Appendix-I

- **Syllabus for Aerospace Engineering and Applied Mechanics:**

Linear algebra, Calculus: Functions of single variable, Taylor's series, Beta and Gamma functions, sequence and series, Laplace transformation, Fourier series. Complex variables: Analytic functions, Cauchy-Riemann equations. Vector Calculus: Gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, Stokes, Gauss and Green's theorems. Ordinary differential equation and Partial differential equation. Statistical moments and distribution functions, definitions of probability and simple theorems, conditional probability.

Force Systems, Moments and Couples, Resultants and Components, Conditions for Equilibrium, Truss; Frames and Machines, Friction, Properties of Area.

Stress, Strain, stress at a point, stress-strain of ductile and brittle materials, pure shear, Elastic constants, relation among the Elastic constants, thermal stress, Bi-axial stress, Complex stress and strain, Mohr's circle , thin-walled pressure vessels, Shear force and bending moment, bending of beams due to transverse load, Euler-Bernoulli's Equation, stresses in bending, Torsion of circular shaft, Combined bending, torsion and axial thrust, Deflection of beam, Energy methods, Virtual work, Theories of Failure.

Particle dynamics: Conservation Laws – Approaches in terms of Force, Mass and Acceleration; Work and Energy; Linear Impulse and Momentum – Impact; Angular Impulse and Momentum – Central Force Motion. Rigid body dynamics: Definition of Rigid Bodies and Kinematic constraints, Kinematics of Rigid Bodies, Linear and Angular Momentum, Kinetic energy, Conservation Principles – linear and angular Momentum and Energy, Impulsive Forces and Moments, Free Motion of an Axisymmetric Body.

Vibration model and equations of motion, Energy method, Rayleigh method, Different Kinds of Damping, Forced vibration: harmonic excitation, Rotating unbalance, Vibration isolation, Energy dissipation, Vibration measuring instruments, Properties of vibrating systems: Flexibility matrix, Stiffness matrix, Stiffness of beam elements, Eigenvalues and eigenvectors, Orthogonal properties of eigenvectors, Modal matrix, Modal damping in forced vibration.

Continuum; Eulerian and Lagrangian description of motion; Fluid properties (viscosity, compressibility, speed of sound); Dimensions and Units; Flow visualization; Classification of fluid flow; Equation for hydrostatic pressure variation, manometers, pressure variation in atmosphere; Fluids in rigid body motion - uniform linear acceleration and rigid body rotation.

Equation of motion along a streamline (Euler's Eq.) and normal to a streamline, Bernoulli's equation and its applications; Laminar and turbulent flow through pipes, Darcy's equation for fully developed flow, Hagen-Poiseuille equation and Moody diagram, critical Reynolds number, major and minor head loss; kinetic energy correction factor and momentum correction factor; Flow measurements (Pitot tube, orificemeter, venturimeter, etc.)

Continuity equation, Stream function; Kinematics - translation, rotation and deformation of a fluid element, Vorticity and Circulation; Momentum equation

Integral and differential analysis of fluid flow, Reynolds transport theorem, Conservation equations for mass, linear momentum, angular momentum & energy, and their applications; continuity and momentum equation in unidirectional flow.

Buckingham's Pi theorem; Geometric, Kinematic and Dynamic similarity, Dimensionless parameters

General classifications, Basic theory of turbomachine, Impulse and Reaction (Pelton, Francis, and Kaplan) turbines. Draft tube, Application of similarity principle on hydraulic turbine, Specific speed, Characteristic curve, Governing of turbines.

Couette flow; Poiseuille flow, Creeping flow, laminar boundary layer equation; integral analysis of boundary layer over a flat plate; similarity transformation, Blasius solution for flat plate; boundary layer transition; boundary layer separation, flow past streamlined and bluff bodies, lift and drag

Aerodynamic force, moment and pressure coefficients; lift and drag, elements of propulsion: propeller; reciprocating engine; jet propulsion; turbojet engines; basic concepts of stability and control; static stability and dynamic stability.

- **Syllabus for Chemistry:**

IUPAC nomenclature of organic molecules including regio- and stereoisomers.

Principles of stereochemistry**:** Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction.

Aromaticity**:** Benzenoid and non-benzenoid compounds – generation and reactions.

Organic reactive intermediates**:** Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes.
Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.
Common named reactions and rearrangements – applications in organic synthesis.

Organic transformations and reagents: Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic). Chemo, regio and stereoselective transformations.

Concepts in organic synthesis: Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups.
Asymmetric synthesis: Chiral auxiliaries, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution – optical and kinetic.

Pericyclic reactions – electrocyclisation, cycloaddition, sigmatropic rearrangements and other related concerted reactions. Principles and applications of photochemical reactions in organic chemistry.

Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S).
Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids.
Chemical periodicity & Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules.
Concepts of acids and bases, Hard-Soft acid base concept, Non-aqueous solvents.

Main group elements and their compounds: Allotropy, synthesis, structure and bonding, industrial importance of the compounds.
Transition elements, coordination compounds & Inner transition elements.

Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis.

Cages and metal clusters.

Analytical chemistry & Characterisation of different compounds through different techniques (e.g. IR, UV-Vis, NMR, Mass spectroscopic, XRD etc).
Bioinorganic chemistry**:** photosystems, porphyrins, metalloenzymes, oxygen transport, electron- transfer reactions; nitrogen fixation, metal complexes in medicine.
Nuclear chemistry: nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis.
Basic principles of quantum mechanics: Postulates; operator algebra; exactly-solvable systems**:** particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling.
Approximate methods of quantum mechanics: Variational principle; perturbation theory up to second order in energy; applications.
Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle.
Chemical bonding in diatomics; elementary concepts of MO and VB theories; Huckel theory for conjugated π-electron systems.
Chemical applications of group theory; symmetry elements; point groups; character tables; selection rules.
Molecular spectroscopy**:** Rotational and vibrational spectra of diatomic molecules; electronic spectra; IR and Raman activities – selection rules; basic principles of magnetic resonance.
Chemical thermodynamics: Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; elementary description of phase transitions; phase equilibria and phase rule; thermodynamics of ideal and non-ideal gases, and solutions.
Statistical thermodynamics: Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities – calculations for model systems.
Electrochemistry**:** Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations.

Chemical kinetics**:** Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; enzyme kinetics; salt effects; homogeneous catalysis; photochemical reactions.

Colloids and surfaces**:** Stability and properties of colloids; isotherms and surface area; heterogeneous catalysis.
Solid state**:** Crystal structures; Bragg's law and applications; band structure of solids.

Polymer chemistry**:** Molar masses; kinetics of polymerization.

Data analysis**:** Mean and standard deviation; absolute and relative errors; linear regression; covariance and correlation coefficient.

- **Syllabus for Civil Engineering:**
  - **Structural Engineering:**

Energy methods; Principles of virtual work; Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Simple bending theory, flexural and shear stresses; buckling of column.

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

Construction Materials: Structural steel - composition, material properties and behaviour; Concrete - constituents, mix design; Project planning and network analysis - PERT and CPM.

Concrete Structures: Working stress, and Limit state design concepts; Design of beams, slabs, columns; Bond and development length; Prestressed concrete; Analysis of beam sections at transfer and service loads.

Steel Structures: Working stress and Limit state design concepts; Design of tension and compression members, beams and beam- columns, column bases; Connections - simple and eccentric.

  - **Geotechnical Engineering:**

Origin of soils, soil structure and fabric; Three-phase system and phase relationships, index properties; Unified and Indian standard soil classification system; Permeability - one dimensional flow, Darcy's law; Seepage through soils - two-dimensional flow, flow nets, uplift pressure, piping; Principle of effective stress, capillarity, seepage force and quicksand condition; Compaction in laboratory and field conditions; One-dimensional consolidation, time rate of consolidation; Mohr's circle, stress paths, effective and total shear strength parameters, characteristics of clays and sand.

Sub-surface investigations - scope, drilling bore holes, sampling, plate load test, standard penetration and cone penetration tests; Earth pressure theories - Rankine and Coulomb; Stability of slopes - finite and infinite slopes, method of slices and Bishop's method; Stress distribution in soils - Boussinesq's and Westergaard's theories, pressure bulbs; Shallow foundations - Terzaghi's and Meyerhoff's bearing capacity theories, effect of water table;

Combined footing and raft foundation; Contact pressure; Settlement analysis in sands and clays; Deep foundations - types of piles, dynamic and static formulae, load capacity of piles in sands and clays, pile load test, negative skin friction.

- **Water Resources Engineering:**

Channel Hydraulics - Energy-depth relationships, specific energy, critical flow, slope profile, hydraulic jump, uniform flow and gradually varied flow

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

Duty, delta, estimation of evapo-transpiration; Crop water requirements; Design of lined and unlined canals, head works, gravity dams and spillways; Design of weirs on permeable foundation; Types of irrigation systems, irrigation methods; Water logging and drainage; Canal regulatory works, cross-drainage structures, outlets and escapes.

- **Environmental Engineering:**

Quality standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water; Sewage and sewerage treatment, quantity and characteristics of wastewater; Primary, secondary and tertiary treatment of wastewater, effluent discharge standards; Domestic wastewater treatment, quantity of characteristics of domestic wastewater, primary and secondary treatment; Unit operations and unit processes of domestic wastewater, sludge disposal.

Types of air pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits; Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

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

- **Transportation Engineering:**

Geometric design of roadways - cross-sectional elements, sight distances, horizontal and vertical alignments; Geometric design of railway track; Airport runway length, taxiway and exit taxiway design, Runway orientation.

Type of roadway pavements; Roadway pavement materials - desirable properties and quality control tests; Design of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible pavement and rigid pavements using IRC guidelines; Distresses in pavements.

Traffic studies on volume, speed, density, travel time, delay, parking, origin-destination, accident; Analysis of traffic data including accident; Microscopic and macroscopic parameters of traffic flow - fundamental relationships, PCU; Types of intersections and channelization; Traffic management – traffic signal, sign and marking; Highway capacity and level of service; Travel demand analysis.

- **Syllabus for Computer Science and Technolgy:**
  - **Engineering Mathematics:**

Discrete Mathematics: Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Groups. Graphs: connectivity, matching, coloring.
Combinatorics: counting, recurrence relations, generating functions.

Linear Algebra: Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LU decomposition.

Calculus: Limits, continuity and differentiability. Maxima and minima. Mean value theorem. Integration.

Probability: Random variables. Uniform, normal, exponential, poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem.

- **Computer Science and Information Technology**

Digital Logic:

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

Computer Organization and Architecture:

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

Programming and Data Structures:

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

Algorithms:

Searching, sorting, hashing. Asymptotic worst case time and space complexity.

Algorithm design techniques: greedy, dynamic programming and divide-and-conquer.

Graph search, minimum spanning trees, shortest paths.

Theory of Computation:

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

Compiler Design:

Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation.

Operating System:

Processes, threads, inter-process communication, concurrency and synchronization. Deadlock. CPU scheduling. Memory management and virtual memory. File systems.

Databases:

ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control.

Computer Networks:

Concept of layering. LAN technologies (Ethernet). Flow and error control techniques, switching. IPv4/IPv6, routers and routing algorithms (distance vector, link state). TCP/UDP and sockets, congestion control. Application layer protocols (DNS, SMTP, POP, FTP, HTTP). Basics of Wi-Fi. Network security: authentication, basics of public key and private key cryptography, digital signatures and certificates, firewalls.

- **Syllabus for Humanities and Social Sciences:**

Management:
1. Understanding Marketing Management
2. Analyzing Marketing Opportunities
3. Shaping Marketing Offers based on the chosen strategies
4. Managing and Delivering Marketing Programs

English:

1. English Language Teaching (ELT)
2. Translation Studies
3. Renaissance Literature
4. Gender Studies
5. Indian Writing in English

Sociology:
1. Organizations and Institutions
2. Social Change and Development
3. Conflict and Cooperation
4. Individual and Collective
5. Culture, Science and Technology

Economics:
1. Market, Resource and Distribution
2. Fiscal Policy, Monetary Policy, Inflation and Growth
3. Trade policy and Development
4. Political Economy: Environment, Science and Technology

Finance:
1. Analytical Tools: Corporate finance and Investment
2. Risk and Return Management
3. Capital Structure and Cost of Capital
4. Budgeting and Portfolio theory

- **Syllabus for Information Technology:**

Discrete mathematics and graph theory, Data structures, Digital logic, Signal system and circuits, Computer organization and architectures, Communication systems, Theory of automata, Operating systems, Computer networks, Database management systems, Micro-processors, Design and analysis of algorithms.

- **Syllabus for Mathematics:**

Analysis:

Elementary set theory, finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, supremum, infimum.

Sequences and series, convergence, limsup, liminf.

Bolzano Weierstrass theorem, Heine Borel theorem.

Continuity, uniform continuity, differentiability, mean value theorem.

Sequences and series of functions, uniform convergence.

Riemann sums and Riemann integral, Improper Integrals.

Monotonic functions, types of discontinuity, functions of bounded variation, Lebesgue measure, Lebesgue integral.

Functions of several variables, directional derivative, partial derivative, derivative as a linear transformation, inverse and implicit function theorems.

Metric spaces, compactness, connectedness. Normed linear Spaces. Spaces of continuous functions as examples.

Linear Algebra:

Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations.

Algebra of matrices, rank and determinant of matrices, linear equations.

Eigenvalues and eigenvectors, Cayley-Hamilton theorem.

Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms.

Inner product spaces, orthonormal basis.

Quadratic forms, reduction and classification of quadratic forms

Complex Analysis:

Algebra of complex numbers, the complex plane, polynomials, power series, transcendental functions such as exponential, trigonometric and hyperbolic functions.
Analytic functions, Cauchy-Riemann equations

Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Maximum modulus principle, Schwarz lemma, Open mapping theorem.

Taylor series, Laurent series, calculus of residues.

Conformal mappings, Mobius transformations.

Algebra:

Permutations, combinations, pigeon-hole principle, inclusion-exclusion principle, derangements.

Fundamental theorem of arithmetic, divisibility in Z, congruences, Chinese Remainder Theorem, Euler's Ø- function, primitive roots.

Groups, subgroups, normal subgroups, quotient groups, homomorphisms, cyclic groups, permutation groups, Cayley's theorem, class equations, Sylow theorems.

Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domain, principal ideal domain, Euclidean domain.

Polynomial rings and irreducibility criteria.

Fields, finite fields, field extensions, Galois Theory.

Topology:

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

Ordinary Differential Equations (ODEs):

Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs.

General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function.

Partial Differential Equations (PDEs):

Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs.

Classification of second order PDEs, General solution of higher order PDEs with constant coefficients, Method of separation of variables for Laplace, Heat and Wave equations.

Numerical Analysis :

Numerical solutions of algebraic equations, Method of iteration and Newton-Raphson method, Rate of convergence, Solution of systems of linear algebraic equations using Gauss elimination

and Gauss-Seidel methods, Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration, Numerical solutions of ODEs using Picard, Euler, modified Euler and
Runge-Kutta methods.

Calculus of Variations:

Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations.

Linear Integral Equations:

Linear integral equation of the first and second kind of Fredholm and Volterra type, Solutions with separable kernels. Characteristic numbers and eigenfunctions, resolvent kernel.

Classical Mechanics:

Generalized coordinates, Lagrange's equations, Hamilton's canonical equations, Hamilton's principle and principle of least action, Two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations.

Probability and Statics:

Descriptive statistics, exploratory data analysis:

Sample space, discrete probability, independent events, Bayes theorem. Random variables and distribution functions (univariate and multivariate); expectation and moments. Independent random variables, marginal and conditional distributions. Characteristic functions. Probability inequalities (Tchebyshef, Markov, Jensen). Modes of convergence, weak and strong laws of large numbers, Central Limit theorems (i.i.d. case).

Markov chains with finite and countable state space, classification of states, limiting behaviour of n-step transition probabilities, stationary distribution, Poisson and birth-and-death processes.

Standard discrete and continuous univariate distributions. sampling distributions, standard errors and asymptotic distributions, distribution of order statistics and range.

Methods of estimation, properties of estimators, confidence intervals. Tests of hypotheses: most powerful and uniformly most powerful tests, likelihood ratio tests. Analysis of discrete data and chi-square test of goodness of fit. Large sample tests.

Simple nonparametric tests for one and two sample problems, rank correlation and test for independence. Elementary Bayesian inference.

Gauss-Markov models, estimability of parameters, best linear unbiased estimators, confidence intervals, tests for linear hypotheses. Analysis of variance and covariance. Fixed, random and mixed effects models. Simple and multiple linear regression. Elementary regression diagnostics. Logistic regression.

Multivariate normal distribution, Wishart distribution and their properties. Distribution of quadratic forms. Inference for parameters, partial and multiple correlation coefficients and related tests. Data reduction techniques: Principle component analysis, Discriminant analysis, Cluster analysis, Canonical correlation.

Simple random sampling, stratified sampling and systematic sampling. Probability proportional to size sampling. Ratio and regression methods.

Completely randomized designs, randomized block designs and Latin-square designs. Connectedness and orthogonality of block designs, BIBD. 2K factorial experiments: confounding and construction.

Hazard function and failure rates, censoring and life testing, series and parallel systems.

Linear Programming Problem:
Linear programming problem, simplex methods, duality.

Elementary queuing and inventory models:
Elementary queuing and inventory models. Steady-state solutions of Markovian queuing models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space, M/G/1.

- **Syllabus for Mechanical Engineering:**

  - **Engineering Mathematics:**

Linear Algebra: Matrix algebra, systems of linear equations, eigen values and eigenvectors.

Calculus: Functions of single variable, limit, continuity and differentiability, mean value theorems, indeterminate forms; evaluation of definite and improper integrals; double and triple integrals; partial derivatives, total derivative, Taylor series (in one and two variables), maxima and minima, Fourier series; gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, applications of Gauss, Stokes and Green's theorems.

Differential equations: First order equations (linear and nonlinear); higher order linear differential equations with constant coefficients; Euler-Cauchy equation; initial and boundary value problems; Laplace transforms; solutions of heat, wave and Laplace's equations.

Complex variables: Analytic functions; Cauchy-Riemann equations; Cauchy's integral theorem and integral formula; Taylor and Laurent series.

Probability and Statistics: Definitions of probability, sampling theorems, conditional probability; mean, median, mode and standard deviation; random variables, binomial, Poisson and normal distributions.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations; integration by trapezoidal and Simpson's rules; 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; impulse and momentum (linear and angular) and energy formulations, collisions.

Mechanics of Materials: Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams;

bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.

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

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

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

- **Fluid Mechanics and Thermal Sciences:**

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

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

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

Applications: *Power Engineering*: Air and gas compressors; vapour and gas power

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

- **Materials, Manufacturing and Industrial Engineering:**

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

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

Machining and Machine Tool Operations: Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, 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 models; safety stock inventory control systems.

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

- **Syllabus for Metallurgy and Materials Engineering:**

Laws of thermodynamics, activity, fugacity, equilibrium constant, applications to metallurgical systems, solutions, phase equilibria, phase stability diagrams, thermodynamics of surfaces, interfaces and defects, basic kinetic laws, order of reactions, rate constants and rate limiting steps; principles of electro chemistry- single, aqueous corrosion and protection of metals, heat transfer – conduction, convection and heat transfer coefficient relations, diffusion and Fick's laws, mass transfer coefficients;

Principles and processes for the extraction of non-ferrous metals – aluminium, copper, zinc, lead, magnesium, nickel, titanium and other rare metals. Metal casting – patterns and moulds including mould design involving feeding, gating and risering, melting, casting practices in sand casting, permanent mould casting, investment casting, continuous casting, near net shape casting and shell moulding, casting defects and repair.

Minerals of economic importance, size classification, Flotation, gravity and other methods of mineral processing; agglomeration, pyrohydro- and electro-metallurgical processes;

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, Elasticity, yield criteria and plasticity; defects in crystals; 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

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, LASER welding, problems associated with welding of steels and aluminium alloys, defects in welded joints, iron and steel making –secondary refining processes including AOD, VAD, VOD, VAR and ESR; ingot and continuous casting; stainless steel making, furnaces and refractories.

Metal forming – fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming; Hot, warm and cold working of metals, recovery, recrystallization and grain growth; industrially important ferrous and non-ferrous alloys, NDT using dye-penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle methods. mechanical testing – tension, compression, torsion, hardness, impact, creep, fatigue, fracture toughness and formability, powder metallurgy.

Fracture – Griffith theory, basic concepts of linear elastic and elasto-plastic fracture mechanics, ductile to brittle transition, fracture toughness; failure analysis.

Elements of X-ray and electron diffraction; principles of scanning and transmission electron microscopy; electronic basis of thermal, optical, electrical and magnetic properties of materials; electronic and opto-electronic materials.

Syllabus for Centre of Excellence for Green Energy and Sensor Systems:

Non-Conventional Energy Sources, Solar Photovoltaics, Solar Thermal, Hydro, Wind and Bio Mass Power, Power Electronics, Communication Systems, Power System, Semiconductor Devices,
Microprocessor and Microcontrollers, Digital Signal Processing, Embedded systems, Electrical Machine, Heat Transfer, Internal combustion engine, Mechanical Measurement and Instrumentation