Confidence intervals; Gauss-Markov theorem; Multiple Linear Regression Model: Estimation of parameters; Identification Problem; Violations of Classical Assumptions, Consequences, Detection and Remedies: Multicollinearity; Heteroscedasticity; Serial correlation; Specification Analysis

Development Economics: Conceptions of Development; Growth Models: The Harrod-Domar model, the Solow model and its variants; Endogenous growth models; Poverty and Inequality: Definitions, Measures and Mechanisms Inequality axioms; Connections between inequality and development; Poverty measurement; Measures of Economic Development

Environmental Economics: Interaction between economy and environment; Choice of policy instrument, Command and Control instrument; Public and environmental goods, Negative externality and market failure; Property rights and market bargain theorem (Coase theorem); The optimal pigouvian tax, Pollution reduction subsidies; Environmental Valuation: Contingent valuation method, Travel cost and Hedonic price method; Cost & Benefit analysis

International Economics: International Trade: Basic concepts and analytical tools; Balance of Payments: Composition, Equilibrium and Disequilibrium and Adjustment Mechanisms; International Trade under imperfect competition; Exchange Rate; Tariff and Non-Tariff barriers to trade; Dumping; Gains from Trade, Terms of Trade; Trade Policy Issues; IMF & World Bank

Money and Banking Money: Concept, functions, measurement; Theories of money supply determination; Financial Institutions, Markets, Instruments; Role of financial markets and institutions; problem of asymmetric information; Financial crises. Capital Market and its Regulation; Non-banking Financial Institutions

Public Economics

Market Failure: Asymmetric Information, Public Goods, Externality; Public Revenue: Taxation and Its principle: Meaning, objectives, and canon of taxation; Theory of the division of tax burden; Benefit receive principle and ability to pay; Classification and choices of taxes; Progressive and non-Progressive Taxation, Incidence and Effects of Taxation; Public Budget and Budget Multiplier; Fiscal Policy; Public expenditure and debt and its management

School of Humanities, Social Sciences and Management

PhD Entrance Test Syllabus: English

I. English Language and Teaching

ELT Terminology; Approaches to Second Language Acquisition and Learning; Language Testing and Evaluation / assessment; Methods and Materials of Teaching Language; Curriculum and Syllabus Design; Language Learning and Teaching Strategies; Research Methods and Materials in English, English Language: concepts, theories, applications, English in Use.

II. English Literature

1. History of English Literature:
Important literary events, forms and trends from the Age of Chaucer to Postmodern Era

2. Literary Forms:
Prose (Fiction and non- fiction), poetry and dramatic types, forms and characteristics. Drama: History, Definition, Form, Types, Characteristics, Major Dramatic Trends from 15th to 21st Century, Major Dramatists (Indian, British and World)

3. Literary Theories
- What Is Literary Theory?
- Traditional Literary Criticism
- Formalism and New Criticism
- Marxism and Critical Theory
- Structuralism and Poststructuralist Theory
- New Historicism and Cultural Materialism
- Ethnic Studies and Postcolonial Criticism
- Gender Studies and Queer Theory
- Cultural Studies
- General Works on Theory
- Literary and Cultural Theory
- Ecocriticism
- Film Studies
- Non-conventional Literature (or Grey Literature)

4. Literary Terms and Devices: Definitions and examples

5. Literatures in Translation Studies (Indian and World Literature): History, Scope, Translation Theory (Literary and Cultural), Approaches and Types, Difference between Indian Writings in English (IWE) and Indian Literatures in English Translation (ILET), Major Literatures (Fiction and Non-Fiction, Drama, Poetry) in Translation.

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PhD Entrance test Syllabus: Psychology

History of Psychology, Schools of Psychology, Human motivation and emotion – types and theories, Personality – types and theories, biological basis of behavior

Social and group processes-history of social psychology, theories and empirical methods in the studies of social psychology, social cognition, perception of self, attitude toward others, conformity, pro-social and bystander behavior

Emergence of cognitive Science, Cognitive revolution, Cognitive Science as an interdisciplinary approach, information processing model, organization of mind, Cognitive processes-perception, attention, learning and memory, language acquisition, comprehension and production. Methods in the study of cognitive science

Introduction to clinical psychology, nature and purpose of clinical assessment, techniques of assessment

References

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- Nolen-Hoeksema, S., Fredrickson, B., Loftus, G. R., & Lutz, C. (2014). *Introduction to psychology*. Washington: Cengage Learning.
- Santrock, J. W. (2021). *Essentials of Life-Span Development,* 7th Edition International Edition, McGraw Hill.
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- Baron, R.A.,Branscombe, N. R., & Byrne, D. Social Psychology (12th ed.) Boston, MA: Pearson/Allyn and Bacon, 2009
- Aronson, E., Wilson, T.D., & Akert, R.M. Social Psychology (7th ed). Upper Saddle River, NJ: Prentice Hall, 2010
- Bermúdez, J.L. Cognitive Science An Introduction to the Science of the Mind 2nd Edition Cambridge University Press, Cambridge, 2010
- Martin V. Butz and Esther F. Kutter How the Mind Comes into Being Introducing Cognitive Science from a Functional and Computational Perspective, first edition, Oxford Univ Pr, 2017
- Bellack A, S., &Hersen, M. (1980). Introduction to Clinical Psychology. Oxford: Oxford University Press. New York: John Wiley & Son.
- Ilusen, M., Kazdin E. A &Bellack S.A. (1991). The Clinical Psychology handbook. 2nd Ed New York: Pregamon press.
- Carson, R. C. Pincka, S., & Butcher, I N. (1999). Abnormal Psychology and Modem Life. 11thed. New York: Addison Wesley Longman Inc

Syllabus for Ph.D. Entrance Exam at SEOCS

Geology

Earth and planetary system – terrestrial planets and moons of the solar system; size, shape, internal structure and composition of the earth; concept of isostasy; elements of seismology – body and surface waves, propagation of body waves in the earth's interior; Heat flow within the earth; Gravitational field of the Earth; geomagnetism and paleomagnetism; continental drift; plate tectonics – relationship with earthquakes, volcanism and mountain building; continental and oceanic crust – composition, structure and thickness. Weathering and soil formation; landforms created by river, wind, glacier, ocean and volcanoes. Basic structural geology - stress, strain and material response; brittle and ductile deformation; nomenclature and classification of folds and faults. Crystallography – basic crystal symmetry and concept of point groups. Mineralogy – silicate crystal structure and determinative mineralogy of common rock forming minerals. Petrology of common igneous, sedimentary and metamorphic rocks. Geological time scale; Geochronology and absolute time. Stratigraphic principles; major stratigraphic divisions of India. Mineral, coal and petroleum resources of India. Introduction to remote sensing. Engineering properties of rocks and soils.

Elements of hydrogeology. Principles and applications of gravity, magnetic, electrical, electromagnetic, seismic and radiometric methods of prospecting for oil, mineral and ground water; introductory well logging. Geomorphic processes and agents; development and evolution of landforms in continental and oceanic settings; tectonic geomorphology. Forces and mechanism of rock deformation; primary and secondary structures; geometry and genesis of planar and linear structures (bedding, cleavage, schistosity, lineation); folds, faults, joints and unconformities; Stereographic projection; shear zones, thrusts and superposed folding; basement-cover relationship. Interpretation of geological maps. Crystallography and mineralogy- Elements of crystal symmetry, form and twinning; crystallographic projection; crystal chemistry; classification of minerals, physical and optical properties of rock- forming minerals. Geochemistry – Cosmic abundance of elements; meteorites; geochemical evolution of the earth; geochemical cycles; distribution of major, minor and trace elements in crust and mantle; elements of high temperature and low temperature geochemical thermodynamics; isotopic evolution of the crust and the mantle, mantle reservoirs; geochemistry of water and water-rock interaction. Classification, forms, textures and genesis of common igneous rocks; magmatic differentiation; binary and ternary phase diagrams; major and trace elements as monitors of partial melting and magma evolutionary processes. Mantle plumes, hotspots and large igneous provinces. Texture, structure and sedimentary processes; petrology of common sedimentary rocks; Sedimentary facies and environments, cyclicities in sedimentary succession; provencance and basin analysis. Important sedimentary basins of India.

Structures and textures of metamorphic rocks. Physico-chemical conditions of metamorphism and concept of metamorphic facies, grade and basic types; metamorphism of pelitic, mafic and impure carbonate rocks; role of bulk composition including fluids in metamorphism; thermobarometry and metamorphic P-T-t paths, and their tectonic significance. Diversity of life through time, mass extinctions- causes and effects; taphonomy - processes of fossilization. Taxonomy. Morphology and functional morphology of invertebrates (bivalves, brachiopods, gastropods, echinoids, ammonites); microfossils (foraminifera, ostracoda, conodonts, bryozoa); Vertebrate paleonology (Equus, Probicidea, Human); Paleobotany (plant, spores, pollens). Basic concepts of

ecology/paleoecology; classification - ecological and taxonomic schemes (diversity and richness). Fossils and paleoenvironments. Principles of stratigraphy and concepts of correlation; Lithostratigraphy, biostratigraphy and chronostratigraphy. Principles of sequence stratigraphy and applications. Stratigraphy of peninsular and extra-peninsular India. Boundary problems in Indian stratigraphy. Ore-mineralogy; ore forming processes vis-à-vis ore-rock association (magmatic, hydrothermal, sedimentary, supergene and metamorphogenic ores); fluid inclusions as ore genetic tools. Coal and petroleum geology; marine mineral resources. Prospecting and exploration of economic mineral deposits - sampling, ore reserve estimation, geostatistics, mining methods. Ore dressing and mineral economics. Distribution of mineral, fossil and nuclear fuel deposits in India. Plate motions, driving mechanisms, plate boundaries, supercontinent cycles. Physico-mechanical properties of rocks and soils; rock index tests; Rock failure criteria shear strength of rock discontinuities; rock mass classification Systems; in-situ stresses; rocks as construction materials; geological factors in the construction of engineering structures including dams, tunnels and excavation sites. Analysis of slope stability. Natural hazards (landslide, volcanic, seismogenic, coastal) and mitigation. Principles of climate change. Hydrogeology – Groundwater flow and exploration, well hydraulics and water quality. Basic principles of remote sensing – energy sources and radiation principles, atmospheric absorption, interaction of energy with earth's surface, aerial-photo interpretation, multispectral remote sensing in visible, infrared, thermal IR and microwave regions, digital processing of satellite images. GIS – basic concepts, raster and vector mode operations

Geophysics

Soild-Earth Geophysics - The earth as a planet; different motions of the earth; gravity field of the earth, Clairaut's theorem, size and shape of earth; geomagnetic field, paleomagnetism; Geothermics and heat flow; seismology and interior of the earth; variation of density, velocity, pressure, temperature, electrical and magnetic properties of the earth. Geodesy - Gravitational Field of the Earth; Geoid; Ellipsoid; Geodetic Reference Systems;

Datum; GPS and DGPS; Levelling and Surveying.

Earthquake Seismology - Elements of elasticity theory- stress and strain tensors, Generalized

Hooke's Law; Body and Surface Waves; Rotational, dilatational, irrorational and equivolumnal waves. Reflection and refraction of elastic waves; Inhomogeneous and evanescent waves and bounded waves; Eikonal Equation and Ray theory; earthquakes-causes and measurements, magnitude and intensity, focal mechanisms; earthquake quantification, source characteristics, seismotectonics and seismic hazards; digital seismographs, Earthquake statistics, wave propogation in elastic media, quantifying earthquake source from seismological data. Elements of Seismic Tomography. Potential and Time Varying Fields - Scalar and vector potential fields; Laplace, Maxwell and Helmholtz equations for solution of different types of boundary value problems in Cartesian, cylindrical and spherical polar coordinates; Green's theorem; Image theory; integral equations in potential and time-varying field theory.

Gravity Methods - Absolute and relative gravity measurements; Gravimeters; Land, airborne, shipborne and bore-hole gravity surveys; Tensorial Gravity sensors and surveys; various corrections for gravity data reduction – free air, Bouguer and isostatic anomalies; density estimates of rocks; regional and residual gravity separation; principle of equivalent stratum; data enhancement techniques, upward and downward continuation; derivative maps, wavelength filtering; preparation and analysis of gravity maps; gravity anomalies and their interpretation – anomalies due to geometrical and irregular shaped bodies, depth rules,

calculation of mass. Magnetic Methods - Elements of Earth's magnetic field, units of measurement, magnetic susceptibility of rocks and measurements, magnetometers and magnetic gradiometers, Land, airborne and marine magnetic and magnetic gradiometer surveys, Various corrections applied to magnetic data, IGRF, Reduction to Pole transformation, Poisson's relation of gravity and magnetic potential field, preparation of magnetic maps, upward and downward continuation, magnetic anomalies due to geometrical and irregular shaped bodies; Image processing concepts in processing of magnetic anomaly maps; Depth rules; Interpretation of processed magnetic anomaly data; derivative, analytic signal and Euler Depth Solutions. Applications of gravity and magnetic methods for mineral and oil exploration. Electrical Methods - Conduction of electricity through rocks, electrical conductivities of metals, non- metals, rock forming minerals and different rocks, concepts of D.C. resistivity measurement and depth of investigation; Apparent Resistivity and Apparent Chargeability, Concept of Negative Apparent Resistivity and Negative Apparent Chargeability; Theory of Reciprocity, Sounding and Profiling, Various electrode arrangements, application of linear filter theory, Sounding curves over multi-layered earth, Dar-Zarrouk parameters, reduction of layers, Triangle of anisotropy, interpretation of resistivity field data, Principles of equivalence and suppression, self-potential method and its origin; Electrical Resitivity Tomography (ERT); Induced polarization, time and frequency domain IP measurements; interpretation and applications of SP, resistivity and IP data sets for groundwater exploration, mineral exploration, environmental and engineering applications.

Electromagnetic Methods - Geo-electromagnetic spectrum; Biot Savart's Law; Maxwell's Equation, Helmotz Equation, Basic concept of EM induction in the earth, Skin-depth, elliptic polarization, in- phase and quadrature components, phasor diagrams; Response function and response parameters; Ground and Airborne Methods, measurements in different sourcereceiver configurations; Earth's natural electromagnetic methods-tellurics, geomagnetic depth sounding and magnetotellurics; Electromagnetic profiling and Sounding, Time domain EM method; EM scale modeling, processing of EM data and interpretation; Ground Penetrating Radar (GPR) Methods; Effect of conducting overburden;Geological applications including groundwater, mineral environmental and hydrocarbon exploration. Seismic methods - Elastic properties of earth materials; Reflection, refraction and CDP surveys; land and marine seismic sources, generation and propagation of elastic waves, velocity – depth models, geophones, hydrophones, digital recording systems, digital formats, field layouts, seismic noise and noise profile analysis, optimum geophone grouping, noise cancellation by shot and geophone arrays, 2D, 3D and 4D seismic data acquisition, processing and interpretation; CDP stacking charts, binning, filtering, static and dynamic corrections, Digital seismic data processing, seismic deconvolution and migration methods, attribute analysis, bright and dim spots, seismic stratigraphy, high resolution seismics, VSP, AVO, multi-component seismics and seismic interferometry. Reservoir geophysics- Rock Physics and Petrophysics.

Climate Science

Mathematics

Calculus: first and second order ordinary and partial differential equations, separable variable solutions; integrals ; basic concepts in linear algebra and vector calculus, Determinant, inverse

and rank of a matrix; System of linear equations; vector products, gradient, divergence and curl; basic concepts in statistics.

Physics

Basic concepts in laws of motion and gravity, thermodynamics: thermodynamic properties of substances, zeroeth, first and second laws of thermodynamics, carnot cycle; fluid mechanics: properties of fluids, kinematics and pressure and its measurement, dimensional analysis; radiation and heat transfer: conduction, convection and radiation; black body radiation, wave characteristics.

Atmospheric and Oceanic Sciences

Vertical structure of atmosphere and ocean, composition of atmosphere and ocean, concept of climate and climate change, atmospheric radiation, air-sea interaction, atmospheric stability, global warming, Indian Monsoon, Tropical Cyclones, ocean circulation.

English

Grammar and comprehension, written and spoken communication skills

School of Minerals, Metallurgical and Materials Engineering

Written Test Syllabus for PhD Admissions The written test features two sections.

Section - A

Engineering Mathematics

Linear Algebra*:* Matrices and Determinants, Systems of linear equations, Eigen values and Eigen vectors.

Calculus: Limit, continuity and differentiability; Partial derivatives; Maxima and minima

Vector Calculus: Gradient; Divergence and Curl; Line, Surface and volume integrals; Stokes, Gauss and Green's theorems.

Differential Equations: Linear and non-linear first order ODEs

Probability and Statistics: Definitions of probability and sampling theorems, conditional probability, Mean, median, mode and standard deviation.

General aptitude & reasoning

Logical reasoning, Verbal reasoning, Non-verbal reasoning, Data interpretation

English

Sentence formation from phrases, Sentence correction/improvement, Completing statements, Comprehension

Section - B

Principles of Metallurgy and Materials Engineering

Atomic structure and Bonding: Electrons in atoms, Bonding forces and energies, Ionic bonding, Covalent Bonding, Metallic Bonding, Secondary bonding.

Structure of Crystalline Solids: Crystalline and noncrystalline materials, Crystal structures in metals and ceramics, Miller indices, Structure of surfaces and interfaces, nano-crystalline and amorphous structures; solid solutions; solidification;

Imperfections in Solids: Point defects, Line defects and dislocations, Interfacial defects, Bulk or volume defects, significance of defects in materials

Diffusion mechanisms, Steady and non-steady state diffusion, Factors that influence diffusion, heat transfer – conduction, convection and heat transfer coefficient relations, radiation, mass transfer – diffusion and Fick's laws, mass transfer coefficients; momentum transfer – concepts of viscosity, shell balances, Bernoulli's equation, friction factors.

Phase Diagrams: Definitions and basic concepts, Types of phase transformations, Gibbs Phase Rule, Interpretation of binary phase diagrams

Mechanical Properties of Materials: Elastic deformation, Plastic deformation, elements of dislocation theory – types of dislocations, slip and twinning, source and multiplication of dislocations, yield criteria, Interpretation of tensile stress-strain curves, Measurement of hardness in materials

Electrical Properties of Materials: Electrical conduction, Semiconductivity, Dielectric Behaviour, Ferroelectric and Piezoelectric Behaviour

Thermal Properties: Heat capacity, Thermal expansion, Thermal conductivity, Thermal stresses

Magnetic Properties: Basic concepts, Diamagnetism, Paramagnetism, Ferromagnetism, Antiferromagnetism, Ferrimagnetism, Influence of temperature, Domains and Hysteresis

Optical Properties: Interaction of light with solids, Optical properties of metals and non-metals

Thermodynamics and Rate Processes

Laws of thermodynamics, activity, equilibrium constant, applications to metallurgical systems, solutions, phase equilibria, basic kinetic laws, order of reactions, rate constants and rate limiting steps; principles of electro chemistry-single electrode potential, electrochemical cells and polarizations.

Physical Metallurgy

Principles of heat treatment of steels, and aluminium alloys; recovery, recrystallization and grain growth; elements of X-ray and electron diffraction; principles of optical, scanning and transmission electron microscopy.

Mechanical Metallurgy

Strengthening mechanisms; tensile, fatigue and creep behaviour; Superplasticity; fracture – Griffith theory, basic concepts of linear elastic and elastoplastic fracture mechanics, ductile to brittle transition, fracture toughness.

Manufacturing Processes

Metal casting – patterns and moulds, melting, casting practices in sand casting, permanent mould casting, investment casting and shell moulding; Hot, warm and cold working of metals; Metal forming – fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming; Metal joining – soldering, brazing and welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; Welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints; Powder metallurgy – production of powders, compaction and sintering; NDT using dye penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle methods.