INDICATIVE SYLLABUS

SYLLABUS FOR THE POST OF OFFICER (TECH. OPRS- MECHANICAL/ELECTRICAL/ ELECTRONICS/ METALLURGY)-

SR. NO.	DISCIPLINE	TOPICS
1.	Mechanical Engineering	**1. Engineering Mathematics:** **2. Manufacturing Technology** (i) Tooling for conventional and non-conventional machining processes. (ii) Mould and die design, Press tools, Cutting tools; Holding tools: Jigs and fixtures, Principles, applications and design; press tools-configuration, design of die and punch. (iii) Principles of forging die design. (iv) Metrology: Dimensions, forms and surface measurements, Limits. Fit and tolerances; Iinear and angular measurements; comparators; gauge design; interferometry. (v) Alignment and testing methods; tolerance analysis in manufacturing and assembly. (vi) Assembly practices: Manufacturing and assembly. Process planning, selective assembly, Material handling and devices. **3. Kinematics and Theory of Machines:** (i) Classification of mechanisms-Basic kinematics concepts and definition-Degree of freedom, mobility. (ii) Grashof's law, Kinematic inversions of four bar chain and slider crank chains-Limit positions. (iii) Mechanical advantage-Transmission angle- Description of some common mechanisms. (iv) Quick return mechanism, straight line generators-Universal Joint-Rocker mechanisms. (v) Displacement, velocity and acceleration analysis of simple mechanisms. (vi) Graphical velocity analysis using instantaneous centers. (vii) Velocity and acceleration analysis using loop closure equations. (viii) Kinematic analysis of simple mechanisms-slider crank mechanism dynamics- Coincident points. (ix) Classification of cams and followers. (x) Involute and cycloidal gear profiles, gear parameters. (xi) Fundamental law of gearing and conjugate action, spur gear contact ratio. (xii) Interference/undercutting-helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics. **4. Manufacturing Processes:** (i) Casting and moulding (ii) Introduction to bulk and sheet metal forming. (iii) Plastic deformation and yield criteria. (iv) Fundamentals of hot and cold working processes (v) Load estimation for bulk forming (forging, rolling, extrusion, drawing) and sheet forming (shearing, deep drawing, bending) principles of powder metallurgy. (vi) Metal cutting: Single and multi-point cutting; Orthogonal cutting, various force components: Chip formation, Tools wear and tool life, Surface finish and integrity, Machinability, Cutting tools materials, Cutting fluids, Coating; Turning, Drilling, Milling and finishing processes, Introduction to CNC machining. (vii) Joining/fastening processes: Physics of welding, brazing and soldering; design considerations in welding, Solid and liquid state joining processes; Adhesive bonding. (viii) Unconventional Machining Processes: Abrasive Jet Machining, Water Jet Machining, Abrasive Water Jet Machining, Ultrasonic Machining, principles and process parameters. (ix) Electricals Discharge Machining, principle and processes parameters, MRR, surface finish, tool wear, dielectric, power and control circuits, wire EDM; Electro—chemical machining (ECM), etchant & maskant, process parameters, MRR and surface finish. (x) Laser Beam Machining (LBM), Plasma Arc Machining (PAM) and Electron Beam Machining. **5. Design of Machine Elements:** (i) Limits, fits and standardization, Review of failure theories for static and dynamic loading (including fatigue failure). (ii) Design of shafts under static and fatigue loadings. (iii) Analysis and design of sliding and rolling contact bearings, Design of transmission

elements: spur, helical, bevel and worm gears; belt and chain drives, design of springing: helical compression, tension, torsional and leaf springs.

(iv) Design of joints; threaded fasteners, pre-loaded bolts and welded joints.

(v) Analysis and applications of power screws and couplings, Analysis of clutches and brakes.

6. Automation in manufacturing:

(i) Why automation, Current trends, CAD, CAM, CIM; Rigid automation: Part handling, Machine tools.

(ii) Flexible automation: Computer control of Machine Tools and Machining Centers.

(iii) Computer Aided Design: Fundamentals of CAD- Hardware in CAD-Computer Graphics Software and Data Base, Geometric modeling for downstream applications and analysis methods.

(iv) Computer Aided Manufacturing: CNC technology, PLC, Micro-controllers, CNC- Adaptive Control.

(v) Low cost automation: Mechanical & Electro mechanical Systems, Pneumatics and Hydraulics.

(vi) Introduction to Modeling and Simulation: Product design, process route modeling, Optimization techniques, Case studies & industrial applications.

(vii) Sensors and transducers: classification, Development in Transducer technology, Opto-electronics-Shaft encoders, CD Sensors, Vision System, etc.

(viii) Drives and Actuators: Hydraulic and Pneumatic drives, Electrical Actuators such as servo motor and Stepper motor, Drive circuits, open and closed loop control; Embedded Systems.

(ix) Hardware Structure, Software Design and Communication, Programmable Logic Devices, Automatic Control and Real Time Control Systems.

(x) Smart materials: Shape Memory Alloy, Piezoelectric and Magnetostrictive Actuators: Materials, Static and dynamic characteristics.

(xi) Micromechatronic systems: Microsensors, Microactuators ; Micro-fabrication techniques LIGA Process: Lithography, etching, Micro-joining etc. Examples thereof.

7. Microprocessors in Automation:

(i) Number Systems, codes, digital electronics: Logic Gates, combinational circuits design, Flip-flops.

(ii) Sequential logic circuits design: Counters, Shift registers.

(iii) Introduction to 8085 Functional Block Diagram, Registers.

(iv) ALU, Bus systems, Timing and control signals.

(v) Machine cycles, instruction cycle and timing states, instruction timing diagrams, Memory interfacing.

(vi) Assembly Language Programming: Addressing modes, Instruction set, simple programs in 8085; Concept of Interrupt, Need for Interrupts, Interrupt structure, Multiple Interrupt request and their handling.

(vii) Interfacing Analog to Digital Converter & Digital to Analog converter.

(viii) Multiplexed seven segments LED display systems, Stepper Motor Control.

(ix) Introduction to Digital Control: sampling theorem, Signal conversion and Processing, Z-Transform, Digital Filters, Implementation of Digital Algorithm.

8. Composite Materials:

(i) Definition and applications of composite materials, Fibers-glass, carbon, ceramic and aramid fibers.

(ii) Matrices- polymer, graphite, ceramic and metal matrices.

(iii) Characteristics of fibers and matrices.

(iv) Manufacturing of composite materials, bag moulding, compression moulding, pultrusion, filament welding, other manufacturing processes.

(v) Basic assumptions of laminated anisotropic plates, symmetric laminates, angle ply laminates, cross ply laminates, laminate structural moduli, evaluation of lamina properties, determination of lamina stresses.

9. Fluid Mechanics And Fluid Machines

10. Instrumentation and Control

11. Heat Transfer

12. Solid Mechanics

13. Kinematic and Theory of Machines

		14. Internal Combustion Engines **15. Mechatronic systems** **16. Microprocessors in Automation** **17. Composite Materials** **18. Computer Aided Design** **19. Refrigeration and Air Conditioning** **20. Finite Element analysis** **21. Power Plant Engineering** **22. Gas Dynamics and Jet Propulsion** **23. Process Planning and cost Estimation** **24. Principles of Management** **25. Automobile Engineering** **26. Design of Transmission Systems** **27. Total Quality Management** **28. Energy Conservation and Management** **29. Concept of Engineering Mathematics** **30. Knowledge of Computer System Microsoft Office, Excel etc.** **31. Industrial Management** **32. Hoists Lifts , Lifting tackles Testing ,Alloys & Machining, Forming**
2.	Electrical Engineering	**1. Professional Elective Courses & Electronic Machine & Drives** (i) Line-Commutated and Active PWM Rectifiers (ii) Electrical Drives (iii) Electrical and Hybird Vehicles (iv) Electrical Machine Design (v) Power System Protection (vi) HVde Transmission Systems (vii) Power Quality and FACTS (viii) High Voltage Engineering (ix) Electrical Energy Conservation and Auditing (x) Industrial Electrical Systems (xi) Power System Dynamics and Control (xii) Digital Control Systems (xiii) Digital Single Processing (xiv) Computer Architecture (xv) Electromagnetic Waves (xvi) Computational electromagnetics (xvii) Control Systems Design (xviii) Advanced Electric Drives **2. Program Core Courses:** (i) Electrical Circuit Analysis (ii) Analog Electronic Circuits (iii) Electrical Machines-I (iv) Electromagnetic Fields (v) Digital Electronics (vi) Electrical Machines-II (vii) Power Electronics (viii) Singles and Systems (ix) Power Systems (x) Control Systems (xi) Microprocessors **3. Mathematics-II (Linear Algebra, Transform Calculus and Numerical Methods)** **4. Concept of Engineering Mathematics** **5. Knowledge of Computer System Microsoft Office, Excel etc.** **6. Industrial Management** **7. Power factor Control, PLC , SCADA , Substation & Maintenance , Switchgears & Transformers, Mechatronics.**

3.	Electronics Engineering	**1. Program core courses (Electronic devices and Digital System design)** (i) Electronic Devices (ii) Digital System Design (iii) Signal and System (iv) Network Theory (v) Analog and Digital Communication (vi) Analog and Digital Communication Laboratory (vii) Analog circuits (viii) Microcontrollers (ix) Electromagnetic Waves (x) Computer Architecture (xi) Control Systems (xii) Computer Network **2. Program Elective Courses** (i) Microwave Theory and Techniques (ii) Fiber Optic communication (iii) Information Theory and Coding (iv) Speech and Audio processing (v) Introduction to MEMS (vi) Adaptive Signal Processing (vii) Antennas and Propagation (viii) Bio-Medical Electronics (ix) Mobile Communication and Networks (x) Digital Image & Video processing (xi) Mixed Signal Design (xii) Wireless Sensor networks (xiii) CMOS Design (xiv) Power Electronics (xv) Satellite Communication (xvi) High Speed Electronics (xvii) Wavelets (xviii) Embedded Systems (xix) Nano Electronics (xx) Error Correcting Codes **3. Concept of engineering Mathematics** **4. Knowledge of computer system Microsoft Office, Excel etc.** **5. Industrial Management.** **6. Mechatronics, VLSI , Cyber Security, Biometric Systems.**
4	Metallurgy Engineering	**1. Introduction to Materials Engineering :-** (i) Design, synthesis & processing, characterization, applications of materials. (ii) Failure analysis & forensics of different types of materials starting from common metals and alloys to exotic materials . (iii) Examples and case studies will be taken up and shown to the students (iv) In parallel with Modules 1,2and3): Demonstrations using sophisticated and state-of-the-art instruments pertaining to aspects of synthesis, processing, characterization and failure analysis will be carried out in the laboratories. (v) In parallel with Modules 1,2and3): Comprehensive visits/conducted Tours to the research laboratories will be carried out in the laboratories. (vi) Videos and simulations describing materials and their properties will be shown along with specific and interesting case studies. **2. Mechanical properties of Materials :-** (i) Strength of materials - Mohr's circle representation, elements of elasticity and plasticity, yield criteria. (ii) Deformation of ideal crystal, crystal defects, dislocation theory, dislocations in FCC, BCC, and HCP structures, stress fields and energies of dislocations, forces on and between dislocations, reactions and interaction of dislocations, dislocation-precipitate interactions. (iii) Plastic deformation of single crystals and polycrystals. Strain hardening, cold work, recovery and recrystallization. (iv) Effect of grain boundaries, yield point phenomenon, strain ageing, dynamic strain ageing. Tensile flow properties, effects of strain rate and temperature, ductile/brittle transition. (v) Introduction to creep, fatigue and fracture mechanics. **3. Physical Metallurgy :-**

(i) Phase diagrams — binary and ternary, principles of alloying, Hume-Rothery rules. Strengthening mechanisms — solid solution, work hardening, precipitation hardening, dispersion strengthening.
(ii) Iron carbon diagram, isothermal and continuous cooling transformation diagrams; influence of alloying elements on transformation characteristics.
(iii) Heat treatment - annealing, normalizing, hardening and tempering of steels, hardenability.
(iv) Introduction to important ferrous alloys (stainless and special steels, cast irons), aluminum alloys titanium alloys, copper base alloys.
(v) Superalloys, shape memory alloys-classifications, heat treatment, properties and applications.

4. **Materials Chemistry and Characterization :-**
(i) Chemical analysis to identify and quantify different elements in ferrous and non-ferrous alloys by wet chemistry routes.
(ii) Chemical analysis to identify and quantify different elements in ferrous and non-ferrous alloys by instrumental methods.
(iii) Application of chemical analysis to experiments involving mass transfer.
(iv) Application of chemical analysis to experiments involving extractive metallurgy & corrosion.
(v) Application of chemical analysis to experiments involving fluid property measurements.
(vi) Specimen preparation for scanning electron microscopy, transmission electron microscopy.
(vii) Control of composition and quality of steel using slags- ferrous slags, physical chemistry of slag metal reactions.

5. Materials Processing:-
(i) Principles of plasticity related to metal forming, cold warm, and hot working, dynamic recovery and recrystallization. Basic metal forming processing such as Rolling, Forging, Extrusion, Wire Drawing, Sheet metal working.
(ii) Welding versus other joining processes, Welding processes, welding processes, welding metallurgy, TTT and CCT diagrams, carbon equivalent, welding of ferrous and non-ferrous alloys, joining of dissimilar metals.

6. Nanomaterials :-
(i) History of nano materials.
(ii) Discussion of the Feynman talk -There is plenty of room at the bottom.
(iii) Synthesis routes for nano and ultra fine grained materials: bottom up and top down approaches.
(iv) Specific synthesis routes such as vapor deposition, sol-gel, rapid solidification processing, high energy ball milling, cryo rolling, and equal channel angular extrusion.
(v) Thermodynamics of nanomaterials.
(vi) Mechanical property aspects of nanomaterials, inverse Hall-Petch relationship.
(vii) Specific nano materials and their applications such as:
Carbon nanostructures (Nanotubes, nanohoms, graphene, buckyballs etc).
Semiconducting nanomaterials - Quantum confinement, Quantum wells, quantum wires and quantum dots.
Magnetic nanomaterials - super paramagnetism.
Ferroclectric, nano ceramics.
Superplasticity
Nanocomposites
(viii) Characterization techniques fomr the perspective of nanomaterials.

7. Surface Engineering :-
(i) Need for engineered surface, definition and principles
(ii) Conventional surface hardening methods
(iii) Methods involving no change in the chemical composition of the surface
(iv) Methods involving change in chemical composition of the surface
(v) Application of advanced techniques such as ion and electron beam towards creating new engineered surface
(vi) Controlled high quality surface modification by techniques such as CVD, PVD. Plasma, laser, ion bombardment
(vii) Effect of process variables and structure -property correlations
(viii) Thermo - chemical, thermo - mechanical and thermal processes
(xi) Treatments for industrial components
(x) Case studies

8. Powder Metallurgy & Foundry Technology :-
(i) Powder production.

		(ii) Powder characterization (iii) Powder treatment (iv) Powder compaction (v) Pressureless powder shaping (vi) Sintering theory, sintering kinetics, sintering technology, consolidation. (vii) Defects in P/M route and their control, treatment of powder metallurgy components (viii) Pattern making, moulding and core making, Metal mould casting, gating and risering, melting. (ix) Casting defects and quality control (x) Heat treatment of castings (xi) Use of CAD CAM in foundries 9. **Phase Transformations :-** (i) Definition and types of Phase transformations. (ii) Diffusion: Fick's laws of diffusion, solution of Fick's second law and its applications, atomic model of diffusion and role of crystal defects, temperature dependence of diffusion coefficient. (iii) Kirkendall effect. Diffusional transformation in solids and diffusionless transformation in solids. (iv) Nucleation and growth - energy considerations; homogeneous nucleation, heterogeneous nucleation, growth kinetics, overall transformation rates. (v) Crystal interfaces and microstructure. Microstructure evolution including recrystallization and grain growth. (vi) Precipitation from solid solution: Homogeneous and hetrogeneous nucleation of precipitates, the aging curve, mechanisms of age hardening, examples from Al-Cu and other alloy systems . (vii) Martensitic Transformations: General characteristics of martensitic reactions, similarity to deformation twinning, bain distortion, crystallography and kinetics of martensitic transformations, examples from ferrous and non-ferrous alloy systems. (viii) Order-disorder Transformation Examples of ordered structures, long and short range order, detection of super lattices, influence of ordering on properties. (ix) Spinodal decomposition. **10. Concept of Engineering Mathematics.** **11. Knowledge of Computer System Microsoft Office, Excel etc.** **12. Industrial Management.** **13. Machining, Forming Tools, Dies, Punches, Moulds, Inserts, Collets, Heat treatment**

IN ADDITION TO ABOVE SYLLABUS, THE FOLLOWING TOPICS ARE ALSO ADDED (COMMON FOR ALL ABOVE):

- ISO standards
- Quality Management 7QC tools. SPC/SQC Techniques
- Calibration, Gauging, Digital Measurements
- Safety Guidelines, Factory Act,
- Environment Aspects , Discharge and their control
- Industry 4.0
- Engg Math + Engg. Drawing
- Material handling
- BS Standards for materials & Material testing

SYLLABUS FOR THE POST OF OFFICER (TECH. OPRS- PRINTING) AND THE POST OF OFFICER (TECH CONTROL-INK/LAB/QA/QC/CONTROL) FOR THE DISCIPLINE OF PRINTING TEHNOLOGY -

SR. NO.	DISCIPLINE	TOPICS
1.	Printing Technology	**1. Introduction to Printing Process:-** (i) Basic of Print Media & Printing Technique (ii) Digital Printing Technology (iii) Technology of offset printing (iv) Flexography Printing (v) Principle and Technology of Gravure & Screen Printing (vi) Printing & Technology of offset Printing (Dry-Wet) (vii) Principle & technology of Intaglio Printing **2. Basic Principles of Imaging Techniques :-** (i) **Pre-Press:** – (a) DTP, Camera Processing, Conversion to film output- negative, CTP technology, surface preparation for letterpress, lithography, dry-wet offset, screen, gravure & flexography. (b) Basic concept of printing designs- Layout style, art work, Typography, Symbol & logos, layout and colour etc. (ii) **Presses:-** Configuration of machine part and accessories, Dry-Wet offset, flexography, gravure, intaglio, digital and screen printing machines. **3. Technology Security Printing:-** (i) Introduction of security printing (ii) Requirement of security printing (iii) Counterfeiting creation graphics (iv) Types of security product (v) Overt & Covert features **4. Security Printing Inks:-** (i) Type of Security Printing Inks (ii) Migrating Heat reactive Ink (iii) Erasable & Fugitive Inks (iv) Copy protection & Thermo chromic Ink (v) Penetrating Ink (vi) OVI & UV Curing Ink (vii) IR Ink (viii) Monochromic Ink (ix) Water Resistant &Invisible Phosphorescent Ink tec **5. Security Substrates:** Security Fibers, Planchettes, Fluorescent Hi-Lites, Iridescent coating, Security threads, Holographic foil, Colour Centered paper, Chemically Void, Toner fused Paper, Visible security fibers, Invisible fluorescent fibers and Other security papers. **6. Print Processes used in Security Printing:-** (i) Printing Processes such as Gravure, Offset, Intaglio, Flexo, Letterpress, Screen, Variable Data Printing. (ii) Software and Digital printing equipment used for variable data printing (iii) Recent trends and developments in security printing (iv) Process of Gravure, offset, Intaglio, Flexo Image Carrier (v) Inking, Drying and Impression system of offset, Intaglio, Flexo etc. **7. Printing Electronics:** (i) Materials in Printed Electronics (ii) Basic Electronic components (iii) Printing Process used for printing electronics (iv) Impact Printing Processes: Offset, Screen, Gravure, Flexography (v) Non-impact printing processes-Inkjet Drop on demand for production of PE, scope and limitations, Printed Electronics Applications, Advances and Future Trends. **8. Maintenance Management of Printing Machines**: (i) Printing machine technology in sheetfed & Webfed Offset Printing Machines (ii) Flexography Digital Printing Machine (iii) Maintenance Management (iv) Preventive Maintenance

		(v) Corrective Maintenance (vi) Quality and Safety in Maintenance (vii) Predictive Maintenance Techniques (viii) Breakdown Maintenance and Reconditioning and Replacement Theory **9. Management information System and Cost:** (i) Basics concepts of Management (ii) Basic of MIS (iii) Requirement & Types of MIS (iv) Enterprise Management Systems (v) Costing & Estimation (vi) Print Production Planning and Control **10. Concept of engineering Mathematics** **11. Knowledge of computer system Microsoft Office, Excel etc.** **12. Industrial Management.** **13. Pollution from printing, CNC M/Cs in printing, Tooling**

IN ADDITION TO ABOVE SYLLABUS, THE FOLLOWING TOPICS ARE ALSO ADDED (COMMON FOR ALL ABOVE):

- ISO standards
- Quality Management 7QC tools. SPC/SQC Techniques
- Calibration, Gauging, Digital Measurements
- Safety Guidelines, Factory Act,
- Environment Aspects , Discharge and their control
- Industry 4.0
- Engg Math + Engg. Drawing
- Material handling
- BS Standards for materials & Material testing

SYLLABUS FOR THE POST OF OFFICER(TECH CONTROL- INK/LAB/QA/QC/CONTROL) IN TH DISCIPLINES OF CHEMICAL ENGG. , PULP & PAPER ENGG. AND MSc. (CHEMISTRY) -

SR. NO.	DISCIPLINE	TOPICS
1.	Chemical Engineering	**1. Thermodynamics-I** i. Introduction- scope of thermodynamics, Dimensions and Units, Temperature, Pressure, Work, Energy, Heat ii. Energy conservation & first law of thermodynamics; State functions; Equilibrium; Phase Rule; Reversible process; Constant P,V, T processes; Mass and energy balances for open systems. iii. Phases, phase transitions, PVT behavior; description of materials – Ideal gas law, van der Waals, virial and cubic equations of state; Reduced conditions & corresponding states theories; correlations in description of material properties and behavior. iv. Heat effects-latent heat, sensible heat, standard heats of formation, reaction and combustion. v. Statements of the second law; Heat engines, Carnot's theorem,; Thermodynamic Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law; Entropy balance for open systems; Calculation of ideal work, Lost work. vi. Thermodynamic property of fluids, Maxwell relations, 2-phase systems, graphs and tables of thermodynamic properties. vii. Application of thermodynamics to flow processes-pumps, compressors and turbines. viii. Thermodynamic analysis of steam power plants; Rankine cycle; Internal combustion engine, Otto engine; Diesel engine; Jet engine. ix. The Carnot refrigerator; Vapor-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes. **2. Thermodynamics-II** i. Review of first and second law of thermodynamics. ii. Vapor-liquid equilibrium: phase rule, simple models for VLE;VLE by modified Raoult's law; VLE from K-value correlations; Flash calculations. iii. Solution Thermodynamics: fundamental property relationships, free energy and chemical potential, partial properties, definition of fugacity and fugacity coefficient of pure species and species in solution, the ideal solution and excess properties. iv. Liquid phase properties from VLE, Models for excess Gibbs energy, heat effects and property change on mixing. v. UNIFAC and UNIQUAC models. vi. Liquid-Liquid Equilibria; Vapor-Liquid-Liquid Equilibria; Solid-Liquid Equilibria; Solid-Gas Equilibria. vii. Chemical reaction equilibria: equilibrium criterion, equilibrium constant, evaluation of equilibrium constant at different temperatures, equilibrium conversion of single reactions, multireaction equilibria. viii. Introduction to molecular/statistical thermodynamics. **3. Heat Transfer** i. Heat Transfer Fundamentals: Modes of heat transfer, thermal diffusivity and heat transfer coefficient; Differential equations of heat transfer; special forms. ii. Conductive heat transfer - one dimensional problems, heat transfer from extended surfaces, two and three dimensional problems, Insulation. iii. Convective heat transfer - natural and forced convection; Dimensional analysis; Thermal boundary layer; Analogies and Correlations. iv. Design of heat transfer equipment - double pipe heat exchanger, concept of LMTD, DPHE sizing; shell and tube heat exchanger Kern's method for design, effectiveness-NTU method, construction aspects in brief, Bell Delaware Method. v. Design aspects of finned tube and other compact heat exchangers. vi. Basics of Heat transfer with phase change - Introduction to boiling,

Introduction to condensation.

vii. Design aspects of Condensers, Reboilers and Evaporators.

viii. Heat Transfer to Agitated tanks, unsteady state heat transfer.

ix. Introduction to Radiative Heat Transfer, Design aspects of Furnaces.

4. Mass Transfer-I

i. Constitutive laws of diffusion; unsteady state diffusion.

ii. Convective mass transfer, interphase mass transfer and mass transfer coefficients, mass transfer correlations.

iii. Mass transfer theories/models.

iv. Effect of chemical reaction on mass transfer.

v. Equilibrium stages and transfer units: number and height of transfer units; stage efficiency.

vi. Gas absorption plate and packed column design; reactive absorption.

vii. Batch distillation; continuous binary fractionation.

viii. Azeotropic distillation; use of steam.

ix. Introduction to multicomponent distillation.

5. Mass Transfer-II

i. Perspective on unified approach to operations.

ii. Liquid-liquid Extraction.

iii. Leaching & Washing.

iv. Adsorption, Ion-Exchange; Fixed bed absorbers, breakthrough.

v. Simultaneous Heat & Mass Transfer: Humidification and Dehumidification.

vi. Simultaneous Heat and Mass Transfer: Drying.

vii. Design of Cooling Towers.

viii. Membrane processes.

ix. Ultrafiltration and Osmosis, Reverse Osmosis.

6. Fluid Mechanics

i. Introduction to fluids, Continuum hypothesis, Forces on fluids, Normal and shear stresses.

ii. Fluid statics - pressure distribution, Manometry, Forces on submerged bodies (planar and curved), Buoyancy, Rigid body motion (translation and rotation).

iii. Kinematics of fluid flow- Eulerian and Lagrangian descriptions, Flow visualization, Stream function, Vorticity and Circulation, Kinematic decomposition of flow motion.

iv. System and control volume approaches, Reynolds transport theorem, Integral balances – mass and momentum, Euler's equation of motion, Bernoulli equation and applications, Turbulent flow, Head loss in pipe flow, Moody diagram.

v. Flow measurement, Transportation of fluids - pumps, selection and design of pumps.

vi. Differential analysis: mass and momentum balances, Navier-Stokes equation, Unidirectional flow, Viscous flow, Stokes law, Skin drag and pressure drag.

vii. Potential flow, Potential function, Solution of Laplace equation.

viii. Boundary layer theory, Blasius solution, Boundary layer separation, Drag and lift force on immersed body.

ix. Similitude analysis, Lubrication approximation.

x. Compressible flows, Blowers and compressors.

xi. Introduction to turbulence: Structure of turbulence, visualization of turbulence, Reynolds decomposition, Spectral nature of turbulence and Kolmogorov hypothesis.

7. Numerical Methods in Chemical Engineering

i. Introduction, Approximation and Concept of Error & Error Analysis.

ii. Linear Algebraic Equations: Methods like Gauss elimination, LU decomposition and matrix inversion, Gauss-Siedel method, Chemical engineering problems involving solution of linear algebraic equations.

iii. Root finding methods for solution on non-linear algebraic equations: Bisection, Newton Raphson and Secant methods Chemical engineering problems involving solution of non-linear equations.

iv. Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression.

v. Numerical integration: Trapezoidal rule, Simpson's rule, integration with unequal segments, quadrature methods, Chemical engineering problems

involving numerical differentiation and integration.

vi. Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single, and a system of ODEs.

vii. Introduction to Partial Differential Equations: Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method.

8. Chemical Reaction Engineering-I

i. Reactions and reaction rates - stoichiometry, extent of reactions, conversion, Selectivity Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory.

ii. Ideal reactors - generalized material balance, design equations, graphical interpretation.

iii. Sizing and analysis of ideal batch, mixed (CSTR), plug flow and recycle reactors – solving design equations for constant and variable density systems, reactors in series and parallel.

iv. Analysis and correlation of experimental kinetic data - data collection & plotting, linearization of rate equations, differential and integral method of analysis.

v. Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions.

vi. Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions.

vii. RTD theory and analysis of non-ideal reactors.

9. Chemical Reaction Engineering-II

i. Introduction to Catalysis, homogeneous and heterogeneous catalysis. Preparation and characterisation of catalysts.

ii. Physical and chemical adsorption, Adsorption isotherms, Determination of BET surface area and pore volume of the Catalyst.

iii. Kinetics of solid catalyzed gas phase reaction.

iv. Laboratory reactors for catalytic gas solid reactions. Design concepts.

v. Mass transfer, Diffusion and Chemical reactions in catalysts. Effects of external mass transfer and heat transfer, Effectiveness factor. Design aspects of catalytic reactors.

vi. Non-catalytic gas-solid reactions, different model for gas-solid reactions.

vii. Gas liquid reactions, film and penetration theories, enhancement factor in gas-liquid reactions, gas-liquid reactors.

10. Process Control

i. Introductory Concepts: Need for control and automation, control logic, servo and regulatory control, block diagrams, control structures (feedback vs. feed forward), process and instrumentation diagrams.

ii. Laplace transforms, solution of ODEs using Laplace transform.

iii. Transfer function approach, response of first order systems: step, impulse and sinusoidal response, first order systems in series.

iv. Second order systems, higher order systems, transportation lag and dead time.

v. Linear closed loop systems, development of block diagrams, classical feedback controllers.

vi. Final control element (control valves), block diagram reduction techniques.

vii. Closed loop response, servo and regulatory problems.

viii. Stability analysis, Routh stability criterion, Root locus diagrams (rule based).

ix. Introduction to frequency response, notion of stability.

x. Bode diagrams, Nyquist plots, Bode and Nyquist stability criterion.

xi. Controller tuning: Ziegler-Nichols method, Cohen-Coon method.

xii. Introduction to advanced controllers: cascade control, feed forward control, ratio control, Smith-predictor, IMC, MPC, dead-time compensation.

xiii. Introduction to digital control.

11. Engineering and Solid Mechanics

i. Introduction, Point Kinematics: Moving point in various coordinate systems (Cartesian, Cylindrical, Path).

ii. Rigid body kinematics: Translation and rotation, relative motion, angular velocity, General motion of a rigid body, General relative motion.

iii. Equivalent force systems, Resultant forces, Linear and Angular Momentum, Laws of motion (Euler's Axioms), Free Body Diagrams, Dynamics of point mass models of bodies.

iv. Equilibrium of rigid bodies, distributed forces, Analysis of structures: Trusses,

Forces in Beams: Shear Force and Bending Moment.

v. Frictional forces, Laws of Coulomb friction, impending motion.

vi. Inertia tensor, Principal Moments of Inertia, Moment of momentum relations for rigid bodies, Euler's Equations of Motion.

vii. State of stress at a point, equations of motion, principal stress, maximum shear stress, Concept of strain, strain displacement relations, compatibility conditions, principal strains, transformation of stress/strain tensor, state of plane stress/strain.

viii. Uniaxial stress and strain analysis of bars, thermal stresses, Torsion of circular bars and thin walled members, Bending of straight/curves beams, transverse shear stresses, deflection of beams, Buckling of columns.

12. Material Science

i. Introduction to materials, bonding between atoms: metallic bonding, ionic bonding, covalent bonding, Van der Waals bond, thermal expansion, elastic modulus and melting point of materials, Role of materials selection in design, structure-property-processing performance relationships.

ii. Miller indices of directions and planes, packing of atoms inside solids, close-packed structures, structure of ceramics, ionic solids, glass and polymers, density of various materials.

iii. Imperfections in solids: vacancies, equilibrium concentration of vacancies, interstitial and substitutional impurities in solids, dislocations, types and characteristics of dislocations, interfacial defects, stacking faults.

iv. Structure of materials and Strength of Materials: Yield strength, tensile strength and ductility of materials: stress strain behaviour of metals, ceramics and polymers, tensile test, plastic deformation, necking, creep behaviour and fatigue.

v. Semi-crystalline materials: Classification, structure and configuration of ceramics, polymers, copolymers, liquid crystals and amphiphiles.

vi. Non-crystalline/amorphous materials: Silicates, glass transition temperature, viscoelasticity.

vii. Polymer nano-composite materials: Nanocomposites, role of reinforcement-matrix interface strength on composite behavior.

viii. Corrosion, Degradation and Recycling.

ix. Biomaterials, material related to catalyst such as zeolites, silica etc. and other selected materials.

x. Introduction to experimental techniques: XRD, NMR, PSA, etc. for material characterization highlighting links between molecular structure and macroscopic properties.

13. Material and Energy Balance Computations

i. Introductory concepts of units, physical quantities in chemical engineering, dimensionless groups, "basis" of calculations.

ii. Material Balance: Introduction, solving material balance problems without chemical reaction.

iii. Material Balance: With chemical reaction, Concept of stoichiometry and mole balances, examples, including combustion.

iv. Material Balances with recycle, bypass and purge.

v. Gases, Vapours and Liquids: Equations of state, Vapour pressure, Clausius-Clapeyron equation, Cox chart, Duhring's plot, Raoult's law,.

vi. Energy balance: open and closed system, heat capacity, calculation of enthalpy changes.

vii. Energy balances with chemical reaction: Heat of reaction, Heat of combustion.

viii. Crystallization, Dissolution.

ix. Humidity and Saturation, humid heat, humid volume, dew point, humidity chart and its use.

14. Transport Phenomena

i. Introduction to Transport Phenomena, Formulation of transport problems from nature.

ii. Vector and Tensor Analysis: Basic concepts.

iii. Basics of momentum transport: Euler/Lagrangian viewpoint, laminar and turbulent flows, boundary layers, stress tensor.

iv. Shell momentum balances, equations of change, dimensional analysis, applications to isothermal flow of Newtonian & non Newtonian fluids.

v. Basics of energy transport, conductive, convective and viscous dissipation energy fluxes.

		vi. Equations of change for non-isothermal systems, dimensional analysis, and applications to steady-state conduction and convection. vii. Basics of mass transport, mechanisms, and mass and molar fluxes. viii. Derivation of equation of continuity for a binary mixture and its application to convection- diffusion problems. ix. Unsteady-state momentum, heat and mass transport, formulation of basic equations and similarity transform method. **15. Electrical & Electronics Engineering** i. Elements in an Electrical circuit: R, L, C, Diode, voltage and current sources. ii. DC circuits, KCL, KVL, Network theorems, Mesh and nodal analysis. iii. Step response in RL, RC, RLC circuits. iv. Phasor analysis of AC circuits. v. Single-phase and 3-phase circuits. vi. Two port networks, BJT, CE and small signal model, operational amplifiers, model and applications. vii. Introduction to digital circuits. viii. Transformers: modelling and analysis. ix. Energy in magnetic field. x. Electromechanical energy conversion: principles and examples. xi. Principles of measurement of voltage, current and power. **16. Engineering Graphics** i. Instructions for graphic science and visualization. ii. Free hand sketching of isometric & orthographic views and interpretation of drawings. iii. Dimensioning, sectioning and datum planes. iv. Constraints and assembly drawings. v. Engineering animation including motion curves, coordinating multiple moving parts under joint-constraints and the notion and impact of lighting and camera. vi. Compositing and physics engines (gravity, collision, dynamics, fluid simulation. **17. Management information System and Cost** **18. Concept of engineering Mathematics** **19. Knowledge of computer system Microsoft Office, Excel etc.** **20. Industrial Management**
2.	Pulp & Paper Engineering	**1. Introduction – to Pulp and Paper Manufacturing-** i. **Introduction**: Importance of paper, definitions of pulp, paper and paperboard; Flow sheet of complete pulp and paper making process. ii. **Fibrous Raw Materials for Paper Making:** Plant fibers, plant kingdom, plant body and organization of fibers and other cells in plant. iii. **Raw Material Structure:** Structure of softwoods, hardwoods, and non-woods; Pulpwood species; Cell types; Ultrastructure of cell wall; Physical properties, variability, and defects of raw materials. iv. **Chemistry of Fibrous Raw Materials:** Gross composition; Distribution of wood constituents, cellulose, hemi-cellulose, lignin, extractives, and inorganic components; Lignin-hemicellulose bonds; Comparison of different raw materials. v. **Preparation of Fibrous Raw Material:** Transportation, procurement, handling, storage and preservation; Debarking, chipping, depithing, screening, cleaning, and conveying operations. vi. **Pulping and Recovery:** Pulping processes; Washing, screening and cleaning; Recovery of chemicals; Bleaching of pulp; Preparations of stock for paper making; Secondary fiber utilization; Non-fibrous additives to paper making stocks. vii. **Papermaking:** Stock handling and approach flow system; Paper forming; Pressing and drying; Surface treatments; Finishing; Coating; Properties and testing of pulp and paper. **2. Pulping** i. **Introduction**: Overview of alkaline pulping, kraft and soda pulping, standard terminologies. ii. **Kraft Pulping:** Description of kraft cooking process, kraft recovery cycle, composition and analysis of white liquor, chemical reactions and process variables, dependence of time and temperature, H-factor, control parameters; Effect of raw material on pulp

quality; Evaluation of pulps, kappa number, viscosity, and drainability.

iii. **Pulp Mill Operations:** Batch and continuous digesters and their operations, heating systems, blowing, cold blowing, and blow heat recovery system.

iv. **Kraft Process Modifications:** Digester additives; Extended delignification processes; Modified continuous cooking, SuperBatch, rapid displacement heating process; Oxygen delignification; Polysulphide pulping.

v. **Pulping of Non-woods:** Collection, handling and storage of agri- residue and other non-wood fibrous raw materials; Pulping equipment and cooking processes; Comparison of non-wood pulps with wood pulps.

vi. **Mechanical Pulping:** Classification of mechanical pulping process; Grinders, pulp-stone, RMP, CRMP, TMP, and CTMP; Control practices and testing methods; Properties and end uses of mechanical pulps.

vii. **Semichemical and Chemimechanical Pulping:** Types of high-yield pulping processes; Neutral sulphite semichemical (NSSC) pulping; Cold soda, acid sulphite, bisulphate, and hot sulphite chemimechanical pulping processes; Composition of cooking liquors and chemical reactions; Process variables and characteristics of pulps.

viii. **Washing:** Processing of pulp before washing; Mechanisms of washing, physico-chemical aspects of lignin removal in washing, operating targets for brown stock washing systems, displacement ratio, Norden efficiency, dilution factor, washing losses, factors affecting pulp washing; Washing equipments.

ix. **Screening:** Mechanisms of screening, efficiency, variables affecting screening efficiency; Types of screens, pressure screens and their applications, medium consistency screens; Process flow sheets for screening of different types of pulps; Control of screens.

x. **Cleaning:** Mechanisms of cleaning, centrifugal cleaners, forward and reverse cleaners, high density cleaners; Process design calculations, process flow sheets for cleaning different types of pulps; Control of cleaners; Combinations of screens and centrifugal cleaners.

xi. **Bleaching Fundamentals:** Objectives of bleaching, ECF and TCF bleaching; Bleachability and its measurement, brightness and its measurement, brightness reversion, P.C. number; Bleaching reactions, reaction kinetics and operating variables for different bleaching agents like Cl_2, $C10_2$, 0_2, 0_3, hypochlorite, H_20_2; Bio-bleaching agents, dithionite.

xii. **Bleaching Operations:** Stages of bleaching, oxygen delignification, chlorination, extraction, hypochlorite bleaching, ozone bleaching, peroxide bleaching; Operating variables for different bleaching stages; ECF and TCF bleaching systems for chemical pulps; Bleaching systems for mechanical and high yield pulps.

xiii. **Secondary Fiber Processing:** Grades of secondary fiber, sources, supply and demand; Effect of recycling on paper quality; Handling, storage, and sorting of wastepaper; Hydrapulpers, screening, cleaning, and bleaching; Impact of secondary fibers on paper machine.

xiv. **Deinking:** Principles of deinking, washing and floatation deinking, deinking chemicals, deinking efficiency and quality of deinked pulp, variables affecting deinking efficiency; Flotation cell; Application of enzymes in drinking; Disposal of deinking waste.

3. Papermaking process

i. **Introduction**: Surface and colloid chemistry interactions, fiber water systems, thermodynamics of cellulose water system; Electrokinetic behavior of stock, charge determination, zeta potential, cationic demand.

ii. **Refining:** Mechanism of refining, variables affecting refilling, controlling parameters; Types of refiner; Effect of refining on pulp and paper properties.

iii. **Sizing:** Basic surface science considerations in sizing, measurement of sizing; Types of sizing agents, rosin, AKD, ASA; Trouble-shooting of sizing problems.

iv. **Strength Additives:** Dry and wet strength additives, mechanisms of strength development, factors affecting wet and dry strength properties.

v. **Fillers and Dyes:** Types of fillers, properties of fillers, effect of fillers on optical and mechanical properties of paper; Dyes and pigments, dying of paper.

vi. **Control Chemicals at the Wet End:** Retention aids, drainage aids, defoamers, deflocculants and pitch controlling agents.

vii. **Approach Flow System:** Description of different functions in approach flow system such as control of consistency, freeness and thick stock flow, dilution, screening and cleaning, deaeration, pulse attenuation; Fan pump, flow distributor, headbox, and slice.

viii. **Sheet Structure:** Consolidation of the web, fiber bonding, characterization of the sheet structure, formation, fiber orientation, relative bonded area, sheet density, anisotropy, crowding factor, formation index.

		ix.	**Wet End of Paper Machine:** Configuration and layout of fourdrinier machine; Drainage elements, table roll, hydrafoil, wet end suction boxes; Dandy roll, couch roll, and other fourdrinier table elements; Gap formers, hybrid formers; Introduction to board making; Effect of machine parameters on formation of the sheet, flocculation and headbox consistency, agitation and shake on the wire.
		x.	**Stock and White Water Systems:** Short circulation and long circulation loops; Closing of white water system.
		xi.	**Wet Pressing:** Press section, mechanism of pressing, types of presses, operating variables, press felt characteristics; Common paper defects originated in press sections; Hot pressing.
		xii.	**Drying:** Drying theory, conventional cylinder dryers and their modifications, material of construction, steam and condensate handling systems, control of condensate removal systems, hoods and hood exhaust, calculations on drying rates, heat and mass transfer in drying and ventilation systems; Dryer section runnability; Effect of drying parameters on sheet properties; Convective drying, Flakt and infrared drying.
		xiii.	**Surface Sizing:** Surface sizing chemicals, size press configurations, modified size press designs, alternatives to the size press.
		xiv.	**Yankee Dryers:** Design and construction, steam and condensate handling; Tissue creping.
		xv.	**Calendering and Supercalendering:** Operating variables for calender stacks, sheet variables, supercalenders, gloss calenders, soft calenders, anti-deflection rolls, crowning of rolls.
		xvi.	**Winding:** Winding theory, types of winders, roll structure control, slitting operation, roll defects, paper defects.
		xvii.	**Broke Systems:** Broke system design and control for different types of broke
		xviii.	**Cross-Direction Control:** Benefits of improved CD uniformity, online measurement, CD control of grammage, moisture, caliper, and smoothness.
		xix.	**Paper Machine Showers and Doctors:** Showers, shower application, doctors and their applications, installation and maintenance.
		xx.	**Drives:** Types of drives and regulators, power requirements for different sections of paper machine.
		xxi.	**Paper Machine Vacuum Systems:** Vacuum generating equipment, vacuum requirement of different sections, vacuum piping design.
		xxii.	**Paper Machine Clothing:** Selection of forming, press, and dryer fabrics.
		xxiii.	**Paper Machine Corrosion, Vibrations and Safety:** Corrosion in paper machine, corrective measures, material selection; Machine vibrations, measurement and control; General practices for operation, maintenance and safety.
		4.	**Paper Properties**
		i.	**Introduction**: Different grades of papers, boards and newsprint, and their specifications; BIS and ISO standards of paper; Paper properties and their dependence on paper making processes; Calibration of instruments.
		ii.	**Physical Properties:** Definitions and methods of determination of grammage, caliper, bulk, smoothness and porosity; Standardization of size.
		iii.	**Mechanical Properties:** Definitions and methods of determination of tensile strength, tear strength, burst strength, folding endurance, and bending stiffness.
		iv.	**Optical Properties:** Interaction of light with paper, reflectance; Definitions and methods of determination of brightness, opacity, gloss and color.
		v.	**Resistance Properties:** Permeation of fluid through paper, water absorbancy, Cobb test, oil absorbancy, air/gas permeability.
		vi.	**Interrelation between Properties:** Dependence of properties on water content and temperature; Standard test conditions.
		vii.	**Statistical treatment of measured data.**
		5.	**Chemical of Paper Technology**
		i.	**Introduction:** Kraft and Soda recovery cycles, standard terms; impact of pulping; Quality and concentration of black liquor; Influence of dilution; Composition of black liquor for wood and non-woods.
		ii.	**Black Liquor Characterization:** Chemical properties: TDS, TSS, RAA, TA, organically bound sodium, elemental analysis; Physico-chemical properties: colloidal stability at high concentration, viscosity and rheological behavior at different concentrations, foaming characterization, boiling point rise; Thermal properties: calorific value, thermal conductivity, specific heat, swelling volume ratio, IPDT, TIG; Polymeric properties, dialysis in cellulose membrane and molecular sieve chromatography, gel filtration.
		iii.	**Black Liquor Oxidation:** Chemical reactions, parameters affecting black liquor oxidation, impact on calorific value; Processes available and their description.
		iv.	**Desilication of Black Liquor:** Sources of silica, its effect on concentration and

			incineration; Various processes available and their description.
		v.	**Concentration of Black Liquor:** Types of evaporators, construction details, merits and demerits; Concept of multiple effect evaporators (MEE); Calculations of steam requirement, steam economy and heat transfer area for single effect and multiple effect evaporators; Factors affecting steam economy, steam pressure and vacuum; Various feeding sequences; Condensate handling systems.
		vi.	**Process Control Parameters:** Scale formation and their remedies; Instrumentation and control of MEEs; Optimum cycle time, calculations based on maximum heat transfer rate and minimum total cost; Factors affecting optimal number of effects; Types of condensers, cooling water requirements, surface condenser calculations, steam jet ejectors, entrainment ratio, motive steam requirement, performance factors, ejector load calculation.
		vii.	**Direct contact Evaporators:** Principle, types, advantages and disadvantages; Construction details; Calculations of water evaporation and heat transfer area; Process design calculations of cyclone evaporator and venturi scrubber.
		viii.	**Black Liquor Combustion:** Process chemistry, droplet formation, disintegration mechanisms and models, kinetic models for drying, devolatilization, swelling, char combustion, sulfide reduction and carbon oxidation, char bed cooling, flow and mixing in Kraft recovery boilers, single jet penetration in furnace, entrainment and carryover, potassium enrichment, volatilization of chloride, deposits and boiler plugging; Thermal performance analysis models.
		ix.	**Causticization:** Process chemistry and kinetics, models to predict the effect of various variables on causticizing efficiency; Design of clarifier and washing equipments; Advances in causticization; Analysis of clarified white liquor; Mud washers and filters.
		x.	**Lime Mud Reburning:** Process description, lime kiln internals; Variables affecting lime reburning efficiency, quality of lime.
		xi.	**Nonconventional Chemical Recovery Systems:** Wet air oxidation (WAO); CHEMREC process; Super critical water oxidation (SCWO); Indirect gasification process.
		6.	**Printing and Packaging Papers**
		i.	**Printing:** Printing processes, letterpress, flexography, gravure, lithography, and screen printing; Printing plates; Printing presses; Printing inks; Ink transfer; Halftone printing; Color reproduction; Plate making and printing operation; Paper and paperboard properties required for printing; Reprography.
		ii.	**Pigment Coating:** Raw materials for paper coating, base stock, pigments, binders, and additives; Coating mixture preparation, pigment coating formulations; Pigment coating processes; Drying of pigment coated paper; Calendering and finishing of pigment coated papers; Properties of pigment coated papers.
		iii.	**Packaging:** Elements of packaging technology, approaches to package development; Requirement of paper and paperboard for different types of packages: sacks, cartons, and aseptic packaging.
		iv.	**Paper Board Manufacturing:** Cylinder mold machines and other cylindrical formers, multi-fourdrinier machines for board manufacture.
		v.	**Converting:** Corrugating, laminating, paper laminates, aqueous and solvent coatings, extrusion coating, hot melt coating.
		7.	**Environmental Management**
		i.	**Introduction:** Environmental issues for process industries; Emissions and effluents; Environmental policy of India, environmental laws and standards, corporate responsibility for environmental protection.
		ii.	**Pollution Prevention:** Process modification; Recovery of by- products from industrial emissions and effluents, principles of 3 R, reduction, recycle and reuse of wastes; Energy and fresh water minimization, energy recovery; Preventive maintenance and housekeeping for limiting fugitive emission and leakages; Pollution dispersion and diffusion.
		iii.	**Pre and Primary Treatment:** Dilution, neutralization, sedimentation, coagulation and flocculation.
		iv.	**Biological Treatment:** Anaerobic and aerobic treatment of carbonaceous matter; Various treatment systems such as trickling filters, lagoons, UASB reactors and activated sludge processes; Sludge disposal and management; Tertiary treatment methods.
		v.	**Air Pollution Control:** Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by adsorption and adsorption.
		vi.	**Air Pollution Control:** Particulate emission control by mechanical separation and electrostatic precipitation.
		vii.	**Solid Wastes:** Solid disposal; Decontamination and sterilization; Compositing, landfill

		and briquetting; Pyrolysis, gasification and incineration. **8. Heat & Mass Transfer** i. Modes of Heat Transfer ii. Conduction iii. Convection iv. Radiation v. Heat Exchangers vi. Condensation vii. Boiling viii. Evaporator ix. Crystallization x. Diffusion xi. Interphase Mass Transfer xii. Distillation xiii. Solid-Liquid Extraction xiv. Liquid-Liquid Extraction xv. Absorption xvi. Adsorption xvii. Humidification and Dehumidification xviii. Drying xix. Membrane Separation **9. Fluid Particle Mechanics** i. Particle Size Analysis ii. Size Reduction iii. Storage and Handling of Solids iv. Motion of Particles in Fluids v. Sedimentation vi. Flow of Fluid through Packed Beds vii. Filtration viii. Fluidization ix. Fluid-Solid Conveying x. Unit and Dimensions xi. Fluid Statics xii. Fluid Flow Phenomena xiii. Basic Equations of Fluid Flow xiv. Incompressible Flow in Pipes and Channels xv. Flow of Compressible Fluids xvi. Flow Measurement xvii. Boundary Layer and Turbulence xviii. Pumping of Fluids xix. Agitation and Mixing of Fluids **10. Material and Energy Balance** i. Stoichiometric and Composition Relations ii. Behavior of Gases iii. Vapor Pressure iv. Humidity and Saturation v. Material Balance vi. Energy Balance vii. Fuels and Combustion viii. Unsteady State Processes **11. Management information System and Cost** **12. Concept of engineering Mathematics** **13. Knowledge of computer system Microsoft Office, Excel etc.** **14. Industrial Management.**
3.	Chemistry	(i) **Introduction to Chemistry** - Entropy and free energy changes in chemical processes, chemical equilibria, phase transformations, structure and dynamics of microscopic systems, physical basis of atomic and molecular structure, three-dimensional arrangement of atoms in molecules, structure and reactivity of organic, inorganic and organometallic compounds, basic strategies for synthesis of carbon and silicon containing compounds, coordination chemistry, role of inorganic chemistry in living systems (ii) **Chemical Synthesis of Functional Materials**- Experiments involve the following:

			Titrations, Surface Tension and Viscosity, Potentiometery, Conductometry, Preparation of metal complexes and important organic compounds, Kinetics, Chromatography, Qualitative and quantitative estimation of organic compounds.
		(iii)	**Applied Chemistry - Chemistry at Interfaces-**Unit processes in organic synthesis. Laboratory vs. industrial synthesis. Role of medium in directing synthetic outcomes, organized media. Natural and synthetic constrained systems (inorganic and organic) for control of reactivity in organic reactions. Phase transfer catalysts, polymer and supported reagents for control of reactions. Green Chemistry. Heterogeneous and homogeneous catalysis, surface chemistry, kinetics of catalyzed reactions. Industrial catlysis.
		(iv)	**Quantum Chemistry-**Basic concepts and postulates of quantum mechanics, Hydrogen atom, Quantization of angular momentum, Many electron atoms, Variation theorem, Perturbation theory, Molecular orbital and valence bond theories, Introductory treatment of semi-empirical and ab initio calculations on molecular systems, Density functional theory.
		(v)	**Stereochemistry & Organic Reaction Mechanisms**-Stereochemistry of acyclic and cyclic compounds including chiral molecules without a chiral centre, Reaction mechanisms (polar and free radical) with stereochemical considerations, Reactive intermediates: generation, structure, and reactivity.
		(vi)	**Photochemistry & Pericyclic Reactions**-Pericyclic reaction, Introduction and classification, Theory of pericyclic reactions: correlation diagrams, FMO, and PMO methods, Cycloadditions reactions, Molecular rearrangements (pericyclic and non-pericyclic), Photochemistry: basics and mechanistic principles, Photochemical rearrangements, Reactivity of simple chromophores.
		(vii)	**Main Group Chemistry**-General properties of p block elements, bonding, historical landmarks, and periodic properties, Introduction to group theory, Chemistry of alkali and alkaline earth metals, Chemistry of group 13, 14, 15, and 16 elements, Halogen chemistry, Chemistry of rare gases.
		(viii)	**Instrumental Methods of Analysis** -Measurement basics and data analysis, Introduction to spectrometric methods and components of optical instruments, Atomic absorption, fluorescence, emission, mass, and X-ray spectrometry, Introduction to and applications of uv-vis molecular absorption, luminescence, infrared, Raman, nuclear magnetic resonance, and mass spectroscopy/ spectrometry, Introduction to electroanalytical methods: potentiometry, coulometry, and voltammetry, Introduction to chromatographic separation: gas, high-performance liquid, supercritical fluid, and capillary electrophoresis chromatography, Introduction to thermal methods of analysis.
		(ix)	**Molecular Thermodynamics**-Basics concepts, Review of first, second, and third laws of thermodynamics, Gibb's free energy, Extra work, Chemical potential, Ideal and non ideal solution, Phase rule, Phase diagram, Solutions, Chemical equilibrium, Postulates of statistical thermodynamics, Ensembles, Monoatomic and polyatomic ideal gases, Molar heat capacities, Classical statistical mechanics.
		(x)	**Chemical Dynamics & Surface Chemistry**-Kinetics of simple and complex reactions, Transport properties, Theories of reaction rates and dynamics of gas and liquid phase reactions, Experimental techniques to study fast reactions, Photochemical reactions, Surface phenomena and physical methods for studying surfaces, Heterogeneous and homogeneous catalysis.
		(xi)	**Organic Synthesis**-Formation of carbon-carbon bonds including organometallic reactions, Synthetic applications of organoboranes and organosilanes, Reactions at unactivated C-H bonds, Oxidations, Reductions, Newer Reagents, Design of organic synthesis, Retrosynthetic analysis, Selectivity in organic synthesis, Protection and deprotection of functional groups, Multistep synthesis of some representative molecules.
		(xii)	**Transition and Inner Transition Metal Chemistry**-Introduction to coordination chemistry, Crystal field theory, Ligand field theory, Molecular orbital theory, Magnetic and spectral characteristics of inner transition metal complexes, Substitution, Electron transfer and photochemical reactions of transition metal complexes, Physical, spectroscopic, and electrochemical methods used in the study of transition metal complexes, Metal-metal bonded compounds and transition metal cluster compounds, Uses of lanthanide complexes: as shift reagents, as strong magnets, and in fluorescence, Bioinorganic chemistry: introduction, Bioinorganic chemistry of iron: hemoglobin, myoglobin, cytochromes, Bioinorganic chemistry of zinc, cobalt, and copper.

		(xiii)	**Basic Organometalic Chemistry**-Organometallic chemistry of main group, transition, and inner transition metals. Synthesis and applications of BuLi, Grignard, organoaluminum, and organozinc reagents, 18 electron rule, Metal carbonyls: bonding and infrared spectra, phosphines and NHC's, Alkenes and alkynes, carbenes and carbynes (Fisher and Schrock), Hapto ligands with hapticity from 2-8, Oxidative addition and reductive elimination, 1,1 and 1,2-migratory insertions and beta hydrogen elimination, Mechanism of substitution reactions, Fluxionality and hapticity change, Organometallic clusters, C-H activation: agostic and anagostic interactions, Homogeneous catalysis: hydrogenation, hydroformylation, methanol to acetic acid processes, and Wacker oxidation, Introduction to cross coupling and olefin metathesis reactions, Olefin oligomerization and polymerization.
		(xiv)	**Structure & Function of Cellular Biomolecules**-Prokaryotic and eukaryotic cells, Structure and function of proteins, carbohydrates, nucleic acids, and lipids. Biological membranes, Enzymes: classification, kinetics, mechanism, and applications. Basic concepts of microbial culture, growth, and physiology.
		(xv)	**Molecular Biochemistry**-Central dogma, DNA replication and repair, Transcription, Translation, Recombinant DNA technology, Basic concept of metabolism: glycolysis, TCA cycle, ß-oxidation, Amino acid transamination and urea cycle.
		(xvi)	**Solid State Chemistry**-Crystal chemistry, Bonding in solids, Defects and non-stoichiometry, A range of synthetic and analytical techniques to prepare and characterize solids, Electronic, magnetic, and superconducting properties, Optical properties which include: luminescence and lasers, nanostructures and low dimensional properties, etc.
		(xvii)	**Statistical Mechanics & Molecular Simulation Methods**-Micro- and macroscopic state of a classical system, Phase space, Ergodicity and mixing in phase space, Theory of ensembles, Classical fluids, Phase transitions and relaxation phenomena, Monte Carlo, molecular dynamics, and Brownian dynamics, Computer simulations, Brownian motion, Langevin equation, Elucidation of structural, dynamic, and thermodynamic properties of complex fluids and soft matter.
		(xviii)	**Selected Topics in Spectroscopy**-Franck-Condon principle, Fermi Golden rule, Normal mode analysis, Multi-photon spectroscopy, Molecular beam techniques, Non-linear laser spectroscopy, Two-level systems, Precession, Rabi frequency, Nutation, Block equations, Multi-dimensional NMR techniques.
		(xix)	**Group Theory & Spectroscopy**-Symmetry operations, Review of point and space groups, Applications of group theoretical techniques in spectroscopy, Chemical bonding, Crystallography, Theoretical treatment of rotational, vibrational, and electronic spectroscopy, Magnetic spectroscopy.
		(xx)	**Biophysical Chemistry**-Structure and conformations of proteins, nucleic acids and other biological polymers, Techniques for the study of biological structure and function, Configurational statistics and conformational transitions, Thermodynamics and kinetics of ligand interactions, Regulation of biological activity, Bioinformatics: Genomics and proteomics.
		(xxi)	**Supramolecular Chemistry**-Non-covalent associations, Molecular recognition, Design and applications of molecular hosts: crown compounds, cyclophanes, cyclodextrins, etc., Nano technology, Molecular clefts, tweezers, and devices, Self assembly and replication.
		(xxii)	**Recent Trends in Organic Chemistry**-Recent advances in organic synthesis, spectroscopy, and reaction mechanisms.
		(xxiii)	**Bio-organic and Medicinal Chemistry**-Bio-organic: Amino acids, polypeptides, and enzyme models, Medicinal: definitions and classifications, Pharmaceutical, pharmacokinetic, and pharmacodynamic phases, Drug-receptor interactions, Intra- and intermolecular forces, Solvent effects, Ligand binding, Docking and design, Drug metabolism.
		(xxiv)	**Physical Methods of Structure Determination of Organic Compounds**-Applications of UV, IR, NMR, and mass spectral methods in structure determination of organic compounds.
		(xxv)	**Chemistry of Heterocyclic Compounds-**Chemistry of heterocyclic compounds containing one, two, and three heteroatoms, Total synthesis of representative natural products.
		(xxvi)	**Physical Methods in Inorganic Chemistry**-Use of NMR spectroscopy for structural elucidation of simple inorganic and organometallic compounds using

			chemical shifts and heteronuclear coupling constants, Relaxation phenomena in inorganic compounds, Double resonance technique and its applications, EPR spectroscopy for the identification of inorganic radicals, Introduction to Mossbauer spectroscopy, Factors influencing chemical shifts and quadrupolar splitting, Structural information: X-ray diffraction methods (powder and single crystal), Finger printing of solids from powder data and determination of crystal structures by Rietveld analysis and single crystal studies.
		(xxvii)	**Inorganic Polymers**-Homo and heterocatenated inorganic polymers: general introduction, Polyphosphazenes: synthetic routes and bonding features, Polymerization of organo/organometallic substituted phosphazenes and their applications, Polysilanes: synthesis and characterization of polysilanes, unique electronic and optical properties and its applications, Polysiloxanes: precursors used in synthesis of polysiloxanes via anionic and cationic polymerization methods, properties and environmental aspects, Polysiloles and their comparison with polythiophenes, Introduction to organometallic polymers: synthesis of poly(ferrocenylsilane)s and their applications. Catalytic methods for homo and hetero-catenated polymers, Characterization methods (spectroscopy, gel permeation chromatography, differential scanning calorimetry).
		(xxviii)	**Applied Organometallic Chemistry**-Introduction to homogeneous catalysis, TON and TOF, Some aspects of commonly used ligands in homogeneous catalysis, such as, CO, amines, phosphines, NHC's, alkenes, alkynes, carbenes, carbynes, etc., Recent developments in hydrogenation and hydroformylation and their asymmetric variations using OM catalysts, Wacker oxidation, Monsanto and Cativa processes, Olefin and alkyne trimerization and oligomerization, Olefin polymerization using Ziegler-Natta, Titanium group metallocenes, Post metallocene late TM catalysts and FI catalysts, Olefin and alkyne metathesis, Grubbs I, II, and III, Schrock, and Schrock-Hoveyda catalysts, Types of metathesis such as RCM, ROM, ROMP, ADMET, and EM. Applications in industry, Palladium and nickel catalyzed cross coupling reactions such as Suzuki, Heck, Sonogashira, Stille, Negishi, Hiyama, Buchwald-Hartwig, decarboxylative cross coupling, and alpha arylation of carbonyls, Fischer Tropsch Process, C-H activation of alkyls and aryls using transition metal complexes, Organometallic polymers, Bio-organometallic chemistry: Vitamin B-12, Planar chirality of metal sandwich compounds and their applications in industry (e.g. Josiphos catalyst), Ferrocene based drugs, Sustainable catalysis for pharmaceuticals and industry using organometallics.
		(xxix)	**Bio-Inorganic Chemistry**-Introduction of bio-inorganic chemistry, General properties of biological molecules, Physical methods in bio-inorganic chemistry, Binding of metal ions and complexes to biomolecule active centers, Synthesis and reactivity of active sites, Atom and group transfer chemistry, Electron transfer in proteins, Frontiers of bio-inorganic chemistry: some topics of current research interest.
		(xxx)	**Microbial Biochemistry-**Microscopic examination of microorganisms, classification, morphology and fine structure of microbial cells, cultivation, reproduction and growth, pure culture techniques, Basic microbial metabolisms, Concepts of their genetics: transformation, transduction, and conjugation, Important microorganisms and enzymes.
		(xxxi)	**Food Chemistry and Biochemistry**-Carbohydrates: structure and functional properties of mono-oligopolysaccharides including starch, cellulose, pectic substances, and dietary fibers, Essential amino acids, proteins, and lipids in food and their impact on functional properties, vitamins and minerals, Food flavours: terpenes, esters, ketones, and quinines; Food additives, Bioactive constituents in food: isoflavones, phenol, and glycosides; Enzymes: enzymatic and non-enzymatic browning, enzymes in food processing, oxidative enzymes, Food biochemistry: balanced diet, PER, anti-nutrients and toxins, nutrition deficiency diseases.
		(xxxii)	**Applied Biocatalysis**-Introduction to enzymes and enzyme catalysed reactions, Classification and mechanism of reaction, Purification and characterization of enzymes, Michelis Menten kinetics, Industrial enzymes, Applications of enzymes in diagnostics, analysis, biosensors, and other industrial processes and bio-transformations, Enzyme structure determination, stability, and stabilisation, Enzyme immobilization and concept of enzyme engineering, Nanobiocatalysis.
		(xxxiii)	**Design and Synthesis of Organic Molecules**-Selectivity in organic synthesis: chemo-, regio-, stereo- and enantioselectivity. Target-oriented synthesis: Designing organic synthesis, Retrosynthetic analysis, disconnection approach, linear and convergent synthesis. Diversity-oriented synthesis: concept of forward-synthetic

			analysis, appendage diversity, skeletal diversity, stereochemical diversity, complexity and diversity. Asymmetric Synthesis: Use of chiral catalysts, organocatalysis, chiron approach and N-heterocyclic carbenes. Principles and use of enzymes in the syntheis of industrially important sugar / fatty acid esters, sugar nucleotide derivatives ; enantiomeric pure compounds and biobased platform chemicals.
		(xxxiv)	**Synthesis of Organic and Inorganic Compounds**-Single, double and multi-stage preparation of organic, inorganic and organometallic compounds; experiments involving the concepts of protecting groups and selectivity; identification of compounds through thin-layer chromatography and their purification by column chromatography. Characterization of synthesized compounds using IR, UV, 1H-NMR and mass spectromteric techniques.
		(xxxv)	**Principles and practice of NMR and Optical Spectroscopy**-Fundamentals of FT NMR spectroscopy, relation between structure and NMR properties, one-dimensional spectroscopy (1H, 13C, DEPT, steady state NOE, saturation transfer) and an introduction to two-dimensional NMR (COSY, NOESY, and HSQC) and their use in structure elucidation. Principles and analytical applications of optical spectroscopic methods including atomic absorption and emission, UV-Visible, IR absorption, scattering, and luminescence.
		(xxxvi)	**Synthesis of Industrially Important Inorganic Materials**-Modern methods applied in the synthesis of inorganic, organometallic and polymer materials. Handling of air and moisture sensitive compounds, dry box, glove bag, Schlenk line and vacuum line techniques. Methods of purification of and handling of reactive industrial gases. Methods of purification of inorganic compounds and crystallization of solids for X-ray analysis. General strategies, brief outline of theory and methodology used for the synthesis of inorganic/ organometallic molecules to materials including macromolecules. Emphasis will be placed how to adopt appropriate synthetic routes to control shape and size of the final product, ranging from amorphous materials, porous solids, thin films, large single crystals, and special forms of nanomaterials. A few examples of detailed synthesis will be highlighted in each category of materials.
		(xxxvii)	**Cheminformatics and Molecular Modelling**-Chemistry & Information technology, chemical / biochemical data collation, retrieval, analysis & interpretation, hypothesis generation & validation, development of structure activity/property relationships, artificial intelligence techniques in chemistry. Building molecules on a computer, quantum and molecular mechanics methods for geometry optimization, Simulation methods for molecules and materials.
		(xxxviii)	**Material Characterization**-Compositional analysis of solid materials by X-ray and electron microscopic techniques. Basic concepts of diffraction techniques (powder and single crystal) in elucidating the crystal structures organic, inorganic and hybrid materials. Applications of electron microscopic techniques (scanning and transmission) for morphological and nanostructural features. Thermal analytical methods for correlating structural information and monitoring phase transition. Emphasis will be placed on the above techniques for industrially important materials and the interpretation and evaluation of the results obtained by various methods.
		(xxxix)	**Chemical Separation and Electro analytical Methods**-Theory and applications of equilibrium and non-equilibrium separation techniques. Extraction, countercurrent distribution, gas chromatography, column and plane chromatographic techniques, electrophoresis, ultracentrifugation, and other separation methods, Modern analytical and separation techniques used in biochemical analysis. Principles of electrochemical methods, electrochemical reactions, steady-state and potential step techniques; polarography, cyclic voltammetry, chrono methods, rotating disc and ring disc electrodes, concepts and applications of AC impedance techniques.
		(xl)	**Chemistry of Industrial Catalysts**-Fundamental aspects of Catalysis - Homogeneous & heterogeneous catalysis -The role of catalytic processes in modern chemical manufacturing -organometallic catalysts -catalysis in organic polymer chemistry -catalysis in petroleum industry - catalysis in environmental control.
		(xli)	**Chemistry of Nanostructured Materials**-Introduction; fundamentals of nanomaterials science, surface science for nanomaterials, colloidal chemistry; Synthesis, preparation and fabrication: chemical routes, self assembly methods, biomimetic and electrochemical approaches; Size controls properties (optical, electronic and magnetic properties of materials) - Applications (carbon nanotubes

			and nanoporous zeolites; Quantum Dots, basic ideas of nanodevices).
		(xlii)	**Applied Spectroscopy**-Applications of advanced 1D-NMR techniques such as nOe, 1D 13C-NMR (including APT and DEPT) techniques, multinuclear NMR spectroscopy, 2D NMR techniques (COSY, HETCOR, HSQC, HMBC, NOESY, ROESY etc.) for the structural and stereochemical determination of organic compounds. Introduction to various types of ionizations (such as EI, CI, MALDI, field ionization/desorption, electrospray ionization) and analyzers (such as quadrupole, time of flight, triple quadupole, QqTOF, ion-trap) in mass spectrometry for MS, MS/MS and MSn applications. Determination of peptide sequencing using mass spectrometric techniques.
		(xliii)	**Applications of P-block Elements and their Compounds**-Introduction, Structure, bonding and recent discussions on d orbital participation. Boranes, carboranes and metallaboranes and their use in BNCT and as control rods in nuclear reactors, modern electron counting methods such as Jemmis rules, chemistry of B(0) and B(1). GaAs, GaN, InSnO3: Synthesis and applications in solar cells, LED and as transparent conducting materials. Fullerenes, nanotubes, graphene, silicates, aluminosilicates, zeolites and their applications. Silicones and their industrial applications. Si(II) and Ge(II) chemistry. NHC's and their use in stabilizing main group compounds. Nitrogen based fertilizers, Ammonia, Haber-Bosch Process, nitrogen based explosives, hydrazines as rockel fuels, applications of azides and pentazenium. Phosphorus based fertilizer processes, phosphorus based pesticides, phosphorus-nitrogen compounds as multidentate ligands, superbases, dendrimer cores and polymers. Phosphines and their industrial uses. Frustrated Lewis acid bases as catalysts. Superacids and their uses. Sulphonamides, industrial applications of sulfur and selenium. Fluorine in pharmaceuticals, fluoropolymers.
		(xliv)	**Applied Biocatalysis**-Introduction to enzymes and enzyme catalysed reactions. Classification and mechanism of reaction. Purification and characterization of enzymes. Michelis Menten kinetics, Industrial enzymes. Applications of enzymes in diagnostics, analysis, biosensors and other industrial processes and bio-transformations.Enzyme structure determination, stability and stabilisation. Enzyme immobilization and concept of enzyme engineering. Nanobiocatalysis.
		(xlv)	**Chemistry of Heterocyclic Compounds**-Chemistry of heterocyclic compounds containing one, two and three heteroatoms. Total synthesis of representative natural products.
		(xlvi)	**Organo and organometallic catalysis**-Introduction. Enamine catalysis. Iminium catalysis. Asymmetric proton catalysis. Ammonium ions as chiral templates. Chiral Lewis bases as catalysts. Asymmetric acyl transfer reactions. Ylide based reactions. Transition metal catalyzed reactions. C-H activation. N-Heterocyclic carbenes.
		(xlvii)	**Reagents in Synthetic Transformations**-The course will cover the applications of various oxidation and reduction reactions in organic chmeistry with s[pecial emphasis on special reagents that are used for selective transformations. Use of organolithium and organoboron compoinds in organic synthesis and olefin metathesis will also serve a part of the course.
		(xlviii)	**Molecular Modelling and Simulations: Concepts and Techniques**-Review of Basic Concepts: Length and Time Scales, Intermolecular Interactions and Potential Energy Surfaces, Evaluation of Long-range interactions Static and Dynamic Properties of Simple and Complex Liquids Molecular Dynamics: Microcanonical and other ensembles; Constrained simulations; non-equilibrium approaches Monte Carlo Methods: Random Numbers and Random Walk, Metropolis Algorithm in various ensembles, Biased Monte Carlo Schemes Free Energy Estimations: Mapping Phase Diagrams, Generating Free Energy Landscapes, Collective Variables Rare Event Simulations and Reaction Dynamics, Advanced Topics: First principles molecular dynamics, Quantum Monte Carlo methods, Coarse-Graining and Multiscale Simulations for Nanoscale Systems, Quantum mechanics/molecular mechanics (QM/MM) approaches. (To some extent, coverage of advanced topics will depend on research interests of students and faculty since this is a Pre-Ph.D. course).
		(xlix)	**Management information System and Cost**
		(l)	**Knowledge of computer system Microsoft Office, Excel etc.**
		(li)	**Industrial Management.**

SYLLABUS FOR THE POST OF OFFICER (TECH. SUPPORT – CIVIL)

SR. NO.	DISCIPLINE	TOPICS
1.	Civil Engineering	**1. Introduction to Civil Engineering :-** (i) *History of Civil engineering:* Early constructions and developments over time; Ancient monuments & Modern marvels; Development of various materials of construction and methods of construction; Works of Eminent civil engineers. (ii) *Overview of National Planning for Construction and Infrastructure Development:* Position of construction industry vis-a-vis other industries, five year plan outlays for construction; current budgets for infrastructure works; (iii) *Fundamentals of Architecture & Town Planning:* Aesthetics in Civil Engineering, Examples of great architecture, fundamentals of architectural design & town planning; Building Systems (HVAC, Acoustics, Lighting, etc.); LEED ratings; Development of Smart cities. (iv) *Fundamentals of Building Materials:* Stones, bricks, mortars, Plain, Reinforced & Prestressed Concrete, Construction Chemicals; Structural Steel, High Tensile Steel, Carbon Composites; Plastics in Construction; 3D printing; Recycling of Construction & Demolition wastes. (v) *Basics of Construction Management & Contracts Management:* Temporary Structures in Construction; Construction Methods for various types of Structures; Major Construction equipment; Automation & Robotics in Construction; Modern Project management Systems; Advent of Lean Construction; Importance of Contracts Management. (vi) *Environmental Engineering & Sustainability:* Water treatment systems; Effluent treatment systems; Solid waste management; Sustainability in Construction; (vii) *Geotechnical Engineering:* Basics of soil mechanics, rock mechanics and geology; various types of foundations; basics of rock mechanics & tunneling. (viii) *Hydraulics, Hydrology & Water Resources Engineering:* Fundamentals of fluid flow, basics of water supply systems; Underground Structures; Underground Structures Multi-purpose reservoir projects. (ix) *Ocean Engineering:* Basics of Wave and Current Systems; Sediment transport systems; Ports & Harbours and other marine structures. (x) *Power Plant Structures:* Chimneys, Natural & Induced Draught Colling towers, coal handling systems, ash handling systems; nuclear containment structures; hydro power projects. (xi) *Structural Engineering:* Types of buildings; tall structures; various types of bridges; Water retaining structures; Other structural systems; Experimental Stress Analysis; Wind tunnel studies; (xii) *Surveying & Geomatics:* Traditional surveying techniques, Total Stations, Development of Digital Terrain Models; GPS, LIDAR; (xiii) *Traffic & Transportation Engineering:* Investments in transport infrastructure development in India for different modes of transport; Developments and challenges in integrated transport development in India: road, rail, port and harbour and airport sector; PPP in transport sector; Intelligent Transport Systems; Urban Public and Freight Transportation; Road Safety under heterogeneous traffic; Sustainable and resilient pavement materials, design, construction and management; Case studies and examples. (xiv) *Repairs & Rehabilitation of Structures:* Basics of corrosion phenomena and other structural distress mechanisms; some simple systems of rehabilitation of structures; Non-Destructive testing systems; Use of carbon fibre wrapping and carbon composites in repairs. (xv) *Computational Methods, IT, IoT in Civil Engineering:* Typical software used in Civil Engineering- Finite Element Method, Computational Fluid Dynamics; Computational Geotechnical Methods; highway design (MX), Building Information Modelling; Highlighting typical available software systems (SAP, STAAD, ABAQUS, MATLAB etc.) **2. Computer-aided Civil Engineering Drawing :-** (i) *Introduction:* Introduction to concept of drawing, Interpretation of typical drawing, planning drawing to show information concisely and comprehensively; optimal layout of drawings and Scales; Introduction to computer aided drawing, co-ordinate systems, reference planes. (ii) *SYMBOLS AND SIGN CONVENTIONS:* Materials, Architectural, Structural, Electrical and Plumbing symbols. Rebar drawings and structural steel

		fabrication and connections drawing symbols, welding symbols; dimensioning standards. (iii) *MSONRY BONDS:* English Bond and Flemish Bond — Corner wall and Cross walls - One brick wall and one and half brick wall. (iv) *BUILDING DRAWING:* Terms, Elements of planning building drawing, Methods of making line drawing and detailed drawing. Site plan, floor plan, elevation and section drawing of small residential buildings. Foundation plan. Roof drainage plans. Depicting joinery, standard fittings & fixtures, finishes. Use of Notes to improve clarity. (v) *PICTORIAL VIEW:* Principles of isometrics and perspective drawing. Perspective view of building. Fundamentals of Building Information Modelling (BIM)(3) **3. Materials, Testing & Evaluation :-** (i) *Introduction to Engineering Materials covering,* Cements, M-Sand, Concrete (plain, reinforced and steel fibre/ glass fibre-reinforced, light-weight concrete, High Performance Concrete, Polymer Concrete) Ceramics, and Refractories, Bitumen and asphaltic materials, Timbers, Glass and Plastics, Structural Steel and other Metals, Paints and Varnishes, Acoustical material and gee-textiles, rubber and asbestos, laminates and adhesives, Graphene, Carbon composites and other engineering- materials including properties and uses of these. (ii) *Introduction to Material Testing covering,* What is the "Material Engineering"?; Mechanical behavior and mechanical characteristics; Elasticity — principle and characteristics; Plastic deformation of metals; Tensile test—standards for differentmaterial. (brittle, quasi-brittle, elastic and so on) True stress — strain interpretation of tensile test; hardness tests; Bending and torsion test; strength of ceramic; Internal friction, creep —fundaments and characteristics; Brittle fracture of steel — temperature transition approach; Background of fracture mechanics; Discussion of fracture toughness testing — different materials; concept of fatigue of materials; Structural integrity assessment procedure and fracture mechanics. (iii) *Standard Testing & Evaluation Procedures covering,* Laboratory for mechanical testing; Discussion about mechanical testing; Naming systems for various irons, steels. **4. Instrumentation & Sensor Technologies for Civil Engineering Applications.** **5. Engineering Geology** **6. Disaster Preparedness & Planning Management** **7. Introduction to Fluid Mechanics** **8. Introduction to Solid Mechanics** **9. Surveying and Geomatics** **10. Materials, Testing & Evaluation** **11. Mechanics of Materials** **12. Hydraulic Engineering** **13. Structural Engineering** **14. Geotechnical Engineering** **15. Hydrology and water Resourcing Engineering** **16. Environmental Engineering** **17. Transportation Engineering** **18. Construction Engineering & Management** **19. Engineering Economy, Estimation & costing** **20. Concept of engineering Mathematics** **21. Knowledge of computer system Microsoft Office, Excel etc.** **22. Industrial Management.**