SRMJEEE (PG)

Syllabus for SRM Joint Entrance Examination – Engineering PG

S.No	PG Program Specializations
1	Aerospace Engineering
2	Automobile Engineering
3	Biomedical
4	Biotechnology
5	Chemical Engineering
6	Civil Engineering
7	Computer Science Engineering
8	Electrical Engineering
9	Electronics and Communication Engineering
10	Food Processing
11	Instrumentation Engineering
12	Mechatronics
13	Materials Science
14	Mechanical Engineering
15	Industrial Safety

Aerospace Engineering

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: Engineering Mechanics and Strength of Materials

Force systems, equilibrium and free-body diagrams; centroid and moment of inertia; kinematics and kinetics of particles and rigid bodies; work-energy and impulse-momentum principles; stress, strain and elastic constants; axial loading, torsion and bending; shear force and bending moment diagrams; principal stresses and Mohr's circle; buckling of columns and structural stability; introduction to fatigue and fracture mechanics.

Section 3: Fluid Mechanics

Fluid properties and fluid statics; fluid kinematics and dynamics; continuity, momentum and energy equations; Bernoulli's equation and its applications; laminar and turbulent flows; internal and external flows; boundary layer theory; flow separation and wake formation; dimensional analysis and similitude; fundamentals of compressible and incompressible flows.

Section 4: Engineering Thermodynamics and Heat Transfer

Basic concepts and laws of thermodynamics; properties of pure substances; first and second laws of thermodynamics; thermodynamic processes and cycles including Otto, Diesel and Brayton cycles; entropy and enthalpy; heat transfer by conduction, convection and radiation; one-dimensional steady-state heat conduction; forced and natural convection; heat exchangers; introduction to combustion and thermal management.

Module 5: Aerodynamics and Aerospace Fundamentals

Properties of air and standard atmosphere; fundamental aerodynamic principles; incompressible and compressible flows; subsonic, transonic and supersonic flow fundamentals; airfoil geometry and aerodynamic characteristics; lift, drag and pitching moment; basic wing aerodynamics; boundary layers and flow separation; shock waves and expansion waves; fundamentals of aircraft configurations and aerodynamic performance.

Module 6: Engineering Materials and Structural Mechanics

Engineering materials and their mechanical properties; ferrous and non-ferrous alloys; material selection and heat treatment; fundamentals of structural analysis; bending, shear and torsion; thin-walled structures; structural stability and buckling; fatigue and fracture mechanics; composite materials and their applications; fundamentals of advanced materials and additive manufacturing.

Module 7: Energy Conversion and Propulsion Systems

Fundamentals of energy conversion; internal combustion engines and gas turbines; thermodynamic cycles and their applications; compressors, turbines and pumps; combustion fundamentals; principles of thrust generation; introduction to turbojet, turbofan, turboprop and turboshaft engines; rocket propulsion fundamentals; nozzle flow and performance; energy efficiency and propulsion system performance.

Module 8: Dynamics, Vibrations, Control Systems and Instrumentation

Kinematics and dynamics of mechanical systems; free and forced vibrations; natural frequency and damping; single-degree-of-freedom systems; fundamentals of control systems; open-loop and closed-loop systems; transfer functions and feedback control; basic sensors and transducers; measurement of pressure, temperature, force, velocity and acceleration; fundamentals of data acquisition and instrumentation.

Module 9: Manufacturing Processes and Computational Engineering

Conventional manufacturing processes including casting, forming, welding and machining; advanced manufacturing techniques; computer-aided design and manufacturing; engineering drawing and geometric modelling; fundamentals of numerical simulation; introduction to Computational Fluid Dynamics (CFD); governing equations and discretisation; meshing and

grid generation; introduction to Finite Element Analysis (FEA); applications of computational engineering in aerospace and mechanical systems.

Module 10: Applied Engineering and Aerospace Systems

Fundamentals of aircraft configurations and components; basic principles of flight mechanics; aircraft performance including lift, drag, range and endurance; fundamentals of structural and thermal systems; fluid machinery and energy systems; basic principles of mechatronic systems and automation; introduction to aerospace instrumentation and measurement; fundamentals of orbital mechanics and space systems; applications of interdisciplinary engineering in aircraft, spacecraft and propulsion systems.

Automobile Engineering

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: Mechanics and Machine Design

Free body diagrams and equilibrium, virtual work; impulse and momentum; kinematics and dynamics of particles and rigid bodies in plane motion; energy formulations. Design for static and dynamic loading, gears, shafts, bearings, springs, brakes and clutches, riveted, bolted and welded joints.

Section 3: Strength of Materials

Stress and strain, elastic constants, Mohr's circle, thin cylinders, shear force and bending moment diagrams, bending and shear stresses, deflection of beams, torsion, thermal stresses, stress concentration, fatigue, failure theories.

Section 4: Thermodynamics and Heat Transfer

Zeroth, First and Second laws, availability, properties of pure substances, ideal and real gases, air-standard cycles (Otto, Diesel, Dual, Brayton), fuels and combustion; conduction, convection, radiation, heat exchangers, engine cooling.

Section 5: Fluid Mechanics

Fluid properties, fluid statics, conservation of mass, momentum and energy, Bernoulli's equation, laminar and turbulent flow, flow through pipes, boundary layer, lift and drag, dimensional analysis.

Section 6: Automotive Engines

Construction and working of SI and CI engines, combustion in SI and CI engines, knocking, fuel injection and carburetion, electronic injection systems, supercharging and turbocharging, lubrication and cooling systems, performance and testing, alternative fuels (bio-fuels, hydrogen, CNG, LPG), emission standards.

Section 7: Automotive Transmission

Friction clutches, different types of gear boxes, Wilson gear box, fluid couplings and torque converters, hydrostatic drive systems, electric drive, Continuously Variable Transmission (CVT), propeller shaft, universal joints, differential and final drive, axles.

Section 8: Automotive Electrical

Automotive electrical systems; battery construction and characteristics; starting and charging systems; ignition systems; automotive wiring and electrical circuits; sensors and actuators used in automobiles, Starter motor and alternator,

Section 9: Automotive Electronics

Electronic control units (ECUs); engine management systems; electronic fuel injection and ignition control; multiplexing and CAN communication; LIN and automotive communication protocols; onboard diagnostics (OBD); electronic braking and stability control systems; automotive instrumentation and dashboard systems.

Section 10: Electric and Hybrid Vehicles

Configurations of EVs and hybrid vehicles (series, parallel, series-parallel), traction motors (DC, BLDC, induction, PMSM), battery types and Battery Management Systems, charging methods and infrastructure, regenerative braking, fuel cell vehicles, energy management strategies.

Biomedical Engineering

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: Electrical Circuits

Circuit Elements, Laws and theorems, Resonance and Coupled circuits.

Section 3: Signals and Systems

Continuous and Discrete Signal and Systems, Sampling theorem, Laplace and Fourier transforms, transfer function, convolution, correlation, Impulse response, frequency response, basics of IIR and FIR filters.

Section 4: Electronic devices and circuits

Characteristics and applications of diode, BJT and MOSFET, Characteristics and applications of operational amplifiers, Logic circuits, Principles of ADC and DAC, Microprocessor-architecture, interfacing memory and input- output devices.

Section 5: Sensors and measurements

Sensors - resistive, capacitive, inductive, piezoelectric, Hall effect, electro chemical, optical; signal conditioning circuits.

Section 6: Human Anatomy and Physiology

Homeostasis; Basics of organ systems - musculoskeletal, respiratory, circulatory, excretory, endocrine, nervous, gastro-intestinal and reproductive.

Section 7: Biomaterials: Properties of biomaterials, Fundamental characteristics of implants, Biomaterial characterization techniques.

Section 8: Biomechanics: Kinematics of muscles and joints - forces and stresses in joints, Hard and soft tissue mechanics.

Section 9: Medical imaging Techniques: Instrumentation and image formation techniques in medical imaging modalities such as X-Ray, Computed Tomography, Magnetic Resonance Imaging, Ultrasound.

Section 10: Biomedical Instrumentation: Principles of measuring blood pressure, body temperature, respiratory measurements and cardiac output measurement, Operating principle of medical equipment - sphygmomanometer, ventilator, cardiac pacemaker, defibrillator, pulse oximeter, hemodialyzer.

Section 11: Control system: Transfer function, Mathematical Modeling, Block diagram reduction, Control system components, Transient and steady state analysis, Stability analysis, Frequency domain analysis.

Biotechnology

Section 1: Cell structure, function

Eukaryotic vs prokaryotic cell; Structure and function- plasma membrane, cell wall; cytoplasm, nucleus & nucleolus, endoplasmic reticulum, Golgi apparatus, ribosomes, mitochondria, chloroplast, lysosome, microbodies, vacuoles, extracellular matrix & cell junction; cytoskeleton; flagella & cilia; plant vs animal cell.

Section 2: Properties of nucleic acids, protein synthesis

Nucleic acids- DNA & RNA- types, structure, physical & chemical properties, and replication; Transcription and post-transcriptional modifications in prokaryotes & eukaryotes; translation and post-translational modification in prokaryotes & eukaryotes; protein folding, sorting and transport; protein degradation.

Section 3: Gene manipulation, transgenic microbes

Vector systems; promoters, terminators, and regulatory elements; selectable markers and reporter genes; gene transfer methods; selection of recombinants; Transgenic microbes- GEMs in bioremediation; bioterrorism; healthcare; industry; agriculture; concern and safety measures.

Section 4: Plants and animals

Plants – Classification; transport of minerals and water; transpiration; photorespiration; plant nutrition & photosynthesis; plant hormones; photo morphogenesis and vernalization; seed physiology; nitrogen metabolism;

Animals – Classification; nervous system; sense organs; blood vascular system; endocrine system; lymphatic system; respiratory system; digestive system; excretory system and reproductive system.

Section 5: Metabolism and bio-energetic

Food and Fuel; Metabolic pathways with oxidation-reduction reactions; Free energy changes in metabolic reactions; Glucose, glycogen, and their metabolic regulation; Nitrogen-amino acid and fatty acid metabolism; Photosynthesis in plants; Biosynthesis of amino acids, lipids, and nucleotides.

Section 6: Gene regulation

Overview of the regulation of gene expression; Prokaryotic gene regulation; Eukaryotic gene regulation; Nucleic acid replication, Transcription, Translation, and their regulatory mechanisms in prokaryotes and eukaryotes; Epigenetic, Transcriptional, Post-transcriptional, Translational, Post- translational control of gene expression; Mechanism of alternative splicing and its regulation.

Section 7: Enzyme kinetics, fermentation process, production of commercially important enzymes Classification of enzymes; Mechanism of enzyme action; Kinetics of single substrate reactions; estimation of Michelis-Menten parameters, Multi-substrate reactions-mechanisms and kinetics; turnover number; types of inhibition & models- substrate & product; Allosteric regulation of enzymes and Monod Changeux Wyman model; Effects of pH and temperature on enzyme action & deactivation kinetics. Industrial production of enzymes; Application of enzymes in food processing, pharmaceutical, and textile industries.

Section 8: Recombinant proteins

Protein production and characterization; Recombinant protein expression inbacteria; Restriction and modification enzymes; Chromatography method used in protein purification; Sequencing, Blotting, Electrophoresis and labelling; Therapeutic recombinant proteins production in bacteria and plants; Applications of recombinant proteins.

Section 9: Microbial growth kinetics

Modes of microbial cell division; Cell cycle and its phases; Kinetic studies on cell growth; Monod equation and its importance; Michaelis- Menten equation; Lineweaver-Burk plot; Hybrid logistic- Monod and Luedeking-Piret equation; Factors affecting cell growth; Environmental influence on microbial growth.

Section 10: Biosafety, Bioethics and Intellectual Property Rights

Biosafety – levels of biosafety, risk factors and types, and mechanism of handling. Biosafety considerations for large-scale production of microorganisms; Ethical issues in food, agricultural and animal biotechnology. Bioethics and Intellectual property; Types of Intellectual property; Patents; Scope and nature of patenting; Purpose and advantages of patent laws; Industrial designs, Trademarks, Trade secret, geographical indications and copyrights; Publishing Vs Patenting.

Section 11: Bio conversion

Biomass sources and classification; Biomass property for conversion process; Biomass conversion processes (Biological, Thermal, Chemical and Hybrid conversions); Various types of biofuels and organic commodity chemicals from biomass; Algae biorefineries; Integrated Biorefinery process and products; Life cycle Assessment; Techno-economic evaluation.

Section 12: Fermentation kinetics, bioreactors

Chemical engineering principles applied to biological system; Principle of reactor design; ideal and non-idea multiphase bioreactors; mass and heat transfer; Rheology of fermentation fluids; Aeration and agitation; Media formulation and optimization; Kinetics of microbial growth, substrate utilization and product formation; Sterilization of liquid media and air and kinetics; Batch, fed-batch and continuous processes; Various types of microbial and enzyme reactors; Instrumentation control and optimization; Unit operations in solid-liquid separation and liquid- liquid extraction; Process scale up, economics and feasibility analysis.

Section 13: Genomics and proteomics

Introduction to structural organization of genome in Prokaryotes and Eukaryotes; DNA sequencing principles and translation to large scale projects; Tools for genome analysis; Genome sequencing projects of microbes, plants and animals; Protein analysis (includes measurement of concentration, amino acid composition, N- terminal sequencing); Peptide fingerprinting; Characterization and identification of proteome using mass Spectrometry, (MALDI- TOF, Tandem mass spectrometry; Protein sequencing by Edman degradation and analysis); Pharmacogenetics High throughput screening in the genome for drug discovery identification of gene targets; Functional genomics and proteomics analysis of microarray data (Protein and peptide microarray-based technology; PCR- directed protein in situ arrays; Structural proteomics).

Section 14: Computer application in Biotechnology

Major bioinformatic resources and search tools; Sequence and structure database; Sequence analysis (bio molecular sequence file formats, scoring matrices, sequence alignment, phylogeny); Data mining and analytical tools for genomic and proteomic studies; Molecular dynamics and simulations (basic concepts including force fields, protein-protein, protein-nucleic acid, protein- ligand interaction).

Section 15: Nano Biotechnology

Functional principles of Nanobiotechnology; Self-assembling nanostructures; Protein and peptide- based nanostructures- S-layers-chemistry and structure;DNA-based nanostructures-DNA-protein nanostructures; Basic characterization techniques; pharmaceutically important nanomaterial, drug nanoparticles.

Section 16: Application of Biotechnology system Biotechnology

Introduction and basic concepts in biological systems; System microbiology and developmental systems biology; Genotype-phenotype mapping; Enzyme kinetics and noise in gene expression; Gene expression networks; Optimality and robustness; Tools for system biology; Next generation sequencing (NGS) and it s applications; Metabolic networks and flux analysis.

Chemical Engineering

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: Process Calculations

Unit and standards, Material Balance Calculation, Energy Balance Calculations, Saturation and Humidity, and Combustion Calculations

Section 3: Fluid Mechanics

Fluid Statics, Fluid Flow, Flow meters, Transportation of Fluids, Flow Past Immersed Bodies

Section 4: Mechanical Operations

Size Analysis, Size Reduction, Size Separation, Filtration, and Agitation

Section 5: Thermodynamics

Energy and its Transformation, Reversible and Irreversible Processes, First Law of Thermodynamics, PVT Relationship, Second Law of Thermodynamics, Refrigeration, Thermodynamics Relations, Flow Processes, Solution Thermodynamics, Phase Equilibrium, Reaction Equilibrium

Section 6: Heat Transfer

Conduction, Convection, Boiling, Condensation, Heat Exchangers, Evaporation, and Radiation

Section 7: Mass Transfer

Diffusion, Convective Mass Transfer, Gas-Liquid Contractors, Tray Efficiencies, Absorption, Distillation, and Drying

Section 8: Reaction Engineering

Reaction kinetics, Design of Reactors, Non-isothermal Reactors, Heterogeneous Reactions, Catalytic Reactions

Section 9: Process Control

Laplace Transforms, Qualitative Response of System, Open-loop Response of Dynamics systems, Dynamics of Controllers, Stability Analysis of Feedback systems

Section 10: Process Economics and Design

Cost Estimation, Depreciation, Interest and Investment Costs, Mechanical Design of Process Equipment

Section 11: Chemical Technology

Construction Material for the Process Industries, Safety Tips, Water Conditioning, Fuel Gases, Sulfuric acid, Chlor-Alkali Industries, Petroleum Processing, and Fertilizers.

Civil Engineering

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: Structural Engineering

Strength of Materials, Structural Analysis and Design: Bending moment and shear force in statically determinate beams, Simple stress and strain relationship stress and strain in two dimensions, Principal stresses, Stress transformation, Mohr's circle, Simple bending theory, Flexural and shear stresses, unsymmetrical bending, shear centre, Thin-walled pressure vessels, Uniform torsion, Bucking of column, Combined and direct bending stresses, Analysis of statically determinate trusses, arches, beams, cables and frames, displacements in statically determinate structures and analysis of statically indeterminate structures by force/energy methods, analysis by displacement methods (Slope deflection method and Moment distribution method), influence lines for determinate and indeterminate structures, Basic concepts of matrix methods of structural analysis, Method of superposition.

Design of RC and Steel Elements: Concrete technology – properties of concrete, basics of mix design, Concrete design – basic working stress and limit state design concepts, Analysis of ultimate load capacity and design of members subjected to flexure, shear, compression and torsion by limit state methods, basic elements of pre- stressed concrete, Analysis of beam and design of sections at transfer and service loads of elements, Analysis and design of torsion and compression members, beams and bam columns, Column bases, Connections simple and eccentric, Beam – Column connections, Plate girders and trusses, plastic analysis of beams and frames.

Section 3: Geotechnical Engineering

Origin of soils, Soil classification, Three-phase system, Fundamental definitions, relationship and interrelationships, Permeability and seepage, Effective stress principle, Consolidation, Compaction, Shear strength, Index properties, Unified and Indian standard soil classification system, Quicksand condition, Mohr's circle, Stress – Strain characteristics of clays and sand – Stress paths, Sub-surface investigation – scope, Drilling bore holes, Sampling, Penetration tests, Plate load test, Earth pressure theories, Effect of water table, layered soils, Stability of slopes – Infinite slopes, Finite slopes, Foundation type foundation design requirements, Shallow foundation bearing capacity, Effect of shape, Water table and other factors, Stress distribution, Settlement analysis in sands and clays, Deep foundations – pile types, Dynamic and static formulae, Load capacity of piles in sands and clays, Negative skin friction, standard penetration and cone penetration tests, Rankine and Coulomb, Bishop's method, Boussinesq's theory, Shallow foundations – Terzaghi's and Meyerhoff's bearing capacity theories, Combined footing and raft foundation.

Section 4: Water Resources Engineering

Fluid Mechanics and Hydraulics: Properties of fluids, Fluid statics, Principle of conservation of mass, momentum, Energy and corresponding equations, potential flow, Applications of momentum and Bernoulli's Equation, Laminar and Turbulent flow, Flow in pipes, Pipe networks, Concept of boundary layer and its growth, Uniform flow, Critical flow and gradually varied flow in channels, Specific energy concept, Hydraulic jump, Forces on immersed bodies, Flow measurements in channels, Tanks and pipes, Dimensional analysis and hydraulic modeling, Kinematics of flow, Velocity triangles and specific speed of pumps and turbines, Concept of lift and drag.

Hydrology and Irrigation: Hydrologic cycle, Rainfall, Evaporation, Infiltration, Stage discharge relationships, Unit hydrographs, Flood estimation, Reservoir capacity, Reservoir and channel routing, Well hydraulics. Irrigation Design of lined and unlined canals, Waterways, Head works, Gravity dams and spillways, Design of weirs on permeable foundation, Types of irrigation system- methods, Water logging and drainage, Cross drainage structure. Surface and Groundwater Resources- Reservoir - capacity; channel routing; Surface run-off models; Surface water management; Rain water harvesting and storage. Aquifers; Vadose and saturated zones; - Types and their parameters - porosity, permeability, transmissivity and storage coefficient; Darcy's law and applications; Steady state well hydraulics.

Section 5: Environmental Engineering

Air and Water pollution: Air Pollution: - Types -Sources and impacts, Air pollution meteorology, Air pollution control, Air quality standards and limits. Global effects of air pollution – Greenhouse gases, global warming, climate change, urban heat islands, acid rain, ozone hole. Water pollution- Ground and surface water pollution-Soil contamination and leaching of contaminants into groundwater- pollution control - Water Quality- Quality standards, Basic unit processes and operations for water treatment. Drinking water standards, - Surface water treatment, - Treatment of waste water, Sludge disposal, effluent discharge standards, Quality of characteristics of domestic wastewater, Primary and secondary treatment unit operations and unit processes of domestic wastewater, Sludge disposal.

Waste Management: Hazardous waste management: Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal- Management of biomedical waste, plastic waste and E-waste: Sources, generation and characteristics; Waste management practices including storage, collection and transfer Environmental Law and Policy – Objectives; Polluter pays principle, Precautionary principle; The Water and Air Acts with amendments; The Environment (Protection) Act (EPA) 1986; National Green Tribunal Act, 2010; National Environment Policy; Principles of International Law and International treaties

Section 6: 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 and Traffic Engineering: 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 7: Geomatics Engineering

Surveying and mapping: Principles- 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. Mapping-Importance to engineering projects, Types - Scales and uses, Plotting accuracy, Coordinate systems- Map projections, Datum – MSL, Geoid, spheroid, WGS-84. GPS-GNSS- Principle, Components of GNSS, Data collection methods, DGPS, Errors in observations and corrections Remote sensing and GIS: Basics of Aerial remote sensing . Types of Aerial photographs, Flying height and scale, Relief (height) displacement, Stereoscopy, 3-D Model, Height determination using Parallax Bar, Digital Elevation Model (DEM), Slope. Satellite Remote sensing -Basic concepts - Electromagnetic spectrum, Spectral signature, Resolutions-Spectral, Spatial, Temporal and Radiometric, Platforms and Sensors, Remote Sensing Data Products - PAN, Multispectral, Microwave, Thermal, Hyperspectral, Visual interpretation and Digital image characteristics: image processing. Geographical Information System - Data Sources, Data Models and Data Structures, DBMS, spatial and non-spatial database generation , Various Spatial and Non spatial analysis.

Computer Science Engineering

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: Programming Methodology & Software Engineering:

General Concepts: Modular Approach, clarity and simplicity of expressions, use of proper names for identifiers, Comments, Indentation; Running and Debugging programs, Syntax errors, Run-time errors, Logical errors.

Problem solving methodologies: Understanding and solution for the problem, writing code to optimizing execution time and memory storage, breaking down solution into simple steps, control structure - conditional control and looping. Software life-cycle models, software requirements specification, object-oriented design, UML, design patterns, user interface design, coding and unit testing, integration and systems testing, debugging techniques.

Section 3: Data Structure and Algorithms:

Arrays, Sparse Matrix, Linked List, Queue – Priority and Circular Queues, Stack - Applications of Stack, Tree - Traversal Techniques of Tree, Binary search Trees, Expression Trees, AVL trees, Minimum Spanning Trees, Shortest Path Algorithms, Recurrence Relations, Sorting and Searching Algorithm Analysis, Analysis of Algorithms based on Greedy, Dynamic, Back Tracking and Branch and Bound Techniques, Knapsack using Greedy, Dynamic and Branch and Bound Techniques, Randomized Quick sort, Hashing, P,NP, NP-complete and NP-Hard

Section 4: Database systems

Introduction: Database- Data Management System-Data models: ER-Relational hierarchical-Functional components of DBMS- Data abstraction

ER Design: Attributes-Entity-Relationship-weak entity-specialization-generalization aggregation- conversion rules from ER to tables-design issues

SQL: Basic SQL commands-DDL-DML-DCL-built in functions-joins-subqueries: single row and multiple row subqueries-PL/SQL-Triggers

Normalization: Functional Dependencies-Types: 1,2,3 and BCNF, fourth and Fifth Normal forms-closure set of attributes-canonical cover.

Transaction and Recovery: Transaction Properties-states of transaction-concurrency control techniques: Lock based techniques- Time based protocols- Recovery mechanism: Log based recovery- shadow paging techniques-check points.

Section 5: Operating System

Process, threads, inter process communication, process synchronization, CPU scheduling, Deadlocks, memory management, paging, segmentation, virtual memory, demand paging, page fault, page replacement algorithms, thrashing, working set model, Disc scheduling, Files and Directories.

Section 6: Computer Networks

OSI model-Data transmission models – Topologies-IPV4-IPV6-Classful and Classless addressing - Subnetting- Supernetting-RIPv1 and RIPv2-Framing and Flow control-CSMA, CSMA/CD-Interdomain and intra-domain routing-NAT-BGP-ICMP-IGMP-ARP-RARP-TCP-UDP-SCTP-DNSTelNet-Full Duplex- Half Duplex-FTP-TFTP-HTTP-DHCP-HTTP-SMTP-POP3 – Auto Configuration-Renumbering-Tunnelling – ATM-Communication using HDLC- PPP services

Section 7: Computer Architecture and organization

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

Electrical Engineering

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: 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 3: 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 4: 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 5: 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 6: 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 7: 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 8: Electrical and Electronic Measurements

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

Section 9: 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: Butterworth, VCOs and timers, combinatorial and sequential logic circuits, multiplexers, demultiplexers, Schmitt triggers, sample and hold circuits, A/D and D/A converters.

Section 10: 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.

Electronics and Communication Engineering

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: Networks

Circuit Elements, Nodal and Mesh Analysis- Networks theorems: Thevenin, Norton's, Superposition, Maximum power transfer Resonance – Coupled circuits – AC steady state and Transient Analysis

Section 3: Electronic Devices

Energy bands in intrinsic and extrinsic semiconductors, Charge carriers in semiconductors – semiconductor junctions – semiconductor diodes and its types – transistors – FET – SCR – IGBT – DIAC – TRIAC – UJT – Power supplies

Section 4: Analog and Digital Circuits

Biasing methods and small signal models – Transistor amplifier and analysis. Op-amp circuits: Amplifiers, summers, differentiators, integrators, active filters, Schmitt triggers, and oscillators. Boolean algebra – Logic gates – Logic families – Sequential and combinational circuits –– Comparators, timers, multivibrators, Sample and hold circuits. ADC and DAC

Section 5: Digital Electronics

Logic Families-TTL, MOS, CMOS; Flip Flop and Timing Circuits- set-reset laches, D-flipflop, R-S flip-flop, J-K Flip- flop, Master slave Flip flop, edge triggered flip-flop, T flip-flop: Registers and counters - Synchronous/Asynchronous counter operation, Up/down synchronous

counter, application of counter, Serial in/Serial out shift register, parallel in/ parallel out shift register, Bi-directional register.

Section 6: Microprocessor and Microcontroller

Intel 8085 microprocessor – Intel 8086/8088 microprocessor – Intel 8031/8051 microcontroller – Programmable interfacing devices – Applications.

Section 7: Analog and Digital Communication

Analog modulation and demodulation - AM, FM and PM, Random signals, noise, noise temperature and noise figure, Concepts of information theory, Error detection and correction, Digital modulation and demodulation – PCM, ASK, FSK, PSK, BPSK, QPSK and QAM, TDM, FDM, Multiple Access techniques, Optical communication - Optical sources and detectors, Optical fibers – attenuation and dispersion characteristics.

Section 8: Control Systems

Open loop and closed loop control system, Block Diagram reduction techniques, transfer function and signal flow diagram, Frequency Response and System analysis: Bode plot, Polar Plot, Nyquist Plot; Stability criterion: Routh-Hurwitz, Root Locus and Nyquist stability, On-off controller, Proportional(P), Proportional-Integral (PI), Proportional-Derivative (PD), PID controllers.

Section 9: Signals and Systems

Signals and classifications, Systems and Classifications, Continuous time signal analysis – Fourier Series, Fourier transform and properties, Laplace Transform and properties, Discrete time signal analysis – DTFT and properties, Z-Tranform and properties, Linear Time Invariant Continuous and Discrete Systems – Series and Parallel.

Section 10: Electromagnetics

Elements of Vector calculus (Gradient, divergence and curl), Gauss and Strokes Theorem, Maxwell equations and uniform plane waves: Wave propagation in dielectrics and conductors, skin effect, normal incidence. Transmission lines, Smith chart, impedance matching, Transients and pulse propagation on transmission line. Rectangular and circular waveguides, light propagation in optical fibers, dipole and monopole antennas, linear antenna arrays.

Food Processing

Section 1: Bioprocess Engineering: Properties of Vapors and Gases. Energy Balances/Conservation of Energy; Entropy; Ideal Gas Mixtures and Psychometrics. Steady-state Heat Transfer; One- dimensional Heat Conduction; Heat Transfer through a Composite Wall; Conduction, Forced Convection; Overall Heat Transfer Coefficient; Heat Exchangers; Radiation Heat Transfer. Basic bioprocess engineering and reactor concepts; Stoichiometry , mass and energy balances; Fluid flow and mixing in bioreactors; Heat transfer in bioprocesses; Mass transfer in bioprocess; Reaction and cell growth kinetics; Downstream processing unit operations. Process instrumentation

Section 2: Food Engineering: Dimensions and units, Evaporation, crystallization, distillation, mechanical separations, size reduction and mixing, properties of food, blanching, pasteurization, sterilization, extrusion, aseptic processing, drying, material handling, dairy plant engineering, cereal processing, fat and oil processing, sugar cane processing, food preservation, storage, non-thermal food processing, bakery and confectionary, meat and poultry processing, Food safety and waste management, food packaging technology

Section 3: Biochemistry and nutrition: Enzymes, Coenzymes, Cofactors, Elements of carbohydrates, fat and protein metabolism, Elements of photosynthesis, Food Requirements, Vitamins and their functions in the body, Minerals and their functions in body, Elements in protein biosynthesis-Nucleic acids and their importance.

Section 4: Microbiology: Microorganism, isolation of microorganism, identification, stains and staining techniques, Growth, nutrition and physiology of microorganism, diseases and control, microbial genetics, microbial spoilage in food, beneficial microorganism, probiotic and prebiotic. Fermentation-Process, types, design, Fermented food products. Enzymes-production-primary and secondary metabolites, application in food industry.

Instrumentation Engineering

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: Networks

Circuit Elements, Laws and theorems – Resonance – Coupled circuits – AC steady state and Transient Analysis

Section 3: Devices

Energy bands, Charge carriers in semiconductors – semiconductor junctions – semiconductor diodes and its types – transistors – FET – SCR – IGBT – DIAC – TRIAC – UJT – Power supplies

Section 4: Electronic Circuits

Biasing methods and small signal models – Transistor amplifier and analysis – Feedback amplifiers and oscillators – Large signal and tuned amplifiers – Frequency response and wave shaping circuits

Section 5: Digital

Number systems – Boolean algebra – Logic gates – Logic families – Gate level minimization and combinational logic – Synchronous and Asynchronous sequential logic – Memory

Section 6: Microprocessor

Intel 8085 microprocessor – Intel 8086/8088 microprocessor – Intel 8031/8051 microcontroller – Programmable interfacing devices – Applications

Section 7: Control System

Transfer function – Mathematical Modeling – Block diagram reduction - Control system components – Transient and steady-state analysis – Stability analysis – Frequency domain analysis

Section 8: Transducers and Industrial Instrumentation

Basic methods of measurement - Mathematical model of transducer - strain gauges - Resistance strain gauge - Inductive sensor - Capacitive Transducers - Hall effect transducer - Digital transducers - flow meters - Piezo resistive pressure sensor-Resonator pressure sensor – Thermocouples – Accelerometers - Solid level measurement- RTD –Types of RTDs – Bolometers - density measurement

Section 9: Biomedical Instrumentation

ECG-EMG-EEG-EOG measurement - Measurement of blood pH, pCO2, pO2 - Bio-potential Electrodes - Blood flow Measurement – Endoscopy – X- Ray – MRI - Micro and macro Shock hazards

Section 10: Electrical and Electronic measurements and instrumentation

Galvanometer and its applications - PMMC instruments - Power measurement – AC & DC bridges - Schering's bridge – Wien's bridge - resistance measurement- Megger - Digital Storage Oscilloscope (DSO) - AC & DC potentiometers - Instrument transformers - Digital Frequency Meter & Digital Voltmeter - Spectrum Analyzers - Calibration of practical instruments.

Section 11: Process control

Process Variables and dynamics – PI, PD, PID Control – Pneumatic actuators – Electric Actuators - Electronic valve positioner - Control Valves - Damped oscillation method- Z-N open loop tuning technique - Continuous cycling method - Multi-loop Control Schemes - Model Predictive Control - Internal model control (IMC) - Adaptive control

Mechatronics

Section 1: Mathematics

i) Vector Calculus

ii) Determinants and Matrices

iii) Analytic Function Theory

iv) Differential Calculus & Differential Equations

v) Numerical Methods

vi) Probability and Statistics

Section 2: Mechanics of Solids, Fluids, and Thermal Sciences

- **Engineering Mechanics & Solid Mechanics:** Free-Body Diagrams and Equilibrium; Trusses and Frames; Friction; Kinematics and Dynamics of Rigid Bodies in Plane Motion; Stress and Strain, Elastic Constants, Poisson's Ratio; Mohr's Circle; Shear Force and Bending Moment Diagrams; Bending and Shear Stresses; Torsion of Circular Shafts; Column Buckling (Euler's Theory); Deflection of Beams; Strain Gauges and Rosettes.
- **Fluid Mechanics & Dynamics:** Fluid Properties, Statics, Manometry; Continuity Equation, Bernoulli's Equation and Applications (Venturi, Orifice Meters); Laminar and Turbulent Flow, Darcy-Weisbach Equation, Major and Minor Losses in Pipes.
- **Thermodynamics:** Thermodynamic systems and processes; properties of pure substances, behaviour of ideal and real gases; zeroth, first and second laws of thermodynamics, calculation of work, heat, energy changes and entropy changes in various processes; application of first and second laws for analysis of closed and open systems; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.

Section 3: Machine Design

Failure Theories, Static and Dynamic Loading, Fatigue Strength and S-N Curve; Design of Machine Elements: Fasteners (Bolted, Welded, Riveted Joints), Keys, Shafts, Springs, Clutches, Brakes, Rolling and Sliding Contact Bearings; Design of Gears (Spur, Helical, Bevel) and Flexible Drives (Belts, Chains, Ropes).

Section 4: Kinematics and Dynamics of Machines

- **Elements of Mechanisms:** Mobility Criteria (Kutzbach & Grubler Criteria), Grashof's Law, Four-Bar Mechanisms, Single and Double Slider Crank Chains, Inversions.
- **Kinematic & Dynamic Analysis:** Velocity and Acceleration Analysis of Plane Mechanisms; Static and Dynamic Force Analysis, D'Alembert's Principle, Flywheels, Turning Moment Diagrams.
- **Cams, Gears, and Gyroscopes:** Cam Profile Construction (Uniform Velocity, SHM, Uniform Acceleration and Retardation, Cycloidal); Gear Trains; Gyroscopic Couple and Precessional Motion in Vehicles and Ships.
- **Balancing and Vibrations:** Static and Dynamic Balancing of Rotating Masses; Primary and Secondary Balancing of Reciprocating Masses; Free and Forced Vibrations of Single-Degree-of-Freedom (1-DOF) Systems, Damping, Vibration Isolation, Resonance, Critical Speed of Shafts, Torsional Vibrations.

Section 5: Electric Circuits and Networks

- **Network Analysis:** Circuit Elements (R, L, C, M, Dependent & Independent Voltage/Current Sources); Kirchhoff's Laws (KCL, KVL), Node and Mesh Analysis.
- **Network Theorems:** Superposition, Thevenin's, Norton's, Maximum Power Transfer, and Star-Delta Transformations.
- **AC and Transient Analysis:** Steady-State Sinusoidal Analysis, Phasor Concepts, Resonance; Transient Response of DC and AC Networks (RL, RC, RLC Circuits); Two-Port Networks, Balanced Three-Phase Circuits, Complex Power, and Power Factor Correction.

Section 6: Analog, Digital Electronics, and Embedded Systems

- **Analog Electronics:** Diodes, Zener Diodes, BJT, JFET, and MOSFET Biasing and Small-Signal Amplifiers; Operational Amplifiers (Op-Amps) - Characteristics and Applications (Inverting/Non-Inverting Amplifiers, Summers, Integrators, Differentiators, Active Filters, Precision Rectifiers, Schmitt Triggers, Oscillators, 555 Timers); ADC and DAC Circuits.
- **Digital Electronics:** Boolean Algebra, Logic Gates, Combinational Circuits (Multiplexers, Demultiplexers, Encoders, Decoders, Adders/Subtractors); Sequential Circuits (Latches, Flip-Flops, Counters, Shift Registers); PLDs (PLA, PAL).
- **Microcontrollers & Embedded Systems:** Architecture, Instruction Set, and Addressing Modes of 8051 and ARM Controllers; Interrupt Handling, Timers, Counters, PWM Generation; Serial Communication Protocols (SPI, I2C, UART, CAN); RTOS Concepts (Tasks, Scheduling Policies, Semaphores, Inter-Task Communication).

Section 7: Electrical Actuators, Power Electronics, and Drives

- **Electrical Machines:** Principles, Equivalent Circuits, Speed-Torque Characteristics, Speed Control, Starting, and Braking of Single-Phase/Three-Phase Induction Motors, DC Motors, Synchronous Machines, and Transformers.
- **Special Motors:** Operating Principles and Control of Stepper Motors, Servomotors, Brushless DC (BLDC) Motors, and Permanent Magnet DC (PMDC) Motors.
- **Power Electronics:** Semiconductor Switching Devices (SCR, Power MOSFET, IGBT, TRIAC); Phase-Controlled Rectifiers; DC-DC Converters (Buck, Boost, Buck-Boost Converters); Inverters (VSI, CSI, PWM Techniques); Switched Mode Power Supplies (SMPS).
- **Electrical Drives:** Speed Control Methods for DC and AC Drives (Armature Voltage Control, Chopper-fed DC Drives, V/f Control, Inverter/Cycloconverter-fed Induction Motor Drives).

Section 8: Sensors, Transducers, and Signal Conditioning

- **Measurement Characteristics:** Static and Dynamic Characteristics of Sensors, Errors and Calibration, Signal-to-Noise Ratio.

- **Industrial Transducers:**
    - *Displacement, Position & Proximity:* LVDT, RVDT, Potentiometric, Capacitive, Inductive, Hall Effect, Optical Encoders, Eddy Current Sensors.
    - *Force, Pressure, and Acceleration:* Strain Gauges, Load Cells, Piezoelectric Sensors, Accelerometers, Bourdon Tubes, Bellows, Diaphragms.
    - *Temperature and Flow:* RTD, Thermocouples, Thermistors, Hot-wire Anemometers, Ultrasonic and Electromagnetic Flow Meters.
- **Signal Conditioning:** Instrumentation Amplifiers, Data Acquisition Systems (DAQ), A/D and D/A Conversion Interfacing, Filtering, Bridge Circuits (Wheatstone, AC Bridges).

Section 9: Control Systems and Automation

- **Control System Modeling:** Open-loop and Closed-loop Systems, Transfer Functions, Block Diagram Reduction, Signal Flow Graphs; Modeling of Mechanical, Electrical, and Electromechanical Systems.
- **Time & Frequency Domain Analysis:** Transient and Steady-State Analysis, Response of First and Second Order Systems, Steady-State Error Constants; Routh-Hurwitz Stability Criterion, Root Locus, Bode Plots, Polar Plots, Nyquist Stability Criterion, Phase and Gain Margins.
- **Controllers & Compensators:** P, PI, PD, and PID Controllers; Tuning Methods (Ziegler-Nichols); Lead, Lag, and Lead-Lag Compensators.
- **State-Space Analysis:** State-Space Representation, State Transition Matrix, Controllability and Observability, Full-State Feedback Controller Design.
- **Industrial Automation:** Programmable Logic Controllers (PLCs) - Architecture, I/O Modules, Ladder Logic Programming, Timers, Counters, and Latching Circuits; Basics of SCADA, DCS, and Industrial Communication Protocols (Modbus, Profibus, CAN, EtherCAT).

Section 10: Robotics

Robotic classification- serial and parallel manipulators, geometrical configuration, Links and joints, Coordinate systems and degrees-of-freedom; Rotation matrices in 2D and 3D;

homogeneous transformations, forward kinematics. Robot applications- point-to-point and continuous path control, types of end-effectors, robot accuracy and repeatability.

Section 11: Manufacturing Processes, CAD/CAM

- **Manufacturing Processes:** Conventional Machining (Turning, Milling, Drilling, Grinding); Unconventional Machining (EDM, WEDM, AJM, USM); Metal Forming and Joining; CNC Machine Architecture, Drives, Interpolators, and Manual Part Programming (G & M Codes).
- **CAD/CAM & CIM:** 2D/3D Geometric Transformations, Curves (Bezier, B-Spline), Surface and Solid Modeling; Computer-Integrated Manufacturing (CIM), Automated Guided Vehicles (AGVs), Automated Storage and Retrieval Systems (ASRS), Rapid Prototyping/Additive Manufacturing.

Materials Science

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: Quantum Mechanics, Atomics and Molecular Physics

Black body radiation, photoelectric effect – wave-particle duality of radiation– de-Broglie hypothesis of matter waves – Heisenberg's uncertainty principle – Schrödinger's wave equation – physical interpretation of wave function-Eigen-values and Eigen-functions – particle in a box-simple harmonic oscillator-Motion in a central potential-orbital angular momentum–particle in a square-well potential – potential barrier-Spectra of one and many electron atoms-LS and jj coupling - fine structure – spectroscopic terms and selection rules – hyperfine structure – exchange symmetry of wave function –Pauli's exclusion principle-Zeeman and Stark effects- - X-ray – Auger transitions – Compton Effect-basic principles-rotational and vibrational spectra of diatomic molecules- electronic transition in diatomic molecules-Franck-Condon principle-Raman effect-NMR-ESR-Nuclear properties and forces–radioactivity - alpha, beta and gamma radiation.

Section 3: Solid State Physics

Crystal structure , Bravais lattices and its basis, Miller indices- Crystal symmetry, point group and space group elements - crystal diffraction and reciprocal lattice-elementary ideas about point defects and dislocations (edge and screw) - Physical Properties of materials - lattice vibrations, phonons - specific heat of solids – thermal and electrical conductivity - Di-electrics behavior - Polarization mechanisms, Clausius-Mossotti equation, Piezo, Pyro and ferro electricity- free electron theory of metals- Fermi energy and density of states- - Energy levels in One Dimension, Fermi-Dirac Distribution, effect of Temperature on the Fermi-Dirac

Distribution, free electron Gas in Three Dimension-origin of energy bands- Elements of band theory – Electrons motion in periodic potential, concept of holes and effective mass- Hall effect- Different types of materials: Metals, Semiconductors, Composite materials, Ceramics, Alloys, Polymers

Section 4: Lasers

Basic Principle of Laser- Threshold condition-Einstein Coefficients - condition for light amplification - Line shape function - Optical Resonators -CW operation of laser; Critical pumping rate- Population inversion and photon number in the cavity around threshold; Output coupling of laser power- Optical resonators- Cavity modes- Three level and four level systems. Solid State lasers - Ruby and Nd-YAG Laser - Gas lasers - He-Ne and Co2 lasers - semiconductor lasers - Heterojunction lasers - Liquid Dye lasers – Q switching and mode locking. Application of laser in industry-Medical applications -Holography - Theory of recording and reconstruction - application of Holography

Section 5: Electricity and Magnetism

Electrostatics; Coulomb's law, Gauss's law and its applications, Laplace and Poisson equations, boundary conditions Conductors, capacitors, dielectrics, dielectric polarization, volume and surface charges, electrostatic energy, Magnetostatics, Biot-Savart law, Ampere's law, Faraday's law of electromagnetic induction, Maxwell's equations and static and time varying equations, Poynting theorem Lorentz Force and motion of charged particles in electric and magnetic fields, energy and momentum of electromagnetic waves, radiation from a moving charge. Electromagnetic waves in free space, dielectrics, and conductors, Reflection and refraction, polarization, Fresnel's Law, interference, coherence, and diffraction, Dia, Para and Ferromagnetism, Langevin's theory of paramagnetism

Section 6: Thermodynamics

Thermodynamic system – Path and Process – Zeroth law of Thermodynamics – Concept of Temperature – First law of Thermodynamics - Isothermal and Adiabatic Processes – Second law of Thermodynamics – Reversible and Irreversible processes – Carnot's Engine – Thermodynamic Substance of Pure Substances – Kinetic Theory of gases – Law of Equipartition Energy – Ideal and Real Gases – Equation of State – Thermodynamic relation – T-ds relation – Maxwell's Equation – Phase Transitions – Gibbs's Phase Rule – Van't Hoff's Equation

Section 7: Material Chemistry

Atomic structure – Bohr's theory – Exclusion principle – Hund's rule – Afbau principle – Periodic law and arrangement of elements – Bonding structure – Ionic, Covalent, Metallic, Weak bonds- Acids and Bases- Chemical periodicity - Structure and bonding in homo- and heteronuclear molecules (VSEPR Theory) - Allotropes of carbon: graphite, diamond, C60. Synthesis and reactivity of inorganic polymers of Si and P – Hydrocarbons - IUPAC Nomenclature - Hybridization – Aromaticity – Huckel's rule – Tautomerism – Stereochemistry – Electrochemistry - Electrochemical cells; standard electrode potentials: applications – corrosion and energy conversion

Section 8: Biology and Health Sciences

Anatomy: Cardiovascular System-Respiratory System-Excretory System. Physiology: Chemical composition of the body -Neurons & membrane potentials. Basic Cell biology: Cell components- Cell membrane structure- DNA structure. Genetics: DNA replication-transcription and translation- Bacteriology: Bacterial cell- structure and function. Virology: Bacteriophage-Microbes- Types. Common infectious diseases: Hepatitis, Malaria, HIV/AIDS. Cancers: Types and Classification. Biochemistry: Amino acids- Carbohydrates- Lipids. Immunology: components and response to foreign body

Section 9: Electronics

Semiconductors: Intrinsic and extrinsic semiconductors, Fermi level, P-N junction diodes-Bipolar junction transistors and its applications, field effect transistors, JFET, MOSFET, MESFET, MODFET and CCD: Various structures and their functioning, I-V characteristic studies and applications, Transistor circuits in CE, CB, CC modes, Amplifier circuits with transistors-Operational amplifier and its applications: Inverting, non -inverting, adder, sub tractor, differentiator, wave form generator, comparator, filters (LPF, BPF, HPF), Schmitt trigger, the 555 timer -Gates, flip flops, switches, registers, counters, multivibrators, principles of A/D and D/A converters, applications of A/D and D/A Converters, Regulators

Section 10: Microelectronic and Microsystem Technology

Silicon –semiconductor technology, wafer processing, oxidation, epitaxial, deposition, Photo Lithography, ion implantation and diffusion, n-well CMOS process, p-well CMOS process, Twin tub CMOS process and silicon on insulator, Microsystems, MEMS/NEMS Fundamentals, Fabrication Techniques MEMS materials-:Bulk micromachining , Surface micromachining, Applications of MEMS/NEMS- Sensors and Transducers: Mechanical- Chemical, Biological, -thermal, Light and magnetic Transducers.

Mechanical Engineering

Section 1: Mathematics

(i) Vector calculus

(ii) Determinants and Matrices

(iii) Analytic function theory

(iv) Differential Calculus, Multiple Integrals and ordinary Differential Equations

(v) Numerical Methods

(vi) Probability and Statistics

Section 2: Mechanics and Machine Design

Trusses and frames; Free body diagrams and equilibrium, virtual work; impulse and momentum (linear and angular), kinematics and dynamics of particles & of rigid bodies in plane motion and energy formulations, collisions. Design for static and dynamic loading, Failure theories, fatigue strength and the S-N diagram, gears, shafts, rolling and sliding contact bearings, springs, brakes and clutches, principles of the design of machine elements like riveted, bolted and welded joints

Section 3: Material Science and Metallurgy

Constitution of alloys and phase diagrams, steels, cast iron, TTT diagram, heat treatment of ferrous and non-ferrous metal, surface modification techniques, non-metallic materials, mechanical properties and testing, crystal defects and strengthening mechanisms, conducting and semi conducting materials, magnetic and dielectric materials, Engineering ceramics, Engineering and commodity polymers.

Section 4: Thermodynamics

Basic concepts, Zeroth, First and Second laws of thermodynamics; thermodynamic system and processes; Carnot cycle. irreversibility and availability; behaviour of ideal and real gases, thermodynamic relations, properties of pure substances, calculation of work and heat in ideal processes; analysis of thermodynamic cycles related to energy conversion, Fuel and combustion.

Section 5: Refrigeration and Air Conditioning

Vapor compression cycle effects of condenser and evaporator pressure on COP- multi-pressure system and low temperature refrigeration. Working principles of Vapour absorption systems and adsorption cooling systems. Air conditioning loads: Outside and inside design conditions; Heat transfer through structure, Solar radiation, Electrical appliances, Infiltration and ventilation

Section 6: Production Technology

Foundry Technology, Hot and Cold working, metal forming processes, metal joining processes, welding metallurgy, welding defects, Metal cutting, center lathe and special purpose lathe, drilling, milling, grinding, gear cutting, broaching unconventional machining processes.

Section 7: Automotive Engines

Development in Bio-fuels and hydrogen as engine fuels. Emission standards. Electronic injection systems methods of using all the fuels in SI and CI engines. Performance, emission and combustion behaviour of the fuels in SI and CI engines.

Section 8: Automotive Transmission

Construction and operation of friction clutches. Different types of gear boxes. Fluid couplings and torque converters. Wilson gear box. Hydrostatic drive systems. Electric drive. Continuously Variable Transmission (CVT) types of car bodies' classification of bus bodies.

Section 9: Strength of Materials

Stress and strain, stress-strain relationship and elastic constants, Mohr's circle for plane stress and plane strain, thin cylinders; shear force and bending moment diagrams; bending and shear stresses; deflection of beams; thermal stresses; Stress concentration factor; Fatigue Strength and S-N curve; failure theories

Section 10: Metrology and Measurements

Linear and angular measurements, Interferometry-laser interferometers – Types, Computer Aided Inspection, Basic concept of CMM- Types of CMM, Machine vision, Form Measurement-Straightness, Flatness, Roundness, Surface finish measurement, Measurement of power, flow and temperature

Section 11: Engineering Materials, Processing of Plastics and Computer Aided Manufacturing

Dual phase steels, high strength low alloy steel, transformation included plasticity steel, maraging steel, smart materials, - WC, TiC, TaC, Al_2O_3, SiC, Si_3N_4, CBN, diamond –Different types of polymer and plastic processing operations and engineering aspects- Axis measuring system - Turn Mill Center - CNC - Multi Axis (5 And 6 Axis) Machines with Live Tools - Manual part programming for CNC turning and machining centre.

Section 12: Product Design, Process Planning and Cost Estimate, Design of Jigs and Fixtures Integrating product and process design, manufacturing analysis and CAD/CAM integration, design methodology for automated manufacture- Project Co-ordination, sorting out the projects and Work breakdown structure.

Determination of material cost, Labour cost - Determination of labour cost, Estimation in forging shop, Estimation of Machining Time. Classification of Jigs and Fixtures, Fundamental Principles of design of Jigs and Fixtures.

Section 13: Operations Research

Graphical method-Solutions to LPP using simplex algorithm-Two phase method, Big M method- Transportation problems: Northwest corner rule, least cost method, MODI method. Assignment problem, Hungarian algorithm, travelling salesman problem. PERT and CPM method in project estimation.

Section 14: Operations Management

Delphi techniques. Market Research. Nominal Group Technique- Moving Average Methods, Exponential Smoothing Methods. Monitoring and Control of Forecasts. Procedure for developing MPS, MRP, Lot si zing methods of MRP, Tools for capacity planning, Capacity Requirement planning. Objectives and Activities of Production Activity Control, Job shop Control.

Section 15: Quality Control Reliability and Maintenance

Construction and application of X bar, R and S charts. Cp, Cpk and Cpm estimation. Time to failure distributions – Probability plotting: Exponential, Weibull - Goodness of fit tests – Survival graphs. Reliability testing: Failure terminated test. Time terminated test. Upper and lower MTBFs. Sequential Testing. Reliability growth monitoring. Reliability allocation.

Industrial Safety

Section 1: Mathematics

Vector calculus; Determinants and Matrices; Analytic function theory; Differential Calculus, Multiple Integrals and ordinary Differential Equations; Numerical Methods; Probability and Statistics

Section 2: Material Science

Constitution of alloys and phase diagrams, heat treatment processes, and surface modification techniques. Conducting materials – ferrous and non-ferrous metals; polymers and ceramics, conducting and semiconducting materials, and magnetic and dielectric materials; advanced materials – biomaterials and nanomaterials. Mechanical properties – stress and strain, the stress-strain relationship, and elastic constants; testing methods – tension, compression, hardness, fatigue, and creep. Nondestructive techniques.

Section 3: Thermodynamics

Basic concepts, thermodynamic systems and processes. The zeroth, first and second laws of thermodynamics; Carnot cycle. Irreversibility and availability, behaviour of ideal and real gases, thermodynamic relations; properties of pure substances. Calculation of work and heat in ideal processes. Analysis of thermodynamic cycles related to energy conversion.

Section 4: Production Technology

Casting, metalworking processes—hot and cold operations, and metal joining processes—welding, brazing, soldering, and welding defects. Machining processes — centre lathe and special-purpose lathe, drilling, milling, grinding, gear cutting, broaching, and unconventional machining processes. Fundamentals of CAD/CAM integration, design methodology for automated manufacture, project coordination, sorting out the projects, and work breakdown structure. Determination of material and labour costs.

Section 5: Digital technology

Basics of Data Science and AI; Fundamentals of computers and information technology. Hardware, software and operating systems. Data representation, storage and processing. Computer networks and internet fundamentals. Cloud computing and digital communication. Basics of databases and data management

Section 6: Operations Research

Graphical method-Solutions to LPP using simplex algorithm-Two phase method, Big M method- Transportation problems: Northwest corner rule, least cost method, MODI method. Assignment problem, travelling salesman problem. PERT and CPM method in project estimation.

Section 7: Basics of Electrical and Electronics

Basic electrical quantities – Voltage, Current, Resistance and Power. Ohm's Law – Basic understanding and simple applications.AC and DC electricity – Basic differences. Electrical power and energy consumption (kW and kWh). Basic working principles of electric motors and generators. Basic understanding of batteries and transformers. Electric short circuit and overloading. Earthing – Purpose and importance. Basic protective devices – Fuse, MCB and RCCB.

Section 8: Civil and Construction

Basics of project planning and site safety. Water and wastewater treatment, air pollution control, solid waste management (crucial for industrial hygiene)- Properties of fluids, flow through pipes (relevant for ventilation and industrial water systems) - Soil mechanics basics (relevant for site safety). Fundamentals of Geographic Information Systems (GIS). Remote Sensing and its industrial applications.

Section 9: Chemical Sciences

Petroleum product storages, storage tanks and vessel-drum and cylinder storage- ware house, storage hazard assessment of LPG and LNG; Pipe works and valves- heat exchangers. piping and instrumentation diagram of any process industry. Gaseous pollutants: - Primary and Secondary Pollutants; Chemical reactions in the atmosphere – Process design for Volatile Organic Compounds (VOCs) control - operational system for chemicals usage. Hazards associated with fermentation, cell culture, microbial processing, and downstream processing Guidelines to be followed in Medical Laboratories. Importance of Personal protective equipment, safe handling of biological samples.