

Reaction mechanism: Methods of determining reaction mechanisms. Nucleophilic and electrophilic substitutions and additions to multiple bonds. Elimination reactions. Reactive intermediates- carbocations, carbanions, carbenes, nitrenes, arynes, free radicals. Molecular rearrangements involving electron deficient atoms.

Organic synthesis: Synthesis, reactions, mechanisms and selectivity involving the following- alkenes, alkynes, arenes, alcohols, phenols, aldehydes, ketones, carboxylic acids and their derivatives, halides, nitro compounds and amines. Use of compounds of Mg, Li, Cu, B and Si in organic synthesis. Concepts in multistep synthesis- retrosynthetic analysis, disconnections, synthons, synthetic equivalents, reactivity umpolung, selectivity, protection and deprotection of functional groups.

Pericyclic reactions: Electrocyclic, cycloaddition and sigmatropic reactions. Orbital correlation, FMO and PMO treatments.

Photochemistry: Basic principles. Photochemistry of alkenes, carbonyl compounds, and arenes. Photooxidation and photoreduction. Di- π - methane rearrangement, Barton reaction.

Heterocyclic compounds: Structure, preparation, properties and reactions of furan, pyrrole, thiophene, pyridine, indole and their derivatives.

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

Spectroscopy: Principles and applications of UV-visible, IR, NMR and Mass spectrometry in the determination of structures of organic molecules.

4.5.10 Electronics and Communication Engineering (EC)

Engineering Mathematics

Linear Algebra: Matrix Algebra, Systems of linear equations, Eigen values and eigen vectors.

Calculus: Mean value theorems, Theorems of integral calculus, Evaluation of definite and improper integrals, Partial Derivatives, Maxima and minima, Multiple integrals, Fourier series. Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equation (linear and nonlinear), Higher order linear differential equations with constant coefficients, Method of variation of parameters, Cauchy's and Euler's equations, Initial and boundary value problems, Partial Differential Equations and variable separable method.

Complex variables: Analytic functions, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, Residue theorem, solution integrals.

Probability and Statistics: Sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Discrete and continuous distributions, Poisson, Normal and Binomial distribution, Correlation and regression analysis.

Numerical Methods: Solutions of non-linear algebraic equations, single and multi-step methods for differential equations.

Transform Theory: Fourier transform, Laplace transform, Z-transform.

Electronics And Communication Engineering

Networks: Network graphs: matrices associated with graphs; incidence, fundamental cut set and fundamental circuit matrices. Solution methods: nodal and mesh analysis. Network theorems: superposition, Thevenin and Norton's maximum power transfer, Wye-Delta transformation. Steady state sinusoidal analysis using phasors. Linear constant coefficient differential equations; time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits. 2-port network parameters: driving point and transfer functions. State equations for networks.

Electronic Devices: Energy bands in silicon, intrinsic and extrinsic silicon. Carrier transport in silicon: diffusion current, drift current, mobility, and resistivity. Generation and recombination of carriers. p-n junction diode, Zener diode, tunnel diode, BJT, JFET, MOS capacitor, MOSFET, LED, p-i-n and avalanche photo diode, Basics of LASERS. Device technology: integrated circuits fabrication process, oxidation, diffusion, ion implantation, photolithography, n-tub, p-tub and twin-tub CMOS process.

Analog Circuits: Small Signal Equivalent circuits of diodes, BJTs, MOSFETs and analog CMOS. Simple diode circuits, clipping, clamping, rectifier. Biasing and bias stability of transistor and FET amplifiers. Amplifiers: single- and multi-stage, differential and operational, feedback, and power. Frequency response of amplifiers. Simple op-amp circuits. Filters. Sinusoidal oscillators; criterion for oscillation; single-transistor and op-amp configurations. Function generators and wave-shaping circuits, 555 Timers. Power supplies.

Digital circuits: Boolean algebra, minimization of Boolean functions; logic gates; digital IC families (DTL, TTL, ECL, MOS, CMOS). Combinatorial circuits: arithmetic circuits, code converters, multiplexers, decoders, PROMs and PLAs. Sequential circuits: latches and flip-flops, counters and shift-registers. Sample and hold circuits, ADCs, DACs. Semiconductor memories. Microprocessor(8085): architecture, programming, memory and I/O interfacing.

Signals and Systems: Definitions and properties of Laplace transform, continuous-time and discrete-time Fourier series, continuous-time and discrete-time Fourier Transform, DFT and FFT, z-transform.

Sampling theorem. Linear Time-Invariant (LTI) Systems: definitions and properties; causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay. Signal transmission through LTI systems.

Control Systems: Basic control system components; block diagrammatic description, reduction of block diagrams. Open loop and closed loop (feedback) systems and stability analysis of these systems. Signal flow graphs and their use in determining transfer functions of systems; transient and steady state analysis of LTI control systems and frequency response. Tools and techniques for LTI control system analysis: root loci, Routh-Hurwitz criterion, Bode and Nyquist plots. Control system compensators: elements of lead and lag compensation, elements of Proportional-Integral-Derivative (PID) control. State variable representation and solution of state equation of LTI control systems.

Communications: Random signals and noise: probability, random variables, probability density function, autocorrelation, power spectral density. Analog communication systems: amplitude and angle modulation and demodulation systems, spectral analysis of these operations, superheterodyne receivers; elements of hardware, realizations of analog communication systems; signal-to-noise ratio (SNR) calculations for amplitude modulation (AM) and frequency modulation (FM) for low noise conditions. Fundamentals of information theory and channel capacity theorem. Digital communication systems: pulse code modulation (PCM), differential pulse code modulation (DPCM), digital modulation schemes: amplitude, phase and frequency shift keying schemes (ASK, PSK, FSK), matched filter receivers, bandwidth consideration and probability of error calculations for these schemes. Basics of TDMA, FDMA and CDMA and GSM.

Electromagnetics: Elements of vector calculus: divergence and curl; Gauss' and Stokes' theorems, Maxwell's equations: differential and integral forms. Wave equation, Poynting vector. Plane waves: propagation through various media; reflection and refraction; phase and group velocity; skin depth. Transmission lines: characteristic impedance; impedance transformation; Smith chart; impedance matching; S parameters, pulse excitation. Waveguides: modes in rectangular waveguides; boundary conditions; cut-off frequencies; dispersion relations. Basics of propagation in dielectric waveguide and optical fibers. Basics of Antennas: Dipole antennas; radiation pattern; antenna gain.

4.5.11 Electrical Engineering (EE)

Engineering Mathematics

Linear Algebra: Matrix Algebra, Systems of linear equations, Eigen values and eigen vectors.

Calculus: Mean value theorems, Theorems of integral calculus, Evaluation of definite and improper integrals, Partial Derivatives, Maxima and minima, Multiple integrals, Fourier series. Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equation (linear and nonlinear), Higher order linear differential equations with constant coefficients, Method of variation of parameters, Cauchy's and Euler's equations, Initial and boundary value problems, Partial Differential Equations and variable separable method.

Complex variables: Analytic functions, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, Residue theorem, solution integrals.

Probability and Statistics: Sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Discrete and continuous distributions, Poisson, Normal and Binomial distribution, Correlation and regression analysis.

Numerical Methods: Solutions of non-linear algebraic equations, single and multi-step methods for differential equations.

Transform Theory: Fourier transform, Laplace transform, Z-transform.

Electrical Engineering

Electric Circuits and Fields: Network graph, KCL, KVL, node and mesh analysis, transient response of dc and ac networks; sinusoidal steady-state analysis, resonance, basic filter concepts; ideal current and voltage sources, Thevenin's, Norton's and Superposition and Maximum Power Transfer theorems, two-port networks, three phase circuits; Gauss Theorem, electric field and potential due to point, line, plane and spherical charge distributions; Ampere's and Biot-Savart's laws; inductance; dielectrics; capacitance.

Signals and Systems: Representation of continuous and discrete-time signals; shifting and scaling operations; linear, time-invariant and causal systems; Fourier series representation of continuous periodic signals; sampling theorem; Fourier, Laplace and Z transforms.

Electrical Machines: Single phase transformer – equivalent circuit, phasor diagram, tests, regulation and efficiency; three phase transformers – connections, parallel operation; auto-transformer; energy conversion principles; DC machines – types, windings, generator characteristics, armature reaction and commutation, starting and speed control of motors; three phase induction motors – principles, types, performance characteristics, starting and speed control; single phase induction motors; synchronous machines – performance, regulation and parallel operation of generators, motor starting, characteristics and applications; servo and stepper motors.

Power Systems: Basic power generation concepts; transmission line models and performance; cable performance, insulation; corona and radio interference; distribution systems; per-unit quantities; bus impedance and admittance matrices; load flow; voltage control; power factor correction; economic operation; symmetrical components; fault analysis; principles of over-current, differential and distance protection; solid state relays and digital protection; circuit breakers; system stability concepts, swing curves and equal area criterion; HVDC transmission and FACTS concepts.

Control Systems: Principles of feedback; transfer function; block diagrams; steady-state errors; Routh and Nyquist techniques; Bode plots; root loci; lag, lead and lead-lag compensation; state space model; state transition matrix, controllability and observability.

Electrical and Electronic Measurements: Bridges and potentiometers; PMMC, moving iron, dynamometer and induction type instruments; measurement of voltage, current, power, energy and power factor; instrument transformers; digital voltmeters and multimeters; phase, time and frequency measurement; Q-meters; oscilloscopes; potentiometric recorders; error analysis.

Analog and Digital Electronics: Characteristics of diodes, BJT, FET; amplifiers – biasing, equivalent circuit and frequency response; oscillators and feedback amplifiers; operational amplifiers – characteristics and applications; simple active filters; VCOs and timers; combinational and sequential logic circuits; multiplexer; Schmitt trigger; multi-vibrators; sample and hold circuits; A/D and D/A converters; 8-bit microprocessor basics, architecture, programming and interfacing.

Power Electronics and Drives: Semiconductor power diodes, transistors, thyristors, triacs, GTOs, MOSFETs and IGBTs – static characteristics and principles of operation; triggering circuits; phase control rectifiers; bridge converters – fully controlled and half controlled; principles of choppers and inverters; basis concepts of adjustable speed dc and ac drives.

4.5.12 Geology and Geophysics (GG)

4.5.12.1 *Part A: Common To Geology And Geophysics*

Earth and Planetary system, size, shape, internal structure and composition of the earth; atmosphere and greenhouse effect; isostasy; elements of seismology; physical properties of the interior of the earth; continents and continental processes; physical oceanography; geomagnetism and paleomagnetism, continental drift, plate tectonics.

Weathering; soil formation; action of river, wind, glacier and ocean; earthquakes, volcanism and orogeny. Basic structural geology, mineralogy and petrology. Geological time scale and geochronology; stratigraphic principles; major stratigraphic divisions of India. Engineering properties of rocks and soils. Ground water geology. Geological and geographical distribution of ore, coal and petroleum resources of India.

Introduction to remote sensing. Physical basis and applications of gravity, magnetic, electrical, electromagnetic, seismic and radiometric prospecting for oil, mineral and ground water; introductory well logging.

4.5.12.2 *Part B – Section 1: Geology*

Crystal symmetry, forms, twinning; crystal chemistry; optical mineralogy, classification of minerals, diagnostic physical and optical properties of rock forming minerals.

Igneous rocks – classification, forms and textures, magmatic differentiation; phase diagrams and trace elements as monitors of magma evolutionary processes; mantle melting models and derivation and primary magmas. Metamorphism; controlling factors, metamorphic facies, grade and basic types; metamorphism of pelitic, mafic and impure carbonate rocks; role of fluids in metamorphism; metamorphic P-T-t paths and their tectonic significance; Igneous and metamorphic provinces of India; structure and petrology of sedimentary rocks; sedimentary processes and environments, sedimentary facies, basin analysis; association of igneous, sedimentary and metamorphic rocks with tectonic setting.

Stress, strain and material response; brittle and ductile deformation; primary and secondary structures; geometry and genesis of folds, faults, joints, unconformities; cleavage, schistosity and lineation; methods of projection, tectonites and their significance; shear zone; superposed folding; basement cover relationship.

Morphology, classification and geological significance of important invertebrates, vertebrates, microfossils and palaeoflora; stratigraphic principles and Indian stratigraphy.

Geomorphic processes and agents; development and evolution of landforms; slope and drainage; processes on deep oceanic and near-shore regions; quantitative and applied geomorphology.

Ore mineralogy and optical properties of ore minerals; ore forming processes vis-à-vis ore-rock association (magmatic, hydrothermal, sedimentary and metamorphogenic ores); ores and metamorphism; fluid inclusions as an ore genetic tool; prospecting and exploration of economic minerals; sampling, ore reserve estimation, geostatistics, mining methods. Coal and petroleum geology; origin and distribution of mineral and fuel deposits in India; marine geology and ocean resources; ore dressing and mineral economics.

Cosmic abundance; meteorites; geochemical evolution of the earth; geochemical cycles; distribution of major, minor and trace elements; elements of geochemical thermodynamics, isotope geochemistry; geochemistry of waters including solution equilibria and water rock interaction.

Engineering properties of rocks and soils; rocks as construction materials; role of geology in the construction of engineering structures including dams, tunnels and excavation sites; natural hazards. Ground water geology – exploration, well hydraulics and water quality. Basic principles of remote sensing – energy sources and radiation principles, atmospheric absorption, interaction of energy with earth's surface, air-photo interpretation, multispectral remote sensing in visible, infrared, thermal IR and microwave regions, digital processing of satellite images. GIS – basic concepts, raster and vector mode operation.

4.5.12.3 *Part B – Section 2: Geophysics*

The earth as a planet; different motions of the earth; gravity field of the earth, Clairaut's theorem, size and shape of earth; geochronology; seismology and interior of the earth; variation of density, velocity, pressure, temperature, electrical and magnetic properties of the earth; earthquakes-causes and measurements, magnitude and intensity, focal mechanisms, earthquake quantification, source characteristics, seismotectonics and seismic hazards; digital seismographs, geomagnetic field, paleomagnetism; oceanic and continental lithosphere; plate tectonics; heat flow; upper and lower atmospheric phenomena.

Scalar and vector potential fields; Laplace, Maxwell and Helmholtz equations for solution of different types of boundary value problems in Cartesian, cylindrical and spherical polar coordinates; Green's theorem; Image theory; integral equations in potential theory; Eikonal equation and Ray theory. Basic concepts of forward and inverse problems of geophysics, Ill-posedness of inverse problems.

'G' and 'g' units of measurement, absolute and relative gravity measurements; Land, airborne, shipborne and bore-hole gravity surveys; various corrections in gravity data reduction – free air, Bouguer and isostatic anomalies; density estimates of rocks; regional and residual gravity separation; principle of equivalent stratum; upward and downward continuation; wavelength filtering; preparation and analysis of gravity maps; gravity anomalies and their interpretation – anomalies due to geometrical and irregular shaped bodies, depth rules, calculation of mass.

Earth's magnetic field – elements, origin and units of measurement, magnetic susceptibility of rocks and measurements, magnetometers, Land, airborne and marine magnetic surveys, corrections, preparation of magnetic maps, upward and downward continuation, magnetic anomalies-geometrical shaped bodies, depth estimates, Image processing concepts in processing of magnetic anomaly maps; Interpretation of processed magnetic anomaly data.

Conduction of electricity through rocks, electrical conductivities of metals, non-metals, rock forming minerals and different rocks, concepts of D.C. resistivity measurement, various electrode configurations for resistivity sounding and profiling, application of filter theory, Type-curves over multi-layered structures, Dar-Zarrouck parameters, reduction of layers, coefficient of anisotropy, interpretation of resistivity field data, equivalence and suppression, self potential and its origin, field measurement, Induced polarization, time and frequency domain IP measurements; interpretation and applications of IP, ground-water exploration, environmental and engineering applications.

Basic concept of EM induction, Origin of electromagnetic field, elliptic polarization, methods of measurement for different source-receiver configuration, components in EM measurements. Skin-depth, interpretation and applications; earth's natural electromagnetic field, tellurics, magneto-tellurics; geomagnetic depth sounding principles, electromagnetic profiling, methods of measurement, processing of data and interpretation. Geological applications including groundwater, mining and hydrocarbon exploration.

Seismic methods of prospecting; Elastic properties of earth materials; Reflection, refraction and CDP surveys; land and marine seismic sources, generation and propagation of elastic waves, velocity – depth models, geophones, hydrophones, recording instruments (DFS), digital formats, field layouts, seismic noises and noise profile analysis, optimum geophone grouping, noise cancellation by shot and geophone arrays, 2D and 3D seismic data acquisition, processing and interpretation; CDP stacking charts, binning,

filtering, dip-moveout, static and dynamic corrections, Digital seismic data processing, seismic deconvolution and migration methods, attribute analysis, bright and dim spots, seismic stratigraphy, high resolution seismics, VSP, AVO. Reservoir geophysics.

Geophysical signal processing, sampling theorem, aliasing, Nyquist frequency, Fourier series, periodic waveform, Fourier and Hilbert transform, Z-transform and wavelet transform; power spectrum, delta function, auto correlation, cross correlation, convolution, deconvolution, principles of digital filters, windows, poles and zeros.

Principles and techniques of geophysical well-logging. SP, resistivity, induction, gamma ray, neutron, density, sonic, temperature, dip meter, caliper, nuclear magnetic, cement bond logging, micro-logs. Quantitative evaluation of formations from well logs; well hydraulics and application of geophysical methods for groundwater study; application of bore hole geophysics in ground water, mineral and oil exploration.

Radioactive methods of prospecting and assaying of minerals (radioactive and non radioactive) deposits, half-life, decay constant, radioactive equilibrium, G M counter, scintillation detector, semiconductor devices, application of radiometric for exploration and radioactive waste disposal.

Geophysical inverse problems; non-uniqueness and stability of solutions; quasi-linear and non-linear methods including Tikhonov's regularization method, Backus-Gilbert method, simulated annealing, genetic algorithms and artificial neural network.

4.5.13 Instrumentation Engineering (IN)

Engineering Mathematics

Linear Algebra: Matrix Algebra, Systems of linear equations, Eigen values and eigen vectors.

Calculus: Mean value theorems, Theorems of integral calculus, Evaluation of definite and improper integrals, Partial Derivatives, Maxima and minima, Multiple integrals, Fourier series. Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equation (linear and nonlinear), Higher order linear differential equations with constant coefficients, Method of variation of parameters, Cauchy's and Euler's equations, Initial and boundary value problems, Partial Differential Equations and variable separable method.

Complex variables: Analytic functions, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, Residue theorem, solution integrals.

Probability and Statistics: Sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Discrete and continuous distributions, Poisson, Normal and Binomial distribution, Correlation and regression analysis.

Numerical Methods: Solutions of non-linear algebraic equations, single and multi-step methods for differential equations.

Transform Theory: Fourier transform, Laplace transform, Z-transform.

Instrumentation Engineering

Basics of Circuits and Measurement Systems: Kirchoff's laws, mesh and nodal Analysis. Circuit theorems. One-port and two-port Network Functions. Static and dynamic characteristics of Measurement Systems. Error and uncertainty analysis. Statistical analysis of data and curve fitting.

Transducers, Mechanical Measurement and Industrial Instrumentation: Resistive, Capacitive, Inductive and piezoelectric transducers and their signal conditioning. Measurement of displacement, velocity and acceleration (translational and rotational), force, torque, vibration and shock. Measurement of pressure, flow, temperature and liquid level. Measurement of pH, conductivity, viscosity and humidity.

Analog Electronics: Characteristics of diode, BJT, JFET and MOSFET. Diode circuits. Transistors at low and high frequencies, Amplifiers, single and multi-stage. Feedback amplifiers. Operational amplifiers, characteristics and circuit configurations. Instrumentation amplifier. Precision rectifier. V-to-I and I-to-V converter. Op-Amp based active filters. Oscillators and signal generators.

Digital Electronics: Combinational logic circuits, minimization of Boolean functions. IC families, TTL, MOS and CMOS. Arithmetic circuits. Comparators, Schmitt trigger, timers and mono-stable multi-vibrator. Sequential circuits, flip-flops, counters, shift registers. Multiplexer, S/H circuit. Analog-to-Digital and Digital-to-Analog converters. Basics of number system. Microprocessor applications, memory and input-output interfacing. Microcontrollers.

Signals, Systems and Communications: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first- and second order systems. Convolution, correlation and characteristics of linear time invariant systems. Discrete time system, impulse and frequency response. Pulse transfer function. IIR and FIR filters. Amplitude and frequency modulation and demodulation. Sampling theorem, pulse code modulation. Frequency and time division multiplexing. Amplitude shift keying, frequency shift keying and pulse shift keying for digital modulation.

Electrical and Electronic Measurements: Bridges and potentiometers, measurement of R, L and C. Measurements of voltage, current, power, power factor and energy. A.C & D.C current probes. Extension

of instrument ranges. Q-meter and waveform analyzer. Digital voltmeter and multi-meter. Time, phase and frequency measurements. Cathode ray oscilloscope. Serial and parallel communication. Shielding and grounding.

Control Systems and Process Control: Feedback principles. Signal flow graphs. Transient Response, steady-state-errors. Routh and Nyquist criteria. Bode plot, root loci. Time delay systems. Phase and gain margin. State space representation of systems. Mechanical, hydraulic and pneumatic system components. Synchro pair, servo and step motors. On-off, cascade, P, P-I, P-I-D, feed forward and derivative controller, Fuzzy controllers.

Analytical, Optical and Biomedical Instrumentation: Mass spectrometry. UV, visible and IR spectrometry. X-ray and nuclear radiation measurements. Optical sources and detectors, LED, laser, Photo-diode, photo-resistor and their characteristics. Interferometers, applications in metrology. Basics of fiber optics. Biomedical instruments, EEG, ECG and EMG. Clinical measurements. Ultrasonic transducers and Ultrasonography. Principles of Computer Assisted Tomography.

4.5.14 Mathematics (MA)

Linear Algebra: Finite dimensional vector spaces; Linear transformations and their matrix representations, rank; systems of linear equations, eigen values and eigen vectors, minimal polynomial, Cayley-Hamilton Theorem, diagonalisation, Hermitian, Skew-Hermitian and unitary matrices; Finite dimensional inner product spaces, Gram-Schmidt orthonormalization process, self-adjoint operators.

Complex Analysis: Analytic functions, conformal mappings, bilinear transformations; complex integration: Cauchy's integral theorem and formula; Liouville's theorem, maximum modulus principle; Taylor and Laurent's series; residue theorem and applications for evaluating real integrals.

Real Analysis: Sequences and series of functions, uniform convergence, power series, Fourier series, functions of several variables, maxima, minima; Riemann integration, multiple integrals, line, surface and volume integrals, theorems of Green, Stokes and Gauss; metric spaces, completeness, Weierstrass approximation theorem, compactness; Lebesgue measure, measurable functions; Lebesgue integral, Fatou's lemma, dominated convergence theorem.

Ordinary Differential Equations: First order ordinary differential equations, existence and uniqueness theorems, systems of linear first order ordinary differential equations, linear ordinary differential equations of higher order with constant coefficients; linear second order ordinary differential equations with variable coefficients; method of Laplace transforms for solving ordinary differential equations, series solutions; Legendre and Bessel functions and their orthogonality.

Algebra: Normal subgroups and homomorphism theorems, automorphisms; Group actions, Sylow's theorems and their applications; Euclidean domains, Principal ideal domains and unique factorization domains. Prime ideals and maximal ideals in commutative rings; Fields, finite fields.

Functional Analysis: Banach spaces, Hahn-Banach extension theorem, open mapping and closed graph theorems, principle of uniform boundedness; Hilbert spaces, orthonormal bases, Riesz representation theorem, bounded linear operators.

Numerical Analysis: Numerical solution of algebraic and transcendental equations: bisection, secant method, Newton-Raphson method, fixed point iteration; interpolation: error of polynomial interpolation, Lagrange, Newton interpolations; numerical differentiation; numerical integration: Trapezoidal and Simpson rules, Gauss Legendre quadrature, method of undetermined parameters; least square polynomial approximation; numerical solution of systems of linear equations: direct methods (Gauss elimination, LU decomposition); iterative methods (Jacobi and Gauss-Seidel); matrix eigenvalue problems: power method, numerical solution of ordinary differential equations: initial value problems: Taylor series methods, Euler's method, Runge-Kutta methods.

Partial Differential Equations: Linear and quasilinear first order partial differential equations, method of characteristics; second order linear equations in two variables and their classification; Cauchy, Dirichlet and Neumann problems; solutions of Laplace, wave and diffusion equations in two variables; Fourier series and Fourier transform and Laplace transform methods of solutions for the above equations.

Mechanics: Virtual work, Lagrange's equations for holonomic systems, Hamiltonian equations.

Topology: Basic concepts of topology, product topology, connectedness, compactness, countability and separation axioms, Urysohn's Lemma.

Probability and Statistics: Probability space, conditional probability, Bayes theorem, independence, Random variables, joint and conditional distributions, standard probability distributions and their properties, expectation, conditional expectation, moments; Weak and strong law of large numbers, central limit theorem; Sampling distributions, UMVU estimators, maximum likelihood estimators, Testing of

hypotheses, standard parametric tests based on normal, X^2 , t , F – distributions; Linear regression; Interval estimation.

Linear programming: Linear programming problem and its formulation, convex sets and their properties, graphical method, basic feasible solution, simplex method, big-M and two phase methods; infeasible and unbounded LPP's, alternate optima; Dual problem and duality theorems, dual simplex method and its application in post optimality analysis; Balanced and unbalanced transportation problems, u -u method for solving transportation problems; Hungarian method for solving assignment problems.

Calculus of Variation and Integral Equations: Variation problems with fixed boundaries; sufficient conditions for extremum, linear integral equations of Fredholm and Volterra type, their iterative solutions.

4.5.15 Mechanical Engineering (ME)

Engineering Mathematics

Linear Algebra: Matrix algebra, Systems of linear equations, Eigen values and eigen vectors.

Calculus: Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one dimensional heat and wave equations and Laplace equation.

Complex variables: Analytic functions, Cauchy's integral theorem, Taylor and Laurent series.

Probability and Statistics: Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpson's rule, single and multi-step methods for differential equations.

Applied Mechanics And Design

Engineering Mechanics: Free body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion, including impulse and momentum (linear and angular) and energy formulations; impact.

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; torsion of circular shafts; Euler's theory of columns; strain energy methods; thermal stresses.

Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of slider-crank mechanism; gear trains; flywheels.

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

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, spur gears, rolling and sliding contact bearings, brakes and clutches.

Fluid Mechanics And Thermal Sciences

Fluid Mechanics: Fluid properties; fluid statics, manometry, buoyancy; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; viscous flow of incompressible fluids; boundary layer; elementary turbulent flow; flow through pipes, head losses in pipes, bends etc.

Heat-Transfer: Modes of heat transfer; one dimensional heat conduction, resistance concept, electrical analogy, unsteady heat conduction, fins; dimensionless parameters in free and forced convective heat transfer, various correlations for heat transfer in flow over flat plates and through pipes; thermal boundary

layer; effect of turbulence; radiative heat transfer, black and grey surfaces, shape factors, network analysis; heat exchanger performance, LMTD and NTU methods.

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

Applications: *Power Engineering:* Steam Tables, Rankine, Brayton cycles with regeneration and reheat. *I.C. Engines:* air-standard Otto, Diesel cycles. *Refrigeration and air-conditioning:* Vapour refrigeration cycle, heat pumps, gas refrigeration, Reverse Brayton cycle; moist air: psychrometric chart, basic psychrometric processes. *Turbomachinery:* Pelton-wheel, Francis and Kaplan turbines — impulse and reaction principles, velocity diagrams.

Manufacturing And Industrial Engineering

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

Metal Casting: Design of patterns, moulds and cores; solidification and cooling; riser and gating design, design considerations.

Forming: 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.

Joining: Physics of welding, brazing and soldering; adhesive bonding; design considerations in welding.

Machining and Machine Tool Operations: Mechanics of machining, 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, principles of design of jigs and fixtures

Metrology and Inspection: Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly.

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

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

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

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

4.5.16 Mining Engineering (MN)

Engineering Mathematics

Linear Algebra: Matrices and Determinants, Systems of linear equations, Eigen values and Eigen vectors.

Calculus: Limit, continuity and differentiability; Partial Derivatives; Maxima and minima; Sequences and series; Test for convergence; Fourier series.

Vector Calculus: Gradient; Divergence and Curl; Line; surface and volume integrals; Stokes, Gauss and Green's theorems.

Differential Equations: Linear and non-linear first order ODEs; Higher order linear ODEs with constant coefficients; Cauchy's and Euler's equations; Laplace transforms; PDEs –Laplace, heat and wave equations.

Probability and Statistics: Mean, median, mode and standard deviation; Random variables; Poisson, normal and binomial distributions; Correlation and regression analysis.

Numerical Methods: Solutions of linear and non-linear algebraic equations; integration of trapezoidal and Simpson's rule; single and multi-step methods for differential equations.

Mining Engineering

Mechanics: Equivalent force systems; Equations of equilibrium; Two dimensional frames and trusses; Free body diagrams; Friction forces; Particle kinematics and dynamics.

Mine Development, Geomechanics and Ground Control: Methods of access to deposits; Underground drivages; Drilling methods and machines; Explosives, blasting devices and practices.

Geo-technical properties of rocks; Rock mass classification; Ground control, instrumentation and stress measurement techniques; Theories of rock failure; Ground vibrations; Stress distribution around mine openings; Subsidence; Design of supports in roadways and workings; Rock bursts and coal bumps; Slope stability.

Mining Methods and Machinery: Surface mining: layout, development, loading, transportation and mechanization, continuous surface mining systems; Underground coal mining: bord and pillar systems, room and pillar mining, longwall mining, thick seam mining methods; Underground metal mining : open, supported and caved stope methods, stope mechanization, ore handling systems, mine filling.

Generation and transmission of mechanical, hydraulic and pneumatic power; Materials handling: haulages, conveyors, face and development machinery, hoisting systems, pumps.

Ventilation, Underground Hazards and Surface Environment: Underground atmosphere; Heat load sources and thermal environment, air cooling; Mechanics of air flow, distribution, natural and mechanical ventilation; Mine fans and their usage; Auxiliary ventilation; Ventilation planning.

Subsurface hazards from fires, explosions, gases, dust and inundation; Rescue apparatus and practices; Safety in mines, accident analysis, noise, mine lighting, occupational health and risk.

Air, water and soil pollution : causes, dispersion, quality standards, reclamation and control.

Surveying, Mine Planning and Systems Engineering: Fundamentals of engineering surveying; Levels and leveling, theodolite, tachymetry, triangulation, contouring, errors and adjustments, correlation;

Underground surveying; Curves; Photogrammetry; Field astronomy; EDM, total station and GPS fundamentals.

Principles of planning: Sampling methods and practices, reserve estimation techniques, basics of geostatistics and quality control, optimization of facility location, cash flow concepts and mine valuation, open pit design; GIS fundamentals.

Work-study; Concepts of reliability, reliability of series and parallel systems.

Linear programming, transportation and assignment problems, queueing, network analysis, basics of simulation.

4.5.17 Metallurgical Engineering (MT)

Engineering Mathematics

Linear Algebra: Matrices and Determinants, Systems of linear equations, Eigen values and Eigen vectors.

Calculus: Limit, continuity and differentiability; Partial Derivatives; Maxima and minima; Sequences and series; Test for convergence; Fourier series.

Vector Calculus: Gradient; Divergence and Curl; Line; surface and volume integrals; Stokes, Gauss and Green's theorems.

Differential Equations: Linear and non-linear first order ODEs; Higher order linear ODEs with constant coefficients; Cauchy's and Euler's equations; Laplace transforms; PDEs –Laplace, heat and wave equations.

Probability and Statistics: Mean, median, mode and standard deviation; Random variables; Poisson, normal and binomial distributions; Correlation and regression analysis.

Numerical Methods: Solutions of linear and non-linear algebraic equations; integration of trapezoidal and Simpson's rule; single and multi-step methods for differential equations.

Metallurgical Engineering

Thermodynamics and Rate Processes: Laws of thermodynamics, activity, equilibrium constant, applications to metallurgical systems, solutions, phase equilibria, Ellingham and phase stability diagrams, thermodynamics of surfaces, interfaces and defects, adsorption and segregation; basic kinetic laws, order of reactions, rate constants and rate limiting steps; principles of electro chemistry- single electrode potential, electro-chemical cells and polarizations, aqueous corrosion and protection of metals, oxidation and high temperature corrosion – characterization and control; heat transfer – conduction, convection and heat transfer coefficient relations, radiation, mass transfer – diffusion and Fick's laws, mass transfer coefficients; momentum transfer – concepts of viscosity, shell balances, Bernoulli's equation, friction factors.

Extractive Metallurgy: Minerals of economic importance, comminution techniques, size classification, Flotation, gravity and other methods of mineral processing; agglomeration, pyro- hydro- and electro-metallurgical processes; material and energy balances; principles and processes for the extraction of non-ferrous metals – aluminium, copper, zinc, lead, magnesium, nickel, titanium and other rare metals; iron and steel making – principles, role structure and properties of slags, metallurgical coke, blast furnace, direct reduction processes, primary and secondary steel making, ladle metallurgy operations including deoxidation, desulphurization, sulphide shape control, inert gas rinsing and vacuum reactors; secondary refining processes including AOD, VAD, VOD, VAR and ESR; ingot and continuous casting; stainless steel making, furnaces and refractories.

Physical Metallurgy: Crystal structure and bonding characteristics of metals, alloys, ceramics and polymers, structure of surfaces and interfaces, nano-crystalline and amorphous structures; solid solutions; solidification; phase transformation and binary phase diagrams; principles of heat treatment of steels, cast iron and aluminum alloys; surface treatments; recovery, recrystallization and grain growth; industrially important ferrous and non-ferrous alloys; elements of X-ray and electron diffraction; principles of scanning and transmission electron microscopy; industrial ceramics, polymers and composites; electronic basis of thermal, optical, electrical and magnetic properties of materials; electronic and opto-electronic materials.

Mechanical Metallurgy: Elasticity, yield criteria and plasticity; defects in crystals; elements of dislocation theory – types of dislocations, slip and twinning, source and multiplication of dislocations, stress fields around dislocations, partial dislocations, dislocation interactions and reactions; strengthening mechanisms; tensile, fatigue and creep behaviour; super-plasticity; fracture – Griffith theory, basic concepts of linear elastic and elasto-plastic fracture mechanics, ductile to brittle transition, fracture toughness; failure analysis; mechanical testing – tension, compression, torsion, hardness, impact, creep, fatigue, fracture toughness and formability.

Manufacturing Processes: Metal casting – patterns and moulds including mould design involving feeding, gating and risering, melting, casting practices in sand casting, permanent mould casting, investment casting and shell moulding, casting defects and repair; 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 – soldering, brazing and welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints; powder metallurgy; NDT using dye-penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle methods.

4.5.18 Physics (PH)

Mathematical Physics: Linear vector space; matrices; vector calculus; linear differential equations; elements of complex analysis; Laplace transforms, Fourier analysis, elementary ideas about tensors.

Classical Mechanics: Conservation laws; central forces, Kepler problem and planetary motion; collisions and scattering in laboratory and centre of mass frames; mechanics of system of particles; rigid body dynamics; moment of inertia tensor; noninertial frames and pseudo forces; variational principle; Lagrange's and Hamilton's formalisms; equation of motion, cyclic coordinates, Poisson bracket; periodic motion, small oscillations, normal modes; special theory of relativity – Lorentz transformations, relativistic kinematics, mass-energy equivalence.

Electromagnetic Theory: Solution of electrostatic and magnetostatic problems including boundary value problems; dielectrics and conductors; Biot-Savart's and Ampere's laws; Faraday's law; Maxwell's equations; scalar and vector potentials; Coulomb and Lorentz gauges; Electromagnetic waves and their reflection, refraction, interference, diffraction and polarization. Poynting vector, Poynting theorem, energy and momentum of electromagnetic waves; radiation from a moving charge.

Quantum Mechanics: Physical basis of quantum mechanics; uncertainty principle; Schrodinger equation; one, two and three dimensional potential problems; particle in a box, harmonic oscillator, hydrogen atom; linear vectors and operators in Hilbert space; angular momentum and spin; addition of angular momenta; time independent perturbation theory; elementary scattering theory.

Thermodynamics and Statistical Physics: Laws of thermodynamics; macrostates and microstates; phase space; probability 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, critical point.

Atomic and Molecular Physics: Spectra of one- and many-electron atoms; LS and jj coupling; hyperfine structure; Zeeman and Stark effects; electric dipole transitions and selection rules; X-ray spectra; rotational and vibrational spectra of diatomic molecules; electronic transition in diatomic molecules, Franck-Condon principle; Raman effect; NMR and ESR; lasers.

Solid State Physics: Elements of crystallography; diffraction methods for structure determination; bonding in solids; elastic properties of solids; defects in crystals; lattice vibrations and thermal properties of solids; free electron theory; band theory of solids; metals, semiconductors and insulators; transport properties; optical, dielectric and magnetic properties of solids; elements of superconductivity.

Nuclear and Particle Physics: Nuclear radii and charge distributions, nuclear binding energy, Electric and magnetic moments; nuclear models, liquid drop model – semi-empirical mass formula, Fermi gas model of nucleus, 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.

Electronics: Network analysis; semiconductor devices; Bipolar Junction Transistors, Field Effect Transistors, amplifier and oscillator circuits; operational amplifier, negative feedback circuits, **active filters and oscillators**; rectifier circuits, regulated power supplies; basic digital logic circuits, sequential circuits, flip-flops, counters, registers, A/D and D/A conversion.

4.5.19 Production and Industrial Engineering (PI)

Engineering Mathematics

Linear Algebra: Matrix algebra, Systems of linear equations, Eigen values and eigen vectors.

Calculus: Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one dimensional heat and wave equations and Laplace equation.

Complex variables: Analytic functions, Cauchy's integral theorem, Taylor and Laurent series.

Probability and Statistics: Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpson's rule, single and multi-step methods for differential equations.

General Engineering

Engineering Materials: Structure and properties of engineering materials and their applications; effect of strain, strain rate and temperature on mechanical properties of metals and alloys; heat treatment of metals and alloys, its influence on mechanical properties.

Applied Mechanics: Engineering mechanics – equivalent force systems, free body concepts, equations of equilibrium; strength of materials – stress, strain and their relationship, Mohr's circle, deflection of beams, bending and shear stress, Euler's theory of columns.

Theory of Machines and Design: Analysis of planar mechanisms, cams and followers; governors and fly wheels; design of elements – failure theories; design of bolted, riveted and welded joints; design of shafts, keys, spur gears, belt drives, brakes and clutches.

Thermal Engineering: Fluid mechanics – fluid statics, Bernoulli's equation, flow through pipes, equations of continuity and momentum; thermodynamics – zeroth, first and second law of thermodynamics, thermodynamic system and processes, calculation of work and heat for systems and control volumes; air standard cycles; basics of internal combustion engines and steam turbines; heat transfer – fundamentals of conduction, convection and radiation, heat exchangers.

Production Engineering

Metal Casting: Casting processes – types and applications; patterns – types and materials; allowances; moulds and cores – materials, making, and testing; casting techniques of cast iron, steels and nonferrous metals and alloys; solidification; design of casting, gating and risering; casting inspection, defects and remedies.

Metal Forming: Stress-strain relations in elastic and plastic deformation; concept of flow stress, deformation mechanisms; hot and cold working – forging, rolling, extrusion, wire and tube drawing; sheet

metal working processes such as blanking, piercing, bending, deep drawing, coining and embossing; analysis of rolling, forging, extrusion and wire /rod drawing; metal working defects.

Metal Joining Processes: Welding processes – manual metal arc, MIG, TIG, plasma arc, submerged arc, electroslag, thermit, resistance, forge, friction, and explosive welding; other joining processes – soldering, brazing, braze welding; inspection of welded joints, defects and remedies; introduction to advanced welding processes – ultrasonic, electron beam, laser beam; thermal cutting.

Machining and Machine Tool Operations: Basic machine tools; machining processes-turning, drilling, boring, milling, shaping, planing, gear cutting, thread production, broaching, grinding, lapping, honing, super finishing; mechanics of machining – geometry of cutting tools, chip formation, cutting forces and power requirements, Merchant's analysis; selection of machining parameters; tool materials, tool wear and tool life, economics of machining, thermal aspects of machining, cutting fluids, machinability; principles and applications of nontraditional machining processes – USM, AJM, WJM, EDM and Wire cut EDM, LBM, EBM, PAM, CHM, ECM.

Tool Engineering: Jigs and fixtures – principles, applications, and design; press tools – configuration, design of die and punch; principles of forging die design.

Metrology and Inspection: Limits, fits, and tolerances, interchangeability, selective assembly; linear and angular measurements by mechanical and optical methods, comparators; design of limit gauges; interferometry; measurement of straightness, flatness, roundness, squareness and symmetry; surface finish measurement; inspection of screw threads and gears; alignment testing of machine tools.

Powder Metallurgy: Production of metal powders, compaction and sintering.

Polymers and Composites: Introduction to polymers and composites; plastic processing – injection, compression and blow molding, extrusion, calendaring and thermoforming; molding of composites.

Manufacturing Analysis: Sources of errors in manufacturing; process capability; tolerance analysis in manufacturing and assembly; process planning; parameter selection and comparison of production alternatives; time and cost analysis; manufacturing technologies – strategies and selection.

Computer Integrated Manufacturing: Basic concepts of CAD, CAM, CAPP, cellular manufacturing, NC, CNC, DNC, Robotics, FMS, and CIM.

Industrial Engineering

Product Design and Development: Principles of good product design, tolerance design; quality and cost considerations; product life cycle; standardization, simplification, diversification, value engineering and analysis, concurrent engineering.

Engineering Economy and Costing: Elementary cost accounting and methods of depreciation; break-even analysis, techniques for evaluation of capital investments, financial statements.

Work System Design: Taylor's scientific management, Gilbreth's contributions; productivity – concepts and measurements; method study, micro-motion study, principles of motion economy; work measurement – stop watch time study, work sampling, standard data, PMTS; ergonomics; job evaluation, merit rating, incentive schemes, and wage administration; business process reengineering.

Facility Design: Facility location factors and evaluation of alternate locations; types of plant layout and their evaluation; computer aided layout design techniques; assembly line balancing; materials handling systems.

Production Planning and Inventory Control: Forecasting techniques – causal and time series models, moving average, exponential smoothing, trend and seasonality; aggregate production planning; master

production scheduling; MRP and MRP-II; order control and flow control; routing, scheduling and priority dispatching; push and pull production systems, concept of JIT manufacturing system; logistics, distribution, and supply chain management; Inventory – functions, costs, classifications, deterministic and probabilistic inventory models, quantity discount; perpetual and periodic inventory control systems.

Operation Research: Linear programming – problem formulation, simplex method, duality and sensitivity analysis; transportation and assignment models; network flow models, constrained optimization and Lagrange multipliers; simple queuing models; dynamic programming; simulation – manufacturing applications; PERT and CPM, time-cost trade-off, resource leveling.

Quality Management: Quality – concept and costs, quality circles, quality assurance; statistical quality control, acceptance sampling, zero defects, six sigma; total quality management; ISO 9000; design of experiments – Taguchi method.

Reliability and Maintenance: Reliability, availability and maintainability; distribution of failure and repair times; determination of MTBF and MTTR, reliability models; system reliability determination; preventive maintenance and replacement, total productive maintenance – concept and applications.

Management Information System: Value of information; information storage and retrieval system – database and data structures; knowledge based systems.

Intellectual Property System: Definition of intellectual property, importance of IPR; TRIPS and its implications, patent, copyright, industrial design and trademark.

4.5.20 Textile Engineering and Fibre Science (TF)

Engineering Mathematics

Linear Algebra: Matrices and Determinants, Systems of linear equations, Eigen values and eigen vectors.

Calculus: Limit, continuity and differentiability; Partial Derivatives; Maxima and minima; Sequences and series; Test for convergence; Fourier series.

Vector Calculus: Gradient; Divergence and Curl; Line; surface and volume integrals; Stokes, Gauss and Green's theorems.

Differential Equations: Linear and non-linear first order ODEs; Higher order linear ODEs with constant coefficients; Cauchy's and Euler's equations; Laplace transforms; PDEs –Laplace, heat and wave equations.

Probability and Statistics: Mean, median, mode and standard deviation; Random variables; Poisson, normal and binomial distributions; Correlation and regression analysis.

Numerical Methods: Solutions of linear and non-linear algebraic equations; integration of trapezoidal and Simpson's rule; single and multi-step methods for differential equations.

Textile Engineering And Fibre Science

Textile Fibres: Classification of textile fibres; Essential requirements of fibre forming polymers; Gross and fine structure of natural fibres like cotton, wool and silk. Introduction to important bastfibres; properties and uses of natural and man-made fibres; physical and chemical methods of fibre and blend identification and blend analysis.

Molecular architecture, amorphous and crystalline phases, glass transition, plasticization, crystallization, melting, factors affecting T_g and T_m ; Process of viscose and acetate preparation. Polymerization of nylon-6, nylon-66, poly (ethylene terephthalate), polyacrylonitrile and polypropylene; Melt Spinning processes, characteristic features of PET, polyamide and polypropylene spinning; wet and dry spinning of viscose and acrylic fibres; post spinning operations such as drawing, heat setting, tow-to-top conversion and different texturing methods.

Methods of investigating fibre structure e.g., Density, X-ray diffraction, birefringence, optical and electron microscopy, I.R. absorption, thermal methods (DSC, DMA/TMA, TGA); structure and morphology of man-made fibres, mechanical properties of fibres, moisture sorption in fibres; fibre structure and property correlation.

Yarn manufacture and yarn structure & properties: Principles of opening, cleaning and mixing/blending of fibrous materials, working principle of modern opening and cleaning equipments; the technology of carding, carding of cotton and synthetic fibres; Drafting operation, roller and apron drafting principle, causes of mass irregularity introduced by drafting; roller arrangements in drafting systems; principles of cotton combing, combing cycle, mechanism and function, combing efficiency, lap preparation; recent developments in comber; Roving production, mechanism of bobbin building, roving twist; Principle of ring spinning, forces acting on yarn and traveler; ring & traveler designs; mechanism of cop formation, causes of end breakages; working principle of ring doubler and two for one twister, single and folded yarn twist, properties of double yarns, production of core spun yarn, compact spinning, principle of non conventional methods of yarn production such as rotor spinning, air jet spinning, wrap spinning, twist less spinning and friction spinning.

Yarn contraction, yarn diameter, specific volume & packing coefficient; twist strength relationship in spun yarns; fibre configuration and orientation in yarn; cause of fibre migration and its estimation, irregularity index, properties of ring, rotor and air-jet yarns.

Fabric manufacture and Fabric Structure: Principles of cheese and cone winding processes and machines; random and precision winding; package faults and their remedies; yarn clearers and tensioners; different systems of yarn splicing; features of modern cone winding machines; different types of warping creels; features of modern beam and sectional warping machines; different sizing systems, sizing of spun and filament yarns, modern sizing machines; principles of pirn winding processes and machines; primary and secondary motions of loom, effect of their settings and timings on fabric formation, fabric appearance and weaving performance; dobby and jacquard shedding; mechanics of weft insertion with shuttle; warp and weft stop motions, warp protection, weft replenishment; functional principles of weft insertion systems of shuttle-less weaving machines, principles of multiphase and circular looms.

Principles of weft and warp knitting; basic weft and warp knitted structures. Classification, production and areas of application of nonwoven fabrics. Basic woven fabric constructions and their derivatives; crepe, cord, terry, gauze, leno and double cloth constructions. Peirce's equations for fabric geometry; elastica model of plain woven fabrics; thickness, cover and maximum sett of woven fabrics.

Textile Testing: Sampling techniques, sample size and sampling errors. Measurement of fibre length, fineness, crimp, strength and reflectance; measurement of cotton fibre maturity and trash content; HVI and AFIS for fibre testing. Measurement of yarn count, twist and hairiness; tensile testing of fibres, yarns and fabrics; evenness testing of slivers, rovings and yarns; testing equipment for measurement test methods of fabric properties like thickness, compressibility, air permeability, drape, crease recovery, tear strength, bursting strength and abrasion resistance. FAST and Kawabata instruments and systems for objective fabric evaluation. Statistical data analysis of experimental results. Correlation analysis, significance tests and analysis of variance; frequency distributions and control charts.

Preparatory Processes: Chemistry and practice of preparatory processes for cotton, wool and silk. Mercerization of cotton. Preparatory processes for nylon, polyester and acrylic and polyester/cotton blends.

Dyeing: Classification of dyes. Dyeing of cotton, wool, silk, polyester, nylon and acrylic with appropriate dye classes. Dyeing polyester/cotton and polyester/wool blends. Batchwise and continuous dyeing machines. Dyeing of cotton knitted fabrics and machines used. Dye fibre interaction. Introduction to thermodynamics and kinetics of dyeing. Methods for determination of wash, light and rubbing fastness. Evaluation of fastness properties with the help of grey scale.

Printing: Styles of printing. Printing thickeners including synthetic thickeners. Printing auxiliaries. Printing of cotton with reactive dyes. Printing of wool, silk, nylon with acid and metal complex dyes. Printing of polyester with disperse dyes. Methods of dye fixation after printing. Resist and discharge printing of cotton, silk and polyester. Printing of polyester/cotton blends with disperse/reactive combination. Transfer printing of polyester. Developments in inkjet printing.

Finishing: Mechanical finishing of cotton. Stiff. Soft, wrinkle resistant, water repellent, flame retardant and enzyme (bio-polishing) finishing of cotton. Milling, decatizing and shrink resistant finishing of wool. Antistat finishing of synthetic fibre fabrics. Heat setting of polyester.

Energy Conservation: Minimum application techniques.

Pollution: Environment pollution during chemical processing of textiles. Treatment of textile effluents.

4.5.21 Engineering Sciences (XE)

4.5.21.1 Section A: Engineering Mathematics (Compulsory)

Linear Algebra: Algebra of matrices, inverse, rank, system of linear equations, symmetric, skew-symmetric and orthogonal matrices. Hermitian, skew-Hermitian and unitary matrices. eigenvalues and eigenvectors, diagonalisation of matrices, Cayley-Hamilton Theorem.

Calculus: Functions of single variable, limit, continuity and differentiability, Mean value theorems, Indeterminate forms and L'Hospital rule, Maxima and minima, Taylor's series, Fundamental and mean value theorems of integral calculus. Evaluation of definite and improper integrals, Beta and Gamma functions, Functions of two variables, limit, continuity, partial derivatives, Euler's theorem for homogeneous functions, total derivatives, maxima and minima, Lagrange method of multipliers, double and triple integrals and their applications, sequence and series, tests for convergence, power series, Fourier Series, Half range sine and cosine series.

Complex variable: Analytic functions, Cauchy-Riemann equations, Application in solving potential problems, Line integral, Cauchy's integral theorem and integral formula (without proof), Taylor's and Laurent's series, Residue theorem (without proof) and its applications.

Vector Calculus: Gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, Stokes, Gauss and Green's theorems (without proofs) applications.

Ordinary Differential Equations: First order equation (linear and nonlinear), Second order linear differential equations with variable coefficients, Variation of parameters method, higher order linear differential equations with constant coefficients, Cauchy-Euler's equations, power series solutions, Legendre polynomials and Bessel's functions of the first kind and their properties.

Partial Differential Equations: Separation of variables method, Laplace equation, solutions of one dimensional heat and wave equations.

Probability and Statistics: Definitions of probability and simple theorems, conditional probability, Bayes Theorem, random variables, discrete and continuous distributions, Binomial, Poisson, and normal distributions, correlation and linear regression.

Numerical Methods: Solution of a system of linear equations by L-U decomposition, Gauss-Jordan and Gauss-Seidel Methods, Newton's interpolation formulae, Solution of a polynomial and a transcendental equation by Newton-Raphson method, numerical integration by trapezoidal rule, Simpson's rule and Gaussian quadrature, numerical solutions of first order differential equation by Euler's method and 4th order Runge-Kutta method.

4.5.21.2 Section B: Fluid Mechanics

Fluid Properties: Relation between stress and strain rate for Newtonian fluids.

Hydrostatics: Buoyancy, manometry, forces on submerged bodies.

Eulerian and Lagrangian description of fluid motion, concept of local and convective accelerations, steady and unsteady flows, control volume analysis for mass, momentum and energy.

Differential equations of mass and momentum (Euler equation), Bernoulli's equation and its applications.

Concept of fluid rotation, vorticity, stream function and potential function.

Potential flow: elementary flow fields and principle of superposition, potential flow past a circular cylinder.

Dimensional analysis: Concept of geometric, kinematic and dynamic similarity, importance of non-dimensional numbers.

Fully-developed pipe flow, laminar and turbulent flows, friction factor, Darcy-Weisbach relation.

Qualitative ideas of boundary layer and separation, streamlined and bluff bodies, drag and lift forces.

Basic ideas of flow measurement using venturimeter, pitot-static tube and orifice plate.

4.5.21.3 Section C: Materials Science

Structure: Atomic structure and bonding in materials. Crystal structure of materials, crystal systems, unit cells and space lattices, determination of structures of simple crystals by x-ray diffraction, miller indices of planes and directions, packing geometry in metallic, ionic and covalent solids. Concept of amorphous, single and polycrystalline structures and their effect on properties of materials. Crystal growth techniques. Imperfections in crystalline solids and their role in influencing various properties.

Diffusion: Fick's laws and application of diffusion in sintering, doping of semiconductors and surface hardening of metals.

Metals and Alloys: Solid solutions, solubility limit, phase rule, binary phase diagrams, intermediate phases, intermetallic compounds, iron-iron carbide phase diagram, heat treatment of steels, cold, hot working of metals, recovery, recrystallization and grain growth. Microstructure, properties and applications of ferrous and non-ferrous alloys.

Ceramics: Structure, properties, processing and applications of traditional and advanced ceramics.

Polymers: Classification, polymerization, structure and properties, additives for polymer products, processing and applications.

Composites: Properties and applications of various composites.

Advanced Materials and Tools: Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behavior, lasers and optical fibers, photoconductivity and superconductivity, nanomaterials – synthesis, properties and applications, biomaterials, superalloys, shape memory alloys. Materials characterization techniques such as, scanning electron microscopy, transmission electron microscopy, atomic force microscopy, scanning tunneling microscopy, atomic absorption spectroscopy, differential scanning calorimetry.

Mechanical Properties: stress-strain diagrams of metallic, ceramic and polymeric materials, modulus of elasticity, yield strength, tensile strength, toughness, elongation, plastic deformation, viscoelasticity, hardness, impact strength, creep, fatigue, ductile and brittle fracture.

Thermal Properties: Heat capacity, thermal conductivity, thermal expansion of materials.

Electronic Properties: Concept of energy band diagram for materials – conductors, semiconductors and insulators, electrical conductivity – effect of temperature on conductivity, intrinsic and extrinsic semiconductors, dielectric properties.

Optical Properties: Reflection, refraction, absorption and transmission of electromagnetic radiation in solids.

Magnetic Properties: Origin of magnetism in metallic and ceramic materials, paramagnetism, diamagnetism, antiferro magnetism, ferromagnetism, ferrimagnetism, magnetic hysteresis.

Environmental Degradation: Corrosion and oxidation of materials, prevention.

4.5.21.4 Section D: Solid Mechanics

Equivalent force systems; free-body diagrams; equilibrium equations; analysis of determinate trusses and frames; friction; simple relative motion of particles; force as function of position, time and speed; force acting on a body in motion; laws of motion; law of conservation of energy; law of conservation of momentum.

Stresses and strains; principal stresses and strains; Mohr's circle; generalized Hooke's Law; thermal strain; theories of failure.

Axial, shear and bending moment diagrams; axial, shear and bending stresses; deflection (for symmetric bending); torsion in circular shafts; thin cylinders; energy methods (Castigliano's Theorems); Euler buckling.

Free vibration of single degree of freedom systems.

4.5.21.5 Section E: Thermodynamics

Basic Concepts: Continuum, macroscopic approach, thermodynamic system (closed and open or control volume); thermodynamic properties and equilibrium; state of a system, state diagram, path and process; different modes of work; Zeroth law of thermodynamics; concept of temperature; heat.

First Law of Thermodynamics: Energy, enthalpy, specific heats, first law applied to systems and control volumes, steady and unsteady flow analysis.

Second Law of Thermodynamics: Kelvin-Planck and Clausius statements, reversible and irreversible processes, Carnot theorems, thermodynamic temperature scale, Clausius inequality and concept of entropy, principle of increase of entropy; availability and irreversibility.

Properties of Pure Substances: Thermodynamic properties of pure substances in solid, liquid and vapor phases, P-V-T behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts, ideal and real gases, equations of state, compressibility chart.

Thermodynamic Relations: T-ds relations, Maxwell equations, Joule-Thomson coefficient, coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron equation.

Thermodynamic cycles: Carnot vapor power cycle, Ideal Rankine cycle, Rankine Reheat cycle, Air standard Otto cycle, Air standard Diesel cycle, Air-standard Brayton cycle, Vapor-compression refrigeration cycle.

Ideal Gas Mixtures: Dalton's and Amagat's laws, calculations of properties, air-water vapor mixtures and simple thermodynamic processes involving them.

4.5.21.6 Section F: Polymer Science and Engineering

Chemistry of high polymers: Monomers, functionality, degree of polymerizations, classification of polymers, glass transition, melting transition, criteria for rubberiness, polymerization methods: addition and condensation; their kinetics, metallocene polymers and other newer techniques of polymerization, copolymerization, monomer reactivity ratios and its significance, kinetics, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for copolymerization-bulk, solution, suspension, emulsion.

Polymer Characterization: Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, polymer crystallinity, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques.

Synthesis and properties: Commodity and general purpose thermoplastics: PE, PP, PS, PVC, Polyesters, Acrylic, PU polymers. Engineering Plastics: Nylon, PC, PBT, PSU, PPO, ABS, Fluoropolymers Thermosetting polymers: PF, MF, UF, Epoxy, Unsaturated polyester, Alkyds. Natural and synthetic rubbers: Recovery of NR hydrocarbon from latex, SBR, Nitrile, CR, CSM, EPDM, IIR, BR, Silicone, TPE.

Polymer blends and composites: Difference between blends and composites, their significance, choice of polymers for blending, blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends, FRP, particulate, long and short fibre reinforced composites.

Polymer Technology: Polymer compounding-need and significance, different compounding ingredients for rubber and plastics, crosslinking and vulcanization, vulcanization kinetics.

Polymer rheology: Flow of Newtonian and non-Newtonian fluids, different flow equations, dependence of shear modulus on temperature, molecular/segmental deformations at different zones and transitions. Measurements of rheological parameters by capillary rotating, parallel plate, cone-plate rheometer. viscoelasticity-creep and stress relaxations, mechanical models, control of rheological characteristics through compounding, rubber curing in parallel plate viscometer, ODR and MDR.

Polymer processing: Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.

Polymer testing: Mechanical-static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness. Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, swelling, ageing resistance, environmental stress cracking resistance.

4.5.21.7 Section G: Food Technology

Food Chemistry and Nutrition: Carbohydrates: Structure and functional properties of mono- oligo-polysaccharides including starch, cellulose, pectic substances and dietary fibre; Proteins: Classification and structure of proteins in food; Lipids: Classification and structure of lipids, Rancidity of fats, Polymerization and polymorphism; Pigments: Carotenoids, chlorophylls, anthocyanins, tannins and myoglobin; Food flavours: Terpenes, esters, ketones and quinones; Enzymes: Specificity, Kinetics and inhibition, Coenzymes, Enzymatic and non-enzymatic browning; Nutrition: Balanced diet, Essential amino acids and fatty acids, PER, Water soluble and fat soluble vitamins, Role of minerals in nutrition, Antinutrients, Nutrition deficiency diseases.

Food Microbiology: Characteristics of microorganisms: Morphology, structure and detection of bacteria, yeast and mold in food, Spores and vegetative cells; Microbial growth in food: Intrinsic and extrinsic factors, Growth and death kinetics, serial dilution method for quantification; Food spoilage: Contributing factors, Spoilage bacteria, Microbial spoilage of milk and milk products, meat and meat products; Foodborne disease: Toxins produced by Staphylococcus, Clostridium and Aspergillus; Bacterial pathogens: Salmonella, Bacillus, Listeria, Escherichia coli, Shigella, Campylobacter; Fermented food: Buttermilk, yoghurt, cheese, sausage, alcoholic beverage, vinegar, sauerkraut and soya sauce.

Food Products Technology: Processing principles: Canning, chilling, freezing, dehydration, control of water activity, CA and MA storage, fermentation, hurdle technology, addition of preservatives and food additives, Food packaging, cleaning in place and food laws.; Grain products processing: Milling of rice, wheat, and maize, parboiling of paddy, production of bread, biscuits, extruded products and breakfast cereals, Solvent extraction, refining and hydrogenation of oil; Fruits, vegetables and plantation products processing: Extraction, clarification concentration and packaging of fruit juice, Production of jam, jelly, marmalade, squash, candies, and pickles, pectin from fruit waste, tea, coffee, chocolate and essential oils from spices; Milk and milk products processing: Pasteurized and sterilized milk, cream, butter, ghee, ice-cream, cheese and milk powder; Animal products processing: Drying and canning of fish, post mortem changes, tenderization and freezing of meat, egg powder.

Food Engineering: Mass and energy balance; Momentum transfer: Flow rate and pressure drop relationships for Newtonian fluids flowing through pipe, Characteristics of non-Newtonian fluids – generalized viscosity coefficient and Reynolds number, Flow of compressible fluid, Flow measurement, Pumps and compressors; Heat transfer: Heat transfer by conduction, convection, radiation, boiling and condensation, Unsteady state heat transfer in simple geometry, NTU- effectiveness relationship of co-current and counter current double pipe heat exchanger; Mass transfer: Molecular diffusion and Fick's Law, Steady state mass transfer, Convective mass transfer, Permeability of films and laminates; Mechanical operations: Energy requirement and rate of operations involved in size reduction of solids, high pressure homogenization, filtration, centrifugation, settling, sieving, flow through porous bed, agitation of liquid, solid-solid mixing, and single screw extrusion; Thermal operations: Energy requirement and rate of operations involved in process time evaluation in batch and continuous sterilization, evaporation of liquid foods, hot air drying of solids, spray and freeze-drying, freezing and crystallization; Mass transfer operations: Properties of air-water vapor mixture; Humidification and dehumidification operations.

4.5.22 Life Sciences (XL)

4.5.22.1 Section H: Chemistry (Compulsory)

Atomic structure and periodicity: Planck's quantum theory, wave particle duality, uncertainty principle, quantum mechanical model of hydrogen atom; electronic configuration of atoms; periodic table and periodic properties; ionization energy, electron affinity, electronegativity, atomic size.

Structure and bonding: Ionic and covalent bonding, M.O. and V.B. approaches for diatomic molecules, VSEPR theory and shape of molecules, hybridisation, resonance, dipole moment, structure parameters such as bond length, bond angle and bond energy, hydrogen bonding, van der Waals interactions. Ionic solids, ionic radii, lattice energy (Born-Haber Cycle).

s.p. and d Block Elements: Oxides, halides and hydrides of alkali and alkaline earth metals, B, Al, Si, N, P, and S, general characteristics of 3d elements, coordination complexes: valence bond and crystal field theory, color, geometry and magnetic properties.

Chemical Equilibria: Colligative properties of solutions, ionic equilibria in solution, solubility product, common ion effect, hydrolysis of salts, pH, buffer and their applications in chemical analysis, equilibrium constants (K_c , K_p and K_x) for homogeneous reactions,

Electrochemistry: Conductance, Kohlrausch law, Half Cell potentials, emf, Nernst equation, galvanic cells, thermodynamic aspects and their applications.

Reaction Kinetics: Rate constant, order of reaction, molecularity, activation energy, zero, first and second order kinetics, catalysis and elementary enzyme reactions.

Thermodynamics: First law, reversible and irreversible processes, internal energy, enthalpy, Kirchhoff's equation, heat of reaction, Hess law, heat of formation, Second law, entropy, free energy, and work function. Gibbs-Helmholtz equation, Clausius-Clapeyron equation, free energy change and equilibrium constant, Trouton's rule, Third law of thermodynamics.

Basis of Organic Reactions Mechanism: Elementary treatment of SN_1 , SN_2 , E_1 and E_2 reactions, Hoffmann and Saytzeff rules, Addition reactions, Markonikoff rule and Kharash effect, Diels-Alder reaction, aromatic electrophilic substitution, orientation effect as exemplified by various functional groups. Identification of functional groups by chemical tests

Structure-Reactivity Correlations: Acids and bases, electronic and steric effects, optical and geometrical isomerism, tautomerism, conformers, concept of aromaticity.

4.5.22.2 Section I: Biochemistry

Organization of life. Importance of water. Cell structure and organelles. Structure and function of biomolecules: Amino acids, Carbohydrates, Lipids, Proteins and Nucleic acids. Biochemical separation techniques and characterization: ion exchange, size exclusion and affinity chromatography, electrophoresis, UV-visible, fluorescence and Mass spectrometry. Protein structure, folding and function: Myoglobin, Hemoglobin, Lysozyme, Ribonuclease A, Carboxypeptidase and Chymotrypsin. Enzyme kinetics including its regulation and inhibition, Vitamins and Coenzymes.

Metabolism and bioenergetics. Generation and utilization of ATP. Metabolic pathways and their regulation: glycolysis, TCA cycle, pentose phosphate pathway, oxidative phosphorylation, gluconeogenesis, glycogen and fatty acid metabolism. Metabolism of Nitrogen containing compounds: nitrogen fixation, amino acids and nucleotides. Photosynthesis: the Calvin cycle.

Biological membranes. Transport across membranes. Signal transduction; hormones and neurotransmitters.

DNA replication, transcription and translation. Biochemical regulation of gene expression. Recombinant DNA technology and applications: PCR, site directed mutagenesis and DNA-microarray.

Immune system. Active and passive immunity. Complement system. Antibody structure, function and diversity. Cells of the immune system: T, B and macrophages. T and B cell activation. Major histocompatibility complex. T cell receptor. Immunological techniques: Immunodiffusion, immunoelectrophoresis, RIA and ELISA.

4.5.22.3 Section J: Botany

Plant Systematics: Systems of classification (non-phylogenetic vs. phylogenetic – outline), plant groups, molecular systematics.

Plant Anatomy: Plant cell structure, organization, organelles, cytoskeleton, cell wall and membranes; anatomy of root, stem and leaves, meristems, vascular system, their ontogeny, structure and functions, secondary growth in plants and stellar organization.

Morphogenesis & Development: Cell cycle, cell division, life cycle of an angiosperm, pollination, fertilization, embryogenesis, seed formation, seed storage proteins, seed dormancy and germination.

Concept of cellular totipotency, clonal propagation; organogenesis and somatic embryogenesis, artificial seed, somaclonal variation, secondary metabolism in plant cell culture, embryo culture, *in vitro* fertilization.

Physiology and Biochemistry: Plant water relations, transport of minerals and solutes, stress physiology, stomatal physiology, signal transduction, N₂ metabolism, photosynthesis, photorespiration; respiration, Flowering: photoperiodism and vernalization, biochemical mechanisms involved in flowering; molecular mechanism of senescence and aging, biosynthesis, mechanism of action and physiological effects of plant growth regulators, structure and function of biomolecules, (proteins, carbohydrates, lipids, nucleic acid), enzyme kinetics.

Genetics: Principles of Mendelian inheritance, linkage, recombination, genetic mapping; extrachromosomal inheritance; prokaryotic and eukaryotic genome organization, regulation of gene expression, gene mutation and repair, chromosomal aberrations (numerical and structural), transposons.

Plant Breeding and Genetic Modification: Principles, methods – selection, hybridization, heterosis; male sterility, genetic maps and molecular markers, sporophytic and gametophytic self incompatibility, haploidy, triploidy, somatic cell hybridization, marker-assisted selection, gene transfer methods viz. direct and vector-mediated, plastid transformation, transgenic plants and their application in agriculture, molecular pharming, plantibodies.

Economic Botany: A general account of economically and medicinally important plants- cereals, pulses, plants yielding fibers, timber, sugar, beverages, oils, rubber, pigments, dyes, gums, drugs and narcotics. Economic importance of algae, fungi, lichen and bacteria.

Plant Pathology: Nature and classification of plant diseases, diseases of important crops caused by fungi, bacteria and viruses, and their control measures, mechanism(s) of pathogenesis and resistance, molecular detection of pathogens; plant-microbe beneficial interactions.

Ecology and Environment: Ecosystems – types, dynamics, degradation, ecological succession; food chains and energy flow; vegetation types of the world, pollution and global warming, speciation and extinction, conservation strategies, cryopreservation, phytoremediation.

4.5.22.4 Section K: Microbiology

Historical Perspective: Discovery of microbial world; Landmark discoveries relevant to the field of microbiology; Controversy over spontaneous generation; Role of microorganisms in transformation of organic matter and in the causation of diseases.

Methods in Microbiology: Pure culture techniques; Theory and practice of sterilization; Principles of microbial nutrition; Enrichment culture techniques for isolation of microorganisms; Light-, phase contrast- and electron-microscopy.

Microbial Taxonomy and Diversity: Bacteria, Archea and their broad classification; Eukaryotic microbes: Yeasts, molds and protozoa; Viruses and their classification; Molecular approaches to microbial taxonomy.

Prokaryotic and Eukaryotic Cells: Structure and Function: Prokaryotic Cells: cell walls, cell membranes, mechanisms of solute transport across membranes, Flagella and Pili, Capsules, Cell inclusions like endospores and gas vesicles; Eukaryotic cell organelles: Endoplasmic reticulum, Golgi apparatus, mitochondria and chloroplasts.

Microbial Growth: Definition of growth; Growth curve; Mathematical expression of exponential growth phase; Measurement of growth and growth yields; Synchronous growth; Continuous culture; Effect of environmental factors on growth.

Control of Micro-organisms: Effect of physical and chemical agents; Evaluation of effectiveness of antimicrobial agents.

Microbial Metabolism: Energetics: redox reactions and electron carriers; An overview of metabolism; Glycolysis; Pentose-phosphate pathway; Entner-Doudoroff pathway; Glyoxalate pathway; The citric acid cycle; Fermentation; Aerobic and anaerobic respiration; Chemolithotrophy; Photosynthesis; Calvin cycle; Biosynthetic pathway for fatty acids synthesis; Common regulatory mechanisms in synthesis of amino acids; Regulation of major metabolic pathways.

Microbial Diseases and Host Pathogen Interaction: Normal microbiota; Classification of infectious diseases; Reservoirs of infection; Nosocomial infection; Emerging infectious diseases; Mechanism of microbial pathogenicity; Nonspecific defense of host; Antigens and antibodies; Humoral and cell mediated immunity; Vaccines; Immune deficiency; Human diseases caused by viruses, bacteria, and pathogenic fungi.

Chemotherapy/Antibiotics: General characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs.

Microbial Genetics: Types of mutation; UV and chemical mutagens; Selection of mutants; Ames test for mutagenesis; Bacterial genetic system: transformation, conjugation, transduction, recombination, plasmids, transposons; DNA repair; Regulation of gene expression: repression and induction; Operon model; Bacterial genome with special reference to *E.coli*; Phage λ and its life cycle; RNA phages; RNA viruses; Retroviruses; Basic concept of microbial genomics.

Microbial Ecology: Microbial interactions; Carbon, sulphur and nitrogen cycles; Soil microorganisms associated with vascular plants.

4.5.22.5 Section L: Zoology

Animal world: Animal diversity, distribution, systematics and classification of animals, phylogenetic relationships.

Evolution: Origin and history of life on earth, theories of evolution, natural selection, adaptation, speciation.

Genetics: Principles of inheritance, molecular basis of heredity, mutations, cytoplasmic inheritance, linkage and mapping of genes.

Biochemistry and Molecular Biology: Nucleic acids, proteins, lipids and carbohydrates; replication, transcription and translation; regulation of gene expression, organization of genome, Krebs's cycle, glycolysis, enzyme catalysis, hormones and their actions, vitamins.

Cell Biology: Structure of cell, cellular organelles and their structure and function, cell cycle, cell division, chromosomes and chromatin structure. Eukaryotic gene organization and expression (Basic principles of signal transduction).

Animal Anatomy and Physiology: Comparative physiology, the respiratory system, circulatory system, digestive system, the nervous system, the excretory system, the endocrine system, the reproductive system, the skeletal system, osmoregulation.

Parasitology and Immunology: Nature of parasite, host-parasite relation, protozoan and helminthic parasites, the immune response, cellular and humoral immune response, evolution of the immune system.

Development Biology: Embryonic development, cellular differentiation, organogenesis, metamorphosis, genetic basis of development, stem cells.

Ecology: The ecosystem, habitats, the food chain, population dynamics, species diversity, zoogeography, biogeochemical cycles, conservation biology.

Animal Behaviour: Types of behaviours, courtship, mating and territoriality, instinct, learning and memory, social behaviour across the animal taxa, communication, pheromones, evolution of animal behaviour.

4.5.22.6 Section M: Food Technology

Food Chemistry and Nutrition: Carbohydrates: Structure and functional properties of mono- oligo-polysaccharides including starch, cellulose, pectic substances and dietary fibre; Proteins: Classification and structure of proteins in food; Lipids: Classification and structure of lipids, Rancidity of fats, Polymerization and polymorphism; Pigments: Carotenoids, chlorophylls, anthocyanins, tannins and myoglobin; Food flavours: Terpenes, esters, ketones and quinones; Enzymes: Specificity, Kinetics and inhibition, Coenzymes, Enzymatic and non-enzymatic browning; Nutrition: Balanced diet, Essential amino acids and fatty acids, PER, Water soluble and fat soluble vitamins, Role of minerals in nutrition, Antinutrients, Nutrition deficiency diseases.

Food Microbiology: Characteristics of microorganisms: Morphology, structure and detection of bacteria, yeast and mold in food, Spores and vegetative cells; Microbial growth in food: Intrinsic and extrinsic factors, Growth and death kinetics, serial dilution method for quantification; Food spoilage: Contributing factors, Spoilage bacteria, Microbial spoilage of milk and milk products, meat and meat products; Foodborne disease: Toxins produced by Staphylococcus, Clostridium and Aspergillus; Bacterial pathogens: Salmonella, Bacillus, Listeria, Escherichia coli, Shigella, Campylobacter; Fermented food: Buttermilk, yoghurt, cheese, sausage, alcoholic beverage, vinegar, sauerkraut and soya sauce.

Food Products Technology: Processing principles: Canning, chilling, freezing, dehydration, control of water activity, CA and MA storage, fermentation, hurdle technology, addition of preservatives and food additives, Food packaging, cleaning in place and food laws.; Grain products processing: Milling of rice, wheat, and maize, parboiling of paddy, production of bread, biscuits, extruded products and breakfast cereals, Solvent extraction, refining and hydrogenation of oil; Fruits, vegetables and plantation products processing: Extraction, clarification concentration and packaging of fruit juice, Production of jam, jelly, marmalade, squash, candies, and pickles, pectin from fruit waste, tea, coffee, chocolate and essential oils from spices; Milk and milk products processing: Pasteurized and sterilized milk, cream, butter, ghee, ice-cream, cheese and milk powder; Animal products processing: Drying and canning of fish, post mortem changes, tenderization and freezing of meat, egg powder.

Food Engineering: Mass and energy balance; Momentum transfer: Flow rate and pressure drop relationships for Newtonian fluids flowing through pipe, Characteristics of non-Newtonian fluids – generalized viscosity coefficient and Reynolds number, Flow of compressible fluid, Flow measurement, Pumps and compressors; Heat transfer: Heat transfer by conduction, convection, radiation, boiling and condensation, Unsteady state heat transfer in simple geometry, NTU- effectiveness relationship of co-current and counter current double pipe heat exchanger; Mass transfer: Molecular diffusion and Fick's Law, Steady state mass transfer, Convective mass transfer, Permeability of films and laminates; Mechanical operations: Energy requirement and rate of operations involved in size reduction of solids, high pressure homogenization, filtration, centrifugation, settling, sieving, flow through porous bed, agitation of liquid, solid-solid mixing, and single screw extrusion; Thermal operations: Energy requirement and rate of operations involved in process time evaluation in batch and continuous sterilization, evaporation of liquid foods, hot air drying of solids, spray and freeze-drying, freezing and crystallization; Mass transfer operations: Properties of air-water vapor mixture; Humidification and dehumidification operations.

5 Post-Exam Related Information

5.1 GATE Score

After the evaluation of the answers, the raw marks obtained by a candidate will be converted to a normalized GATE Score.

From 2013, the GATE score will be computed by a new formula.

The GATE Score of a candidate is computed from:

$$S = S_q + (S_t - S_q) \frac{M - M_q}{\bar{M}_t - M_q},$$

where,

- S = GATE Score (normalised) of a candidate,
- M = Marks obtained by a candidate in a paper,
- M_q = Qualifying Marks for general category candidates in the paper,
- \bar{M}_t = Average Marks of top 0.1% or 10 (which ever is higher) of candidates in the paper,
- S_t = GATE Score assigned to \bar{M}_t (around 900), and
- S_q = GATE Score assigned to M_q (around 300).

M_q is usually 25 marks (out of 100) or $\mu + \sigma$, which ever is higher. Here μ is the mean of marks in a paper and σ is the standard deviation.

After the declaration of the results, a GATE Scorecard will be issued to all the candidates of a paper whose marks are equal to or above the qualifying marks of SC/ST/PD candidates in that paper. There is no provision for the issue of Additional GATE scorecard.

The GATE 2013 Committee with the NCB has the authority to decide the qualifying mark for each GATE paper. In case any claim or dispute arises in respect of GATE 2013, it is hereby made absolutely clear that the Courts and Tribunals in Mumbai and Mumbai alone shall have the exclusive jurisdiction to entertain and settle any such dispute or claim.

5.2 GATE 2013 Results

GATE 2013 results will be announced on March 15, 2013 at 10:00 hrs and will be available on the GATE Online Applicant Website.

GATE 2013 score is valid for TWO YEARS from the date of announcement of the results.

GATE 2013 results may be made available on payment basis to interested organizations (educational institutions, R & D laboratories, industries, etc.) in India and abroad based on a Memorandum of Understanding (MOU) between IIT Bombay and the requesting organization. Details in this regard can be obtained from the Chairman, GATE, IIT Bombay.

5.3 GATE Score Card

Scorecard will be issued (mailed to the correspondence address given in the application) to all the candidates for a paper whose marks are equal to or above the qualifying marks of SC/ST/PD candidates in that paper. **There is no provision for issue of additional GATE scorecards.**

The GATE 2013 Committee with the NCB's approval has the authority to decide the qualifying score for each GATE paper. In case any claim or dispute arises in respect of GATE 2013, it is hereby made absolutely clear that the Courts and Tribunals in Mumbai and Mumbai alone shall have the exclusive jurisdiction to entertain and settle any such dispute or claim.

6 Frequently Asked Questions (FAQ)

6.1 Application Process

1. **How do I apply ONLINE?** Go to the link How to apply? On website (www.gate.iitb.ac.in/gate2013), read the instructions and apply from the link provided in the main page.
2. **Can I use one email address to fill multiple application forms?** NO, one email address can be used for only one application form.
3. **Why should I choose two examination cities?** Generally, you will be allotted a centre in the examination city of your first choice. Only in cases where it becomes difficult to accommodate you in the examination city of your first choice, your second choice will be considered.
4. **My power/internet connection failed during application process, what do I do?** If you have clicked on “Save” during application process, the data you entered up to that time has been stored online. Simply login back to the GATE application website and continue the application process.
5. **You are asking only the SC/ST/PD candidates to enclose the category certificate. What about the OBC (non-creamy layer) candidates? Do they have to enclose the category certificate too?** NO. OBC (non-creamy layer) candidates do not have to enclose the category certificate since their application fee is same as that of the general category candidates. However, in the application, you can indicate the category to which you belong to. You need to produce the category certificate only to the admitting institute at the time of admission.
6. **How do I make the fee payment for GATE 2013 examination?** You can make the payment during the ONLINE application process by choosing one of the following options:
 1. *Online Payment: Netbanking through the payment gateway.*
 2. *Challan Payment: Payment by cash at any branch of Canara Bank or State Bank of India.*
7. **I want to pay online by my credit card, but I don't see that option!** You can only use internet banking (netbanking) facilities for online payment. Credit cards will not be accepted.
8. **If I want the Online Payment (Netbanking) option, how should I complete the application process?** After filling all the fields in the ONLINE application form, choose Online Payment option and proceed for payment by following the instructions.
 1. Your browser screen will re-directed to the bank you choose. Login with your Internet banking credentials and confirm the payment.
 2. After confirming the payment, you will be re-directed back to GATE application website.

3. At the end of this process, a PDF file will be generated with the following pages:
 1. Page 1: Instructions and Address slip (of where you need to send the hard copy) to be pasted on an A4 sized envelope
 2. Page 2-3: Two copies (one for you one to be sent to GATE office) of application form with bottom part showing certificate to be signed by principal. One copy for the candidate and another to be sent to GATE office.
4. Take a print out of the entire file and follow instructions in link How to apply? to complete the application process.
9. **My power/internet connection failed during online payment. What do I do ?** When you can get back online, first check the status of your payment on the GATE application website.
 1. If the payment was received by GATE, you can continue the process of printing the application form.
 2. If the payment was not received by GATE, you have to start with the payment step again (choice of Online or Chalan), to complete payment.
10. **My netbanking account has been debited (money taken out) more than once. How do I get the money back ?** This can happen if your bank account was used more than once or you pressed refresh or back/forward button of your internet browser. Please check your bank account after 48 hours. Any unaccounted or excess money that was received on behalf of GATE 2013 from this account will automatically be returned back (credited) to the same bank account.
11. **My bank account has been debited (money taken out), but GATE Application website says that the payment has not been received. What do I do?** This happened because of some failure in internet transactions (including failure of internet connection at your end). As soon as possible, you MUST initiate a fresh payment process on the GATE application website, and make the payment again. The money that was debited (taken out) from your account the first time, will be credited (put back) to your bank account within 48 hours. You will be charged only once. Any excess/unaccounted debits will be returned to you.
12. **If I want the Bank Challan option, how should I complete the application process?** After filling in all the fields in the ONLINE application form, choose Bank Challan option and proceed for payment by following the instructions.
 1. At the end of this process, a PDF file will be generated with the following pages:
 1. Page 1: Instructions and Address slip where you need to send hard copy.
 2. Page 2-3: Two copies (one for you one to be sent to GATE office) of application form with bottom part showing certificate to be signed by principal.
 3. Page 4: page for candidates who select “bank challan” way of payment (as against the net banking). This page will contain 3 copies of challan.

2. Take a print out of the entire file and follow instructions in link *How to apply?* on website www.gate.iitb.ac.in/gate2013 to complete the application process.
13. **Do I have to send the printout of the application form?** YES. At the end of the Application process a PDF file of the application is generated. You have to affix your photograph, signature and enclose other documents along with this print out and send to the concerned GATE office. This is REQUIRED in addition to the uploading of the image files.
14. **I have attached the documents online, do I have to send the hard copy as well?** No, apart from the application, you do not have to provide hard copies of documents you have submitted online.
15. **Should I attest the photograph for application form?** NO. Photographs must not be attested application form or uploading. You must bring a valid photo ID card to the examination center.
16. **When and how will I know the status of my application?** You can check the status of your application by logging in at the applicant website.
17. **After completing the ONLINE application process and generating a PDF file, will I be able to change my application data?** NO. After completing all the steps upto PDF application form generation in ONLINE application process, you can only download the application form and cannot modify the data. Hence you need to be very careful while entering the data. You may also save a partially filled application and login in again at a later point in time to complete and submit the application.
18. **I have missed to take a print of my ONLINE application at the end of my application process. How will I get access to it?** You can login using Login id (email) and password you had set up and take a printout.

6.2 Admit card

1. **When will I receive my admit card?** Admit card can only be downloaded from the zonal GATE websites from 5th December 2012. Sending Admit cards by post has been discontinued.
2. **Is the Admit card alone sufficient to gain entry to the exam?** No. Bring the admit card at the test center **along with** at least one original (not photocopied / scanned copy) and valid (not expired) photo identification. ONLY one of the following photo identifications is permitted: Driving license, Passport, PAN Card, Voter ID, College ID, Employee identification card, or a notarized Affidavit with Photo, Signature, Date of Birth and Residential Address. Photocopies of the original identification document are not acceptable. Candidates will not be permitted to take the test if original and valid photo identification is not presented.

6.3 GATE 2013 Exam

1. **For how many GATE papers can I apply?** A candidate can apply for only ONE of the 21 papers listed in the GATE INFORMATION BROCHURE or GATE website. The choice of the appropriate paper is the responsibility of the candidate. Some guidelines in this respect are suggested below.
 1. The candidate is expected to appear in a paper appropriate to the discipline of his/her qualifying degree.
 2. The candidate is, however, free to choose any paper according to his/her admission plan, keeping in mind the eligibility criteria of the institutions in which he/she wishes to seek admission
2. **After submission of application, am I permitted to change my GATE Examination Paper and Examination City?** Requests for change of GATE Examination paper after the submission of Application Form will not be considered. However, requests for change of examination city will be accepted till November 20, 2012 with a fee of ₹ 400/- to be paid in the form of a demand draft in favour of “Chairman GATE 2013”, payable at Mumbai. Please send this DD to the Zonal office where you sent the application form.
3. **Will I be provided with any white paper for rough work and calculations during the test?** For OFFLINE Examination, the question paper itself contains some blank sheets on which you can do the rough work. Rough work cannot be done on any other paper/sheet as no additional paper will be provided during the test. For ONLINE Examination, a notepad provided to the candidate can be used to do the rough work.
4. **Am I allowed to leave the examination hall during the test?** NO. Candidates will NOT be allowed to leave the examination hall for any reason during the test. For OFFLINE exam, candidates are allowed to leave the hall only after the Optical Response Sheet (ORS) from all the candidates in the examination hall have been collected and accounted for. For ONLINE examination, candidates are allowed to leave the lab only after the closure of the test at the scheduled end of examination in a session.
5. **What items are not permitted to be brought with me inside the examination venue?** Electronic diary, mobile phone, and any such electronic gadgets, blank papers, clip boards and log-tables will not be allowed in the examination venue.
6. **Can I use a calculator during the exam?** Yes. You are permitted to use a scientific calculator without data connectivity. If you bring any item that is not permissible inside the examination venue, you will have to keep it at the test center at your own risk.
7. **Will there be any arrangement at the test center for the safe keeping of my personal items such as my mobile phone?** No such arrangements will be possible at the test center.
8. **Is the use of pencils to darken the bubbles in the answer sheet permitted?** NO. The use of pencils to darken the bubbles in the answer sheet has been discontinued. Candidates should use only black ink ballpoint pen for darkening of the bubbles in the answer sheet. Since bubbles darkened by the black ink ballpoint pen cannot be erased, candidates should darken the bubbles in the answer sheet very carefully.

7 Zonal Contacts

GATE is jointly administered and conducted by the Indian Institute of Science and seven Indian Institutes of Technology. Each of the institutes administers a zone and caters to examination cities nearby to the institute. Applicants are assigned a zone at the time of application, based on the first city of choice. Applicants must note this zone number for contact purposes.

From this year candidates must use the GATE online applicant interface to contact Zonal GATE offices, which seek to will provide quicker and clearer information through it. The following methods may be used only if someone is unable to reach the GATE office by the online grievance redressal.

Zone	Contact Address	Phone Number	FAX	EMail Id
1	Chairman, GATE Indian Institute of Science Bengaluru 560 012	080-2293 2392	080-2360 1227	gate[at]gate.iisc.ernet.in
2	Chairman, GATE Indian Institute of Technology Bombay, Powai, Mumbai 400 076	022-2576 7068	022-2572 3706	gateoffice[at]iitb.ac.in
3	Chairman, GATE Indian Institute of Technology Delhi, Hauz Khas, New Delhi 110 016	011-2659 1749	011-2658 1579	gateoffice[at]admin.iitd.ernet.in
4	Chairman, GATE Indian Institute of Technology Guwahati, Guwahati 781 039	0361-258 2751	0361-258 2755	gate[at]iitg.ernet.in
5	Chairman, GATE Indian Institute of Technology Kanpur, Kanpur 208 016	0512-259 7412	0512-259 0932	gate[at]iitk.ac.in
6	Chairman, GATE Indian Institute of Technology Kharagpur, Kharagpur 721 302	03222-282091	03222-278243	gate[at]adm.iitkgp.ernet.in
7	Chairman, GATE Indian Institute of Technology Madras, Chennai 600 036	044-2257 8200	044-2257 8204	gate[at]iitm.ac.in
8	Chairman, GATE Indian Institute of Technology Roorkee, Roorkee 247 667	01332-284531	01332-285707	gate[at]iitr.ernet.in

8 Appendix A

8.1 Authorities Empowered to Issue certificates (SC/ST)

- District Magistrate/ Additional District Magistrate/ Collector/ Deputy Collector/ Deputy Commissioner/ Additional Deputy Commissioner/ 1st Class Stipendiary Magistrate/ City Magistrate/ Sub-Divisional Magistrate/ Taluk Magistrate/ Executive Magistrate/ Extra Assistant Commissioner.
- Chief Presidency Magistrate/ Additional Chief Presidency Magistrate/ Presidency Magistrate
- Revenue Officer not below the rank of Tashildar
- Sub-Divisional Officer of the area where the Candidate and/or her/his family normally resides
- Administrator/ Secretary to Administrator/ Development Officer (Lakshadweep Islands)

Certificate issued by any other official will not be accepted.

8.2 PD Category:

In order to avail concession under PD category, the candidates should attach a recently obtained proper PD certificate, which shall be required to be submitted to the admitting institution at the time of admission. The onus of verifying PD certificate lies with the admitting institute. The GATE committee will not be responsible for any incorrect declaration of the PD status of candidates.

9 Appendix B: Qualifying Disciplines

These are some of the common qualifying disciplines for the eligibility degree

Discipline: Engineering/Technology	Renewable Energy
Aeronautical Engg.	Rubber Technology
Aerospace Engg.	Textile Engineering & Fibre Science
Agricultural Engg.	All other disciplines in Engg./Technology
Applied Mechanics	
Architecture	Discipline: Sciences
Automobile Engg.	Agricultural Science
Biochemical Engg.	Applied Electronics
Biomedical Engg.	Applied Physics
Biotechnology	Biochemistry
Ceramic & Glass Technology	Bio-Sciences
Chemical Engg.	Chemistry
Chemical Technology	Computer Applications
Civil/Civil & Environmental/Structural Engg./ Construction Engg.	Earth Sciences
Computer Engg./Computer Science & Engg./Technology	Electronics
Control and Instrumentation	Engineering Physics
Electrical Engg./ Electrical and Electronics Engg./Power Engineering	Geology/ Geophysics
Electro-Chemical Engg.	Industrial Chemistry
Electronics & Comm./Electronics Engg./Comm. Engg. /Telecommunication Engg.	Life Science/Veterinary/Animal Science
	Life Sciences
Energy Engg.	Life Sciences (Botany)
Environmental Engg.	Life Sciences (Zoology)
Food Technology/Food Processing Engg.	Materials Science
Industrial Engg.	Mathematics/Applied Mathematics
Industrial Management	Microbiology
Information Science/Information Technology	Nano Science & Technology
Instrumentation/ Electronics/Control	Nuclear Physics
Instrumentation & Process Control	Operations Research
Manufacturing Engg.	Pharmaceutical Sciences/Pharmacy
Material Science and Engineering	Physics
Mechanical Engg.	Radio Physics
Mechatronics	Radio Physics & Electronics
Medical Instrumentation	Statistics
Metallurgical Engg/ Industrial Metallurgy	Textile Chemistry
Mineral Engg./Mineral Dressing	All other disciplines in Sciences
Mining Engg./Technology, Mining & Machinery	
Naval Architecture/Marine Engg.	
Oil Technology	
Paint Technology	
Petro-Chemical Engg.	
Petroleum Engg./Technology	
Planning	
Plastic Technology	
Polymer Technology/Science	
Production & Industrial Engg.	