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: Crystalstructures; Bragg'slaw 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

Mathematical Concepts: Probability and Statistics, Discrete Mathematics, Proposition and Predicate calculus, Digital Systems Design, Linear Algebra

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

Computer Networks: OSI and TCP / IP Protocol Stacks and Layered Architecture; MAC, Network, Transport and Application Layer Protocols

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

Operating Systems: Process Management and Inter Process Communication, Transaction Management and Concurrency Control, Memory Management and File System Design

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

1. Measuring value of Economic Activity (National Income Accounting).

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

4. Agriculture and Rural Development Strategies.

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.

English

1. The Age of Chaucer
2. The Elizabeth an 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, minima l 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.

Numerical Analysis: Numerical solution of algebraic and transcendental equations: bisection, secant method, Newton-Raphson method, fixed point iteration, interpolation: error of polynomial interpolation, Lagrange, Newton interpolations, numerical differentiation, numerical integration: Trapezoidal and Simpson rules, numerical solution of systems of linear equations: direct methods (Gaussian elimination, LU decomposition), iterative methods (Jacobi and Gauss-Seidel), numerical solution of ordinary differential equations: initial value problems: Euler's method, Runge-Kutta methods.

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 di_usion 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

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Cayley- Hamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Special functio ns (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. 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 trapezoid and Simpson's rule, Solution of first order differential equation using Runge -Kutta method. Finite difference methods. Tensors. Introductory group theory: SU(2), 0(3).

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

3. 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. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Dynamics of charged particles in static and uniform electromagnetic fields. Dispersion relations in plasma. Lorentz invariance of Maxwell's equation. Transmission lines and wave guides. Radiation- from moving charges and dipoles and retarded potentials.

4. Quantum Mechanics

Wave-particle duality. Schrodinger 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. 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.

5. 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. 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.

6. Electronics and Experimental Methods

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero- junction 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). AID and DIA converters. Microprocessor and microcontroller basics.

Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting, Linear and nonlinear curve fitting, chi-square test. Transducers (temperature, pressureIvacuum, 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, lock-in detector, box-car integrator, modulation techniques. High frequency devices (including generators and detectors).

7. Atomic & Molecular 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 spectrum lines, LS
& JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer 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.

8. 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. Quasi crystals.

9. 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 nucleon- nucleon 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.

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.

DEPARTMENT OF CIVIL ENGINEERING
Institute of Infrastructure Technology Research and Management (IITRAM)
Maninagar (East), Ahmedabad – 380026 (Gujarat)

Syllabus for Written Test for PhD Civil Engineering (2020-21 Admissions)

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

Candidate shall attempt <u>any ONE SECTION</u> of choice.

<u>Section A</u>

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.

<u>Section B</u>

2. **Water Resources Engineering**
   Fluid Mechanics, Hydrology: Precipitation, Stream flow measurements, Hydrographs, Flood and Flood Routing, Open Channel Hydraulics : Introduction, Uniform Flow, Energy-Depth Relationships, Gradually Varied Flow-Theory & Computations, Rapidly Varied Flow-Hydraulic Jump, Unsteady Flows.

<u>Section C</u>

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

<u>Section D</u>

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.

<u>Section E</u>

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

Elements in an Electrical circuit: R, L, C, Voltage and current sources (independent and dependent/controlled sources with examples). DC circuits, KCL, KVL, Network theorems, Mesh and nodal analysis. Step response in RL, RC, RLC circuits. Basics of semiconductor physics, P-N junction, diode characteristics, diode circuits – clippers and clampers. Characteristics of BJTs. Common Emitter, Common collector configurations of BJTS, biasing of BJTs and its small signal modeling. Basics of operational amplifiers.

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.

Mechanical Engineering

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.

Metal Forming and Sheet Metal Working: Elastic and plastic deformation. Concept of strain hardening. Hot and cold working processes -rolling, forging, extrusion, swaging, wire and tube drawing. Machines and equipment for the processes. Analysis of stress and strains, Yield criteria, Parameters and force calculations. Test methods for formability. Specific roll pressure, Rolling load, Rolling torque, Blanking, Punching, piercing, bending, drawing etc. Analysis of drawing of circular wires, Forces in blanking, Stresses and strains in bending.

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

MIG/MAG welding, TIG welding, Resistance welding. Current–voltage characteristic of arc, Effects of change in arc current for change in arc length, Heat flow characteristics.

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:

Measurement of discharge-Venturimeter, Orifice meter, mouth pieces, Nozzle meter, Rotometer, Weirs, Flow under sluice gates. Time of empting tanks with or without inflow. Measurement of velocity-Pitot tube.

Hydraulic Machines: Turbines: classification of tribunes, Impulse and Reaction turbines, characteristic curves, draft tubes, Pumps: classification of pumps, centrifugal pump, efficiency and power, Output of centrifugal pumps, characteristics curves.

Pipe Hydraulics:

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

Pipe Flow Problems: Losses in pipe flow, pipes in series, pipes in parallel, branching pipes, siphons, multi-reservoir problems, pipe networks, unsteady flow in pipes, water hammer analysis.

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.

Network optimization: Network Optimization Models,Example, The Terminology of Networks, The Shortest-Path Problem, The Minimum Spanning Tree Problem , The Maximum Flow Problem.

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