Institute of Infrastructure, Technology, Research And Management

Syllabus for Written Test

PhD Admission Spring Semester (2021-22)

Part-I

Research Methodology (Common for all disciplines)

- Meaning and Characteristics of research
- Concepts and Methods of research
- Steps of research
- Purpose and scope of inter-disciplinary research
- Selection of research problems
- Literature review
- Application of ICT in Research
- Research ethics
- Types and Functions of Hypothesis
- Sampling, Scaling and Data collection techniques and methods
- Quantitative and Qualitative data analysis
- Reference styles and Citation
- Thesis and manuscript writing

Institute of Infrastructure, Technology, Research And Management

Syllabus for Written Test

PhD Admission Spring Semester (2021-22)

Part-II
Department of Basic Sciences: 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

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Syllabus for Written Test

PhD Admission Spring Semester (2021-22)

Part-II
Department of Basic Sciences: Mathematics

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

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

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

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

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

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

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

Numerical Analysis: Numerical solutions of algebraic and transcendental equations: Bisection, Picard, Newton-Raphson method, Secant, False Position Methods; Rate of convergence. Solution of systems of linear algebraic equations using Gauss elimination, Gauss-Seidel and Jacobi methods. Finite differences, Lagrange, Hermite and spline interpolation. Numerical differentiation and integration. Numerical solutions of ODEs using Picard, Euler, modified Euler and RungeKutta methods.

Calculus of Variations: Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations. Linear Integral Equations: Linear integral equation of the first and second kind of Fredholm and Volterra type, Solutions with separable kernels. Characteristic numbers and eigenfunctions, resolvent kernel.

Some Basic Statistics and Operations Research: Sample space, discrete probability, independent events, Bayes theorem. Random variables and distribution functions (univariate and multivariate); expectation and moments. Independent random variables, marginal and conditional distributions. Linear programming problem, simplex methods, duality. Elementary queuing and inventory models.

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Syllabus for Written Test

PhD Admission Spring Semester (2021-22)

Part-II
Department of Basic Sciences: 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. Timeindependent perturbation theory and applications. Variational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, spinstatistics connection. Spin-orbit coupling, fine structure. WKB approximation. Elementary theory of scattering: phase shifts, partial waves, Born approximation. Relativistic quantum mechanics: KleinGordon 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. Optoelectronic 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, semiempirical 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.

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PhD Admission Spring Semester (2021-22)

Part-II

Department of Civil Engineering

Specialisation – Water Resources Engineering

FLUID MECHANICS

- Properties of Fluids, Pressure and its measurement, Hydrostatic forces on surfaces, Buoyancy and floatation, Analysis of fluid flow by control volume approach and differential approach, Kinematics of flow and ideal (potential) flow, Dynamics of fluid flow, Orifices and mouthpieces, Notches and weirs, Turbulent flow, Flow through pipes, Dimensional and model analysis, Boundary layer flow.

HYDROLOGY

- **Introduction:** Definition; Hydrologic cycle; Water Budget Equation; Appli- cations in engineering.
- **Precipitation:** Types of precipitation; Measurement of precipitation; Rain- gauge network and number of raingauges; Estimation of missing data; Data consistency; Mean rainfall and method of determination; Frequency of point rainfall.
- **Stream flow measurements:** Measurement of stage and velocity; Stream flow measurement methods, Stage-discharge relationship, Extrapolation of rating curve.
- **Hydrographs:** Definition, type and components of Hydrographs; Factors affecting Hydrographs; Methods of base-flow separation; Effective rainfall; Unit hydrograph and its derivations for different durations; S-curve.
- **Flood and Flood Routing:** Floods – Introduction; rational method and time of concentration; Runoff coefficient and its calculation; Flood frequency analysis – Gumbel's method and log Pearson type-III method; Design flood and risk analysis. Flood routing-basic equation of routing; Hydrologic and Hydraulic methods of flood routing.

HYDRAULIC STRUCTURES

- **Reservoirs and planning for dam reservoirs:** Types of Reservoirs, Capacity-Elevation and Area- Elevation curves, Storage zones of Reservoir, Designing capacity of reservoir, Reservoir Sedimentation, Losses and Clear- ance.
- **Design and construction of Gravity Dams:** Forces acting on Gravity dam, Modes of failure and Structural stability of Gravity dams, Stability analysis of gravity dams, Construction of gravity dams.
- **Spillways, Energy dissipator and Spillway gates:** Location of spillway, Design consideration for the main spillway, Straight drop spillway, Ogee spill- way, Trough spillway, side channel spillway, shaft spillway, Syphon spillway, Energy dissipation below various types of spillways, Hydraulic jump, its use as energy disspator and design of stilling basins.

- **River training works:** Introduction and various types of structures adopted for river training works.

IRRIGATION ENGINEERING

- **Introduction:** Definition, Necessity of irrigation, Types of irrigations, Techniques of water distribution in the farms.
- **Irrigation Demand:** Crop water requirement, Duty, Delta, Irrigation Efficiencies, Optimal water use, Consumptive use and its estimation, Consumptive Irrigation Requirement, Net Irrigation Requirement, Soil-Moisture-Irrigation Relationship.
- **Canal Irrigation System:** Important definitions of canal irrigation system, Alluvial and Non-alluvial Canals, Alignment of canals, Distribution system for Irrigation canals, Design capacity of Irrigation Canal, Losses of water in canals, Canal regulation.
- **Sediment transport in Irrigation Channels:** Importance, Forms of bed formation, Mechanics of Sediment Transport, Shield's Entrainment motion, Estimation of Suspended and Bed Loads,
- **Design of Irrigation Channels:** Stability of channel slopes, Design of stable channels, Design procedure for irrigation canals, Maintenance of irrigation canals.
- **Lining of Irrigation Channels:** Advantages and Economics of Lining, Design of Lined Canals, Different Types of Linings, Construction Methods and Usefulness of Lining of Irrigation Canals.

WATER SUPPLY ENGINEERING

- **Estimation of water demand:** Various types of demands, Per-capita demand and factors affecting it. Variation in demands, Design periods, Population forecasting methods.
- **Transporting water through conduits:** Various types of conduits, Hydraulics of Flow, Flow in pipe system, Factors acting on pressure conduits, Types of pipes and pipe appurtenances.
- **Distribution system for water supply:** Layout of distribution networks, Methods of water distributions, Pressure in the distribution system, System of Supply, Distribution reservoirs, Wastage of water in distribution networks, Design and analysis of distribution networks, Appurtenances in the distribution system.

OPEN CHANNEL FLOW

- **Introduction**: Free surface flow overview, Classifications of flows, Types of channels, Pressure and velocity distributions. One dimensional method of flow analysis, continuity, energy and momentum equations.
- **Specific Energy-Depth Relationships**: Specific Energy, Critical depth and its calculation for various channels, Section factor and first hydraulic exponent, Computations of specific energy, Transitions-obstruction and choking.
- **Uniform Flow:** Resistance formulae for free surface flows, Velocity and shear stress distribution, Manning's roughness coefficient, Equivalent roughness, Computation of uniform flow, Standard lined channel, Hydraulically efficient channel sections, Compound channels.

- **Gradually Varied Flow-Theory and Computations:** Differential equation of GVF, Classifications of flow profiles and features of flow profiles, Control sections, Analysis of GVF profiles. Computation of GVF by direct-step and standard-step method.
- **Rapidly Varied Flow-Hydraulic Jump:** Introduction, Momentum equation for hydraulic jump in rectangular channel, Classification of jumps, characteristics of the jump, hydraulic jumps in non-rectangular channels, Use of the Jump as energy dissipator.
- **Unsteady Flows:** Governing equations for gradually varied unsteady flows, Numerical methods to compute unsteady flows, Channel routing by Muskingum Method, Surge in channel: Positive and Negative, Dam break flow problem.
- **Supercritical flow transitions:** Introduction, Response to disturbances, gradually changing boundary, Corner flow, Wave interactions and reflections, Supercritical contractions and expansions.
- **Mobile bed hydraulics:** Introduction, Initiation of sediment particle movement, Formation of bed-forms, Sediment load: Bed, Suspended, Wash and Total load, Design of stable channel (clear water flow), Scouring.

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PhD Admission Spring Semester (2021-22)

Part-II

Department of Electrical and Computer Science Engineering

(Computer Science Engineering)

Data Structures: Linear data structures: arrays, stack, queue, linked lists; non-linear data structures: binary search tree, balanced binary search tree, heap tree, graphs; representation of data structures in computer memory; applications and complexity of operations on / using data structures

Design and Analysis of Algorithms: Asymptotic notations, sorting and search- insertion sort, selection sort, merge sort, quicksort, binary search, design techniques: divide and conquer, greedy, dynamic programming, data structures: heaps, union of disjoint sets, search trees, algorithms on graphs: exploration, connectivity, shortest paths, directed acyclic graphs, spanning trees, Intractability: NP completeness, reductions

Computer networks: TCP/IP protocol stack and design of Internet, application layer: HTTP, FTP, DNS, P2P file sharing, transport layer: Issues related to process-to process communication and reliable data transfer, TCP and UDP operations; network layer: routing, addressing, QoS issues, IPv4 and IPv6 protocols; data link layer: wired and wireless local area networks and protocols

Digital Logic Design: Boolean algebra, logic gates, design of combinational logic circuits - adder, subtractor, multiplier, comparator; sequential logic circuits - flip-flops, registers, counters

Operating Systems: Interprocess communication, deadlock, memory management, file system design, device/IO management.

Basic Mathematics: linear algebra: vector and matrix properties and operations, solving systems of linear equations; probability and statistics, random variables, random processes.

Basic Programming Concepts: Iterative programming (for and while loop constructs), conditional executions, functions, pointers, recursions, fIle handling, procedural and object oriented programming concepts.

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PhD Admission Spring Semester (2021-22)

Part-II

Department of Electrical and Computer Science Engineering

(Electrical Engineering)

ENGINEERING MATHEMATICS:

Linear Algebra: Vector space, basis, linear dependence and independence, matrix algebra, eigenvalues and eigenvectors, rank, solution of linear equations- existence and uniqueness.

Calculus: Mean value theorems, theorems of integral calculus, evaluation of definite and improper integrals, partial derivatives, maxima and minima, multiple integrals, line, surface and volume integrals, Taylor series.

Differential Equations: First order equations (linear and nonlinear), higher order linear differential equations, Cauchy's and Euler's equations, methods of solution using variation of parameters, complementary function and particular integral, partial differential equations, variable separable method, initial and boundary value problems.

Vector Analysis: Vectors in plane and space, vector operations, gradient, divergence and curl, Gauss's, Green's and Stokes' theorems.

Complex Analysis: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, sequences, series, convergence tests, Taylor and Laurent series, residue theorem.

Probability and Statistics: Mean, median, mode, standard deviation, combinatorial probability, probability distributions, binomial distribution, Poisson distribution, exponential distribution, normal distribution, joint and conditional probability

NETWORKS, SIGNALS AND SYSTEMS:

Circuit analysis: Node and mesh analysis, superposition, Thevenin's theorem, Norton's theorem, reciprocity. Sinusoidal steady state analysis: phasors, complex power, maximum power transfer. Time and frequency domain analysis of linear circuits: RL, RC and RLC circuits, solution of network equations using Laplace transform.

Linear 2-port network parameters, wye-delta transformation.

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

ELECTRONIC DEVICES:

Energy bands in intrinsic and extrinsic semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors.

Carrier transport: diffusion current, drift current, mobility and resistivity, generation and recombination of carriers, Poisson and continuity equations.

P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell

ANALOG 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

DIGITAL CIRCUITS:

Number representations: binary, integer and floating-point- numbers. Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders.

Sequential circuits: latches and flip-flops, counters, shift-registers, finite state machines, propagation delay, setup and hold time, critical path delay.

Data converters: sample and hold circuits, ADCs and DACs.

Semiconductor memories: ROM, SRAM, DRAM.

Computer organization: Machine instructions and addressing modes, ALU, data-path and control unit, instruction pipelining

CONTROL SYSTEMS:

Basic control system components; Feedback principle; Transfer function; Block diagram representation; Signal flow graph; Transient and steady-state analysis of LTI systems; Frequency response; Routh-Hurwitz and Nyquist stability criteria; Bode and root-locus plots; Lag, lead and lag lead compensation; State variable model and solution of state equation of LTI systems.

COMMUNICATIONS:

Random processes: autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems.

Analog communications: amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, super heterodyne 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.

ELECTROMAGNETICS:

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.

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PhD Admission Spring Semester (2021-22)

Part-II

Department of Humanities and Social Sciences (HSS)

Economics

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 5. International Economics 7. Balance of Payments 8. Global Institutions

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

D) 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

E) Research Methodology, Basic Statistics, Econometrics, Logical Reasoning and Data Interpretation: 1. Primary and Secondary Research. 2. Techniques of data collection Qualitative and Quantitative. 3. Presentation and analysis 4.Econometric and Statistical tools for social research

F) Current Affairs related to Infrastructure development in India.

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PhD Admission Spring Semester (2021-22)

Part-II

Department of Humanities and Social Sciences (HSS)

English

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

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Part-II

Department of Humanities and Social Sciences (HSS)

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, and sampling. Techniques of data collection-Observation, Questionnaire, and Interview- analysis and interpretations of data, Statistical tools for social research.

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PhD Admission Spring Semester (2021-22)

Part-II

Department of Mechanical and Aero-Space Engineering

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 teat 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.
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.

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 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, PeriodicReview Model