

Section 1: General Biology

Biochemistry: Biomolecules - structure and function; Biological membranes - structure, membrane channels and pumps, molecular motors, action potential and transport processes; Basic concepts and regulation of metabolism of carbohydrates, lipids, amino acids and nucleic acids; Photosynthesis, respiration and electron transport chain. Enzymes - Classification, catalytic and regulatory strategies; Enzyme kinetics - Michaelis-Menten equation; Enzyme inhibition - competitive, non-competitive and uncompetitive inhibition.

Microbiology: Bacterial classification and diversity; Microbial Ecology - microbes in marine, fresh water and terrestrial ecosystems; Microbial interactions; Viruses - structure and classification; Methods in microbiology; Microbial growth and nutrition; Nitrogen fixation; Microbial diseases and host-pathogen interactions; Antibiotics and antimicrobial resistance.

Immunology: Innate and adaptive immunity, humoral and cell mediated immunity; Antibody structure and function; Molecular basis of antibody diversity; T cell and B cell development; Antigen-antibody reaction; Complement; Primary and secondary lymphoid organs; Major histocompatibility complex (MHC); Antigen processing and presentation; Polyclonal and monoclonal antibody; Regulation of immune response; Immune tolerance; Hypersensitivity; Autoimmunity; Graft versus host reaction; Immunization and vaccines.

Section 2: Genetics, Cellular and Molecular Biology

Genetics and Evolutionary Biology: Mendelian inheritance; Gene interaction; Complementation; Linkage, recombination and chromosome mapping; Extra chromosomal inheritance; Microbial genetics - transformation, transduction and conjugation; Horizontal gene transfer and transposable elements; Chromosomal variation; Genetic disorders; Population genetics; Epigenetics; Selection and inheritance; Adaptive and neutral evolution; Genetic drift; Species and speciation.

Cell Biology: Prokaryotic and eukaryotic cell structure; Cell cycle and cell growth control; Cell-cell communication; Cell signalling and signal transduction; Post-translational modifications; Protein trafficking; Cell death and autophagy; Extra-cellular matrix.

Molecular Biology: Molecular structure of genes and chromosomes; Mutations and mutagenesis; Regulation of gene expression; Nucleic acid - replication, transcription, splicing, translation and their regulatory mechanisms; Non-coding and micro RNA; RNA interference; DNA damage and repair.

Section 3: Fundamentals of Biological Engineering

Engineering Principles Applied to Biological Systems: Material and energy balances for reactive and non-reactive systems; Recycle, bypass and purge processes; Stoichiometry of growth and product formation; Degree of reduction, electron balance and theoretical oxygen demand.

Classical Thermodynamics and Bioenergetics: Laws of thermodynamics; Solution thermodynamics; Phase equilibria, reaction equilibria; Ligand binding; Membrane potential; Energetics of metabolic pathways, oxidation and reduction reactions.

Transport Processes: Newtonian and non-Newtonian fluids, fluid flow - laminar and turbulent; Mixing in bioreactors, mixing time; Molecular diffusion and film theory; Oxygen transfer and uptake in bioreactor, k_La and its measurement; Conductive and convective heat transfer, LMTD, overall heat transfer coefficient; Heat exchangers.

Section 4: Bioprocess Engineering and Process Biotechnology

Bioreaction Engineering: Rate law, zero and first order kinetics; Ideal reactors - batch, mixed flow and plug flow; Enzyme immobilization, diffusion effects - Thiele modulus, effectiveness factor, Damkohler number; Kinetics of cell growth, substrate utilization and product formation; Structured and unstructured models; Batch, fed-batch and continuous processes; Microbial and enzyme reactors; Optimization and scale up.

Upstream and Downstream Processing: Media formulation and optimization; Sterilization of air and media; Filtration - membrane filtration, ultra filtration; Centrifugation - high speed and ultra; Cell disruption; Principles of chromatography - ion exchange, gel filtration, hydrophobic interaction, affinity, GC, HPLC and FPLC; Extraction, adsorption and drying.

Instrumentation and Process Control: Pressure, temperature and flow measurement devices; Valves; First order and second order systems; Feedback and feed forward control; Types of controllers - proportional, derivative and integral control, tuning of controllers.

Section 5: Plant, Animal and Microbial Biotechnology

Plants: Totipotency; Regeneration of plants; Plant growth regulators and elicitors; Tissue culture and cell suspension culture system - methodology, kinetics of growth and nutrient optimization; Production of secondary metabolites; Hairy root culture; Plant products of industrial importance; Artificial seeds; Somaclonal variation; Protoplast, protoplast fusion - somatic hybrid and cybrid; Transgenic plants - direct and indirect methods of gene transfer techniques; Selection marker and reporter gene; Plastid transformation.

Animals: Culture media composition and growth conditions; Animal cell and tissue preservation; Anchorage and non-anchorage dependent cell culture; Kinetics of cell growth; Micro C macro-carrier culture; Hybridoma technology; Stem cell technology; Animal cloning; Transgenic animals; Knock-out and knock-in animals.

Microbes: Production of biomass and primary/secondary metabolites - Biofuels, bioplastics, industrial enzymes, antibiotics; Large scale production and purification of recombinant proteins and metabolites; Clinical-, food- and industrial- microbiology; Screening strategies for new products.

Section 6: Recombinant DNA technology and Other Tools in Biotechnology

Recombinant DNA technology: Restriction and modification enzymes; Vectors - plasmids, bacteriophage and other viral vectors, cosmids, Ti plasmid, bacterial and yeast artificial chromosomes; Expression vectors; cDNA and genomic DNA library; Gene isolation and cloning, strategies for production of recombinant proteins; Transposons and gene targeting.

Molecular tools: Polymerase chain reaction; DNA/RNA labelling and sequencing; Southern and northern blotting; In-situ hybridization; DNA fingerprinting, RAPD, RFLP; Site-directed mutagenesis; Gene transfer technologies; CRISPR-Cas; Biosensing and biosensors.

Analytical tools: Principles of microscopy - light, electron, fluorescent and confocal; Principles of spectroscopy - UV, visible, CD, IR, fluorescence, FT-IR, MS, NMR; Electrophoresis; Micro-arrays; Enzymatic assays; Immunoassays - ELISA, RIA, immunohistochemistry; immunoblotting; Flow cytometry; Whole genome and ChIP sequencing.

Computational tools: Bioinformatics resources and search tools; Sequence and structure databases; Sequence analysis - sequence file formats, scoring matrices, alignment, phylogeny; Genomics, proteomics, metabolomics; Gene prediction; Functional annotation; Secondary structure and 3D structure prediction; Knowledge discovery in biochemical databases; Metagenomics; Metabolic engineering and systems biology.

CH	Chemical Engineering
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Section 1: Process Calculations and Thermodynamics

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.

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

Section 2: Fluid Mechanics and Mechanical Operations

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 and similitude, 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.

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.

Section 3: Heat Transfer

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

Section 4: 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 C NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption, membrane separations (micro-filtration, ultra-filtration, nano-filtration and reverse osmosis).

Section 5: Chemical Reaction Engineering

Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, kinetics of enzyme reactions (Michaelis-Menten and Monod models), 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.

Section 6: 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.

Section 7: Plant Design and Economics

Principles of process economics and cost estimation including depreciation and total annualized cost, cost indices, rate of return, payback period, discounted cash flow, optimization in process design and sizing of chemical engineering equipments such as heat exchangers and multistage contactors.

Section 8: 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 fibers).

CE	Civil Engineering
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Section 1: Structural Engineering

Engineering Mechanics: System of forces, free-body diagrams, equilibrium equations; Internal forces in structures; Frictions and its applications; Centre of mass; Free Vibrations of undamped SDOF system.

Solid Mechanics: Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Simple bending theory, flexural and shear stresses, shear centre; Uniform torsion, Transformation of stress; buckling of column, combined and direct bending stresses.

Structural Analysis: Statically determinate and indeterminate structures by force/ energy methods; Method of superposition; Analysis of trusses, arches, beams, cables and frames; Displacement methods: Slope deflection and moment distribution methods; Influence lines; Stiffness and flexibility methods of structural analysis.

Construction Materials and Management: Construction Materials: Structural Steel - Composition, material properties and behaviour; Concrete - Constituents, mix design, short-term and long-term properties. Construction Management: Types of construction projects; Project planning and network analysis - PERT and CPM; Cost estimation.

Concrete Structures: Working stress and Limit state design concepts; Design of beams, slabs, columns; Bond and development length; Prestressed concrete beams.

Steel Structures: Working stress and Limit state design concepts; Design of tension and compression members, beams and beam- columns, column bases; Connections - simple and eccentric, beam-column connections, plate girders and trusses; Concept of plastic analysis - beams and frames.

Section 2: Geotechnical Engineering

Soil Mechanics: Three-phase system and phase relationships, index properties; Unified and Indian standard soil classification system; Permeability - one dimensional flow, Seepage through soils - two - dimensional flow, flow nets, uplift pressure, piping, capillarity, seepage force; Principle of effective stress and quicksand condition; Compaction of soils; One-dimensional consolidation, time rate of consolidation; Shear Strength, Mohr's circle, effective and total shear strength parameters, Stress-Strain characteristics of clays and sand; Stress paths.

Foundation Engineering: Sub-surface investigations - Drilling bore holes, sampling, plate load test, standard penetration and cone penetration tests; Earth pressure theories - Rankine and Coulomb; Stability of slopes - Finite and infinite slopes, Bishop's method; Stress distribution in soils - Boussinesq's theory; Pressure bulbs, Shallow foundations - Terzaghi's and Meyerhoff's bearing capacity theories, effect of water table; Combined footing and raft foundation; Contact pressure; Settlement analysis in sands and clays; Deep foundations - dynamic and static formulae, Axial load capacity of piles in sands and clays, pile load test, pile under lateral loading, pile group efficiency, negative skin friction.

Section 3: Water Resources Engineering

Fluid Mechanics: Properties of fluids, fluid statics; Continuity, momentum and energy equations and their applications; Potential flow, Laminar and turbulent flow; Flow in pipes, pipe networks; Concept of boundary layer and its growth; Concept of lift and drag.

Hydraulics: Forces on immersed bodies; Flow measurement in channels and pipes; Dimensional analysis and hydraulic similitude; Channel Hydraulics - Energy-depth relationships, specific energy, critical flow, hydraulic jump, uniform flow, gradually varied flow and water surface profiles.

Hydrology: Hydrologic cycle, precipitation, evaporation, evapo-transpiration, watershed, infiltration, unit hydrographs, hydrograph analysis, reservoir capacity, flood estimation and routing, surface run-off models, ground water hydrology - steady state well hydraulics and aquifers; Application of Darcy's Law.

Irrigation: Types of irrigation systems and methods; Crop water requirements - Duty, delta, evapo-transpiration; Gravity Dams and Spillways; Lined and unlined canals, Design of weirs on permeable foundation; cross drainage structures.

Section 4: Environmental Engineering

Water and Waste Water Quality and Treatment: Basics of water quality standards - Physical, chemical and biological parameters; Water quality index; Unit processes and operations; Water requirement; Water distribution system; Drinking water treatment.

Sewerage system design, quantity of domestic wastewater, primary and secondary treatment. Effluent discharge standards; Sludge disposal; Reuse of treated sewage for different applications.

Air Pollution: Types of pollutants, their sources and impacts, air pollution control, air quality standards, Air quality Index and limits.

Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

Section 5: Transportation Engineering

Transportation Infrastructure: Geometric design of highways - cross-sectional elements, sight distances, horizontal and vertical alignments.

Geometric design of railway Track - Speed and Cant.

Concept of airport runway length, calculations and corrections; taxiway and exit taxiway design.

Highway Pavements: Highway materials - desirable properties and tests; Desirable properties of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible and rigid pavement using IRC codes.

Traffic Engineering: Traffic studies on flow and speed, peak hour factor, accident study, statistical analysis of traffic data; Microscopic and macroscopic parameters of traffic flow, fundamental relationships; Traffic signs; Signal design by Webster's method; Types of intersections; Highway capacity.

Section 6: Geomatics Engineering

Principles of surveying; Errors and their adjustment; Maps - scale, coordinate system; Distance and angle measurement - Levelling and trigonometric levelling; Traversing and triangulation survey; Total station; Horizontal and vertical curves.

Photogrammetry and Remote Sensing - Scale, flying height; Basics of remote sensing and GIS.

Section 1: Digital Logic

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

Section 2: 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).

Section 3: Programming and Data Structures

Programming in C. Recursion. Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs.

Section 4: Algorithms

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.

Section 5: Theory of Computation

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

Section 6: Compiler Design

Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation. Local optimisation, Data flow analyses: constant propagation, liveness analysis, common sub expression elimination.

Section 7: Operating System

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

Section 8: Databases

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.

Section 9: 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.

EE	Electrical Engineering
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Section 1: Electric circuits

Network Elements: Ideal voltage and current sources, dependent sources, R, L, C, M elements; Network solution methods: KCL, KVL, Node and Mesh analysis; Network Theorems: Thevenin's, Norton's, Superposition and Maximum Power Transfer theorem; Transient response of DC and AC networks, sinusoidal steady-state analysis, resonance, two port networks, balanced three phase circuits, star-delta transformation, complex power and power factor in AC circuits.

Section 2: 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.

Section 3: Signals and Systems

Representation of continuous and discrete time signals, shifting and scaling properties, linear time invariant and causal systems, Fourier series representation of continuous and discrete time periodic signals, sampling theorem, Applications of Fourier Transform for continuous and discrete time signals, Laplace Transform and Z transform. R.M.S. value, average value calculation for any general periodic waveform.

Section 4: Electrical Machines

Single phase transformer: equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three-phase transformers: connections, vector groups, parallel operation; Auto-transformer, Electromechanical energy conversion principles; DC machines: separately excited, series and shunt, motoring and generating mode of operation and their characteristics, speed control of dc motors; Three-phase induction machines: 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 and characteristics, regulation and parallel operation of generators, starting of synchronous motors; Types of losses and efficiency calculations of electric machines.

Section 5: Power Systems

Basic concepts of electrical power generation, AC and DC transmission concepts, Models and performance of transmission lines and cables, Economic Load Dispatch (with and without considering transmission losses), 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, directional and distance protection; Circuit breakers, System stability concepts, Equal area criterion.

Section 6: 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, Stability analysis using Routh-Hurwitz and Nyquist criteria, Bode plots, Root loci, Lag, Lead and Lead-Lag compensators; P, PI and PID controllers; State space model, Solution of state equations of LTI systems.

Section 7: Electrical and Electronic Measurements

Bridges and Potentiometers, Measurement of voltage, current, power, energy and power factor; Instrument transformers, Digital voltmeters and multi-meters, Phase, Time and Frequency measurement; Oscilloscopes, Error analysis.

Section 8: Analog and Digital Electronics

Simple diode circuits: clipping, clamping, rectifiers; Amplifiers: biasing, equivalent circuit and frequency response; oscillators and feedback amplifiers; operational amplifiers: characteristics and applications; single stage active filters, Active Filters: Sallen Key, Butterworth, VCOs and timers, combinatorial and sequential logic circuits, multiplexers, demultiplexers, Schmitt triggers, sample and hold circuits, A/D and D/A converters.

Section 9: Power Electronics

Static V-I characteristics and firing/gating circuits for Thyristor, MOSFET, IGBT; DC to DC conversion: Buck, Boost and Buck-Boost Converters; Single and three-phase configuration of uncontrolled rectifiers; Voltage and Current commutated Thyristor based converters; Bidirectional ac to dc voltage source converters; Magnitude and Phase of line current harmonics for uncontrolled and thyristor based converters; Power factor and Distortion Factor of AC to DC converters; Single-phase and three-phase voltage and current source inverters, sinusoidal pulse width modulation.

EC	Electronics and Communication Engineering
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Section 1: 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.

Section 2: 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.

Section 3: 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.

Section 4: 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.

Section 5: 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.

Section 6: Communications

Random Processes: Auto correlation 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.

Section 7: 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.

ME	Mechanical Engineering
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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 plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; concept of shear centre; deflection of beams; torsion of circular shafts; 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 and Thermal Sciences

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.

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.

MT	Metallurgical Engineering
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Section 1: 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.

Section 2: 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.

Section 3: 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 - aluminium, 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.

Section 4: 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 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, magnetic and optical properties of materials.

Basic forms of corrosion and its prevention.

Section 5: 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.

Section 6: Manufacturing Processes

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

Hot, Warm and Cold Working of Metals: Metal forming - fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming.

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

Powder Metallurgy: production of powders, compaction and sintering.

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

CY	Chemistry
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Section 1: Physical Chemistry

Structure: Postulates of quantum mechanics. Operators. Time dependent and time independent Schrödinger equations. Born interpretation. Dirac bra-ket notation. Particle in a box: infinite and finite square wells; concept of tunnelling; particle in 1D, 2D and 3D-box; applications. Harmonic oscillator: harmonic and anharmonic potentials; Hermite polynomials. Rotational motion: Angular momentum operators, Rigid rotor. Hydrogen and hydrogen-like atoms: atomic orbitals; radial distribution function. Multi-electron atoms: orbital approximation; electron spin; Pauli exclusion principle; Slater determinants. Approximation Methods: Variation method and secular determinants; first order perturbation techniques. Atomic units. Molecular structure and Chemical bonding: Born-Oppenheimer approximation; Valence bond theory and linear combination of atomic orbitals - molecular orbital (LCAO-MO) theory. Hybrid orbitals. Applications of LCAO-MO theory to H_2^+ , H_2 ; orbital theory (MOT) of homo- and heteronuclear diatomic molecules. Hückel approximation and its application to annular π - electron systems.

Group theory: Symmetry elements and operations; Point groups and character tables; Internal coordinates and vibrational modes; symmetry adapted linear combination of atomic orbitals (LCAO-MO); construction of hybrid orbitals using symmetry aspects.

Spectroscopy: Atomic spectroscopy; Russell-Saunders coupling; Term symbols and spectral details; origin of selection rules. Rotational, vibrational, electronic and Raman spectroscopy of diatomic and polyatomic molecules. Line broadening. Einstein's coefficients. Relationship of transition moment integral with molar extinction coefficient and oscillator strength. Basic principles of nuclear magnetic resonance: gyromagnetic ratio; chemical shift, nuclear coupling.

Equilibrium: Laws of thermodynamics. Standard states. Thermochemistry. Thermodynamic functions and their relationships: Gibbs-Helmholtz and Maxwell relations, Gibbs-Duhem equation, van't Hoff equation. Criteria of spontaneity and equilibrium. Absolute entropy. Partial molar quantities. Thermodynamics of mixing. Chemical potential. Fugacity, activity and activity coefficients. Ideal and Non-ideal solutions, Raoult's Law and Henry's Law, Chemical equilibria. Dependence of equilibrium constant on temperature and pressure. Ionic mobility and conductivity. Debye-Hückel limiting law. Debye-Hückel-Onsager equation. Standard electrode potentials and electrochemical cells. Nernst Equation and its application, relationship between Electrode potential and thermodynamic quantities, Potentiometric and conductometric titrations. Phase rule. Clausius-Clapeyron equation. Phase diagram of one component systems: CO_2 , H_2O , S; two component systems: liquid-vapour, liquid-liquid and solid-liquid systems. Fractional distillation. Azeotropes and eutectics. Statistical thermodynamics: micro canonical, canonical and grand canonical ensembles, Boltzmann distribution, partition functions and thermodynamic properties.

Kinetics: Elementary, parallel, opposing and consecutive reactions. Steady state approximation. Mechanisms of complex reactions. Unimolecular reactions. Potential energy surfaces and classical trajectories, Concept of Saddle points, Transition state theory: Eyring equation, thermodynamic aspects. Kinetics of polymerization. Catalysis concepts and enzyme catalysis. Kinetic isotope effects. Fast reaction kinetics: relaxation and flow methods. Diffusion controlled reactions. Kinetics of photochemical and photo physical processes.

Surfaces and Interfaces: Physisorption and chemisorption. Langmuir, Freundlich and Brunauer-Emmett-Teller (BET) isotherms. Surface catalysis: Langmuir-Hinshelwood mechanism. Surface tension, viscosity. Self-assembly. Physical chemistry of colloids, micelles and macromolecules.

Section 2: Inorganic Chemistry

Main Group Elements: Hydrides, halides, oxides, oxoacids, nitrides, sulfides - shapes and reactivity. Structure and bonding of boranes, carboranes, silicones, silicates, boron nitride, borazines and phosphazenes. Allotropes of carbon, phosphorous and sulphur. Industrial synthesis of compounds of main group elements. Chemistry of noble gases, pseudohalogens, and interhalogen compounds. Acid-base concepts and principles (Lewis, Brønsted, HSAB and acid-base catalysis).

Transition Elements: Coordination chemistry - structure and isomerism, theories of bonding (VBT, CFT, and MOT). Energy level diagrams in various crystal fields, CFSE, applications of CFT, Jahn-Teller distortion. Electronic spectra of transition metal complexes: spectroscopic term symbols, selection rules, Orgel and Tanabe-Sugano diagrams, nephelauxetic effect and Racah parameter, charge-transfer spectra. Magnetic properties of transition metal complexes. Ray-Dutt and Bailar twists, Reaction mechanisms: kinetic and thermodynamic stability, substitution and redox reactions. Metal-metal multiple bond.

Lanthanides and Actinides: Recovery. Periodic properties, spectra and magnetic properties.

Organometallics: 18-Electron rule; metal-alkyl, metal-carbonyl, metal-olefin and metal-carbene complexes and metallocenes. Fluxionality in organometallic complexes. Types of organometallic reactions. Homogeneous catalysis - Hydrogenation, hydroformylation, acetic acid synthesis, metathesis and olefin oxidation. Heterogeneous catalysis - Fischer-Tropsch reaction, Ziegler-Natta polymerization.

Radioactivity: Detection of radioactivity, Decay processes, half-life of radioactive elements, fission and fusion processes.

Bioinorganic Chemistry: Ion (Na^+ and K^+) transport, oxygen binding, transport and utilization, electron transfer reactions, nitrogen fixation, metalloenzymes containing magnesium, molybdenum, iron, cobalt, copper and zinc.

Solids: Crystal systems and lattices, Miller planes, crystal packing, crystal defects, Bragg's law, ionic crystals, structures of AX, AX₂, ABX₃ type compounds, spinels, band theory, metals and semiconductors.

Instrumental Methods of Analysis: UV-visible, fluorescence and FTIR spectrophotometry, NMR and ESR spectroscopy, mass spectrometry, atomic absorption spectroscopy, Mössbauer spectroscopy (Fe and Sn) and X-ray crystallography. Chromatography including GC and HPLC. Electroanalytical methods- polarography, cyclic voltammetry, ion-selective electrodes. Thermoanalytical methods.

Section 3: Organic Chemistry

Stereochemistry: Chirality and symmetry of organic molecules with or without chiral centres and determination of their absolute configurations. Relative stereochemistry in compounds having more than one stereogenic centre. Homotopic, enantiotopic and diastereotopic atoms, groups and faces. Stereoselective and stereospecific synthesis. Conformational analysis of acyclic and cyclic compounds. Geometrical isomerism and optical isomerism. Configurational and conformational effects, atropisomerism, and neighbouring group participation on reactivity and selectivity/specificity.

Reaction Mechanisms: Basic mechanistic concepts - kinetic versus thermodynamic control, Hammond's postulate and Curtin-Hammett principle. Methods of determining reaction mechanisms through kinetics, identification of products, intermediates and isotopic labelling. Linear free-energy relationship - Hammett and Taft equations. Nucleophilic and electrophilic substitution reactions (both aromatic and aliphatic). Addition reactions to carbon-carbon and carbon-heteroatom (N and O) multiple bonds. Elimination reactions. Reactive intermediates – carbocations, carbanions, carbenes, nitrenes, arynes and free radicals. Molecular rearrangements.

Organic Synthesis: Synthesis, reactions, mechanisms and selectivity involving the following classes of compounds - alkenes, alkynes, arenes, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, nitriles, halides, nitro compounds, amines and amides. Uses of Mg, Li, Cu, B, Zn, P, S, Sn and Si based reagents in organic synthesis. Carbon-carbon bond formation through coupling reactions - Heck, Suzuki, Stille, Sonogoshira, Negishi, Kumada, Hiyama, Tsuji-Trost, olefin metathesis and McMurry. Concepts of multistep synthesis - retrosynthetic analysis, strategic disconnections, synthons and synthetic equivalents. Atom economy and Green Chemistry, Umpolung reactivity - formyl and acyl anion equivalents. Selectivity in organic synthesis - chemo-, regio- and stereoselectivity. Protection and deprotection of functional groups. Concepts of asymmetric synthesis - resolution (including enzymatic), desymmetrization and use of chiral auxiliaries, organocatalysis. Carbon-carbon and carbon-heteroatom bond forming reactions through enolates (including boron enolates), enamines and silyl enol ethers. Stereoselective addition to C=O groups (Cram, Prelog and Felkin-Anh models).

Pericyclic Reactions and Photochemistry: Electrocyclic, cycloaddition and sigmatropic reactions. Orbital correlations - FMO and PMO treatments, Woodward-Hoffmann rule. Photochemistry of alkenes, arenes and carbonyl compounds. Photooxidation and photoreduction. Di- π -methane rearrangement, Barton-McCombie reaction, Norrish type-I and II cleavage reaction.

Heterocyclic Compounds: Structure, preparation, properties and reactions of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline.

Biomolecules: Structure, properties and reactions of mono- and di-saccharides, physicochemical properties of amino acids, chemical synthesis of peptides, chemical structure determination of peptides and proteins, structural features of proteins, nucleic acids, lipids, steroids, terpenoids, carotenoids, and alkaloids.

Experimental Techniques in Organic Chemistry: Optical rotation (polarimetry). Applications of various chromatographic techniques such as thin-layer, column, HPLC and GC. Applications of UV-visible, IR, NMR and Mass spectrometry in the structural determination of organic molecules.

PH	Physics
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Section 1: Mathematical Physics

Vector Calculus: Linear vector space: basis, orthogonality and completeness; matrices; similarity transformations, diagonalization, eigen values and eigen vectors; linear differential equations: second order linear differential equations and solutions involving special functions; complex analysis: Cauchy-Riemann conditions, Cauchy's theorem, singularities, residue theorem and applications; Laplace transform, Fourier analysis; elementary ideas about tensors: covariant and contravariant tensors.

Section 2: Classical Mechanics

Lagrangian Formulation: D'Alembert's principle, Euler-Lagrange equation, Hamilton's principle, calculus of variations; symmetry and conservation laws; central force motion: Kepler problem and Rutherford scattering; small oscillations: coupled oscillations and normal modes; rigid body dynamics: inertia tensor, orthogonal transformations, Euler angles, Torque free motion of a symmetric top; Hamiltonian and Hamilton's equations of motion; Liouville's theorem; canonical transformations: action-angle variables, Poisson brackets, Hamilton-Jacobi equation.

Special Theory of Relativity: Lorentz transformations, relativistic kinematics, mass-energy equivalence.

Section 3: Electromagnetic Theory

Solutions of electrostatic and magnetostatic problems including boundary value problems; method of images; separation of variables; dielectrics and conductors; magnetic materials; multipole expansion; Maxwell's equations; scalar and vector potentials; Coulomb and Lorentz gauges; electromagnetic waves in free space, non-conducting and conducting media; reflection and transmission at normal and oblique incidences; polarization of electromagnetic waves; Poynting vector, Poynting theorem, energy and momentum of electromagnetic waves; radiation from a moving charge.

Section 4: Quantum Mechanics

Postulates of quantum mechanics; uncertainty principle; Schrodinger equation; Dirac Bra-Ket notation, linear vectors and operators in Hilbert space; one dimensional potentials: step potential, finite rectangular well, tunneling from a potential barrier, particle in a box, harmonic oscillator; two and three dimensional systems: concept of degeneracy; hydrogen atom; angular momentum and spin; addition of angular momenta; variational method and WKB approximation, time independent perturbation theory; elementary scattering theory, Born approximation; symmetries in quantum mechanical systems.

Section 5: Thermodynamics and Statistical Physics

Laws of thermodynamics; macrostates and microstates; phase space; ensembles; partition function, free energy, calculation of thermodynamic quantities; classical and quantum statistics; degenerate Fermi gas; black body radiation and Planck's distribution law; Bose-Einstein condensation; first and second order phase transitions, phase equilibria, critical point.

Section 6: Atomic and Molecular Physics

Spectra of one- and many-electron atoms; spin-orbit interaction: LS and jj couplings; fine and hyperfine structures; Zeeman and Stark effects; electric dipole transitions and selection rules; rotational and vibrational spectra of diatomic molecules; electronic transitions in diatomic molecules, Franck-Condon principle; Raman effect; EPR, NMR, ESR, X-ray spectra; lasers: Einstein coefficients, population inversion, two and three level systems.

Section 7: Solid State Physics

Elements of crystallography; diffraction methods for structure determination; bonding in solids; lattice vibrations and thermal properties of solids; free electron theory; band theory of solids: nearly free electron and tight binding models; metals, semiconductors and insulators; conductivity, mobility and effective mass; Optical properties of solids; Kramer's-Kronig relation, intra- and inter-band transitions; dielectric properties of solid; dielectric function, polarizability, ferroelectricity; magnetic properties of solids; dia, para, ferro, antiferro and ferromagnetism, domains and magnetic anisotropy; superconductivity: Type-I and Type II superconductors, Meissner effect, London equation, BCS Theory, flux quantization.

Section 8: Electronics

Semiconductors in Equilibrium: Electron and hole statistics in intrinsic and extrinsic semiconductors; metal-semiconductor junctions; Ohmic and rectifying contacts; PN diodes, bipolar junction transistors, field effect transistors; negative and positive feedback circuits; oscillators, operational amplifiers, active filters; basics of digital logic circuits, combinational and sequential circuits, flip-flops, timers, counters, registers, A/D and D/A conversion.

Section G: Nuclear and Particle Physics

Nuclear radii and charge distributions, nuclear binding energy, electric and magnetic moments; semi-empirical mass formula; nuclear models; liquid drop model, nuclear shell model; nuclear force and two nucleon problem; alpha decay, beta-decay, electromagnetic transitions in nuclei; Rutherford scattering, nuclear reactions, conservation laws; fission and fusion; particle accelerators and detectors; elementary particles; photons, baryons, mesons and leptons; quark model; conservation laws, isospin symmetry, charge conjugation, parity and time-reversal invariance.

XH-C2 English

C2.1 Multi-genre literatures in English—poetry, the novel and other forms of fiction including the short story, drama, creative non-fiction, and non-fiction prose—with emphasis on the long 19th and 20th centuries.

C2.2 Especially in a comparative context, anglophone and in English translation, literatures from India and, extending to some degree, the larger Indian subcontinent.

C2.3 Literary criticism and theory; critical and cultural intellectual-traditions and approaches widely referred to and used in the discipline of English.

C2.4 History of English literature and English literary studies.

C2.5 Research approaches and methodologies, including interpretive techniques responsive to literary forms, devices, concepts, and genres.

Note:

(i) The five units above list aspects that the question paper will include rather than signal separate modules or sections. These five units listed are not necessarily exclusive to each other either. The question paper will also not be divided into sections corresponding to the above aspects; and

(ii) While the paper will test candidates for a reasonable breadth of disciplinary knowledge, it would prioritize conceptual depth and methodological sensitivity demonstrative of disciplinary training over information, wherever possible.

XH-C3	Linguistics
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C3.1 Language and Linguistics

Language spoken, written and signed; description and prescription; language and cultural heritage; language and social identity; language as an object of inquiry - its structure, units and components; design features; writing systems; biological foundations and language faculty; linguistic competence and performance; levels of grammar; contrast and complementation; rules - context dependent and context free; levels of adequacy for analysis; interdisciplinary approaches; schools of linguistic thought (European, American) and the Indian Grammatical Tradition.

C3.2 Levels of Grammar and Grammatical Analysis

A. Phonetics and Phonology: Vocal tract anatomy; phonation; articulatory parameters; classification of sounds; gestural theory of speech production; cardinal vowels; secondary and co-articulation; suprasegmentals - length, stress, tone, intonation and juncture; IPA; basic physics of sound and of phonation and articulation; acoustic cues for speech sounds; organisation of phones into phonemes; phoneme inventories and cross-linguistic properties; syllable structure and phonological properties; principles of phonological analysis - phonetic similarity, contrastive and complementary distribution, free variation, allophones; linear and non-linear approaches; levels of representation; phonological rules; distinctive features (major class, manner, place, etc.); feature geometry; rule ordering, markedness and unspecified featural values; core principles of lexical phonology, optimality theory, autosegmental phonology and prosodic morphology.

B. Morphology: Concepts of morpheme, morph, allomorph, zero allomorph, conditions on allomorphs; lexeme and word; types of morphemes - structural and functional; affixes vs clitics; grammatical categories; morphological theories - generative, lexicalist, process and distributed morphology; identification of morphemes and parts of speech; alternation; morphophonology; inflection vs. derivation; conjugation and declension; word creation and word formation rules and processes; creativity and productivity, blocking, bracketing paradoxes, constraints on affix ordering; mental lexicon; lexical categories; valency changing operations.

C. Syntax: Basic syntactic units and their types: word, phrase, clause, sentence and their description and generation; grammatical and case relations; key ideas from syntactic theories, Generative Grammars including Minimalist Program, HPSG, Relational Grammar and Lexical Functional Grammar; phrase structure rules (including X-bar theory); universal grammar and cross-linguistic properties; idea of grammaticality judgements; solving the language acquisition problem; diagnostics of structure; syntactic phenomena such as movement, binding, ellipses, case-checking, islands, argument structure etc.; unergatives and unaccusatives.

D. Semantics and Pragmatics: Types of meaning, lexical and compositional; syntax-semantics interface (semantic roles, binding, scope, LF etc.); sense and reference, connotation and denotation, lexical semantic relations (homonymy, hypo/hypernymy, antonymy, synonymy, ambiguity); prototype theory and componential analysis; sentence meaning and truth conditions, contradictions, entailment; basic set theory; propositions, truth values, sentential connectives; arguments, predicates, quantifiers, variables; in/definiteness, mood and modality; language use in context; sentence meaning and utterance meaning; speech acts; deixis; presupposition and implicature: Gricean maxims; information structure; politeness, power and solidarity; discourse analysis.

C3.3 Historical Linguistics

Neogrammarian laws of phonetic change such as Grimm's, Verner's, Grassmann's Laws; genesis and spread of sound change; split and merger; conditioned vs. unconditioned change; lexical diffusion of sound change; analogical changes and paradigm levelling; relative chronology of different changes; study of sound change in progress; morphosyntactic (syncretism, grammaticalisation and lexicalisation) and semantic change (extension, narrowing, figurative speech); linguistic reconstruction - external vs. internal: the comparative method; lexicostatistics; language contact and dialect geography - borrowing and impact of borrowing; pidgins and creoles; bi- and multilingualism as the source for borrowing; dialect geography - dialect atlas; isogloss, focal, transition and relic areas.

C3.4 Sociolinguistics

Micro-and macro approaches to language in society; linguistic repertoire language, dialect, sociolect, idiolect; diglossia; taboo, slang and euphemism; elaborated and restricted codes; speech community and communicative competence; ethnography of speaking; lingua franca; diasporic language; linguistic variables and their co-variation along linguistic/social dimensions; language policies and development (especially in India); language contact and outcomes (language loss, pidginization and creolization); code-mixing and code-switching; language movements - state and societal interventions; script development and modifications; linguistic minorities; language ecology and endangerment linguistic vitality, language endangerment (EGIDS scale), parameters of endangerment, documentation and revitalisation.

C3.5 Areal Typology, Universals, Cross-linguistic Features

Morphological types of languages agglutinative, analytical (isolating), synthetic fusional (inflecting), polysynthetic (incorporating) languages; formal and substantive universals, absolute and statistical universals; implicational and non-implicational universals (Greenberg); linguistic relatedness—genetic, typological and areal classification of languages; universals and parametric variation; word order typology; salient features of South Asian languages - Indo-Aryan, Dravidian, Austro-Asiatic, and Tibeto-Burman language families; Linguistic Survey of India; contact induced typological change.

C3.6 Methods of Analysis

Experimental and non-experimental methods; sampling and tools; identification of variables and their variants; data processing and interpretation; quantitative analysis of data; ethnomethodology; participant observation; field methods and elicitation; document creation; ethics.

C3.7 Applied Linguistics

Psycholinguistics – the study of how humans learn, represent, comprehend, and produce language. Topics include word recognition and storage, sentence production and comprehension, reading, speech perception, language acquisition, neural representation of language, bilingualism, and language disorders.

MA	Mathematics
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Calculus: Functions of two or more variables, continuity, directional derivatives, partial derivatives, total derivative, maxima and minima, saddle point, method of Lagrange's multipliers; Double and Triple integrals and their applications to area, volume and surface area; Vector Calculus: gradient, divergence and curl, Line integrals and Surface integrals, Green's theorem, Stokes' theorem, and Gauss divergence theorem.

Linear Algebra: Finite dimensional vector spaces over real or complex fields; Linear transformations and their matrix representations, rank and nullity; systems of linear equations, characteristic polynomial, eigen values and eigen vectors, diagonalization, minimal polynomial, Cayley-Hamilton Theorem, Finite dimensional inner product spaces, Gram-Schmidt orthonormalization process, symmetric, skew-symmetric, Hermitian, skew-Hermitian, normal, orthogonal and unitary matrices; diagonalization by a unitary matrix, Jordan canonical form; bilinear and quadratic forms.

Real Analysis: Metric spaces, connectedness, compactness, completeness; Sequences and series of functions, uniform convergence, Ascoli-Arzelà theorem; Weierstrass approximation theorem; contraction mapping principle, Power series; Differentiation of functions of several variables, Inverse and Implicit function theorems; Lebesgue measure on the real line, measurable functions; Lebesgue integral, Fatou's lemma, monotone convergence theorem, dominated convergence theorem.

Complex Analysis: Functions of a complex variable: continuity, differentiability, analytic functions, harmonic functions; Complex integration: Cauchy's integral theorem and formula; Liouville's theorem, maximum modulus principle, Morera's theorem; zeros and singularities; Power series, radius of convergence, Taylor's series and Laurent's series; Residue theorem and applications for evaluating real integrals; Rouché's theorem, Argument principle, Schwarz lemma; Conformal mappings, Möbius transformations.

Ordinary Differential Equations: First order ordinary differential equations, existence and uniqueness theorems for initial value problems, linear ordinary differential equations of higher order with constant coefficients; Second order linear ordinary differential equations with variable coefficients; Cauchy-Euler equation, method of Laplace transforms for solving ordinary differential equations, series solutions (power series, Frobenius method); Legendre and Bessel functions and their orthogonal properties; Systems of linear first order ordinary differential equations, Sturm's oscillation and separation theorems, Sturm-Liouville eigenvalue problems, Planar autonomous systems of ordinary differential equations: Stability of stationary points for linear systems with constant coefficients, Linearized stability, Lyapunov functions.

Algebra: Groups, subgroups, normal subgroups, quotient groups, homomorphisms, automorphisms; cyclic groups, permutation groups, Group action, Sylow's theorems and their applications; Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domains, Principal ideal domains, Euclidean domains, polynomial rings, Eisenstein's

irreducibility criterion; Fields, finite fields, field extensions, algebraic extensions, algebraically closed fields

Functional Analysis: Normed linear spaces, Banach spaces, Hahn-Banach theorem, open mapping and closed graph theorems, principle of uniform boundedness; Inner-product spaces, Hilbert spaces, orthonormal bases, projection theorem, Riesz representation theorem, spectral theorem for compact self-adjoint operators.

Numerical Analysis: Systems of linear equations: Direct methods (Gaussian elimination, LU decomposition, Cholesky factorization), Iterative methods (Gauss-Seidel and Jacobi) and their convergence for diagonally dominant coefficient matrices; Numerical solutions of nonlinear equations: bisection method, secant method, Newton-Raphson method, fixed point iteration; Interpolation: Lagrange and Newton forms of interpolating polynomial, Error in polynomial interpolation of a function; Numerical differentiation and error, Numerical integration: Trapezoidal and Simpson rules, Newton-Cotes integration formulas, composite rules, mathematical errors involved in numerical integration formulae; Numerical solution of initial value problems for ordinary differential equations: Methods of Euler, Runge-Kutta method of order 2.

Partial Differential Equations: Method of characteristics for first order linear and quasilinear partial differential equations; Second order partial differential equations in two independent variables: classification and canonical forms, method of separation of variables for Laplace equation in Cartesian and polar coordinates, heat and wave equations in one space variable; Wave equation: Cauchy problem and d'Alembert formula, domains of dependence and influence, non-homogeneous wave equation; Heat equation: Cauchy problem; Laplace and Fourier transform methods.

Topology: Basic concepts of topology, bases, subbases, subspace topology, order topology, product topology, quotient topology, metric topology, connectedness, compactness, countability and separation axioms, Urysohn's Lemma.

Linear Programming: Linear programming models, convex sets, extreme points; Basic feasible solution, graphical method, simplex method, two phase methods, revised simplex method; Infeasible and unbounded linear programming models, alternate optima; Duality theory, weak duality and strong duality; Balanced and unbalanced transportation problems, Initial basic feasible solution of balanced transportation problems (least cost method, north-west corner rule, Vogel's approximation method); Optimal solution, modified distribution method; Solving assignment problems, Hungarian method.



UNIVERSITY GRANTS COMMISSION NET BUREAU

NET SYLLABUS

Subject : Management

Code No. : 17

Unit – I

Management – Concept, Process, Theories and Approaches, Management Roles and Skills

Functions – Planning, Organizing, Staffing, Coordinating and Controlling.

Communication – Types, Process and Barriers.

Decision Making – Concept, Process, Techniques and Tools

Organisation Structure and Design – Types, Authority, Responsibility, Centralisation, Decentralisation and Span of Control

Managerial Economics – Concept & Importance

Demand analysis – Utility Analysis, Indifference Curve, Elasticity & Forecasting

Market Structures – Market Classification & Price Determination

National Income – Concept, Types and Measurement

Inflation – Concept, Types and Measurement

Business Ethics & CSR

Ethical Issues & Dilemma

Corporate Governance

Value Based Organisation

Unit – II

Organisational Behaviour – Significance & Theories

Individual Behaviour – Personality, Perception, Values, Attitude, Learning and Motivation

Group Behaviour – Team Building, Leadership, Group Dynamics

Interpersonal Behaviour & Transactional Analysis

Organizational Culture & Climate

Work Force Diversity & Cross Culture Organisational Behaviour

Emotions and Stress Management

Organisational Justice and Whistle Blowing

Human Resource Management – Concept, Perspectives, Influences and Recent Trends

Human Resource Planning, Recruitment and Selection, Induction, Training and Development

Job Analysis, Job Evaluation and Compensation Management

Unit – III

Strategic Role of Human Resource Management

Competency Mapping & Balanced Scoreboard

Career Planning and Development

Performance Management and Appraisal

Organization Development, Change & OD Interventions

Talent Management & Skill Development

Employee Engagement & Work Life Balance

Industrial Relations: Disputes & Grievance Management, Labour Welfare and Social Security

Trade Union & Collective Bargaining

International Human Resource Management – HR Challenge of International Business

Green HRM

Unit– IV

Accounting Principles and Standards, Preparation of Financial Statements

Financial Statement Analysis – Ratio Analysis, Funds Flow and Cash Flow Analysis, DuPont Analysis

Preparation of Cost Sheet, Marginal Costing, Cost Volume Profit Analysis

Standard Costing & Variance Analysis

Financial Management, Concept & Functions

Capital Structure – Theories, Cost of Capital, Sources and Finance

Budgeting and Budgetary Control, Types and Process, Zero base Budgeting

Leverages – Operating, Financial and Combined Leverages, EBIT–EPS Analysis, Financial Breakeven Point & Indifference Level.

Unit –V

Value & Returns – Time Preference for Money, Valuation of Bonds and Shares, Risk and Returns;

Capital Budgeting – Nature of Investment, Evaluation, Comparison of Methods; Risk and Uncertainly Analysis

Dividend – Theories and Determination

Mergers and Acquisition – Corporate Restructuring, Value Creation, Merger Negotiations, Leveraged Buyouts, Takeover

Portfolio Management – CAPM, APT

Derivatives – Options, Option Payoffs, Option Pricing, Forward Contracts & Future Contracts

Working Capital Management – Determinants, Cash, Inventory, Receivables and Payables Management, Factoring

International Financial Management, Foreign exchange market

Unit - VI

Strategic Management – Concept, Process, Decision & Types

Strategic Analysis – External Analysis, PEST, Porter's Approach to industry analysis, Internal Analysis – Resource Based Approach, Value Chain Analysis

Strategy Formulation – SWOT Analysis, Corporate Strategy – Growth, Stability, Retrenchment, Integration and Diversification, Business Portfolio Analysis - BCG, GE Business Model, Ansoff's Product Market Growth Matrix

Strategy Implementation – Challenges of Change, Developing Programs
McKinsey 7s Framework

Marketing – Concept, Orientation, Trends and Tasks, Customer Value and Satisfaction

Market Segmentation, Positioning and Targeting

Product and Pricing Decision – Product Mix, Product Life Cycle, New Product development, Pricing – Types and Strategies

Place and promotion decision – Marketing channels and value networks, VMS, IMC, Advertising and Sales promotion

Unit –VII

Consumer and Industrial Buying Behaviour: Theories and Models of Consumer Behaviour

Brand Management – Role of Brands, Brand Equity, Equity Models, Developing a Branding Strategy; Brand Name Decisions, Brand Extensions and Loyalty

Logistics and Supply Chain Management, Drivers, Value creation, Supply Chain Design, Designing and Managing Sales Force, Personal Selling

Service Marketing – Managing Service Quality and Brands, Marketing Strategies of Service Firms

Customer Relationship Marketing – Relationship Building, Strategies, Values and Process

Retail Marketing – Recent Trends in India, Types of Retail Outlets.

Emerging Trends in Marketing – Concept of e-Marketing, Direct Marketing, Digital Marketing and Green Marketing

International Marketing – Entry Mode Decisions, Planning Marketing Mix for International Markets

Unit –VIII

Statistics for Management: Concept, Measures Of Central Tendency and Dispersion, Probability Distribution – Binominal, Poison, Normal and Exponential

Data Collection & Questionnaire Design

Sampling – Concept, Process and Techniques

Hypothesis Testing – Procedure; T, Z, F, Chi-square tests

Correlation and Regression Analysis

Operations Management – Role and Scope

Facility Location and Layout – Site Selection and Analysis, Layout – Design and Process

Enterprise Resource Planning – ERP Modules, ERP implementation

Scheduling; Loading, Sequencing and Monitoring

Quality Management and Statistical Quality Control, Quality Circles, Total Quality Management – KAIZEN, Benchmarking, Six Sigma; ISO 9000 Series Standards

Operation Research – Transportation, Queuing Decision Theory, PERT / CPM

Unit –IX

International Business – Managing Business in Globalization Era; Theories of International Trade; Balance of payment

Foreign Direct Investment – Benefits and Costs

Multilateral regulation of Trade and Investment under WTO

International Trade Procedures and Documentation; EXIM Policies

Role of International Financial Institutions – IMF and World Bank

Information Technology – Use of Computers in Management Applications; MIS, DSS

Artificial Intelligence and Big Data

Data Warehousing, Data Mining and Knowledge Management – Concepts

Managing Technological Change

Unit – X

Entrepreneurship Development – Concept, Types, Theories and Process, Developing Entrepreneurial Competencies

Intrapreneurship – Concept and Process

Women Entrepreneurship and Rural Entrepreneurship

Innovations in Business – Types of Innovations, Creating and Identifying Opportunities, Screening of Business Ideas

Business Plan and Feasibility Analysis – Concept and Process of Technical, Market and Financial Analysis

Micro and Small Scale Industries in India; Role of Government in Promoting SSI

Sickness in Small Industries – Reasons and Rehabilitation

Institutional Finance to Small Industries – Financial Institutions, Commercial Banks, Cooperative Banks, Micro Finance.