Chemistry

Periodic table, periodic properties.
Chemical bonding, hybridization, Valence bond and molecular orbital theories.
Concepts of acids and bases.
Coordination compounds and organometallic compounds
Solid state chemistry: Crystal structures; Bragg's law and applications.
Nuclear chemistry, nuclear fission and fusion, nuclear reactor.

Chemical thermodynamics, laws of thermodynamics, energy, entropy, free energy, state and path functions, spontaneity and equilibria.
Phase transitions and phase rule. One and two components systems.
Electrochemistry: Nernst equation, redox systems, electrodes, electrochemical cells; ionic equilibria; pH and buffer solutions. Conductometric and potentiometric titrations.
Chemical kinetics, rate laws and temperature dependence of rate; complex reactions; steady state approximation; collision and transition state theories, unimolecular reactions.
Adsorption, adsorption isotherms, colloids.

Homogeneous and heterogeneous catalysis; Enzyme kinetics;
Photo chemical reactions and quantum yield.

IUPAC nomenclature of organic molecules,
Aromaticity, heterocyclic compounds.
Basic reaction mechanisms, Named reactions. Isomerism, stereochemistry.
Natural products, Drugs and pharmaceuticals.
Polymer chemistry, Polymerization reactions, MW of polymers and their determination,
Nanomaterials,
Environmental impact of chemicals and green chemistry.

Chromatography, theory, classification, applications.
Basic molecular spectroscopy, microwave, IR and UV-Visible spectroscopy. NMR spectroscopy. Instrumentation. Applications.
Thermal methods of analysis: DTA, TG, DSC

Data analysis: Mean and standard deviation; absolute and relative errors; linear regression; covariance and correlation coefficient
Computer Science And Engineering

Syllabus for Ph.D entrance exam


Data Structures And Algorithms: Basic Programming Methodology and Concepts, Linear and Non-linear Data Structures, Algorithm Design and Complexity Analysis, Parallel and Distributed Algorithm Design


Theory of Computation: Finite Automata, Grammars, Context Free Languages, Push Down Automata and Turing Machine

Economics

Detail Syllabus for Economic Entrance Test

A) Microeconomics
1. Demand and Supply Analysis
2. Theory of Production and Cost
3. Welfare Economics

B) Macroeconomics
2. Theory of employment, Consumption, Output, Inflation, Money and Finance
3. Financial and Capital Market
4. Economic Growth and Development

C) International Economics
1. International Trade
2. Balance of Payments
3. Global Institutions

D) Public Finance
1. Theories of taxation, Theories of public expenditure and Theory of public debt management.
2. Environmental Economics
4. State, Market and Planning

E) Indian Economy
1. History of development and planning.
2. Budgeting and Fiscal Policy
3. Poverty, Unemployment and Human Development
5. Foreign trade and Foreign Investment

F) Research Methodology Basic Statistics and Econometrics, Logical Reasoning and Data Interpretation -

Primary and Secondary Research, Techniques of data collection-Qualitative and Quantitative, presentation and analysis, Econometric and Statistical tools for social research.
1. The Age of Chaucer
2. The Elizabethan Age
3. The Jacobean Age to the Puritan Age
4. The Neo-classical Period
5. The Restoration Period and The Augustan Age
6. The Romantic Period
7. The Victorian Period and The Pre-Raphaelites
8. Modern Period
9. Modern British Literature
10. Literary Theory and Criticism: The Classical Period (Plato, Aristotle, Longinus)
11. British Literary Criticism from the Elizabeth Period to the Victorian Period
12. The New Criticism
13. American Literature
14. Indian Writing in English
15. Indian Literature in English Translation
16. National and International Literary Awards
Syllabus for Written Test for PhD Mathematics

**Linear Algebra:** Finite dimensional vector spaces, linear transformations and their matrix representations, rank, systems of linear equations, eigenvalues and eigenvectors, minimal polynomial, Cayley-Hamilton theorem, diagonalization, Hermitian, Skew-Hermitian and unitary matrices, finite dimensional inner product spaces, Gram-Schmidt orthonormalization process.

**Abstract Algebra:** Groups, subgroups, normal subgroups and homomorphism theorems, automorphisms, cyclic groups, permutation groups, Cayley's theorem, Sylow's theorems and their applications, rings, ideals, prime and maximal ideals, quotient rings, Euclidean domains, principle ideal domains and unique factorization domains, fields, finite fields.

**Real Analysis:** Real valued functions of a real variable, continuity and differentiability, sequences and series of functions, uniform convergence, power series, Fourier series, functions of several variables, metric spaces, completeness, Weierstrass approximation theorem, compactness, Lebesgue measure, measurable functions, Lebesgue integral, Fatou's lemma, dominated convergence theorem.

**Complex Analysis:** Algebra of complex numbers, complex plane, polynomials, power series, transcendental functions such as exponential, trigonometric and hyperbolic functions, analytic functions, conformal mappings, bilinear transformations, complex integration: Cauchy's integral theorem and formula, Liouville's theorem, maximum modulus principle, Taylor and Laurent's series, residue theorem and applications for evaluating real integrals.


**Ordinary Differential Equations:** First order ordinary differential equations, existence and uniqueness theorems, systems of linear first order ordinary differential equations, linear ordinary differential equations of higher order with constant coefficients, linear second order ordinary differential equations with variable coefficients, method of Laplace transforms for solving ordinary differential equations, series solutions, Legendre and Bessel functions and their orthogonality.

**Partial Differential Equations:** Linear and quasilinear first order partial differential equations, method of characteristics, second order linear equations in two variables and their classification,
Cauchy, Dirichlet and Neumann problems, solutions of Laplace, wave and diffusion equations in two variables, Fourier series and Fourier transform and Laplace transform methods of solutions for the above equations.

**Topology:** Basic concepts of topology, product topology, connectedness, compactness, countability and separation axioms, Urysohn's Lemma.

**Probability and Statistics:** Probability space, conditional probability, Bayes theorem, independence, random variables, joint and conditional distributions, standard probability distributions and their properties, expectation, conditional expectation, weak and strong law of large numbers, central limit theorem, sampling distributions, maximum likelihood estimators, testing of hypotheses, standard parametric tests based on normal, X2, t, F - distributions, linear regression, interval estimation.

**Operation Research:** Introduction to linear programming problems (LPP), solving LPP, graphical method, simplex method, artificial starting solution, duality of LPP, assignment problems, transportation problems, nonlinear programming.
Physics

1. Mathematical Methods of Physics


2. Classical Mechanics


3. Electromagnetic Theory


4. Quantum Mechanics

5. Thermodynamic and Statistical Physics


6. Electronics and Experimental Methods


7. Atomic & Molecular Physics


8. Condensed Matter Physics


9. Nuclear and Particle Physics

Sociology

1. **The Discipline of Sociology**: The socio-historical and intellectual background of sociology. Contributions of classical sociologists-Auguste Comte, Karl Marx, Emile Durkheim, and Max Weber

2. **Sociological Theories**: Functionalism, Marxism, Symbolic Interactionism, Feminism, Phenomenology and postmodern

3. **Sociology of Development**: Notions of development -Social, economic, human, sustainable, and ecological; Education and Development; Migration and Development

4. **Sociology of India**: Society in India: Caste structure and change, Rural Social structure, Religion in India, Approaches to the study of Indian society

5. **Research Methods**: Objectivity and Subjectivity, Quantitative and Qualitative research methods, Mixed research methods, Research designs, sampling. Techniques of data collection-Observation, Questionnaire, and Interview- analysis and interpretations of data, Statistical tools for social research.
Syllabus for Written Test for PhD Civil Engineering
(2020-21 Admissions)

Type: MCQ – 50 Questions ; Time: 1 hour ; Total Marks: 50

Candidate shall attempt any ONE SECTION of choice.

Section A

1. Structural Engineering
   Fundamentals of Engineering mechanics, solid mechanics, structural analysis, design of RCC structures, design of steel structures, structural dynamics, construction materials and management, Earthquake Engineering.

Section B

2. Water Resources Engineering

Section C

3. Geotechnical Engineering
   Index and engineering properties of soils, slope stability, subsurface exploration, shallow foundations, deep foundations, earth retaining structures, ground improvement techniques.

Section D

4. Transportation Engineering
   - Traffic Engineering – Fundamental parameters of Traffic Flow: Macroscopic and Microscopic Time space diagram: one vehicle & multiple vehicle Fundamental flow diagram: Speed Vs density; flow Vs density; speed Vs flow, Flow Models
   - Highway Geometric Design – Horizontal and Vertical Alignment, Sight Distance, etc.
   - Pavement Engineering – Pavement design, Pavement materials, Pavement maintenance.

Section E

5. Environmental Engineering
   - Water treatment: Sources of water, Quality and quantity of water, Drinking water standards, water requirements, water chemistry, basic unit operations and processes for water treatment.
   - Wastewater treatment: Primary, secondary and tertiary treatment of wastewater, sludge disposal, effluent discharge standards.
   - Air Pollution: Types of pollutants, their sources and impacts, Air quality standards, air pollution meteorology.

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Electrical Engineering PhD Syllabus

1. Basic Electrical and Electronics Engineering


2. Analog and Digital Electronics

Characteristics of diodes, BJT, MOSFET; Simple diode circuits: clipping, clamping, rectifiers; Amplifiers: Biasing, Equivalent circuit and Frequency response; Oscillators and Feedback amplifiers; Operational amplifiers: Characteristics and applications; Simple active filters, VCOs and Timers, Combinational and Sequential logic circuits, Multiplexer, Demultiplexer, Schmitt trigger, Sample and hold circuits, systems and Boolean algebra: Number systems, Codes, error detection and correction codes. Logic functions, minimization of Boolean functions using algebraic, Karnaugh map. Realization using logic gates, Realizing logical expressions using different logic gates and comparing their performance. Design of combinational circuits using combinational ICs: Combinational functions: code conversion, decoding, comparison, multiplexing, demultiplexing, addition, and subtraction. Analysis of Sequential Circuits Latches, Flip Flops – SR, JK D T, Flip flop characteristics, truth table, characteristic table, excitation tables, conversions.

3. Electrical Machines

Single phase transformer: equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three phase transformers: connections, parallel operation; Auto-transformer, Electromechanical energy conversion principles, DC machines: separately excited, series and shunt, motoring and generating mode of operation and their characteristics, starting and speed control of dc motors; Three phase induction motors: principle of operation, types, performance, torque-speed characteristics, no-load and blocked rotor tests, equivalent circuit, starting and speed control; Operating principle of single phase induction motors; Synchronous machines: cylindrical and salient pole machines, performance, regulation and parallel operation of generators, starting of synchronous motor, characteristics; Types of losses and efficiency calculations of electric machines.

4. Electric Circuits

Network graph, KCL, KVL, Node and Mesh analysis, Transient response of dc and ac networks, Sinusoidal steady-state analysis, Resonance, Passive filters, Ideal current and voltage sources, Thevenin’s theorem, Norton’s theorem, Superposition theorem, Maximum power transfer theorem, Two-port networks, Three phase circuits, Power and power factor in ac circuits.

5. Signals and Systems

Continuous-time signals: Fourier series and Fourier transform representations, sampling theorem and applications; Discrete-time signals: discrete-time Fourier transform
DTFT), DFT, FFT, Z-transform, interpolation of discrete-time signals; LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay, digital filter design techniques.

6. **Electromagnetic Fields**

Coulomb's Law, Electric Field Intensity, Electric Flux Density, Gauss's Law, Divergence, Electric field and potential due to point, line, plane and spherical charge distributions, Effect of dielectric medium, Capacitance of simple configurations, Biot-Savart’s law, Ampere’s law, Curl, Faraday’s law, Lorentz force, Inductance, Magnetomotive force, Reluctance, Magnetic circuits, Self and Mutual inductance of simple configurations.

7. **Communication Systems**

Review of signals and spectra, band-limited signals, analysis of signals, distortion in transmission; linear CW modulation, methods of generation, bandwidth efficiency, synchronous and asynchronous detection, frequency division multiplexing; exponential modulation, narrowband PM and FM, transmission bandwidth, generation and detection, de-emphasis and pre-emphasis filtering; pulse modulation, sampling theorem, aliasing, PAM, PWM, PPM, time division multiplexing; pulse code modulation, delta modulation, DPCM; review of random processes and power spectral density, signal space; Noise analysis; Digital communications basic, line codes and their spectra, pulse shaping, inter-symbol interference, Nyquist criterion for distortionless transmission, equalization

8. **Control Systems**

Mathematical modelling and representation of systems, Feedback principle, transfer function, Block diagrams and Signal flow graphs, Transient and Steady-state analysis of linear time invariant systems, Routh-Hurwitz and Nyquist criteria, Bode plots, Root loci, Stability analysis, Lag, Lead and Lead-Lag compensators; P, PI and PID controllers; State space model, State transition matrix.

9. **Power Electronics**

Characteristics of semiconductor power devices: Diode, Thyristor, Triac, GTO, MOSFET, IGBT; DC to DC conversion: Buck, Boost and Buck-Boost converters; Single and three phase configuration of uncontrolled rectifiers, Line commutated thyristor based converters, Bidirectional ac to dc voltage source converters, Issues of line current harmonics, Power factor, Distortion factor of ac to dc converters, Single phase and three phase inverters, Sinusoidal pulse width modulation.

10. **Power Systems**

Power generation concepts, ac and dc transmission concepts, Models and performance of transmission lines and cables, Series and shunt compensation, Electric field distribution and insulators Distribution systems Per-unit quantities Bus admittance matrix Gauss-Seidel and Newton-Raphson load flow methods, Voltage and Frequency control, Power factor correction, Symmetrical components, Symmetrical and unsymmetrical fault analysis, Principles of over-current differential and distance protection; circuit breakers System stability concepts, Equal area criterion.
Classification of Metal Removal Processes and Machine tools: Introduction to Manufacturing and Machining, Basic working principle, configuration, specification and classification of machine tools. Turning, milling, drilling, boring, abrasive processes, super-finishing processes etc.

Mechanics of Machining (Metal Cutting) and Machinability: Geometry of single point cutting tools, Conversion of tool angles from one system to another, Mechanism of chip formation, Orthogonal and oblique cutting, Use of chip breaker in machining, Machining forces and Merchant’s Circle Diagram (MCD), Analytical and Experimental determination of cutting forces, Dynamometers for measuring cutting forces, Cutting temperature – causes, effects, assessment and control, Control of cutting temperature and cutting fluid application, Concept of Machinability and its Improvement, Failure of cutting tools and tool life, Cutting Tool Materials of common use Advanced Cutting Tool Materials.

Casting: Introduction, Solidification- Solidification of pure metals and alloys; nucleation and growth in alloys; solidification of actual castings; progressive and directional solidification; centerline feeding resistance; rate of solidification; Chvorinov's Rule, Risering- Riser design, Gating- Gating systems and their characteristics; the effects of gates on aspiration; turbulence and dross trap, Patterns, Inspection and Quality Control.


Welding: Introduction: Principle of welding, general applications such as construction of bridges, towers, automobiles & electronic circuits, etc. Classification of welding processes, Soldering and brazing. Welded Joints: Introduction to AWS standards. Manual metal arc (MMA) or shielded metal arc (SMA) welding, Submerged arc welding (SAW). Gas metal arc welding (GMAW) or

**Introduction to Plastics & their Processing:** Introduction to plastics, Injection moulding, Extrusion, Blow moulding, calendaring, etc.

**Jigs and Fixtures:** Purposes of jigs and fixtures and their Design principles, Design and Application of typical jigs and fixtures.

**Introduction to Materials science and characterization**

Importance, properties and classification of materials, structure of materials, equilibrium diagrams, strengthening mechanisms heat treatments of steels, powder metallurgy.

**Stresses and Strains**

Stresses, Strains, Modulus of elasticity (E), Modulus of rigidity (G), Bulk Modulus (K), Yield Stresses, Ultimate Stress, Factor of safety, shear stress, Poisson’s ratio. Relationship between E, G and K, bars of varying sections, deformation due to self-weight, composite sections, temperature stress.

General equation for transformation of stress, principal planes and principal stresses, maximum shear stress, stress determination using Mohr’s circle, Principal stresses in shafts subjected to combined torsion, bending & axial thrust, and concept of equivalent torsional and bending moment.

**Shear Force and Bending Moment in Beams**

Axial force, shear force and bending moment diagrams for statically determinate beams including beams with internal hinges for different types of loading. Relationship between rate of loading, shear force and bending moment.

**Theory of Simple Bending and Shear stresses**

Flexure formula for straight beam, moment of inertia, transfer theorem, polar moment of inertia, simple problems involving application of flexure formula, section modulus, moment of resistance, flitched beams.

Beam Deflection – Assumptions and Derivations, Double Integration and Macaulay’s method Moment Area Method and Conjugate Beam Method, Energy methods for deflection
Distribution of shear stress across plane sections commonly used for structural purposes, shear connectors.

**Theory of Simple Torsion**
Torsion in circular shafts-solid & hallow, stresses in shaft when transmitting power, closed coil helical spring under axial load

**Columns and Walls**
Struts subjected to axial loading, concept of buckling, Euler’s formula for struts with different support conditions, limitation, Euler’s and Rankine’s design formulae. Application to member’s subjected to eccentric loads, core of section, problems on chimneys, retaining walls etc. involving lateral loads.

**Thin Cylindrical and Spherical Shells**
Derivation for circumferential and longitudinal stresses for cylindrical and spherical shells under internal pressure and examples

Thermodynamic equilibrium and quasi-static processes, Measurement of temperature and calibration of thermometers, the ideal gas temperature scale, Measurement of pressure, Bourdon pressure gage and manometers, gage and absolute pressure.

Energy Transfer: Work Transfer (definition and calculation), Different modes of work, Displacement Work for various process, Heat Transfer; Modes of heat transfer, Basic laws in conduction, convection and radiation, combined modes of heat transfer

**Review of First law**: First law applied to a system undergoing a cyclic process and a change of state, concept of energy. Application of First Law to control volumes; Nozzle, Diffuser, Compressor, Turbine, Throttling device, Heat Exchanger (only steady flow need be considered).

General Thermodynamic property relations: The Maxwell relations, The TdS relations, Difference in heat capacities; Ratio of heat capacities, The Joule-Thomson coefficient

**Review of Second law**: Ideal processes, Carnot Cycle, Corollaries of second law, Carnot’s theorem, Absolute thermodynamic temperature scale, Clausius inequality; Entropy: Definition, Principles of increase of entropy, calculation entropy for various processes; Available Energy and
Availability: Helmholtz and Gibbs functions, Availability in steady flow, Entropy equation for flow processes, irreversibility.

**Air Standard Cycles:** Carnot, Stirling, Ericsson, Otto, Diesel, and Dual cycles. Brayton cycle: intercooling, reheating and regeneration.

Vapour Cycles: Carnot cycle; Simple Rankine cycle, Techniques for efficiency improvement, Reheat and Regenerative cycles with open & closed feed water heater.

**Vapour Power and Steam Turbines:** *Steam Generator:* Mounting and Accessories, Circulation, fuels and combustions. Steam Nozzles: Types of nozzles, critical pressure ratio and condition for maximum discharge, nozzle efficiency. *Steam Turbine:* Principle and types of steam turbines, compounding of steam turbines, velocity diagram and analysis of steam turbine, condition for maximum efficiency, degree of reaction, reheat factor, governing of steam turbine – throttle, nozzle and bypass governing. Losses in steam turbine, cogeneration. Back pressure, pass out and mixed pressure turbine.

**Internal Combustion Engine and Gas Turbines:** Fuels, Fuel air cycle, actual cycle, SI and CI engines, Combustion in SI and CI engines, Carburetors, Fuel injection, MPFI, performance analysis of the IC engine, Lubrication and cooling system, Hybrid engine

*Gas Turbine:* Principle and Classification, optimum pressure ratio for maximum thermal efficiency, work ratio, air rate, effect of operating variables on the thermal efficiency and work ratio, and air rate, analysis of gas turbine.

**Gas Compressors**

Compressor: Classification; single and multistage; effect of intercooling in reciprocating compressors; volumetric efficiency and power requirement. Centrifugal compressor: classification, energy transfer equations, elementary theory, vector diagram efficiencies; elementary analysis of axial compressors. Roots blower, performance analysis.

**Introduction to linear programming:** Different types of models, formulation of linear programming problems (LPPs), product-mix problems, deterministic models, graphical solution

**Linear Programming (Simplex Method):** Various steps in solving or problems using simplex
Properties of Fluids:

Introduction, Fluid properties and classification; concept of viscosity, compressibility and Elasticity, Surface tension and capillarity. Newton’s law of viscosity, dynamic viscosity, classification of fluids, kinematic viscosity, variation of viscosity with temperature, Surface tension and capillarity.

Fluid Statics:

Pascal law, Hydrostatic law, Relative equilibrium, Pressure measurements- atmospheric pressure, Absolute pressure, Gauge pressure, and Vacuum pressure, Piezometer, Mano-Meters, Forces on immersed bodies: Drag and Lift.

Fluid Kinematics:

Fluid flow methods of analysis of fluid motion, Streamlines, Path lines, Streak lines and Stream tubes. Types of fluid flow-Steady and unsteady flow, Uniform and non-uniform flow, Laminar and turbulent flow, Reynolds number, Reynolds experiment, Rotational and Irrotational flow, Subcritical, critical and Supercritical flow, Compressible and Incompressible flow, One, Two and three dimensional flow, Circulation and vorticity, Stream function and Flownet.

Fluid Dynamics:

Equation of Motion: Euler’s equation, Bernoulli’s equation, Energy correction factor, Coefficients of contraction, velocity and discharge, Differential head meters, Free vortex motion, Analysis of free liquid Jet, Cavitation. Linear momentum equation, Force on pipe junctions and bends, Forces on moving plates and vanes due to fluid flow, Angular momentum, Forced vortex.

Flow Measuring Devices:


Pipe Hydraulics:

Review of the basic equations: continuity, momentum, and energy. Flow through closed conduits: Laminar flow, Turbulent flow.

method. (a) Maximization problems, (b) Minimization problems, minimisation problems (all constraints of the type >), BIG ‘M’ method. Minimising case – constraints of mixed types (< and >), Maximisation case-constraints of mixed type.

**Duality and Sensitivity:** Duality and its concept, dual linear programming, application of elementary sensitivity analysis.

**Transportation problem:** Balanced Transportation Problem, Unbalanced Transportation Problem, Method of Solution, Degeneracy and the Transportation Problem, Testing the Solution for Optimality, Solution of Unbalanced Transportation Problem, Maximization and the Transportation Techniques.

**Assignment Model:** Assignment Table, Method of Solving Assignment Problems.


**PERT/CPM:** Using a Network to Visually Display a Project, Scheduling a Project with PERT/CPM, Dealing with Uncertain Activity Durations, An Evaluation of PERT/CPM.

**Queuing Theory:** Queuing systems and concepts, classification of queuing situations; Kendall’s notation, solution of queuing problems, single channel, single stage, finite and infinite queues with Poisson arrival and exponential service time, applications to industrial problems.

**Forecasting:** Judgmental Forecasting, Time Series, Forecasting Errors

**Inventory Model:** Components, Deterministic, Continuous-Review, Models, Deterministic, Periodic-Review Model