

**CIVIL ENGINEERING**  
**SECOND YEAR**  
**201 MATHEMATICS III**

**FIRST TERM:**

1. **Ordinary Differential Equations and some Special Function:** Series solutions ordinary differential equations, Legendre and Bessel function and their properties.  
8 Lectures
2. **Partial Differential Equations:** Second order linear and quasi-linear partial differential equations, elliptic, parabolic and hyperbolic types, boundary and initial conditions solutions of Dirichlet and Neumann problems for Laplace equation and of heat conduction problems by Fourier method, D'Alembert solution of 1-D wave equation and solution of Cauchy problem.  
8 Lectures
3. **Functions of a Complex Variable:** Review of complex numbers, formulae of Euler and De Moivre, analytic functions, Cauchy Riemann conditions elementary complex functions and analytic function in term of a power series, Laurent series, residue theorem, contour integration.  
8 Lectures

**SECOND TERM:**

**Probability and Statistics:** Axiomatic definition of probability, laws of probabilities classical occupancy problem with illustrations, conditional, probability

multiplication law, independence of events, Bayes rule, discrete and continuous random variables-cumulative distribution functions, probability mass function, probability density function, mathematical expectation, mean, variance, moment generating function and characteristic function, standard probability models-binomial, Poisson, exponential, Weibull, normal and log normal, sampling and sampling distribution  $z$ ,  $t$ , Chi-square and  $F$ , estimation of parameters, use of  $t$ , Chi-square and  $F$  in test significance. 24 Lectures

**BOOKS RECOMMENDED:**

**TEXT BOOKS:**

1. Advance Engineering Mathematics by E. Kreyszig, Wiley eastern Pvt. Ltd. (India)

**REFERENCE BOOKS:**

1. Advance Engineering Mathematics by C.R. Wylie
2. Mathematics of Physics and Modern Engineering by Skolnikoff & Redhelfer
3. Advance Mathematics for Engineers and Physicists by L.A. Pipes

**202 COMPUTATIONAL TECHNIQUES**

**FIRST TERM:**

1. **Types of Computer:** Digital, analog and hybrid, organization of a digital computer system-CPU memory, I/O devices, representation of numbers-integer and floating point arithmetic, round off errors and their propagation.
2. **Introduction to computer languages:** Assembly language, higher languages compilers, problem solving using computers algorithm, flow chart, examples, FORTRAN programming, constant and variables, arithmetic expression I/O statements, specification statement, control statements, subscripted variables, logical expression, function and subroutines, examples of

programming should include numerical as well as non-numeric matrix operations, searching, sorting etc.

- 3. Iterative Techniques for solution of equation:** Simple iteration scheme, Newton-Raphson method, secant method, their rates of convergence, order of errors, etc. roots of polynomial equation, Gaussian elimination, Gauss-Siedel iteration, matrix inversion by Gaussian method, computation of determinant, polynomial approximation.

#### **SECOND TERM:**

Lagrangian interpolation of polynomial, Aitkin's methods, method, Newton's forward difference formula, curve fitting (least square), Trapezoidal method,

Simpson's Rule, order of errors in integrations, solutions of initial value problems, Euler's methods, and 4th order Runge Kutta (algorithm only).

### **COMPUTATIONAL LABORATORY**

#### **FIRST TERM:**

Familiarization with PC and DOS, preparing ASC II files using editors/word processors, system utilities, compiling and running, programme development in FORTRAN, number theoretic problems, series summation, matrix and vector operation, non-numeric data processing, searching and sorting.

#### **SECOND TERM:**

Numerical techniques finding roots of a function, quadrature, integration and solution of differential equations, interpolation and curve fitting solution of linear simultaneous equations and matrix inversions

#### **TEXT BOOKS:**

1. Computer Programming & Numerical Methods (For Engineers) by Swami Saran, P.K. Swami and K.K. Singh, Sarita Publishers, Meerut
2. Computer Oriented Numerical Methods by V. Rajaram, Prentice Hall of India

#### **REFERENCE BOOKS:**

1. Elementary Numerical Analysis by S.D. Conte
2. Introductory Methods of Numerical Analysis by S.S. Shastri
3. Numerical Methods in Engineering by M.G. Salve
4. Computing for Engineering by R. T. Fennes

### **206 MECHANICS OF SOLIDS-I**

#### **FIRST TERM:**

- 1. Introduction and fundamental concepts:** Introduction-purpose and scope of the subject, generalized procedure, basic assumption, types of forces (External and Internal forces), method of sections, constitutive laws, Elastic material, Principle of Super position, St. Venant's Principle Tensile test, generalized Hook's law for isotropic and linear elastic material. 5 Lectures
- 2. Simple stress and stain:** Uniaxial tension or compression of a bar (prismatic and non-prismatic), cases of simple shear, shear strain components in terms of shear stress, Bi-axial and tri-axial tension or compression, Thermal stress and strain, statically determinate system of bars in tension (or compression), thin walled pressure vessels, cylindrical and spherical shells. 8 Lectures
- 3. Shearing Force and Bending Moment:** Use of singularity functions in drawing B.M.D and S.F.D. 6 Lectures
- 4. Stress due to bending:** Pure bending of beams, normal stress and shear stress distribution in a beam subjected to both B.M.D. and S.F.D. 6 Lectures

#### **SECOND TERM:**

1. **Deflection due to bending:** Double integration method, moment area method.  
4 Lectures
2. **Torsion:** Torsion of solid and hollow circular shaft, Torsion of a hollow thin walled shaft, closed coiled helical spring Flanged couple. 5 Lectures
3. **Two-dimensional stress analysis:** Plane stress components on a general plane at a point, Mohr's circle of stress. 6 Lectures
4. **Cases of combined loading:** Bending with tension (or compression) Eccentrically loaded member, core of section, torsion and shear, torsion and bending cases of transmission shafts subjected to bending tension or axial thrust.  
6 Lectures
5. **Elastic strain energy and its application:** Elastic strain energy of a rod under various kinds of loading-Elastic strain, energy for various states of stress, simple applications, Castiglians Theorem. 4 Lectures

#### **LABORATORY WORK:**

Minimum eight experiments bases on the theory covered under the subject.

#### **BOOK RECOMMENDED:**

1. Mechanics of Solids – Kazmi
2. Mechanics of Solids – Singh and Jha
3. Mechanics of Solids – Ryder

#### **REFERENCES:**

1. Mechanics of Solids – Timoshenko and Gere
2. Introduction to Mechanics of Solids – Grandall and Dahl
3. Mechanics of Solids – Popov

## **207 FLUID MECHANICS**

**INTRODUCTION:** Concept of continuum, difference between fluid mechanics and solid mechanics, brief history of classical hydraulics, hydrodynamics and fluid mechanics.

Characteristics properties of fluids- ideal and real fluids, Newtonian and non-Newtonian fluids viscosity, surface tension, capillarity compressibility, fluids statics and buoyancy

Fluid kinematics- Stream lines, path lines, streak lines, velocity potential and stream functions, laminar and turbulent flows, steady and unsteady flows, rotational, irrotational motion-circulation, vorticity, velocity and acceleration.

**FLUID DYNAMICS:** Conservation of mass, principle of momentum and energy, moment of momentum, equation of motion, Euler's equation, Introduction to Navier's-Stokes equation, energy equation, hydraulic and energy gradients.

**LAMINAR FLOW:** Flow through pipes, frictional and other losses.

**TURBULENT FLOW:** Fully developed flows, boundary layer theory, rough and smooth pipe flows.

**DIMENSIONAL ANALYSIS:** Similitude of fluid flows, Hydraulics modeling, non-dimensional parameters (Reynolds, Fronde, Euler, Weber and Mach Numbers)

**FLOW MEASUREMENT:** Piezometer, manometers, pressure gauges, pilot tube, orifices, noticlars and weirs, orifice meter, venturimeter, forces on immersed bodies- drag and lift, asfoil section fluid mechanics, dynamic force exerted by fluid on fixed and moving vanes, racial flow over curved vanes, applications to hydraulic turbine blades, impulse and reaction turbines, reciprocating and centrifugal pumps, pressure due to deviated flow in pipes, jet propulsions.

## 210 SURVEYING I

1. **Scales:** Ordinary, diagonal and Vanier
2. **Distance and Area Measurement:** Instruments chains, tapes, optical square, offset rod etc, errors in chaining, chaining on sloping ground and through obstacles, offsets and their limiting length, instruments for measuring areas
3. **Measurement of Direction and Angles:** Surveying and prismatic compass, true north and magnetic north, bearing of lines, true and magnetic meridian, local attraction, theodolite-temporary adjustment, measurement of vertical and horizontal angles, use of sextant for angle measurement
4. **Measurement of Slopes, Elevation and Heights:** Use of Clinometers, Abney level and hand level in rough leveling, leveling instruments-general description and types temporary adjustments, leveling staff, methods of leveling reciprocal leveling
5. **Plane Table Surveying:** Instruments used in plane tabling, traversing by plane table and methods of plane tabling, two point and three point problem
6. **Theodolite and the Theodolite Traversing:** Types of theodolite, temporary and permanent adjustments sources of errors and their eliminations, theodolite traversing, calculation of latitude and departure, balancing of traverse
7. **Contouring:** Contour line, contour interval, horizontal equivalent, characteristics of contours, methods of contouring, representation of relief, drawing of cross section on contour map
8. **Curves:** Types of curves, elements, setting out of simple curves, composite curve, vertical curves
9. **Tacheometric Survey:** Instruments used in tacheometry, tacheometry, determination of tacheometry constant, tangential method, used of stadia measurement for traversing and contouring

### SESSIONAL:

1. Longitudinal section together with topographic detail using chain compass and leveling instruments
2. Traversing and detailing by plane table
3. Lay out of building by theodolite and tape
4. Setting out of simple curves

### TEXT BOOKS:

1. Surveying and Leveling by T.P. Kanetkar and S.V. Kulkarni, Vol- I & II
2. Surveying and Leveling by B.S. Punmia, Vol- I & II
3. Surveying by Dr. K.R. Arora, Vol- I & II

## 211 BUILDING SCIENCE

### Materials:

Bricks, suitability of clay, manufacture and modular bricks, cement manufacture constituent, properties and tests, lime: types, uses, preparation and property of lime, mortar, cement concrete, ingredient and their purposes, properties of harden, concrete, testing as per as ISI, timber, common

species, defect seasoning, preservation strength, plywood and fiber board and their uses, paints and varnishes bases solvent, driers and pigments, iron and steel, cast iron, mild iron and tar steel and their structure and properties, ceramic glass and plastic glass, glass fiber, reinforced plastics

### **Construction:**

Various types of bonding, principle types of foundations and their suitability, foundation in black cotton soil, design of simple RCC and lime concrete footing foundation, construction of walls, thickness consideration, partition wall, cavity wall, plastering, painting white washing, colour washing and distemping, different types of roofs, inclined roof, lean to roof, shell and domes, various types of covering, rain and damp proof construction, different types of flooring- mosaic, tile flooring, synthetic mats, Epoxy-resin mats, PS flooring, wooden flooring, glazed tiles and marble flooring, doors, windows, ventilators and lintel etc., doors and windows from PVC material and Nuwed (MDF), location, sizes, different types, stair & stair case, types proportioning lift and escalators

## **212 GEOLOGY AND GEOMECHANICS**

### **FIRST TERM:**

#### **A. GEOLOGY:**

##### **1. Physical and Structural Geology:**

(a). Importance of geology in Civil engineering, weathering: geological work by wind, rivers and oceans, earthquake, interior of the earth

(b). Contours, strike and dip, outcrop, unconformity, joints, folds faults, their recognition in the field and engineering importance

2. Mineralogy: Physical properties of minerals, petro logical microscope, optical properties, physical and optical properties of following minerals

i. Silicates:-Quartz, Felspars and Micas

ii. Non-silicates: Hematite, Bauxite and Gypsum

3. Clay minerals: Structures of Kaolinite, Illite, Montmorillonite, Chlorite and Vermiculite groups, engineering behaviour of clay

4. Petrology Elementary knowledge of rock formation, study of Igneous, sedimentary and metamorphic rocks

5. Stratigraphy of India Stratigraphy scale, geological divisions of India, brief account of the following systems: - Archaean and Dharcuer, Vindhya, Gondwana

### **SECOND TERM:**

#### **B. GEOMECHANICS:**

6. Geology behind road metals and building stores, ground water occurrence and prospecting, gravity, magnetic, seismic belts of India

7. Elementary knowledge of Geophysical prospecting, gravity, magnetic, seismic and electrical methods with special reference to foundation and ground water problems

**8.** Introduction to rock mechanics: Continued and particulate approach, discontinuities and classical mechanics, material, intact rock mass, engineering classification of rocks, joints and fissures in rocks, rock quality, designation, boring and logging in rocks, core recovering

**9.** Engineering behaviour of rocks: Rock material and rock mass, institute state of stress in rock mass fold, deformation characteristics of rock materials, compressive strength tests, direct tensile test, indirect tensile test, flexural strength tests of rock, static elastic instants

**10.** Applied rock machines: Openings on rocks, tunneling in rocks, permeability and seepage studies on rocks, design analysis and stability, mining subsidue, rock boiling

## **213 MECHANICAL ENGINEERING**

Introduction to thermodynamic system, properties of system, dimensions and units, temperature and Zeroth Law

Thermodynamic processes: First law of thermodynamics and its application to closed and open systems, laws of perfect gases

Relations between specific heat at constant pressure and at constant volume, PVT relations, second law of thermodynamics and the Carnot cycle, reversible and irreversible process

Thermo-Mechanical aversion cycles: Air standard cycles, Otto, Diesel, Joule cycles, steam, power cycles, Rankin cycles, regenerative and reheat cycles

Boilers: Water tube and fire tube, steam engine and steam turbines, elementary principles

Conventional and Non-conventional Energy Sources: Thermal energy, combustion of fossil fuels, their structures, mass, balance, flue gas analysis, energy release and formation enthalpy

Non-reaching Mixtures: Introduction, mixtures of perfect gases, air-water, vapour mixtures (Psychrometry), adiabatic saturation temperature, wet bulbs temperature and use of psychrometric charts

**CIVIL ENGINEERING**  
**Third Year**  
**CE 301 SURVEYING - II**

1. Field Astronomy: Formula of spherical triangle: Astronomical terms: Astronomical co-ordinate systems. Definition of an Astronomical triangle, circumpolar star's, corrections for altitude, Measurements on celestial bodies, Determination of Azimuth, Times, meridian, Latitude longitude and time
2. Geodetic surveying: Triangulation system, Inter visibility and height of stations Eccentricity of signals, Methods of measurement of angles, Method of repetition and method of reiteration, Reduction of centre, corrections in base line measurement.
3. Trigonometrically, Leveling: Curvature and refraction effects, Axis signal correction, Methods of trigonometrically leveling: Reciprocal observation, Characteristics of contours and contouring methods.
4. Triangulation Adjustments, Definition - Laws of weights, Probable errors, Station adjustment, Figure adjustment of Plane triangular, Spherical triangle (Spherical excess).
5. Hydrographic Surveying, Shore line surveying, Soundings, Gauges, Nautical sextant, Methods of locating soundings, 3-point problem.
6. Photographic Surveying, Photo theodolite, Principle of the method of Terrestrial photogrammetric. Aerial surveying, Aerial photography, Ground control scale of photograph and number of photographs
7. Electronic Distance Measurements, Basic Definitions, Phase of the wave, Units, Types of waves, Distance from Measurement of Transit Time, Measurement of Distance from phase Difference, Carrier waves, Methods of Modulation, Microwave E.D.M. Instruments infrared E.D.M. instruments. Atmospheric calibration of instruments
8. Modern Surveying Methods, Inertial Positioning System, Basic theory, Accelerometers, Gyroscopic Control, Operational, procedure of I.S.S., Application of Internal surveying Systems. Doppler Positioning system, Application of Doppler's system

**SURVEYING (SESSIONAL):**

1. Traversing by triangulation including Polygon correction.
2. Gates traverse calculation and contouring
3. Astronomical survey based upon the surveying theory paper.
4. Laying out of curve.

**TEXT BOOKS:**

1. Plane and Geodetic Surveying Part-I and II by Clarke.
2. Surveying by Norman Thorns
3. Surveying by Kanetkar
4. Surveying by Punmia

## CE 302 STRUCTURAL ANALYSIS-I

1. **FUNDAMENTALS** : Introduction to structural analysis and its concept, Equilibrium, Compatibility and force deformation equation with a simple example to illustrate their use, Equation of condition, Classification of structures (based on availability of equations), Load considerations for familiar structures and its type. (8)
2. **TRUSSES**: General theory: construction and classification, Solution of determinate plane trusses, Principle of virtual work willer Mohr's diagram and their applications for determination of deflections of determinate plane trusses. (10)
3. **THREE-PINNED-STRUCTURES**: Calculation of bending Moment, Sheer force, Axial force for three-hinged arches and diagrams for the same, Dead Load stresses in three-pinned determinate trusses, Analysis of Suspension bridges with and without stiffening girders. (5)
4. **MASONRY STRUCTURES**: Basic concept in gravity structures: Stability check, calculation of stresses in case of dams and chimneys. (5)
5. **INFLUENCE LINES** : Basic concept of moving load influence line, Advantages and uses of influence lines, Influence lines for reactions, Shearing forces and bending moments for determinate beams, absolute maximum shearing forces and bending moment, Influence line for three-hinged arches and stresses in simply supported plane determinate trusses. (10)
6. Analysis of structures by unit load method and conjugate beams method.
7. Continuous and fixed beams: Theorem of three moments-Analysis of fixed beams-settlement of supports.

## CE 303 SOIL MECHANICS

1. Introduction and Nature of Soil: Soil problems in Civil Engineering. A general idea of soil behaviors, Types of soil, Formation, structure and mineralogical composition : Physical and engineering properties of soil-Atter-berg Limits Grain-size analysis by sieving and sedimentation, Activity of clays classification of soils-System of classification Particle size classification, Unified soil classification , Soil map of India. (4)
2. Soil Hydraulics Darcy's law, Measurement of permeability in laboratory and in field, permeability of stratified soils, Factors affecting permeability, Capillarity in soils Neutral Pressure and effective stress-their determination and utility, Quick Sand. (4)
3. Seepage Analysis: Laplace's equation Methods of obtaining flow nets, Flow nets for an isotropic soils: Applications of flow net, Piping and its prevention. (4)
4. **Consolidation**: Definitions and measurement of consolidation, characteristics of soil-void ratio, pressure relationships, Mechanics of consolidation, Terzaghi's theory of one dimensional consolidation, Analysis of consolidation test data, (6)
5. **Shear Strength**: Shear strength parameters of soil: Mohr-coulomb strength theory. Effect of drainage conditions on shear strength direct shear test; Tri axial compression test, Vane shear test and unconfined compression test, Choice of test conditions; pore pressure parameters; Shear strength of cohesion less-soils Liquefaction of sand shear characteristics of saturated clays and silts and partially saturated clays : Determination of in-situ shear strength. (6)
6. Earth Pressure : Introduction : At rest and plastic equilibrium conditions; Rankine's and Coulomb's earth pressure theories; Cullman's and Ruthmann's graphical methods for determination of active earth pressure, Effect of water table and seepage pressure on earth pressure, Wedge theory and Friction circle method for passive earth pressure. (5)



7. Slope Stability: Stability of infinite slopes: Factors of safety; Swedish method; Friction circle; method, slices method and Bishop's method of stability analysis. Stability under conditions of (i) Submergence (ii) Sudden draw down, and (iii) Steady seepage; Location of critical arc; Stability number and chart, Remedial measures against slope failure. (4)

8. Stress Distribution: Boussinesq's equation. Vertical pressure under a uniformly loaded circular area and below the corner of a uniformly loaded rectangular area, Vertical pressure under a line load and under a strip load, Equivalent point load method, Newark's chart, Westergaard's equations, Limitations of elastic formula for soils contact pressure. (4)

9. Compaction: Definition, laboratory compaction tests, theory of compaction factors affecting compacted density, Effect of compaction on soil properties Field compaction methods, Measurement and control of field compaction. (3)

10. Soil Stabilization: Introduction, Mechanical stabilization, Stabilization with cement, lime or bitumen, Chemical Thermal and electrical stabilization, Grouting

11. Miscellaneous: Arching in soils, Terzaghi's theory arching. (3)

### **SOIL MECHANICS (SESSIONALS)**

Records of experiments performed and problems solved based upon the theory paper "Soil Mechanics".

#### **TEXT BOOKS:**

1. Soil Mechanics and Foundation Engg. - Bharat Singh and Shamsher Prakash (Nemchand & Bros.)
2. Soil Mechanics in Engineering Practice - Terzaghi & Peck (John Wiley).

#### **REFERENCE:**

1. Soil Mechanics by Lambe and Whitman.
2. Fundamentals of Soil Mechanics by D.W. Taylor

**Air Pollution:** Major pollutants and their adverse effects on environment (3)

**Water Pollution:** Sources, parameters, kinetics of BOD exertion self-purification of stream WHO drinking standard, MPN communicable water borne diseases (5)

**Water purification supply:** Water demand and variation, estimation of future population, sources of supply collection works, Intake structures, sedimentation, flocculation, coagulation, filtration, disinfection and distribution selfening colour and odour removal, Introduction to pumps and pumping stations. (15)

**Waste Water Treatment:** Sewage characteristics, Sewerage system-Type, design, construction and maintenances. (4)

**Treatment Methods:** Primary and secondary treatments, careens, grit chamber, sedimentation chamber, Principle and design of activated sludge process. Trickling filter-oxidation pond and oxidation ditch. Sludge digestion, Final disposal of sludge and effluents. (15)

**Rural Sanitation:** Septic Tank, Inhofe tank, Sulabh Souchalaya and other cheap methods, Solid waste collection and re-utilization / disposal. (6)

Water supply and sanitary installation in residential buildings

### **ENVIRONMENTAL ENGINEERING (SESSIONALS)**

Record of experiments performed based upon the theory paper "Environmental Engineering".

#### **TEXT BOOKS:**

1. Water and Waste Water Engineering Vol. I & II by Pair, Geyor and Sokun
2. Elements of Public Health Engineering by K.N. Duggal.
3. Text Book of Sanitary Engineering by A.K. Chatterjee

## REFERENCE:

1. Environmental Sanitation by J. Lavabo
2. Water supply Engineering by Babbitt and Donald
3. Air Pollution Hand Book

## CE305 CONCRETE STRUCTURES

1. Introduction to concrete technology: Properties of plain and reinforced concrete, Design of mix. Centering and shuttering, Mixing, Transporting, Laying and Curing, Detailed study of machineries used in concrete construction
2. Analysis of sections subjected to combined bending and axial force, Beams in bending, shear and torsion, Beams curved in plan.
3. Beams and slab construction, two way slabs with special reference I.S. Codes.
4. Foundations Wall and isolated column footings, raft foundation, combined footings, R.C. pile foundation Stair and stair cases.
5. Elements of pre stressed concrete - Various methods of pre-stressing, losses in pre-stressing, Design of simple beams and slabs.
6. Fundamentals of limit state design of R.C.

## CE306 STRUCTURAL DESIGN-I

Standard Tables and Charts may be allowed in the examination.

1. Introduction: standard codes: Design procedure; Strength, Serviceability and Economy. (2)
2. Connections: Welded and riveted; Framed-Connection. Eccentric-connection, brackets. (3)
3. Tension Members: Rolled sections and Built-up sections (2)
4. Compression Members: Rolled sections and Built-up sections; Lacing and Battens; Column basis; grillage foundation etc. (8)
5. Flexural Members: Beams; Plate Girder and Gantry girder. (9)
6. Roof Trusses (6)
7. Pressed steel water tanks (6)
8. Bridges: steel foot bridge with rankers and lateral restraints including end bearings. (5)
9. Tubular structures (2)

### STRUCTURAL DESIGN (SESSIONALS)

#### A. Graphics:

1. Bending moment and Shear force diagrams for simple beams; Force and Stress diagrams for common types of Trusses: Space frames, Shear legs, tripods derricks, etc.
2. Deflection diagrams for simple beams.
3. Stability of masonry structures

B. Design: The course will be same as Structural Design-1. However a minimum of eight detailed design and drawing from the following topics must be submitted:

Topics	No. of plates
1. Roof truss	2
2. Plate Girder	1
3. Gantry Girder	1
4. Bridge truss	1
5. Columns (Compound, laced and battened)	1
6. Grillage foundation	1
7. Connections	1
8. Water tank and staging	1
9. R.C. beams & slabs	1

#### TEXT BOOKS:

1. Design of Steel and Timber Structures. Vazirani & Ratwani
2. Design of Steel and Timber Structures - Ramamrutham.

3. Design of Steel and Timber Structures - Arya & Ajmani
4. I.S. code 800
5. I.S. code 875
6. National Building Code

### CE 307 WATER RESOURCES ENGINEERING - I

#### (A) HYDROLOGY:

1. Introduction: Definition and scope, Hydrologic cycle, Hydrologic equation. Hydrologic process (2)
2. Precipitation: Description and mechanics of the precipitation, process, measurement of rainfall Network of rain gauges, average depth of rainfall over area, depth area-duration analysis, hyetograph. (3)
3. Infiltration: Description of the infiltration process, factors affecting infiltration, measurement, rate curve of infiltration capacity, infiltration indices. (2)
4. Evaporation and Vapor transpiration: Evaporation from water bodies soil surfaces and plants, factors affecting evaporation, methods of reducing evaporation, losses, measurement of Evaporation, process of transpiration vapor-transpiration equations. (3)
5. Run off: Description of run-off process, basic factors effecting run-off rainfall-run-off relationships, rational method electrical formulae to estimate peak flows, measurement of river discharges. (4)
6. Hydrograph analysis: Definition, description and types of hydrograph base flow, unit hydrograph theory and analysis, synthetic unit hydrograph and other modifications of the unit hydrograph.
7. Probabilistic Hydrologic Analysis: Sampling of hydrological data, selection of data series for analysis, recurrence interval and frequency of hydrologic events, methods of frequency analysis. (5)

#### (B) OPEN CHANNEL FLOW:

1. **Description of open channel flow:** Types, states and regimes of open channel flow, geometric and hydraulic elements of open channel flow, velocity distribution. (3)
2. **Energy and Momentum Principles:** Total energy and specific energy, specific force, energy and momentum coefficients, critical flow. (3)
3. Uniform Flow: Velocity of uniform flow, roughness coefficient, design of channels for uniform flow. (4)
4. **Gradually varied flow:** Theory and analysis of gradually varied flow, characteristics and classification of flow profiles, methods of computation and practical problems.
5. **Rapidly varied flow:** Characteristics of rapidly varied flow. Flow over spillways, Hydraulic jump and its analysis, energy loss in hydraulic jump (4)
6. Elements of Alluvial hydraulics: Sediment transport theories - Lacey, Kennedy and tractive force approach, design of earthen channels, River modelling. (4)
7. **Unsteady flow:** Introduction of unsteady flow in open channels, wave propagation, clarity of gravity waves, water hammer.

#### **HYDROLOGY AND OPEN CHANNEL (SESSIONALS):**

Record of experiments performed and problems solved based upon the theory paper hydrology and open channel flow.

#### TEXT BOOKS:

1. Water Resources - Engineering - Linsley V, tranzini
2. Applied Hydrology - Linsley, Kohler & Paulhus
3. Open Channel Hydraulic - V.T Chow

### CE 308 STRUCTURAL MECHANICS

1. **Elements of Elasticity:** Concept of stress, stress tensor, invariants Transformation: Concept of strain, strain tensor, Principal strains, Transformation: Equilibrium Equations: compatibility Boundary condition: Formulation of equations for elastic problems: simple two-

- dimensional Problems in Cartesian-ordinates: Solution by Polynomials. Cantilever with end load: simple beam with u, d. I. Stress function.
2. **Elementary Experimental Stress Analysis:** Principles of photo-elasticity and its apparatus: Mechanical strain gauges, Resistance strain gauges: Principles of measurement and strain analysis. (5)
  3. **Elastic Stability:** Energy method of analysis of long columns; Euler's theory of buckling for long columns; Rankine-Gordon formula; Laterally loaded struts; Unsymmetrical bending of beams; Shearing stress in thin walled members subjected to bending; shear centre; Theories of elastic failure.
  4. **Elements of Plastic Theory:** Plastic hinges; Shape factor; Collapse loads for beams and portal; Effect of axial force and shear on the plastic moment of the section; Uniqueness; Upper bound and lower bound theorems.

**TEXT BOOKS:**

1. Theory of Elasticity - Timoshenko & Goodier
2. Theory of Elastic Stability - Timoshenko and Gere
3. Experimental Stress Analysis - Dally and Ralby
4. Plastic Methods of Structural Analysis - B.G. Neal
5. Steel Structures Vol. III - Vazirani & Ratwani
6. Stress Analysis - Sadhu Singh

**CIVIL ENGINEERING**  
**Fourth Year**  
**CE101 STRUCTURAL ANALYSIS – II**

1. **Consistent Deformation:** Analysis of two hinged and rigid arches, Suspension bridges with two hinged Stiffening girder, Redundant frames, Lack of heat and temperature stresses, and Strain energy method.
2. **Slope Deflection and Moment Distribution:** Continuous beams and portals by slope deflection and moment distribution due to load settlements and temperature variation. Sideway, Simplification due to symmetry and skew symmetry
3. **Structural Theorems:** Linearity principle of superposition-virtual work Energy theorems, Reciprocal theorems, Muller-Breslau's principle.
4. **Flexibility Method:** Elemental flexibility matrices of bar elements, formation of structural flexibility matrix from the elemental ones, Solution of trusses and rigid Portals by the matrix flexibility method.
5. **Stiffeners Method:** Member stiffness matrix Stiffness matrix equation.
6. **Influence Lines:** Influence lines for propped cantilevers, continuous beams and two hinged arches.

**STRUCTURAL ANALYSIS (SESSIONALS)**

Records of experiments performed based upon the theory paper "Structural Analysis I & II".

**CE 402 FOUNDATION ENGINEERING**

1. **SHALLOW FOUNDATIONS:** (10)  
Types and functions of foundations, Depth of foundation, Ultimate and allowable bearing capacity, Shear failure and settlement criteria; Rankine's analysis, Terzaghi's analysis (Derivation of the formulae not required), Local and general shear failure, Effect of water table, Eccentric and inclined loads, Kempton's analysis. Meyerhof's analysis, Brinch Hansen's theory, Terzaghi's theory, Settlement analysis: I, S. recommendations for permissible uniform and differential settlements; Proportion ship of footings. Plate load test, Standard penetration test, Design of footings based on N value, combined footings, Raft foundation its allowable bearing pressure on sands, silts and clays, conventional method of design.
2. **PILE FOUNDATIONS:**  
Uses and types of piles, pile driving equipments bearing capacity of piles-Static and dynamic formulas, Pile load tests Cyclic load tests, Penetration tests, Negative skin friction, Capacity of pile groups-Spacing of piles, settlement of pile groups, Laterally loaded piles.

3. **CAISSONS AND WELL FOUNDATIONS:** (4)  
Types of caisson, Stability analysis of well foundation till and shift, IRC code
4. **SHEET PILES:**  
Types and uses of sheet piles, Analysis of cantilever and anchored sheet piles in cohesion less and cohesive soils, Rome's theory of moment reduction, Capacity of Dead men location of anchorage
5. **EARTH DAMS:**  
Types of section and materials of construction investigations required for construction, Causes of failure and general principles of design. Seepage through earth dams-Determination of prelastic line, Seepage control and filter's, Slope protection, Surface drainage, Construction pore pressure, its effect and control Foundation requirements and cut-of wall, Earth work machines.
6. **SOIL DYNAMICS AND MACHINE FOUNDATIONS:**  
Basic concepts, Vibration of systems with single degree of freedom, Free and forced vibrations with and without damping. Basic models of Vibrating foundation-soil systems, Criteria for satisfactory action of a machine foundation, Design criteria— I, S. Codes, Barkan's method of analysis for various types of machine foundation
7. **EXPANSIVE SOILS:**  
Identification, Swelling pressure Black cotton soils, Stabilization of expansive soils, Foundation on expansive soils
8. **Site Exploration** - Object, programme of exploration, various methods, sampling of soil samples, Sub surface sounding, Geophysical exploration.

#### **CE 403 STRUCTURAL DESIGN - II**

Design and drawing of the following:

(Incorporating the latest IS codes of practice and other relevant codes, standard tables and charts).

1. I.R.C. framed building including foundations of different types.
2. Cantilever and counter fort retaining walls.
3. Simple supported R, C. C. Tee beam cum slab Types Bridge on well foundation.
4. Water tanks-on ground, underground and elevated (including Intze tank).
5. Silos and bunkers

#### **SESSIONAL**

The syllabus is as per theory paper. The design, calculations and drawings should carry equal weight age in marking.

#### **CE 404 WATER RESOURCES ENGINEERING – II**

- A. **PLANNING AND MANAGEMENT OF WATER RESOURCES:**
  1. Occurrence: Surface water, ground water and atmospheric water resources, Dynamics of interaction.
  2. Principles of Planning: River basin development, conjunctive use of surface and ground resources. Multipurpose projects, systems approach.
  3. Reservoirs: Physical characteristics, Yield capacity, sedimentation and operation of reservoirs.
  4. Ground water hydraulics: simple hydraulics and ground water flow. Estimation of recharge and safe rate of withdrawal
  5. Economic and other considerations: Principle of economic analysis, Benefit-cost analysis. Other consideration, Multi-objective planning,
- B. **UTILISATION OF WATER RESOURCES:**
  1. Irrigation: principal Indian crops and their season, water requirement of crops. Duty and Delta, Irrigation methods, General description and layout of headwork Alignment of canals and location of canal structures, Earthen and lined channels, Types of lining and their advantages
  2. **Hydropower:** Nature of demand, Primary and secondary power, load curve and load factor, Head, power and efficiency, Pondage and storage layout of a hydropower plant.

3. **Navigation:** Requirements of a variable Waterway, methods of achieving navigability navigation locks.

**C. WATER RESOURCES PROBLEMS:**

1. Floods: Causes of Floods, flood damage, Flood control measures, Routing of floods through reservoirs. Flood plain managements.
2. Drought Definition, Damages and control measures.
3. Drainage: Causes and control of water losing. Design of a drainage system. Soil salinity and its prevention.
4. River Behaviour: Types and behaviour of rivers. Meandering and cut off River training works.

**TEXT BOOKS:**

1. Water Resource Engineering - R.K. Sharma
2. Irrigation Engineering - G.L. Asawa
3. Water Resources Engg. - Linsley & Franzini
4. Irrigation Engg. - S.K. Gurg

**CE 405: CONSTRUCTION PLANNING & MANAGEMENT**

1. **Principal Engineering Economics Fundamentals :** Interest, depreciation and tax formulas, concepts of Break-even point, Minimum cost point, Rate of return and capitalized cost methods for comparison of alternatives Depreciation, Salvage value.
2. Importance of pre-planning, job planning and management of projects including project planning, Project scheduling and project control, Critical path, method &PERT applied to Civil Engg. - Elements of network, constraints, network, analysis of critical path, optimum project cost and project duration by C, P. M. Technology Three time estimates and PERT network Analysis.
3. Safety in construction: Accident prevention programmes: planning for safety locating hazards, safety equipments.
4. Mass diagram for earthwork, Time and motion study.
5. Construction Equipments:
  - a. Factors affecting selection of equipments
  - b. Cost of moving and operating the equipments.
  - c. A broad based information regarding the working and uses of excavation and transportation of earth.
  - d. A brief introduction of the equipments for drilling, Crushing.
  - e. Grouting - need for grouting materials for grouting, method of grouting, effects of grouting.

- f. Dewatering - various method of dewatering, Pumps for dewatering.
  - g. Forms for concrete construction, concrete batching and mixing plant and various methods of concrete transport.
  - h. Different types of cranes and other lifting and hoisting equipments.
6. Pre-fabrication: Advantages and disadvantages of prefabs, System design principles Modular co-ordinations, few types of pre-fabricated building components.
  7. Principle of General management: The elements of universal management functions, Planning, organising, staffing, directing and control, Authority

## **CE 406 TRANSPORTATION ENGINEERING**

Introduction and role of Highway, Railway, Airways and Waterways in National transport system

### **A. HIGHWAYS:**

1. **Introduction:** Brief survey of road engineering development; History of road construction
2. **Planning of Highways:** Object and requirements of highway planning with special reference to India, Highway network fundamentals, National and functional classification of highways. The Nagpur and 20-years plans, planning process, Elements of highway financing and economics (3)
3. **Geometric Design of Highways:** Introduction - Effect of topography and physical features: effect of traffic, vehicle and road users characteristics; Requirement for horizontal road elements, Elements of road profiles, Right of way and broad cross section, Standardization of Highway gradient, Traffic capacity and the required number of lanes, width for carriageway, and shoulders, Problems of traffic motion on curves. Additional elements on curves of small radius such as super elevation, Extension of width of carriage Away, Transition curves; Provision of visibility on curves elating to minimum sight distance and overtaking sight distance standards for horizontal road elements as per I.R.C (4)
4. **Hill Roads:** Special features and problems, Geometric standards. (1)
5. **Traffic Engineering:** Traffic surveys; Impotence and objects of traffic surveys, Introduction to traffic volume studies, O & D studies. Accident studies, Accident prevention measures, Introduction to traffic control devices, Introduction to types of intersection parking facilities.
6. **Pavement Design:** Pavement structural layers, Types of pavement. Choice of pavement types, General principles of pavement, Analysis and design Group Index method, CBR and its determination, Calculation of flexible and rigid pavements, Thickness as per I.R.C. Effect of temperature on pavement, spacing's of contraction and expansion joints (4)
7. **Highway Material and their properties:** Desirable properties of road aggregates Tar and Bitumen's, Cutback and emulsion. (1)
8. **Highway construction:** Construction of earthen, gravel and soil stabilized roads W. B. M. roads, bituminous roads and C, C. roads, Machinery required for highway construction. (4)

9. Road Drainage: Significance and importance of road drainage, Methods for road drainage. (4)
10. **Highway Maintenance:** Pavement failures and their types, Maintenance of roads. (1)
11. **Route Location and Surveys:** Effect of traffic intensity and volume on route location, Influence of natural condition on Route location. Crossing of water courses. (2)

(B) RAILWAY ENGINEERING:

1. **Introduction:** Role railways in transportation system. Railways and highways-transportation System compared, Historical development of railways in India
2. **Permanent ways:** Alignment and grades, cross-section and its elements, Gauges Grade compensation and widening of gauges on curves. (3)
3. **Signals and Interlocking:** Objects and types of signals and typical locations, methods of locking. (2)
4. **Points and crossings:** Terminology, Turn outs, Crossings and triangles. (2)
5. **Station and Yards:** Selection of site, types and features of station and yards, Ash pits, Examination pits, turn tables, water column.

(C) BRIDGE ENGINEERING:

- Introduction, type of bridge and culvert and their suitability, site selection (2)
- Determination of scour depth, depth of foundation; linear waterway, economic Span, Afflux; freeboard, clearance (2)
- Load forces and stresses in bridge structures, IRC loading. (3)
- Types of bridge: Super structures and flooring and their choice. Details of bearings and joints in Bridge super structure.
- Types of bridge foundation - spread, raft, well and cessions; sinking of well foundation design excluded;
- Method of erection of bridges (3)

TRANSPORTATION ENGINEERING (SESSIONALS)

- A. A visit to railway yard and sketching of various elements etc. as per syllabus of the paper.
- B. Laboratory tests:
  1. Tests on Bitumen
  2. Test on Aggregates as per I, S. S.
  3. Tests on Bituminous mix.

TEXT BOOKS:

1. Highway Engineering by S. K. Khanna - C, E. Justo
2. A course in Highway Engineering by S.P. Bindra.
3. Bridge Engineering by Algia.
4. Permanent Tract by Anita.
5. Highway Engineering by S, B, Sehgal & K.L. Bharat



## CE 407 HYDRAULIC STRUCTURES

### A. HYDRAULIC PRINCIPLES APPLIED TO HYDRAULIC STRUCTURES

1. Percolation: Bligh's method, Lane's weighted creep theory, Potential flow theory, Khoslas simplifications, Model studies, percolation in an earthen dam.
2. Afflux and waterway of bridges weirs and barrages. Free board allowances in dams, embankments, bridges.
3. Scour depth and fair erosion-causes-effects and methods of controlling them.
4. Forces acting on hydraulic structures on dams, weirs and other structures.
5. Formulation problems Rock formulation, permeable foundation etc.
6. Materials in hydraulic structures.

### B. DESIGN OF HYDRAULIC STRUCTURES (AS PER ISI CODE OF PRACTICE)

1. Storage structures: Gravity dams, Buttress dams and Arch dams, earthen dams and earthen embankments, Rock fill dams (stability analysis, section, elevation and plan for all above types.)
2. **Diversion structures:** Weirs & barrages, detailed hydraulic calculations including structural requirements; complete layout of a diversion head works SILT excluders and silt ejectors.
3. **Surpassing and outlet structures:** Spillways and outlets, types, hydraulic design and drawings
4. Control structures: Crest controls, flash boards, stop logs and needles, Vertical lift gates, trestle gates, entrance gates, trestle gate valves, high head regulating valves, Gate installation. Lock in navigation canals.
5. **Conveyance and metering structures:** Conveyance shutting (a) Regulations(b) Falls (c) Cross-drainage works – Aqueducts siphons etc. (d) Draft tube Metering Structures - (i) Weirs, Venturimeter and pushball flumes etc.

### TEXT BOOKS:

1. Irrigation and Hydraulic Structures - S.K. Ghosh
2. Engineering for Dams - 3 volumes - Justin Creager & Hinds
3. Design of Hydraulic Structures-Varshney
4. Irrigation and Power Engg. - Punmia & Lall

## CE 408 ADVANCED ENVIRONMENTAL ENGINEERING

### First Term:-

1. Water work: Water work flow diagram and function of water work unit. (1)
2. **Water collection system:** Design and construction of ordinary wells, tube wells intake wells and infiltration wells / galleries. (4)
3. Water Distribution system : Design of pumps and pumping system, water mains, service mains and appurtenances, service water reservoir, pipe network analysis. (6)

4. Theory of settling, Design of settling tanks, Mechanism of Coagulation -Flocculation, Design of Flash mixer and clarify osculation. (4)
5. Theory of Filtration and Back washing, Design of slow sand, Rapid sand Filtration plants. (6)
6. Theory of disinfection and design of chlorine contact chambers. Theory and design of fixed Bed Eiche Exchange. (4)

**SECOND TERM:**

1. **Sweage works:** Flow sheets and functions of processing units. (1)
2. **Design of sewerage systems:** Sanitary sewers; combined sewers and sewer appuratenances, sewages pumps and pumping stations. (6)
3. **Design of preliminary and primary waste water treatment system:** Racks and screens, Grit chambers and Detritus tanks; Primary setting tanks. (4)
4. Design of septic tanks and Inhofe tanks. (2)
5. Design of secondary treatment systems; Activated sludge plants and Trickling filter plants and secondary treatment tanks. (8)
6. Design of Oxidation ditches and oxidation ponds. (2)
7. Design of sludge digester and solid waste composting systems.

**CE 409 PRESTRESSED CONCRETE DESIGN**

FIRST TERM: (24 lectures)

Fundamentals of press stressing, Classification and types of press stressing, properties of material Various press stressing systems, Losses of press stress. Analysis and design of sections for statically determinate beams for flexure; Design of press stressed concrete slabs, Cable zone, Kern limits and cable profiles, Deflection (short term) : Flexural strength of press stressed concrete sections, Simplified I, S, Code procedures. End block analysis and reinforcement; Transmission length: Anchorage zone stresses.

SECOND TERM: (24 lectures)

Bond stress: Design of shear and torsion reinforcements; Ultimate shear resistance of press stressed concrete sections, Design of press stressed concrete poles and speeders, Circular press stressing and design of press stressed concrete tanks. Design of continuous beams, linear transformation: Concordant cable profile for two-span continuous beams with simple loadings. Limit state design criteria for prestressed concrete members.

RECOMMENDED TEXT BOOKS:

N. Krishna Raju- Press stressed Concrete (Tata McGraw Hill Publishing Co. Ltd., New Delhi)

REFERENCE BOOKS:

1. T. Y, Lin – Press stressed Concrete Structures (Asia Publishers)
2. Y. Guyonn – Press stressed Concrete Vols. -1 & II ((John Wiley & Sons. Iric. New York)

3. Abeles, Bardhan Ray and Turner – Press stressed Concrete Designer's Hand Book (A View Point Publication)

### CE 410 ADVANCED SOIL MECHANICS

#### FIRST TERM:

1. Shear strength of Soils : Physical aspects of shearing resistant, Preliminary theoretical considerations Failure criteria - Generalization of Mohr failure theory; types of shear tests; shearing resistance of saturated clays and remolded clays; significance of pore pressure; Normally consolidated conditions; over consolidated conditions; Effective stress parameters; shearing resistance of granular soils, significance of volume changes due to shear deformation of granular soils, Interpretation of laboratory test results.

2. Retaining walls, Anchored sheet pile bulk heads-Conduits - Factors affecting selection of types of retaining structures, Basic concepts of lateral strain; Wall friction and adhesion; Earth pressure theories, computation of earth pressure for Surcharge load, strip load, line load-Anchored bulk heads; The free earth support method of designing anchored flexible sheet pile bulk heads for non-cohesive soils; the free earth support methods of designing anchored flexible sheet pile bullheads for cohesive soils; simplified equivalent; beam-design procedure, load on underground conduits classes of conduit installation.

3. **Stability of Slopes:** Concept of factor of safety; modes of rupture, Total stress analysis; effective stress analysis Lishop's methods, May's method and Den's method; Effect of pore-pressure.

4. **Field problems; Field measurements:** In-place shear strength; plate load tests; pre-pressure measurements; Horizontal earth movements, surface and subsurface measurements; settlement measurements, settlement plates.

#### SECOND TERM:

5. Pile Foundations: Action of piles - Test piles; bearing capacity of pile foundation; Field determination of shear and end bearing value; Formulas for dynamic and static; pile groups; pile spacing, grouping and factor of safety; efficiency; Distribution of load between vertical and batter piles-lateral resistance of vertical piles, selection of pile and method of installation.

6. Machine Foundation: Basic theory of vibrating masses free vibration, free vibration with damping. Forced vibrations, Vibrating machines effect of soil mass on the equations of motion, spring constants natural frequency of machine foundation and soil system, steps in the design of various types of foundation; Barken method. Pauw's analysis, Evaluation of design parameters, Vibration insulation

7. **Dewatering:** Methods of dewatering and pressure relief; deep well sumps well point systems; deep well drainage; vacuum dewatering system: drainage by electro osmosis: Methods of ground water control: water table and artesian pressure; source of seepage analysis and design formulas: fully penetrating slot; partially penetrating slot.

8. **Anchors:** Definition of soil and rock and or systems; soil anchors; Rock anchors; design features.

**BOOKS RECOMMENDED:**

1. Foundation Engineering - Leonards.
2. Soil Mechanics and Foundation Engineering - J. Jha.
3. Foundation Engineering Design - Teng.
4. Soil Mechanics - T.W. Lambe.
5. Hand book of machine foundation - P. Srinivasulu & C.V. Vaidyanathan.

**CE 411 CONTRACT SPECIFICATION & ACCOUNTS FIRST TERM:**

**METHODS OF BUILDING ESTIMATE:** Long wall-short wall method, Centre line method. Crossing method-including semi-circular, Hexagonal, Octagonal and Segmental bay front of building.

**ESTIMATE OF BUILDING:** Estimate of masonry platform, water tank detailed estimated of single story and double storied residential and public buildings with Kitchen, bath, front and back verandahs having different ceiling heights, Estimate of building having hexagonal semi-circular and segmental bay front, Abstract of costs

**DIFFERENT TYPES OF ROOFS AND THEIR ESTIMATES:** Methods of Calculating quantities of different types of Arches-Semi-circular Arch, Segmental Arch, of 60, Segmental Arch with span and rise given, Segmental Arch with span and angle given, Flat Arch, Estimate of Jack Arch roof.

**PITCHED ROOFS:** Estimate of lean-to-roof, King post truss; and steel roof ruses with purloins, Common rafters and roof covering materials

**RCC WORK:** Types of bars and shapes and calculation of their length. Estimate of R.C.C. lintel, Beam (singly and doubly reinforced.) Square column, circular column and cantilever beams.

**SECOND TERM:**

Earth work: Different methods of calculating earth work for roads, hilly roads, canals and embankments.

**Culverts and Bridges:** Methods of finding out the length of abutments and wing walls below bed level and above body levels. Detailed estimate of slab and Archculverts write straight, return-type and splayed wing walls.

**Analysis of rates:** Rates of materials and labors, calculation of materials of different items of work. Detailed analysis of all items of building projects such as earthwork, concrete, brick work, mortar, D.P.C; rooting of various types of flooring, plaster and pointing woodwork painting white washing, varnishing etc.

Detailed specifications: Detailed specifications of various items of works of building, Project such as earth

work, concreting D.P.C. stone masonry, and brick work flooring, roofing varnishing, distempering, white washing colour washing and wood work.

Contracts and agreements: Various types of contracts and agreement, tenders, Notice inviting tenders, tender document's contract documents escalation factor, termination of contracts, measurement of works, measurement book muster-roll.

**Accounts:** Essential requirements of accounts: P.W.D. system of accounts, classification of transactions, Head of accounts, list of standard objects of expenditure

**BOOKS RECOMMENDED:**

1. Estimating and costing - B.N. Dutta.
2. Estimating and costing - H. Chakraborty.
3. Estimating and costing - S.P. Mahajan.