

Annexure-1

Chemical Engineering Department

Ph.D. Syllabus (Technical Portion)

Heat Transfer

Equation of energy, steady and unsteady heat conduction, convection and radiation, thermal boundary layer, boiling and condensation, single and multiple effect evaporators and their process calculations, types of heat exchangers, design of double pipe, shell and tube heat exchangers,

Mass Transfer

Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption, membrane separations.

Fluid Mechanics

Fluid statics, surface tension, Newtonian and non-Newtonian fluids, transport properties, shell- balances including differential form of Bernoulli equation and energy balance, equation of continuity, equation of motion, equation of mechanical energy, Macroscopic friction factors, dimensional analysis, flow through pipeline systems, velocity profiles, flow meters, pumps and compressors, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile and pressure drop.

Chemical process Calculations

Steady and unsteady state mass and energy balances including multiphase, multi-component, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis.

Mechanical Operations

Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, agitation and mixing; conveying of solids.

Chemical Reaction Engineering

Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, non-ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis; rate and performance equations for catalyst deactivation

Instrumentation and Process Control

Measurement of process variables; sensors and transducers; P&ID equipment symbols; process modeling and linearization, transfer functions and dynamic responses of various systems, systems with inverse response, process reaction curve, controller modes (P, PI, and PID); control valves; transducer dynamics; analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control.

Chemical Engineering Thermodynamics

First and Second laws of thermodynamics. Applications of first law to close and open systems. Thermodynamic properties of pure substances: Equation of State and residual properties. Second law and Entropy., properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria.

Chemical Technology

Inorganic chemical industries (sulfuric acid, phosphoric acid, chlor-alkali industry), fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining and petrochemicals; polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibres).

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Admixtures: Types of admixtures - mineral and chemical admixtures - properties – dosages- effects - usage. Workability - Factors affecting workability, Measurement of workability by different tests, Setting times of concrete, Effect of time and temperature on workability, Segregation & bleeding, Mixing and vibration of concrete, Steps in manufacture of concrete, Quality of mixing water. Hardened concrete: Water Cement ratio , Abram's Law, Nature of strength of concrete, Maturity concept, Strength in tension & compression, Factors affecting strength, Relation between compression & tensile strength, Curing.

Design of Concrete Structure

Introduction to limit state method: Limit state of collapse and limit state of serviceability. Application of Limit state method to rectangular beams for flexure, shear, bond and torsion. Design of singly reinforced beam. Design of doubly reinforced beams. Design of T-and L-beams. Design of one way and two way slabs, Design of staircases. Design of short and long columns with axial and eccentric loading, Design of isolated column footings.

Steel Design

Limit state design method, limit states of strength and serviceability, probabilistic basis for design Riveted, bolted and pinned connections. Welded connections-assumptions, types, design of fillet welds, intermittent fillet weld, plug and slot weld, failure of welded joints, welded joints vs bolted and riveted joints. Tension members, types, net cross-sectional area, types of failure, slenderness ratio, design of tension members, gusset plate. Compression members, effective length, slenderness ratio, types of cross-section, classification of cross-section, design of axially loaded compression members, lacing, battening, design of column bases, and foundation bolts.

Highway Engineering

Geometric design- Design controls, highway cross section elements, cross slope or camber, road width, road margins, typical cross sections of roads, design speed, sight distance, design of horizontal and vertical alignments, horizontal and vertical curves.

Highway Materials:- Properties of sub-grade, sub-base , base course and surface course materials, test on sub-grade soil, aggregates and bituminous materials. Traffic Engineering:- definition , fundamentals of traffic flow, traffic management, prevention of road accidents , elements of transport planning , highway drainage.

Design of Highway Pavements: Flexible pavements and their design, review of old methods, CBR method, IRC:37-2012, equivalent single wheel load factor, rigid pavements, stress in rigid pavement, IRC design method (IRC:58-2011).

Highway Construction: Construction of various layers, earthwork, WBM, GSB, WMM, various types of bituminous layers, joints in rigid pavements, Hot Mix Plants, Construction of Rigid Pavements Highway Maintenance: Various type of failures of flexible and rigid pavements.

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Organization of traffic engineering department and its importance under Indian conditions. Road user characteristics, Human factors governing road user behaviour, Vehicle characteristics, Slow moving traffic characteristics in Indian conditions. Speed, Journey time and delay surveys, vehicle volume counts, classification, Traffic Volume and Origin-Destination survey, statistical methods for traffic engineering, Traffic flow parameters, Speed, density and volume relationships. Parking types, ill effects of parking, off street parking facilities, Traffic regulations, Traffic management measures. High capacity analysis, Capacity of freeways and express ways in rural areas. Design of rotary intersection and capacity of rotary intersection.

Systems approach to transport planning, Stages in transport planning, Trip generation and distribution, Traffic assignment and modal split, Economic evaluation of transportation plans.

Traffic Controls: Traffic Signs- Principles, types and design considerations, Traffic Markings, Traffic Signals - types, optimal cycle length and signal settings.

Fluid Mechanics & WRE

Engineering units of measurement, mass, density, Specific weight, specific volume, specific gravity, surface tension, capillarity, viscosity, Bulk modulus of elasticity, pressure and vapour pressure. Pressure at a point, pressure variation in static fluid, Absolute and gauge pressure, manometers, Forces on plane and curved surfaces (Problems on Gravity Dams and Tainter Gates), Introduction to basic lines - Streamlines, Streaklines, Pathlines. Various types of fluid flow. Velocity potential function, Stream function, Vorticity and Circulation, Flow net. Basic equations of fluid flow like Energy equation, continuity equation and momentum equation. Bernoulli's equation and its Applications. Introduction to laminar & turbulent flow, Reynolds Experiment & Reynolds number. Velocity distribution, Laminar and turbulent boundary Layers and laminar sub layer, boundary layer concept, aging of pipes. Losses due to sudden Expansion and contraction, losses in pipe fittings and valves, concepts of equivalent length, Hydraulic and energy gradient lines.

Precipitation, forms of precipitation, its Measurement and Analysis, Rain gauges, Non-Recording type, Average rainfall over a catchment, depth-area-duration relationships, maximum intensity/depth-duration-frequency relationship, Probable Maximum Precipitation (PMP). Hydrograph: factors affecting runoff hydrograph, components of hydrograph, base flow separation, effective rainfall, unit hydrograph: derivation, limitations, different duration, Synthetic unit hydrograph, IUH. Flood: flood estimation, frequency analysis, Reservoir routing and Channel routing.

Geotechnical Engineering: Mechanical analysis of soil, grain size distribution curve, particle shape, weight volume relationships, specific gravity, unit weight, void ratio, moisture content, and relationships, relative density. Consistency of soil: Atterberg limits - liquid limit, plastic limit, shrinkage limit. Liquidity index and consistency index, activity, soil structure. Engineering classification of soil: IS, USCS, HRB and ASTM. Modes of occurrence of water in soil. Stress conditions in soil- total, effective and neutral stresses and relationships. Permeability - Bernoulli's equation, Darcy's Law, hydraulic conductivity, laboratory

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determination of hydraulic conductivity, equivalent hydraulic conductivity in stratified soil. Seepage- Laplace equation of continuity, flow nets, seepage calculation from a flow net, flow nets in anisotropic soils, seepage through earth dam, critical hydraulic gradient and quick sand condition.

Soil Compaction: mechanism and principles, Standard and Modified Proctor Test, factors affecting compaction, effect of compaction on soil properties, field compaction techniques.

Shear Strength: Mohr-Coulomb failure criterion, shear strength parameters and determination: direct and tri-axial shear test, unconfined compression test, vane shear test. Other methods of determining the un-drained shear strength of soil, sensitivity and thixotropy of clay.

Stabilization of soil: Introduction, mechanical stabilization, cement stabilization, lime stabilization, bituminous stabilization, chemical stabilization, thermal stabilization, electrical stabilization, Introduction to modern methods of stabilization.

Consolidation of soils: Consolidation and compaction, primary and secondary consolidation, Terzaghi's theory of one dimensional consolidation, consolidation test, determination of coefficient of consolidation, determination of consolidation settlement.

Lateral Earth Pressure and Retaining Structures: Concept of earth pressure, Earth pressure at rest, active and passive earth pressure for both cohesionless and cohesive soils,

Earth pressure theories: Rankine's theory, Coulomb's Wedge theory, Graphical methods: Rebhanan's and Culmann's graphical solutions, Stability conditions for retaining walls.

Environmental Engineering:

Types of demand and their contribution - rate of consumption. Characteristics of water: Physical, chemical and biological characteristics of water and their significance, Water quality criteria IS and WHO standards.

Sources of water supply: Infiltration gallery, open wells, tube wells, Intake structures and transportation of water. quantitative and qualitative studies. Hydraulic design of pressure pipe- Materials - laying- joining- testing - pipe appurtenances- Pumps and pumping stations.

Engineered systems for water treatment: Screening, Aeration, sedimentation, softening, coagulation, filtration, ion exchange, and disinfection. advanced water treatment.

Distribution systems: General description of water distribution system. Analysis of distribution networks Operation and maintenance of water supply to buildings - Rural water supply.

Air Pollution: Sources, classification, characteristics, effects, dispersion patterns and behaviour of air pollutants. Emission quantification, limiting concentrations and standards.

Noise Pollution: Structure and measurement of noise. Sources, effects and control of noise pollution, limiting concentrations and standards.

Wastewater Engineering: Physical, chemical and biological characteristics of sewage. Generation and collection of wastewater, sanitary, storm and combined sewerage systems, Quantities of sanitary wastes and storm water. Design of sewerage system. Treatment of sewage: Primary- screening, grit chamber, skimming tanks, sedimentation, Secondary-

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classification of secondary treatments, activated sludge process, trickling filter, Tertiary-Removal of nitrogen and phosphorus, Miscellaneous treatments- oxidation ponds, aerated lagoons. Sludge digestion and handling. Septic tank, Imhoff tank. Disposal of effluent and sludge in land and water bodies, Wastewater disposal standards. Self purification of rivers- Streeter Phelps equation - oxygen sag curve. Sewer Appurtenances: Manholes, Drop manholes, Lampholes, street inlets, catch basins, flushing tanks, storm water regulators, grease and oil-traps, inverted siphons. Population equivalent - drainage in buildings-plumbing systems for drainage.

Surveying:

Theodolite survey-Classification, Essential parts of a transit theodolite, adjustment of theodolites, Measurement of horizontal, vertical angle, deflection angle, Sources of error.

Theodolite traversing: Introduction, Principle, Methods of traversing, Stages in traversing, traverse computations, Problems in theodolite surveying. Levelling: Principles of levelling, Use of dumpy level and levelling staff, Temporary and Permanent adjustment of dumpy level, Reduction of levels by height of instrument & rise and fall method, differential, reciprocal levelling, profile levelling and cross-sectioning, Curvature and refraction error, sensitiveness of level tube, levelling difficulties and common errors.

Contouring: Characteristics, Methods and uses. Computation of Area-Determination of area, computation of areas from plans, calculation of areas by using mid ordinate rule, trapezoidal rule and Simpson's rule.

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3. Computer Science & Engineering (CM)

No-19 IT/CSE&A/262
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Indira Gandhi Institute of Technology, Sarang
Department of Computer Science Engineering & Applications
PhD Entrance Test Syllabus

Digital logic Design:

Boolean algebra. Combinational and sequential circuits. Minimization. Number representations and computer arithmetic (fixed and floating point).

Computer Organization and Architecture:

Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining, pipeline hazards. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

C programming Language, Data structures & Algorithms:

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

Automata Theory & Compiler Design:

Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and context-free languages, pumping lemma. Turing machines and undecidability. Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation. Local optimisation, Data flow analyses: constant propagation, liveness analysis, common subexpression elimination.

Operating System & Database Management:

System calls, processes, threads, inter-process communication, concurrency and synchronization. Deadlock. CPU and I/O scheduling. Memory management and virtual memory. File systems. ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control.

Computer Networks:

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

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4. Electronics & Telecommunication Engineering(ET)

PhD Syllabus for written exam

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.

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,

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.

Power amplifiers: class A, class B, class AB, Push pull amplifier, Class C amplifier

Digital Circuits

Logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders, Design of Combinational Circuit

Sequential circuits: Design of sequential circuit, 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

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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, Superheterodyne receivers.

Information theory: entropy, mutual information and channel capacity theorem.

Digital communications: PCM, DPCM, digital modulation schemes (ASK, PSK, FSK, QAM), bandwidth, inter-symbol interference, MAP, ML detection, matched filter receiver, SNR and BER.

Fundamentals of error correction, Hamming codes, CRC.

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.

Basics of C Programming

Control loop, Data types, Arrays, Pointers

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5. Mechanical Engineering (ME)

Department of Mechanical Engineering Indira Gandhi Institute of Technology, Sarang

Syllabus for Entrance Test for admission in PhD Mechanical Engineering

Section 1: Applied Mechanics and Design

Engineering Mechanics: Free-body diagrams and equilibrium; friction and its applications including rolling friction, belt-pulley, brakes, clutches, screw jack, wedge, vehicles, etc.; trusses and frames; virtual work; kinematics and dynamics of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations; Lagrange's equation.

Mechanics of Materials: Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for planestress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; concept of shear centre; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.

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

Vibrations: Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.

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

Section 2: Fluid Mechanics & Thermal Science

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

Heat-Transfer: Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan-Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis

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

Applications: *Power Engineering*: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. *I.C. Engines*: Air-standard Otto, Diesel and dual cycles. *Refrigeration and air-conditioning*: Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes. *Turbomachinery*: Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines; steam and gas turbines.

Section 3: Materials, Manufacturing and Industrial Engineering

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

Casting, Forming and Joining Processes: Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

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

Section 4: Materials, Manufacturing and Industrial Engineering

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

Casting, Forming and Joining Processes: Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

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

Metrology and Inspection: Limits, fits and tolerances; linear and angular measurements; comparators; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly; concepts of coordinate-measuring machine (CMM).

Computer Integrated Manufacturing: Basic concepts of CAD/CAM and their integration tools; additive manufacturing.

Production Planning and Control: Forecasting models, aggregate production planning, scheduling, materials requirement planning; lean manufacturing.

Inventory Control: Deterministic models; safety stock inventory control systems.

Operations Research: Linear programming, simplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM.



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6. Metallurgical & Materials Engineering (MT)

Metallurgical Thermodynamics

Laws of thermodynamics: First law – energy conservation, Second law – entropy; Enthalpy, Gibbs and Helmholtz free energy; Maxwell's relations; Chemical potential; Applications to metallurgical systems, solutions, ideal and regular solutions; Gibbs phase rule, phase equilibria, binary phase diagram and lever rule, free-energy vs. composition diagrams; Equilibrium constant, Activity, Ellingham and phase stability diagrams; Thermodynamics of point defects, surfaces and interfaces, adsorption and segregation phenomena.

Electrochemistry: Single electrode potential, Electrochemical cells, Nernst equation, Potential pH diagrams.

Transport Phenomena and Rate Processes

Momentum transfer: Concept of viscosity, shell balances, Bernoulli's equation, mechanical energy balance equation, flow past plane surfaces and through pipes.

Heat transfer: Conduction, Fourier's Law, 1-D steady state conduction.

Convection: Heat transfer coefficient relations for forced convection.

Radiation: Black body radiation, Stefan-Boltzman Law, Kirchhoff's Law.

Mass transfer: Diffusion and Fick's laws, Mass transfer coefficients.

Dimensional analysis: Buckingham Pi theorem, Significance of dimensionless numbers.

Basic laws of chemical kinetics: First order reactions, reaction rate constant, Arrhenius relation, heterogeneous reactions, oxidation kinetics.

Electrochemical kinetics: Polarization.

Mineral Processing and Extractive Metallurgy

Comminution techniques, Size classification, Flotation, Gravity and other methods of mineral beneficiation; Agglomeration: sintering, pelletizing and briquetting.

Material and Energy balances in metallurgical processes; Principles and processes for the extraction of non-ferrous metals – aluminum, copper and titanium.

Iron and steel making: Material and heat balance in blast furnace; Structure and properties of slags and molten salts – basicity of slags – sulphide and phosphate capacity of slags; Production of metallurgical coke. Other methods of iron making (COREX, MIDRE)

Primary steel making: Basic oxygen furnace, process dynamics, oxidation reactions, electric arc furnace.

Secondary steel making: Ladle process – deoxidation, argon stirring, desulphurization, inclusion shape control, principles of degassing methods; Basics of stainless steel manufacturing.

Continuous Casting: Fluid flow in the tundish and mould, heat transfer in the mould, segregation, inclusion control.

Physical Metallurgy

Chemical Bonding: Ionic, covalent, metallic, and secondary bonding in materials, Crystal structure of solids – metals and alloys, ionic and covalent solids, and polymers.

X-ray Diffraction – Bragg's law, optical metallography, principles of SEM and TEM imaging.

Crystal Imperfections: Point, line and surface defects; Coherent, semi-coherent and incoherent interfaces.

Diffusion in solids: Diffusion equation, steady state and error function solutions; Examples homogenization and carburization; Kirkendall effect; Uphill diffusion; Atomic models for interstitial and substitutional diffusion; Pipe diffusion and grain boundary diffusion.

Phase transformation: Driving force, Homogeneous and heterogeneous nucleation, growth Kinetics
Solidification in isomorphous, eutectic and peritectic systems, cast structures and macrosegregation, dendritic solidification and constitutional supercooling, coring and microsegregation.

Solid state transformations: Precipitation, spinoidal decomposition, ordering, massive transformation, discontinuous precipitation, eutectoid transformation, diffusionless transformations; Precipitate coarsening, Gibbs-Thomson effect.

Principles of heat treatment of steels, TTT and CCT diagrams; Surface hardening treatments; Recovery, recrystallization and grain growth; Heat treatment of cast iron and aluminium alloys.

Electronic, dielectric, magnetic and optical properties of materials, Basic forms of corrosion and its prevention

Mechanical Metallurgy

Strain tensor and stress tensor, Representation by Mohr's circle, elasticity, stiffness and compliance tensor, Yield criteria, Plastic deformation by slip and twinning.

Dislocation theory: Edge, screw and mixed dislocations, source and multiplication of dislocations, stress fields around dislocations; Partial dislocations, dislocation interactions and reactions.

Strengthening mechanisms: Work/strain hardening, strengthening due to grain boundaries, solid solution, precipitation and dispersion.

Fracture behaviour, Griffith theory, linear elastic fracture mechanics, fracture toughness, fractography, ductile to brittle transition.

Fatigue: Cyclic stress strain behaviour – low and high cycle fatigue, crack growth
Mechanisms of high temperature deformation and failure; creep and stress rupture, stress exponent and activation energy.

Manufacturing Processes

Metal casting: Pattern and Mould design involving feeding, gating and risering, casting practices, casting defects.

Hot, warm and cold working of metals: Metal forming – fundamentals principles of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming.

Metal joining: Principles of welding, soldering, and brazing welding metallurgy, defects in welded joints in steels and aluminum alloys.

Powder metallurgy: production and characterisation of powders, compaction and sintering.

Non-destructive Testing (NDT): Principles of dye-penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle inspection methods.

B: Science

1. Computer Science (CS)

No - 19 IT/CSEA/262
Dt. 04/04/2022

**Indira Gandhi Institute of Technology, Sarang
Department of Computer Science Engineering & Applications
PhD Entrance Test Syllabus**

Digital logic Design:

Boolean algebra. Combinational and sequential circuits. Minimization. Number representations and computer arithmetic (fixed and floating point).

Computer Organization and Architecture:

Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining, pipeline hazards. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

C programming Language, Data structures & Algorithms:

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

Automata Theory & Compiler Design:

Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and context-free languages, pumping lemma. Turing machines and undecidability. Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation. Local optimisation, Data flow analyses: constant propagation, liveness analysis, common subexpression elimination.

Operating System & Database Management:

System calls, processes, threads, inter-process communication, concurrency and synchronization. Deadlock. CPU and I/O scheduling. Memory management and virtual memory. File systems. ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control.

Computer Networks:

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

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Research Methodology

Research Methodology

The syllabus for Written Test on the subject 'Research Methodology' is as follows. Meaning of research problem, Sources of research problem, Criteria characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem. data collection. analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis, Plagiarism, Research ethics. Effective technical writing. how to write report, Paper. Developing a Research Proposal Format of research proposal. a presentation and assessment by a review committee.

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