THAPAR
UNIVERSITY

COURSES SCHEME

&

SYLLABUS

FOR

B.E.

CIVIL ENGINEERING

2017

COURSE SCHEME & SYLLABUS FOR B.E. (CIVIL ENGINEERING), 2017

SEMESTER – I

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UPH004	APPLIED PHYSICS	3	1	2	4.5
2	UTA007	COMPUTER PROGRAMMING I	3	0	2	4.0
3	UEC001	ELECTRONIC ENGINEERING	3	1	2	4.5
4	UTA015	ENGINEERING DRAWING	2	4	0	4.0
5	UHU004	PROFESSIONAL COMMUNICATIONS	2	0	2	3.0
6	UMA003	MATHEMATICS-I	3	1	0	3.5
		TOTAL	16	7	8	23.5

SEMESTER – II

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UCB008	APPLIED CHEMISTRY	3	1	2	4.5
2	UTA009	COMPUTER PROGRAMMING-II	3	0	2	4.0
3	UEE001	ELECTRICAL ENGINEERING	3	1	2	4.5
4	UEN002	ENERGY AND ENVIRONMENT	3	0	0	3.0
5	UTA013	ENGINEERING DESIGN PROJECT-I (6 SELF EFFORT HOURS)	1	0	2	5.0
6	UMA004	MATHEMATICS-II	3	1	0	3.5
7	UES009	MECHANICS	2	1	0	2.5
		TOTAL	18	4	8	27

SEMESTER – III

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UTA014	ENGINEERING DESIGN PROJECT-II (6 SELF- EFFORT HOURS)	1	0	4	6
2	UTA002	MANUFACTURING PROCESS	2	0	3	3.5
3	UMA031	OPTIMIZATION TECHNIQUES	3	1	0	3.5
4	UES010	SOLIDS AND STRUCTURES*	3	1	2	4.5
5	UES011	THERMO- FLUIDS*	3	1	2	4.5
6	UCE306	ARCHITECTURE DRAWING & BUILDING CONSTRUCTION	2	0	2	3.0
7	UCE308	BUILDING MATERIALS	2	0	2	3.0
		TOTAL	16	3	15	28

*: UES010, UES011 Lab to be conducted every alternative week

SEMESTER – IV

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UES012	ENGINEERING MATERIALS	3	1	2	4.5
2	UMA007	NUMERICAL ANALYSIS	3	1	2	4.5
3	UCE508	DESIGN OF CONCRETE STRUCTURES-I	3	1	0	3.5
4	UCE404	STRUCTURAL ANALYSIS (7 SELF EFFORT HOURS)	3	1	2	8.0
5	UCE403	SURVEYING	3	1	3	5.0
		TOTAL	15	5	9	25.5

SEMESTER – V

SR. NO.	COURSE NO.	TITLE	L	T	P	CR.
1.	UCE501	SOIL MECHANICS	3	1	2	4.5
2.	UCE401	HYDROLOGY & GROUND WATER	3	1	0	3.5
3.	UCE507	ADVANCED STRUCTURAL ANALYSIS	3	1	0	3.5
4.	UCE609	DESIGN OF STEEL STRUCTURES – I	3	1	0	3.5
5.	UCE509	TRANSPORTATION ENGINEERING – I	3	0	2	4.0
6.	UCE506	CONSTRUCTION MANAGEMENT	3	1	0	3.5
7.	UTA012	INNOVATION AND ENTREPRENEURSHIP (5 SELF EFFORT HOURS)	1	0	2	4.5
8.	UCE692	GROUP DESIGN PROJECT (START)	-	-	2	-
9	UCE491	SURVEY PROJECT	-	-	-	4.0
		TOTAL	19	5	6	31.0

: UTA012 Lab to be conducted every alternative week

SEMESTER – VI

SR. NO.	COURSE NO.	TITLE	L	T	P	CR.
1.	UCE606	WATER AND WASTE WATER ENGINEERING	3	1	2	4.5
2.	UCE607	FOUNDATION ENGINEERING	3	1	2	4.5
3.	UCE603	HYDRAULIC ENGINEERING	3	1	2	4.5
4.	UCE608	DESIGN OF CONCRETE STRUCTURES– II	2	1	0	2.5
5.	UCE605	TRANSPORTATION ENGINEERING – II	3	1	0	3.5
6.		ELECTIVE- I	3	1	0	3.5
7.	UCE692	GROUP DESIGN PROJECT (6 SELF EFFORT HOURS)	1	0	2	5.0
		TOTAL	18	6	8	28

SEMESTER – VII

SR. NO.	COURSE NO.	TITLE	L	T	P	CR.
1.	UCE794	**PROJECT SEMESTER****	-	-	-	**20.0**

** To be carried out in Industry / Research Institution

OR

SR. NO.	COURSE NO.	TITLE	L	T	P	CR.
1.	UCE701	GROUND IMPROVEMENT	3	1	0	3.5
2.		ELECTIVE – II	3	1	0	3.5
3.	UCE795	PROJECT (6 SELF EFFORT HOURS)	1	-	10	9.0
4.	UCE796	PRACTICAL TRAINING (SIX WEEKS)				4.0
		TOTAL	**7**	**2**	**10**	**20.0**

OR

SR. NO.	COURSE NO.	TITLE	L	T	P	CR.
1.	UCE797	**START UP SEMESTER****	-	-	-	**20.0**

** Based on hands on work on Innovations and Entrepreneurship

SEMESTER –VIII

SR. NO.	COURSE NO.	TITLE	L	T	P	CR.
1.	UCE805	DESIGN OF STEEL STRUCTURES II	3	2	0	4.0
2.	UCE804	SEISMIC ANALYSIS AND DESIGN	3	1	2	4.5
3.	UCE806	DESIGN OF HYDRAULIC STRUCTURES	3	1	0	3.5
4.	UHU005	HUMANITIES FOR ENGINEERS	2	0	2	3.0
5.	UCE892	CAPSTONE PROJECT (INCLUDE 13 SELF STUDY HOURS)	0	0	3	8.0
6.		ELECTIVE – III	3	1	0	3.5
7.		GENERIC ELECTIVE	3	0	0	3.0
		TOTAL	**17**	**5**	**7**	**29.5**

TOTAL CREDITS: 212.5

List of Electives

Elective – I

SR. NO.	COURSE NO.	TITLE	L	T	P	CR.
1.	UCE831	BRIDGE ENGINEERING	3	1	0	3.5
2	UCE834	ADVANCED TRANSPORTATION ENGINEERING	3	1	0	3.5
3	UCE833	WATER RESOURCES PLANNING AND MANAGEMENT	3	1	0	3.5
4	UCE612	ENVIRONMENTAL LEGISLATION AND IMPACT ASSESSMENT	3	1	0	3.5

Elective – II

SR. NO.	COURSE NO.	TITLE	L	T	P	CR.
1.	UCE725	ADVANCED CONSTRUCTION MATERIALS AND TECHNIQUES	3	1	0	3.5
2	UCE723	GROUND WATER ENGINEERING	3	1	0	3.5
3	UCE724	SITE ORGANIZATION AND SAFETY MANAGEMENT IN CONSTRUCTION	3	1	0	3.5

Elective – III

SR. NO.	COURSE NO.	TITLE	L	T	P	CR.
1.	UCE848	TRANSPORTATION PLANNING AND MANAGEMENT	3	1	0	3.5
2	UCE832	GEO-TECHNIQUES	3	1	0	3.5
3	UCE849	AIR QUALITY AND CONTROL ENGINEERING	3	1	0	3.5
4	UCE844	REMOTE SENSING AND GIS	3	1	0	3.5
5	UCE845	PRESTRESSED CONCRETE	3	1	0	3.5
6	UCE846	SOIL DYNAMICS AND MACHINE FOUNDATION	3	1	0	3.5
7	UCE850	HYDRO POWER ENGINEERING	3	1	0	3.5

GENERIC ELECTIVE

S.NO.	CODE	TITLE	L	T	P	CR
1	UHU006	INTRODUCTORY COURSE IN FRENCH	3	0	0	3.0
2.	UCS001	INTRODUCTION TO CYBER SECURITY	3	0	0	3.0

3.	UHU007	EMPLOYABILITY DEVELOPMENT SKILLS	2	2	0	3.0
4.	UEN004	TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT	3	0	0	3.0
5.	UHU008	INTRODUCTION TO CORPORATE FINANCE	3	0	0	3.0
6.	UHU009	INTRODUCTION TO COGNITIVE SCIENCE	3	0	0	3.0
7.	UPH063	NANO SCIENCE AND NANO-MATERIALS	3	0	0	3.0
8	UMA066	GRAPH THEORY AND APPLICATIONS	3	0	0	3.0

UCE308: BUILDING MATERIALS

	L	T	P	Cr
	2	0	2	3.0

Course Objectives: To expose students to the various building and general construction products and their associated quality, durability, warrantees and availability.

Cement: Manufacture, basic properties of cement compounds, grades, packing storage, quality control and curing.

Aggregates: Classification, characteristics, soundness of aggregates, fineness modulus.

Lime & Mortar: Classifications & Properties

Concrete: Introduction, properties of concrete, water cement ratio, workability, compressive strength, grades, *Production of Concrete*: Batching, mixing, transportation, placing, compaction and curing of concrete, quality control of concrete, concrete mix design. *Introduction to HPC, SCC and FRC*

Admixtures and Superplasticizers: Functions, classification, accelerating admixture, water reducing admixture, retarding admixture, air-containing admixture.

Bricks: Composition of good brick earth, harmful ingredients, manufacture of bricks, characteristics of good bricks, shapes, classification of bricks as per IS 1077-1985 and testing.

Stones: Classification of rocks, test for stones, characteristics of a good building stone, deterioration of stones, common building stones of India

Timber: Classification and identification of timber, defects in timber, characteristics of good timber, seasoning of timber.

Metals: Manufacture of steel, market forms of steel e.g. mild steel and HYSD steel bars, rolled steel sections. Thermo Mechanically Treated (TMT) Bars.

Miscellaneous Materials: Asphalt, Bitumen, insulating materials, materials for doors and windows, paints.

Laboratory Work: Tests on: Cement, fine aggregates, coarse aggregates, fresh and hardened concretes, tests on bricks, tests on Steel.

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Evaluate various properties of concrete
2. Evaluate various properties of the basic construction materials such as brick, stone timber, metals
3. Evaluate the properties of miscellaneous materials such as bitumen, paints, distempering, materials for structural repairs
4. Perform various quality control tests for the various civil engineering materials by performing different lab tests on materials.

Text Books
1. *Gambhir M. L., Concrete Technology, Tata McGraw Hill Publishing Co. Ltd., New Delhi(2004).*
2. *Rangawala S. C., Engineering Materials, Charotar Publishing House, Anand (1992).*

Reference Books
1. *Shetty M. S., Concrete Technology: Theory and Practice, S. Chand & Company (2010).*
2. *Kumar Sushil, Engineering Materials, Metropolitan Press (1994).*
3. *Kumar Sushil, Building Construction, Standard Publishers and Distributors (1990).*
4. *Punmia B. C., Building Construction, Laxmi Publishing House (1993).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	35

UCE306: ARCHITECTURE DRAWING AND BUILDING CONSTRUCTION

	L	T	P/D	Cr
	2	0	2	3.0

Course Objective: To expose students to the concepts of architectural drawings and building construction.

Introduction to Architecture Drawing: Proportion, orientation, site plan, working drawing Building layout, Architectural, structural working drawings, Modular co-ordination and drawing on modules, Building bye-laws.

Foundations: Types spread, arch, combined, cantilevered, Raft, Grillage, Piles & wells, Footings in block cotton soil, Basement & Retaining walls

Masonry: Stone & Brick**:** Brick masonry, Bonds and junctions, Walling, Mud wall, Sun-dried bricks, burnt bricks, stones walling, load bearing & non load bearing brick masonry for multistoried constructions, brick panel walling, reinforced masonry. Bonds & junctions

Prefabricated Construction: Prefabricated components, Assembly at site, Low cost housing & hollow blocks.

Damp Proof Course: Points of its requirement in buildings, D.P.C. at Plinth level, in basement and roof tops etc. joints in prefabricated construction. Anti termite treatment

Lintels & Arches: Location and construction details in wood, brick, stone and R.C.C.

Stairs & Stair cases: Suitability of location, stairs in multistoried buildings, Residential and public buildings, Fire escape, Stairs in timber, stone, brick, RCC and Metal Drawings in Plan elevation and sections. Hand rail & railings, description and sketches of lifts escalators.

Doors &Windows: Details, location in buildings, sizes & construction for wooden & metal, Battened braced, framed, flush and paneled, sliding, folding telescopic, with louvers, collapsible. Windows in timber & Metal casement, double hung, Dormer, Corner, Fanlight, skylight, clear storey etc. Low cost ideas, Revolving doors, Aluminum door and windows.

Roofing and Flooring: Types of Flooring, Flat roofs: Waffle floor, channels, cored units etc., inclined roofs.
Form Work, Scaffolding, underpinning.

Exercises:
1.   Drawings of all the above components e.g. Brick masonry bonds and junctions, DPC, Lintels and Arches, Stairs, Doors & Windows, Roof & roof coverings
2.   A plan of building consisting two stories with three/four rooms:
- Plan, Elevations & Section (Modular)
- Site Plan (Bye laws application)
- Foundation for walls – Construction details,
- Proposed doors – Construction with details,
- Roof & floor – details in construction
- Stair case details

Course Learning Outcomes (CLO):

Upon completion of this course, the students will be able to:

1. Plan and draw constructional details of different building components
2. Capable of working with an architect and contractor
3. Prepare building plans and other components for a project
4. Capable of supervise building constructions

Text Books:

1. *Singh, Gurcharan, Building Construction Engineering, Standard Book House (1994).*
2. *Sharma, S. K., Building Construction, S. Chand and Company (2012).*

Reference Books:

1. *Kumar, Sushil, Building Construction, Standard Publisher and Distributors (1990).*
2. *Punima, B. C., Building Construction, Laxmi Publishing House (2002).*
3. *Sharma and Kaul, A Text Book of Building Construction, S. Chand and Company (1987).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

UCE403: SURVEYING

L	T	P	Cr
3	1	3	5

Course objective: Surveying as a subject in civil engineering aims to provide basic knowledge about principles of surveying for a location, and its application in design and construction of engineering projects. The students develop skills using surveying instruments including measuring tapes, theodolites, and advanced measurement equipment such as total stations.

Surveying: Definition, classification of surveys, Principle, distorted or shrunk scales, precision in surveying.

Chain Surveying: Instruments for measuring distances, chains, tapes, ranging – direct & indirect, chaining on sloping ground, mistakes in chaining, corrections for linear measurements. Reconnaissance, station selection, limiting length of offsets, field notes.

Compass Traversing: Instruments used in traversing, bearings, meridians, declination, dip of magnetic needle, bearing of lines from included angles, local attraction, closing error and its removal.

Plane Table Surveying: Introduction to plane table surveying, principle, instruments, working operations, setting up the plane table, centering, leveling, Orientation, methods of plane table survey, two and three point problems, danger circle, Lehmann's Rules, errors.

Leveling: Definitions of terms used in leveling, different types of levels, parallax, staves, adjustments, bench marks, classification of leveling, booking and reducing the levels, rise and fall method, line of collimation method, errors in leveling, permanent adjustments, corrections to curvature and refraction, setting out grades, longitudinal leveling.

Contours: Definition, representation of reliefs, horizontal equivalent, contour interval, characteristics of contours, methods of contouring, contour gradient, uses of contour maps.

Theodolite: Types of theodolites, measurement of angles, temporary and permanent adjustments, closed & open traverse, omitted measurements, consecutive and independent co-ordinates, advantages and disadvantages of traversing closing error, Bowditch & Transit Rules

Tacheometry: Definitions and terms used in tacheometery, difference between theodolite and tacheometer, principle of tacheometry, determination of constants, angular tacheometry with staff vertical and staff inclined, Merits and Demerits; Anallatic lens, tangential method of tachometry, subtense method of tacheometry.

Trigonometric Leveling: Definitions & terms, curvature & refraction Methods: direct & reciprocal, eye and object correction, coefficient of refraction.
Curves setting: Definition, elements of a simple curve, different methods of setting out a simple circular curve, elements of a compound curve, reverse curves, transition curves, their characteristics and setting out, vertical curves, setting out vertical curves, sight distances.

Total Station: Working principle and survey with total station.

Global Positioning Systems (GPS): Working principle, Types of GPS, Corrections, Application of GPS. DGPS-working principle.

Digital Elevation model: Introduction and application

Field astronomy: Introduction, basic principle and application

Remote sensing: Basic concepts, Principle and applications

Photogrammetry: Concepts and application for map preparation

Laboratory work
1. Measurement of distances / offsets. With chain and tape
2. Leveling Exercises.
3. Measurement of vertical and horizontal angles with theodolite.
4. Tacheometric Survey and Tacheometric Constants.
5. Plane table survey of an area.
6. Setting out curves.
7. Fixing points with DGPS and survey with DGPS
8. Surveying with Total Station.
9. Layout of building in the field using Total Station

Course learning outcome (CLO):
Upon completion of this course, the students will be able to:
1. Survey an area under various topography and obstructions.
2. Prepare the plan or map of the area surveyed.
3. Analyse, report and where appropriate distribute the survey errors.
4. Set out curve and building lay out.
5. Perform instruments checks to ensure they meet the specifications.

Text Books:
1. *Subramanian, R. Surveying and Leveling*, Oxford (2007).
2. *Venkatramaiah, C., A Text Book of Surveying, Universities Press (1996).*
3. *Kanetkar, T.P., and Kulkarni, S.L., Surveying and Leveling Part I and II, Pune Vidhyarthi Griha Prakashan (2006).*

Reference Books:
1. *Punmia, B.C., Jain, Ashok Kumar and Jain, Arun Kumar, Surveying Vol. I and II, Laxmi Publications (2005).*
2. *Agor, R., Surveying, Khanna Publishers (1982).*
3. *Singh, Narinder, Surveying, Tata McGraw Hill (1992).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

UCE404: STRUCTURAL ANALYSIS

	L	T	P	Cr
	3	1	2	8.0

Course Objective: This course aims to develop an understanding of the techniques of structural analysis used to calculate the member forces, stresses, strains and displacements of statically determinate and indeterminate structures. This is followed by an understanding of the influence lines for determinate structures.

Displacements: Geometric methods : Moment area method and conjugate bean method; Energy Methods: Strain energy in members, Betti's and Maxwell's Laws of reciprocal deflections, Concept of Virtual work and its applications, Castigliano's theorems, Unit load method for 2D-frames.

Indeterminate Structures: Introduction, Static and kinematic indeterminacies, Stability of structures, Internal forces in two and three-dimensional structures.

Analysis of Indeterminate Beams and Frames: Classical Methods: Methods of consistent deformation, Method of least work, and Theorem of three moments; Conventional methods of Analysis of rigid frames: Slope deflection method, Moment distribution method; Approximate methods: Portal method, and Cantilever method.

Moving Loads and Influence Line Diagrams for Statically Determinate Structures: Bending moment and shear force diagrams due to single and multiple concentrated rolling loads and uniformly distributed moving loads, Equivalent UDL, Muller Breslau principle**:** Influence lines for beams, Girders with floor beams and pin jointed frames calculations of the maximum and absolute maximum, shear force and bending moment envelopes.

Laboratory Work:
List of Experiments:
1. To verify Betti's Law
2. To find the deflection of a pin connected truss.
3. To determine the flexural rigidity (E1) of a given beam.

Experimental Project/assignment/Micro Project: Students in a group will do the following project:
 1. Design and build a lightweight "pop up shelter".
 2. Design and construct a 2 m simply supported beam made from newspaper s (6no) to support 3 kg (baby monkey).The structure will be constructed from pin jointed ties and struts made from news papers. The project will be completed in two stages:

Stage One: Design Exercises: Design and Testing Structures [Wks 3 to 6]

Stage Two: Construction: Manufacture and Build Final Structure [Wks 8 to 13]

The evaluation will be based on following:

Group Assignments (70%)
Week 6: Group design and structural testing report (25%)

Week 10: Structure construct (15%)
Week 11: Group construction report (25%)
Week 12: Video (5%)
Individual Assignment – Obligatory (30%)
Week 2 to 12: Design Journal
[Design (15%) & Construction (15%)]

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Calculate deformation of statically determinate structures using geometric and energy methods.
2. Analyze statically indeterminate beams using classical and conventional methods.
3. Develop qualitative diagrams showing the displaced shape, bending moments and support reactions for an indeterminate plane frame.
4. Draw influence line diagrams for statically determinate beams and frames.

Text Books:
1. Wang, C. K., Indeterminate Structural Analysis, Tata McGraw-Hill Education Pvt. Ltd (1983).
2. Norris & Wilbur, Elementary Structural Analysis, McGraw Hill Publisher (1983).
Reference Books:
1. Dayaratnam, P., Advanced Structural Analysis, Tata McGraw Hill Publishers (1983).
2. Punmia, B. C. and Jain, A. K., Theory of Structures, Luxmi Publications (2003).

Evaluation Scheme

Sr. No.	Evaluation Elements	Weights (%)
1.	MST	15
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quiz/Lab evaluations	10
4.	Project	40

UCE508:DESIGN OF CONCRETE STRUCTURES-I

	L	T	P	Cr
	3	1	0	3.5

Course Objective: To expose the students to design philosophies & methodologies of various methods of design for reinforced concrete elements.

Introduction: Reinforced concrete, definition, properties of materials, grades of concrete and reinforcing steel, stress-strain curves, permissible stresses, shrinkage, creep, design philosophies working stress design, ultimate strength and limit state design method.

Limit State Design Method: Introduction, Limit States, Characteristic values, characteristic strength, characteristic loads, design values for materials and loads, factored loads.
Limit State of Collapse (Flexure): Types of failures, assumptions for analysis and design of singly reinforced, doubly reinforced sections, and flanged sections, Design of Lintels, Design of one-way slabs and two-way rectangular slabs, Circular slabs: Slabs with different edge conditions

Limit State of Collapse (Shear, bond and torsion): Introduction - Design for shear, structural components subjected to torsion, design of rectangular beam section for torsion, development length, continuation of reinforcement (beyond cut off points).
Limit State of Serviceability: Deflection, effective span to effective depth ratio, modification factors for singly reinforced, doubly reinforcement and flanged beams, crack formation and its control.
Limit State of Collapse (Compression): Columns and their classification, reinforcement in columns, assumptions, short and long (both tied and helical) columns subjected to axial load, short columns subject to axial, uniaxial and biaxial bending, Interaction Diagrams
Limit State Design of miscellaneous structures: Design of isolated footings, Design of staircases.
Introduction to Working Stress Design Method
Application of SP 16 and Detailing of Reinforcement: Use of SP: 34, Codal Provision for RC Elements: (I) General (II) for ductility.

Project Work:

Project would be based on "Design of Concrete Mixes of Different Grades, Study of Strength Properties and Flexural Behaviour of RCC Beams"

1. Design and development of Concrete Mix of a particular Grade of concrete
2. At the age of 28 days, measurement of strength properties such as Compressive Strength, Splitting Tensile Strength, Flexural strength, and Modulus of Elasticity.
3. Study of behaviour of any one type of the RCC beams made of same grade of concrete, subjected to flexure.

   a)   Balanced Section
   b)   Under - reinforced Section
   c)   Over - reinforced Section

Course learning Outcome (CLO):

Upon completion of this course, the students will be able to:

1. Design and detail flexural elements such as beams, slabs etc.
2. Design the flexural member for shear ,bond and torsion
3. Design and detail compression members
4. Design other elements such as footings, stair-case

Text Books:

1. *Gambhir, M. L., Reinforced Concrete Design, Prentice Hall of India(2013).*
2. *Jain, A. K., Limit State Design of Reinforced Concrete, Nem Chand Brothers(2002).*
3. *Ram Chandra, Limit State Design, Standard Book House(2011).*

Reference Books:

1. *Pillai &Menon, Reinforced Concrete Design, Tata McGraw Hill Publishers(2005).*
2. *Varghese, P. C., Limit State Design of Reinforced Concrete, Prentice Hall of India(2008).*
3. *Sinha, S. N. and Roy, Fundamentals of Reinforced Concrete, S Chand Publishers(2014).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	24
2.	EST	36
3.	Sessionals, Lab Project, Assignments/Tutorials, /Quiz	40

UCE501: SOIL MECHANICS

	L	T	P	Cr
	3	1	2	4.5

Course Objectives: This subject aims to develop an understanding of soil as civil engineering material and to introduce the students about the basic concepts and principles of soil mechanics. Further they will be introduced to the concepts of compaction, consolidation and determination of shear strength of soil.

Introduction*:* Soil formation, various soil types.

Phase relationships: Index properties, sieve & hydrometer analysis, Atterberg's limits, sensitivity, thixotropy, and plasticity charts. Determination of engineering properties of soil.Indian standard and Unified classification systems of soils.

Clay Mineralogy: Introduction to Clay minerals their characteristics. Soil structure, granular soil fabric.

Seepage and Permeability: Darcy's law, validity of Darcy's Law, seepage velocity, factors affecting permeability, Laboratory and field determination of permeability. Flow net and its properties, Laplace equation, methods of drawing flow net, seepage through earth dams, exit gradient and seepage pressures, phenomenon of piping and heaving, filters. Anisotropy, Permeability of layered soils.

Effective Stress Principle: Capillarity, types of head, seepage forces, quick sand condition, and critical hydraulic gradient.

Compaction: Compaction tests, OMC, factors affecting compaction, control of compaction, field compaction equipment and their suitability. Stresses in Soils:Stresses beneath various loaded areas, Boussinesq and Westergarrd's formulae, pressure bulbs, Newmark's chart. Approximate methods

Compressibility and Consolidation: Terzaghi's theory, time rate of consolidation, consolidation test, Compressibility & Coefficient of Consolidation, NC, OC soils, determination of pre-consolidation pressure, settlement analysis, secondary consolidation.

Shear Strength: Definition, Mohr's stress circle, Mohr-Coulomb strength theory, direct, triaxial, unconfined and vane shear tests. Drainage conditions, Concept of pore pressure coefficients, shear characteristics of normally consolidated, over consolidated clays and dense and loose sands, Dilatancy, residual strength, Introduction to stress path.

Laboratory Work:
The students will be introduced to Index and Engineering properties of soils to complement the theory component of the course by performing experiments. They will perform related experiments as per BIS specifications.

1. Determination of field density by Core cutter & Sand replacement method
2. Grain size Analysis by Mechanical & Hydrometer Method.
3. Determination of Specific Gravity by Pycnometer.
4. Determination of Liquid Limit, Plastic limit & Shrinkage limit.
5. Determination of Permeability by constant head & variable head permeameter.
6. Consolidation Test
7. Unconfined Compression Test.
8. Direct Shear Test.

Experimental Project/assignment/Micro Project: Students in groups of 4 to 6 will do the projects

1. Bringing soil samples from the field classify them by performing lab tests and then determining the optimum moisture content and maximum dry density.
2. Based on OMC and MDD they will prepare samples for determination of CBR.

Course learning Outcome (CLO):
Upon completion of this course, the students will be able to:
1. Determine the index and engineering properties of soil
2. Evaluate the influence of water on engineering properties of soil
3. Evaluate the compressibility characteristics of soils in engineering practices
4. Determine the shear strength of soils by various methods

Text Books:
1. *GopalRanjan& A.S.R. Rao, Basic and Applied Soil mechanics, New Age Publisher, New Delhi (2016)*
2. *V.N.S. Murthy, A text book on Soil Mechanics and Foundation Engineering, U.B.S. Publisher, New Delhi.(2005)*
3. *Parshotham Raj, Geotechnical Engg., Pearson , New Delhi.(2013)*

Reference Books:
1. *Das B.M., Principles of Soil Mechanics, Thomson Publisher, USA.*
(2015)
2. *Venkatramaiah Geotechnical Engg., New Age Publisher, New Delhi.*
(2012)
3. *Singh Alam Modern Geotechnical Engineering, CBS Publishers, New Delhi.(2014)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizzes/Lab Evaluations)	40

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UCE401: HYDROLOGY AND GROUNDWATER

	L	T	P	Cr
	3	1	0	3.5

Course objective: The overall objective of this course is to acquaint students to the engineering aspects of water science. The students will learn different pathways of water movement, estimation and analysis of various components of pathways and its applications in designing various water related projects.

Introduction: Hydrologic cycle, Scope and Applications.

Precipitation*: Measurement by rain gauge and other methods, estimation of missing data, consistency of records, optimum number of rain gauge station, mean precipitation, presentation and analysis of rainfall data.

Abstractions from Precipitation: Factors affecting Evaporation measurement, infiltration, factors affecting Infiltration, measurement and presentation, Infiltration indices.

Run off: Run-off estimation, rainfall-runoff correlation, flow duration curve, flow mass curve, hydrographs, base flow separation, unit hydrographs and its application, distribution graph, synthetic unit hydrograph, Instantaneous unit hydrograph

Stream flow measurement: Velocity measurement: floats, velocity rods, current meters, discharge computation: velocity area method, moving boat method, dilution method, slope area method, stage discharge curve.

Floods Frequency analysis: Peak flood estimation, methods of frequency analysis, flood routing

Ground Water Hydraulics: Type of aquifers, aquifer constants, Darcy's law, Steady flow towards fully penetrating well, Equation of motion and its applications to ground water flow problems, introduction to the use of distributed groundwater models.

Course learning outcome (CLO):
Upon completion of this course, the students will be able to:
1. Recognize various components of hydrologic cycle and evaluate water availability based on water budget equation
2. Perform analysis on precipitation, evaporation and infiltration data for various applications.
3. Estimate runoff generated from watershed based on empirical and hydrograph analysis.
4. Estimate discharge of rivers using various methods
5. Aply principles of flood frequency analysis and flood routing to forecast floods
6. Apply hydraulic principles of groundwater flow in different geological formations.

Text Books:

1. *Subramanya, K., Engineering Hydrology, Tata McGraw-Hill Publication(2015)*
2. *Reddy, Jaya Rami., A textbook of Hydrology, University Science Press, New Delhi (2014)*
3. *Raghunath, H. M., Hydrology: Principles, analysis and Design, New Age International Publishers(2015)*

Reference Books:

1. *Chow, V.T., Maidment, D.R., and Mays, L.W., Applied Hydrology, Mc-Graw-Hill International Editions, New York (2006)*
2. *Misstear, B., Banks, D., and Clark, L., Water Wells and Boreholes, John Wiley& Sons Ltd, UK(2013)*
3. *Shaw, E.M., Beven, K.J., Chappell, N.A., and Lamb, R. , Hydrology in Practice, Spon Press, New York(2014)*
4. *Viessman, W. and Lewis, G.L., Introduction to Hydrology, Prentice Hall of India Pvt Limited, New Delhi (2012)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE507: ADVANCED STRUCTURAL ANALYSIS

	L	T	P	Cr
	3	1	0	3.5

Course Objective: This course aims to develop an understanding of the two basic types of Approaches of Systems and Element Approach for analyzing indeterminate structures.This is followed by an understanding of the analysis of cables in various structures and finally introduction to Finite Element Method applied to 1-D bar element.

Analysis of typical structures: Two hinged and three hinged arches, influence lines for thrust, radial shear and bending moment, Analysis of cables.

Introduction to system approach: Force and Displacement methods

Matrix Force Method: Introduction to flexibility approach, Choice of redundant, static equilibrium matrix, deformation compatibility matrix, member flexibility matrix, static equilibrium and deformation compatibility checks. Application for trusses, continuous beams and rigid frames

Matrix Displacement or Stiffness Method: Introduction to displacement approach, calculation of kinematic indeterminacy, development of stiffness matrices for continuous beams and rigid jointed frames, Development of matrix displacement approach and application to continuous beams and rigid frames

Transformation Matrices: Element Approach: Introduction to Element Approach, Development of force transformation matrices and system flexibility matrix using element approach, Development of transformation matrices and system stiffness matrix using element approach, Analysis of structures using element approach.

Experimental Project/assignment/Micro Project: Students in groups of 4 to 6 will develop work sheet for analyzing plane frame structure using either Stiffness/Flexibility Method and verify the same using standard analysis and design software (STAAD)

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Analyze two hinged and three hinged arches and cables
2. Develop stiffness matrices of different types of structures using System Approach and subsequently analyze the structures.
3. Develop system stiffness matrix using transformation matrices and subsequently analyze the structures using Element Approach.
4. Develop system flexibility matrices for different types of structures using System Approach and subsequently analyze the structures.
5. Develop system flexibility matrix using force transformation matrices and subsequently analyze the different structures using Element Approach.

Text Books:

1. Gere J. M. and Weaver W.; Matrix Analysis of Framed Structures, CBS Publishers & Distributors(2012)

2. Pandit G. S. and Gupta S. P.; Structural Analysis – A Matrix Approach; Tata McGraw Hill Education Pvt. Ltd.(2001)

Reference Books:

1. *Martin H. C.; Matrix Structural Analysis, McGraw Hill Book Company, New York.(1966)*

2. *PrakashRao D. S.; Structural Analysis – A Unified Approach, Tata McGraw Hill Publishing (2008)*

3. *Reddy C. S.; Basic Structural Analysis, Tata McGraw Hill Publishers.(2001)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weights (%)
1.	Mid Semester Test	30
2.	End Semester Test	45
3.	Sessionals (Includes Assignments/Projects//Quiz Evaluations)	(5 + 10+ 10) = 25

UCE609: DESIGN OF STEEL STRUCTURES-I

	L	T	P	Cr
	3	1	0	3.5

Course Objectives: This subject aims to develop an understanding of the design of steel sections when subjected to various kinds of external loads. The basic structural members like tension member, compression member and beams along with their connection will be designed.

Introduction: Loads, structural steels and their specifications, structural elements, steel vs. concrete and timber, design specifications as per IS: 800, structural layout, strength and stiffness considerations, efficiency of cross-section, safety and serviceability considerations.IS2062-2011

Riveted/Bolted Connection: Riveting and bolting, their types, failure of riveted joint, efficiency of a joint, design of riveted joint, concentric riveted joints, advantages and disadvantages of bolted connections, stresses in bolts.

Welded Connection: Types of welded joints, design of welded joint subjected to axial loads, welded joints subjected to eccentric loads, simple, semi-rigid and rigid connections.

Tension Members: Types of tension members, net area, net effective area for angles, tees, design of tension members, tension splice, and lug angles.

Compression Members: Axially loaded columns, effective length, slenderness ratio, allowable stresses, general specifications, design of axially loaded members, laced and battened columns and their design, built up compression members, eccentrically loaded columns and their design, column splice and its design, encased columns.

Column Bases: Introduction, slab base, gusseted base, column base subjected to moment, grillage foundation.

Flexural Members (Beams): Design criteria, permissible stresses, laterally supported beams and their design laterally unsupported beams and their design, web buckling, web crippling, built up beams, encased beams, members subjected to bending and compression.

Plastic Design: Introduction, advantages and disadvantages, strength of tension and compression members, theory of plastic bending, plastic hinge mechanism, collapse load analysis, static and mechanism method, distributed loading, design consideration.

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Design tension members
2. Design the bolted and welded connections between various structural components
3. Design compression members and column bases with and without eccentric loading
4. Find out ultimate load of the structural systems using plastic analysis
5. Design flexural members

Text Books:

1. *Subramanya, N, Design of Steel Structures, N. Subramanian, Oxford University Press(2008).*
2. *Duggal, S.K. Limit State Design of Steel structures, McGraw Hill (2009.)*

Reference Books:

1. *Ajmani, A. L. and Arya, A. S., Design of Steel Structures, Nem Chand and Brothers (2000).*

2. *Dunham, C.W., Planning of Industrial Structures, John Wiley and Sons (2001).*
3. *Gary, W., Steel Designer's Manual, Prentice Hall (2008).*
4. *Glover, F., Structural Pre-cast Concrete, Oxford Publishers (1963..)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE509: TRANSPORTATION ENGINEERING – I

	L	T	P	Cr
	3	0	2	4.0

Course Objective: The objective of the course is to enable students study different types of pavements, to analyze road pavement structures, to differentiate between the different types of materials used and to design and construct road pavements. Another objective is to expose the students to geometric design, both vertical and horizontal and to enable the civil engineering students to study the road user characteristics and formulate fundamental principles of traffic flow, traffic characteristic measurements.

General: Different modes of transport, Development of Transport System, Phased development of Roads in India.

Planning of Highways: Planning & Management of Highways, Various road plans developed in India, Road patterns, Highway Surveys & Alignment, Design, Drawings, Estimates & Project Report.

Geometric Design of Highways: Introduction, Highways Classification, Right of way, Land width, width of formation, Thickness of pavement, Sight Distances, Stopping site distance, overtaking sight distance, overtaking zones, camber, Road Curves, Transition Curves, Super elevation. Widening at curves, IRC-recommendations for various geometric design parameters.

Construction of Roads: Various types of bituminous constructions and their selection, Construction of earth, gravel, water bound macadam, surface dressing, premixed carpet, bituminous macadam, bituminous concrete, mastic asphalt, cement concrete pavements.

Types of bituminous binders and properties: Manufacturing of bitumen, Paving bitumen specifications as per IS 73: 2013, comparison between bitumen, tar, cut back & emulsion, Modified binders and its rheology.

Pavements: Factors affecting design of pavements. Structure of Flexible pavement and its design procedure as per IRC 37:2001, 2012 and IRC72: 2007, Construction of Cement Concrete Roads & its layer specifications, Design of PQC pavements as per IRC 58 & SP 062.

Failures of flexible and rigid pavements: Causes of Failures and Remedial Measures, Maintenance of flexible and rigid pavements, pavement evaluation and its strengthening.

Traffic Studies: Definition of Traffic Engineering, Various faces of Traffic Engineering, Road user characteristics, Importance of traffic studies, spot speed, speed and delay and origin and destination studies. Traffic accident studies, Causes of accidents and Remedial Measures, Parking studies.

Drainage: Introduction, Importance & Principles of Highway Drainage, Surface Drainage, Sub Surface drainage.

Highway Maintenance: Introduction, Maintenance of Earth, gravel, WBM Roads, Bituminous Roads, Cement Concrete pavements.

Highway Economics: Economics of Pavement types, Economic Evaluation of Highway Schemes, Life Cycle Costing.

Laboratory Work*: The students will perform various quality control tests as per Indian Road Congress (IRC) & Ministry of Road Transport & Highways (MORTH) specifications for the various layers of the pavement section. Paving bitumen & bituminous mix testing like penetration value, softening point, viscosity & binder rheology, ductility value, centrifugal extraction, aggregate strength tests, pavement layer gradation & stability - flow analysis, Deflection studies for the granular layers of the flexible & rigid pavements.

Experimental Project/assignment/Micro Project: Students in groups of 4 to 6 will do the projects:
1. Calculate the un-soaked and soaked CBR value of different soil samples.
2. Design the flexible pavement as per IRC 37:2012 for the given traffic data.
3. Design the rigid pavements as per the IRC guidelines.

Course learning Outcome (CLO):

Upon completion of this course, the students will be able to:
1. Quantify the specifications of various road construction materials required
2. Perform geometric design of highways and expressways
3. Perform analysis and design of flexible and rigid pavements
4. Address highway maintenance, drainage and economic issues
5. Perform the traffic studies necessary before making changes to or designing new road Infrastructure

Text Books:
1. *Khanna S.K. and C.E.G. Justo,HighwayEngineerin, Nemchand Bros(2012).*
2. *Kadyali L. R.; Highway Engineering, Nem Chand & Brothers, Roorkee (2004).*

Reference Books:
1. *Sharma & Sharma; Principle and Practice of Highway Engineering, Asia Publishing House, New Delhi (2010).*
2. *Rao G. V.; Transportation Engineering, Tata McGraw Hill Publisher, New Delhi (1999).*
3. *Yoder E. J.; Principles of Pavement Design, John Wiley & Sons (1975).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

UCE506: CONSTRUCTION MANAGEMENT

	L	T	P	Cr
	3	1	0	3.5

Course Objective: This subject aims to develop an understanding of principles and techniques of estimating construction costs, with emphasis on quantity take-off and pricing elements of work. It also covers the basic principles, techniques, and practices used as management tools by contractors to plan, schedule, and control time and costs on building various infrastructure projects.

Quantity Surveying and Cost Estimation: Definitions, objectives, role and functions of quantity surveyor, Pre-tender survey, Quantity measurements, Bill of quantities, analysis of rates for different items of work. Specifications. General and detailed specifications for different items of work. Estimates and budgets types and their preparation. Estimate of Buildings, Roads, Building Bye Laws, Taking-off quantities, Methods of measurement, e-tendering, Bill of quantities.

Contracts: Definition, need, importance, types of contracts and their characteristics, procedure for tendering and contracts, evaluation and examination of tenders, award of work, Joint Ventures, Concession Agreements. Valuation, its types.Determination of value of a property, Calculation of standard rent. Definitions, functions, characteristics of project, planning and principles of Planning and Management.

Network Techniques: Bar milestone charts Planning and scheduling of PERT / CPM, Time cost optimization, Probability concepts Allocation of resources and resource levelling, Updating, controlling and monitoring, Work Breakdown Schedule (WBS).

Material& Equipment Management: Importance, scope, objectives and functions, identification of source and vendor analysis, purchase, procurement procedure, inventory control, EOQ analysis. Importance, need, functions and principles of equipment management, types of equipment and their uses, selection planning and matching of construction plant and equipment.

Account Procedure of PWD Works: Classification of Works, Muster Roll, and Deposit works. Cash Book, Imprest, temporary Advance, Stores, Indent, Tools and Plants

Experimental Project/assignment/Micro Project:
1. Complete cost estimation of the building and highway projects including taking off and assemble bill of quantities.
2. Development of a contract document for the infrastructure project.
3. Planning & Scheduling of an infrastructure projects.

Course learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Perform the rate analysis for the various construction activities
2. Estimate the cost for the building and the road projects
3. Perform the project planning, scheduling, time-cost optimization, resource allocation and project controlling
4. Prepare the contract documents for a given project
5. Apply various material & equipment management techniques in a project
6. Assemble bill of quantities

Text Books:

1. *Kohli D. D.; A Text book on Estimating and Costing and Accounts, S. Chand & Company New Delhi(1994).*
2. *R.L. Peurifoy, W.B. Ledbetter and C.J. Schexnayder, "Construction planning and methods", Fifth editions, McGraw Hill International edition(1996).*

Reference Books:

1. *Seetharaman S., Construction Engineering and Management, Umesh Publication Delhi(2001).*
2. *Punima B. C. and Khandelwal; Project Planning and Control with PERT and CPM,Laxmi Publication New Delhi(2002).*
3. *K.K. Chitkara, Construction project management: planning, scheduling and controlling, Tata McGraw-Hill (1998).*
4. *B. Sengupta and H Guha, "Construction management and planning", Tata McGraw Hill(1995).*
5. *L.S. Srinath, PERT and CPM principles and Application, Third edition, Affiliated east-west press Pvt Ltd(2001)*
6. *J. Singh, Heavy Construction-Planning, equipment and method, Oxford & IBH Publishing Co. Pvt(1993)*
7. *Datta B. N. Estimating and Costing in Civil Engineering, U.B.S. Publisher(2010)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessional (include Assignments/Projects/Tutorials/Quizzes)	30

UCE692: GROUP DESIGN PROJECT (START)

L	T	P	Cr
0	0	2	-

Course Objectives: The main objective of the project is to gain hands-on experience in tackling the planning, analysis and design issues in open-ended structural design projects while performing the analysis and design of representative structural system and components. This project work covers various aspects including planning, architectural design, geotechnical constraints, structural analysis and design and construction planning & scheduling.

During the project, various experts from industry/academics/public body are invited to deliver talks on relevant issues like:-
- Planning & preparation of architectural drawings of the building.
- Design of building frames: Load pattern, design of continuous beams/slabs and detailing of various structural components as per the relevant Indian codal guidelines.
- Preparation of detailed structural drawings.
- Design of various allied services for the building project.
- Preparation of general & special conditions of the contract for the project including specifications of the building based upon utility & functional aspects.
- Preparation of the detailed cost estimation for the project.

The final project report should include the following
- Description of the General Design Problem, Constraints, Functions, Design Life, and Other Relevant Considerations.
- Design Assumptions, Analysis Methodologies Employed, and a Flowchart of the Design Process
- Specific Design Considerations and Architectural Considerations
- Design Details Including:
    - Load Types, Loads, and Load Cases
    - Analysis and Design Computations
    - Deformed Shapes
    - Member Dimensions and Reinforcement Details.
- Written and Illustrated Descriptions of the Architectural, Structural Designs including the services and bill of quantities.
- Conclusion

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Function as a member of the design team.
2. Develop the general arrangement drawings.
3. Produce detailed structural design & drawings and viable construction sequence.
4. Produce a bill of quantities and calculate approximate construction cost.

Reference Books:
1. *Varghese, P. C., Limit State Design of Reinforced Concrete, PHI Publishers(2000)*
2. *Jain, A.K., Reinforced Concrete-Limit State Design, Nem Chand & Bros (2014)*

3. *Pillai & Menon, Reinforced Concrete Design, Tata McGraw Hill Publishers(2014)*

Evaluation Scheme:

Activity	Submission time line	Weightage
Problem Formulation & Design Flow Chart	End of week 4th of fifth semester	5%
Midway report-1	End of fifth semester (Before the start of EST of 5th Semester)	20%
Midway report-2	Before the start of MST of 6th Semester	30%
Final Assessment & Final Report & Presentation	End of Sixth semester	45% (Report = 20%) (Presentation & Viva Voce = 25%)

UCE491: SURVEY PROJECT

	L	T	P	Cr
	-	-	-	4.0

Course Objective: To expose student to the various surveying tools and techniques in the field. The students, after completing their second year, are supposed to go on a survey camp, which shall be held over a period of three to four weeks, either at the university or at some site outside. As a part of this they have to prepare a topographical sheet of the area highlighting the main features including contouring etc.

Course Learning Outcome (CLO):
Upon completion of this course, the students will be able to:
 1. Perform basic surveying on a considerably difficult hilly terrain
 2.Set up traverse stations, base-line measurements, fly leveling, detailing, and contouring

UCE606: WATER AND WASTE WATER ENGINEERING

	L	T	P	Cr
	3	1	2	4.5

Course Objective: To introduce the water supply and sanitation systems, designing the components associated with the water supply and sanitation systems, and suitable treatment processes for both water supply and wastewater.

Water and water supply system: Water quality, source of surface water pollution, water quality standards; Water demand, components of water supply system; water intake works; Water transmission systems

Water treatment: Water treatment plants and components; Technologies for the removal of suspended, colloidal and dissolved solids and for disinfection; Design of coagulation-flocculation-settling, slow sand and rapid gravity filtration, membrane filtration, ion exchange, adsorption and chlorination units.

Wastewater system: Quantification of sewage; Characterization of sewage; Types of sewerage systems; Design of sewers and storm sewers, sewer outfalls and sewer appurtenances

Wastewater treatment: Components; Design of screens, degritters, clarifiers and roughing filters; Activated Sludge, UASB and modified UASB reactors, and Waste stabilization pond systems, vegetated ponds and constructed wetland systems; Sewage treatment plant sludge handling facilities.

Laboratory work:
pH, acidity, alkalinity and hardness testing; DO, BOD and COD; Solids (TSS, VSS and TDS); Nutrients (TKN, TN and TP); SVI and Settling tests; Chlorination, residual chlorine and MPN test; Oil and grease and pesticides; Iron, fluorides, sulfates, chlorides, sulfides and phenols

Experimental Project/assignment/Micro Project: Students in groups of 4 to 6 will do the projects on:
1. Design of Sewerage systems
2. Design of Water treatment plants/Sewage treatment plants

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Characterize water and wastewater
2. Design a water supply system/sewerage system
3. Conceive and design a water treatment plant
4. Conceive and design a sewage treatment plant

Text Books:

1. *Garg, S.K ,Environmental Engineering, Vol. I,.Khanna Publishers, New-Delhi.(1990)*
2. *Manual on Water Supply and Treatment by Ministry of Urban Development, New Delhi (1999.)*
3. *Manual on sewerage and sewage treatment, Ministry of Urban Development, New Delhi (1995)*
4. *P.N. Modi; Sewage Treatment and disposal & Waste Water Engineering, Standard Book*

House New-Delhi (1995)

References Books:

1. *Met Calf & Eddy Wastewater Engineering, McGraw Hill (2003).*
2. *Peavy, Rowe and Tchobanglous, Environmental Engineering, McGraw Hill (1993).*
3. *Fair, Geyer &Okun, Water and Waste Water Engineering (Vol. 1&2), John Wiley, New York(1967).*
4. *Sawyer, McCarty &Parkins, Environmental Chemistry, McGraw Hill (2003).*
5. *Standard Methods for the Examination of Water and Waste Water, American Public Health Association (2014).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizs/Lab Evaluation)	40

UCE607: FOUNDATION ENGINEERING

	L	T	P	Cr
	3	1	2	4.5

Course Objective: This subject aims to expose the students to geotechnical design of different types of shallow and deep foundations. Further they will be expose to understanding of earth pressure for stability of retaining structures along with various techniques for stability of slopes.

Soil Exploration: Introduction to soil exploration, scope, soil exploration for different structures, spacing, significant depth, boring and sampling techniques, bore hole plan, types of samples, penetration test (SCP and SPT), sample disturbances and Geophysical methods.

Earth Pressure: At rest condition, states of plastic equilibrium, Rankine and Coulomb's theories for active and passive conditions, Influence of surcharge, water table, wall friction, open cuts.

Stability of Slopes: Infinite slope, types of failure, total and effective stress analysis, Taylor's stability numbers, concept of factors of safety, method of slices, modified method of slices, Swedish's circle method, friction circle method, effect of sudden draw down and submergence.

Bearing Capacity: Definitions, introduction to shallow and deep foundation, depth of foundation, Concept of net and gross bearing capacity.Terzaghi's general bearing capacity equation, IS code equation, factors affecting bearing capacity. Settlements for clays and sands, permissible settlements, bearing capacity by penetration tests, Influence of eccentric and inclined loads, proportioning of footings, plate load test.

Pile Foundations: Types, function, selection of piles, pile driving formulae, equipment, point, bearing and friction piles. Load carrying capacity of single pile, group action, spacing of piles, Negative skin friction, settlement of pile groups, under-reamed piles.

Caissons and Wells: Introduction, components, shapes, stability of well foundation, Terzaghi's method of analysis, sinking of well, tilts and shifts.

Machine Foundation: Definition, types, problem of machine foundation, soil spring constants.

Laboratory Work:
The students will be introduced to various laboratory & field experiments as per BIS specifications.

1. Determination of Relative density of coarse grained soils in dry and saturated conditions.
2. Determination of shear strength at different densities by Direct shear test.
3. Determination of MDD and OMC at different compactive effort by compaction test.
4. Determination of Unconfined compressive strength at different compactive efforts.
5. Determination of compressibility characteristics of fine grained soils by Consolidation test.
6. Determination of bearing capacity by Standard Penetration test.

7. Determination of shear strength of sands by Tri-axial shear test.
8. Determination of bearing capacity by Plate load test.
9. Determination of bearing capacity by static and dynamic cone Penetration test.
10. Determination of bearing capacity by lab and field vane shear test.

Experimental Project/assignment/Micro Project: Students in groups of 4 to 6 will do the projects by conducting test like SPT , PLT and lab tests, the students will determine the safe bearing capacity for various structures like Multistoried buildings, OHSR etc.

Course learning Outcome:
Upon completion of this course, the students will be able to:
1. Design and analyze problems related to shallow and machine foundations
2. Analyze lateral earth pressure for design of earth retaining structures
3. Assess stability of natural/man-made slopes under varying in-situ material properties
4. Design and analyze problems related to pile and well foundations

Text Books:
1. *Gopal Ranjan& A.S.R. Rao, Basic and Applied Soil mechanics, New Age Publisher, New Delhi (2008).*
2. *Murthy V.N.S., Advanced Foundation Engineering, C.B.S. Publisher, New Delhi (2009).*
3. *Parshotham Raj, Geotechnical Engg., Pearson , New Delhi (2009).*

References Books:
1. *Bowles J.E., Foundation Analysis and Design, McGraw Hill Book Company, New York (2009).*
2. *Arora K.R., Soil Mechanics & Foundation Engineering, by, Standard Publishers, New Delhi (2010).*
3. *Saran Swami, Soil Dynamics and Machine Foundations, Galgotia Publishers, New Delhi (2008).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

UCE603: HYDRAULIC ENGINEERING

	L	T	P	Cr
	3	1	2	4.5

Course Objectives: This course aims to develop an understanding of the model studies of hydraulic structures and design of open channel sections under different situations. Further, this course aims to expose the students to various aspects of applications of laminar flow, turbulent flow, boundary layer formation and drag and lift to real flow situations.

Dimensional Analysis: Methods and model studies.

Flow in open channels: Continuity equation, analysis of uniform flow, most economical channel sections, specific energy, specific force, applications to channel transitions, analysis of non-uniform flow, water surface profiles, hydraulic jump, surges, pressure transients.

Discharge Measurement: Notches, weirs, venturiflume, standing wave flume, freeoverfall.

Flow in pipes: Navier-Stokes equations for laminar flow, laminar flow through pipe and parallel plates, laminar flow past a sphere, shear stress in turbulent flow, velocity distribution equations for turbulent flow in pipes, Resistance of smooth, rough and commercial pipes, Reynolds equations of turbulence, pipe network analysis, water distribution system.

Boundary layer and flow around submerged bodies: Boundary layer characteristics, Von-Karman momentum integral equation and its applications to velocity profiles, drag and lift on submerged bodies, development of lift on a cylinder and airfoil.

Pumps and Turbine: Introduction to various types of pumps and turbines

Laboratory Work: Students will perform following basic experiments in hydraulic Engineering

1. To determine the viscosity of liquid and to verify stokes Law
2. To determine Manning's coefficient of roughness for the bed of a given flume.
3. To measure the velocity distribution in a rectangular flume and to determine the energy and momentum correction factors.
4. To study the flow characteristics through a rectangular open channel transition.
5. To study the formation of hydraulic jump in a horizontal rectangular open channel.
6. To measure velocity distribution over a flat surface in a wind stream and to determine the displacement and momentum thickness.
7. To measure the pressure distribution around a cylinder/airfoil placed in a wind stream and to calculate the coefficient of drag.
8. To study the pressure distribution along the spillway surface.

Experimental Project/Assignment/Micro Project: Students in groups of 4 to 6 will do projects on weirs, velocity distribution using Pitot tube and micro current meter in channels of different shapes, free overfall, drag and lift on various body shapes, design water distribution system using EPANET software.

Course learning Outcomes (CLO):

Upon completion of this course, the students will be able to:
1. Analyze the significant variables in hydraulic problems and to predict the performance of hydraulic prototypes
2. Design the most economical channel sections and to use the specific energy and specific force concepts in channel transitions
3. Analyze the water surface profiles under different flow situations

4. Develop head discharge relationship for discharge measuring hydraulic structures
5. Employ the concepts of laminar, turbulent flow and boundary layer formation in real flow situations
6. Design water distribution networks

Text Books:
1. *Modi and Seth, Fluid Mechanics and Fluid Machines, Standard Book House, New Delhi.(2010)*
2. *Subramanya K., Flow in open Channels, Tata McGraw Hill, New Delhi.(2008)*
3. *French R. H, Open Channel Hydraulics, McGraw Hill Publishing Company, New York.(2007)*

Reference Books:

1. *Som and Biswas, Introduction to Fluid Mechanics and Machines, Tata McGraw Hill, New Delhi.(2012)*
2. *Rangaraju K. G., Flow through Open Channels, Tata McGraw Hill, New Delhi.(2008)*
3. *Schlichting H., Boundary Layer Theory, Tata McGraw Hill, New Delhi.(2008)*
4. *Henderson F. M: Open Channel Flow, McMillan, New York.(2007)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes'/Lab Evaluations)	40

UCE608: DESIGN OF CONCRETE STRUCTURES II

	L	T/D	P	Cr
	2	1	0	2.5

Course Objective: The subject aims to develop an understanding of design and detailing of domes, beams curved in plan, various types of combined footings. Subject also covers the design concepts of water retaining and earth retaining structures.

Domes: Analysis and design of spherical and conical domes

Beams curved in plan: Reinforced Concrete Design Circular beam loaded uniformly and supported on symmetrically placed columns.

Water Tanks: Introduction, general design requirements on no crack basis, Design of circular and rectangular tanks resting on ground, Design philosophy for design of overhead tanks, intze type tanks and their staging and foundation

Combined Footings: Different types, design of rectangular, trapezoidal, strap and raft footings, Pile Foundations.

Retaining Walls: Types, behavior, stability requirements, design of cantilever type retaining walls. Introduction to design of counterfort retaining wall.

Experimental Project/assignment/Micro Project:
Students will be required to design and prepare structural drawing for Intze type watertank.

Course learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Analyze and design R.C.C. domes and beams curved in plan.
2. Design RCC water tanks
3. Design various types of combined footings
4. Design cantilever type retaining walls

Text Books:

Jain, A.K., Reinforced Concrete-Limit State Design, Nem Chand & Bros (1999).

Reference Books:

Varghese, P. C., Limit State Design of Reinforced Concrete, PHI Publishers (2002).

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

	L	T	P	Cr
	3	1	0	3.5

Course Objective: This subject aims to develop an understanding of the basics and design of various components of railway engineering as per the Indian railway guidelines. Further to this, subject also aims at introducing the detail concepts of the airport engineering and to give the students the confidence of delivering a complete geometric and structural design of runway, taxiway and apron pavements.

Railway Engineering: Permanent way, gauges in railway tracks, typical railway track cross-section, coning of wheels, Function of rails, requirement of rails, types of rail sections – comparison of rail types, length of rail, rail wear, rail failures, creep of rails, rail fixtures and fastenings – Fish plates, spikes, bolts, chairs, keys, bearing plates.

Sleepers: Functions and requirements of sleepers, classification of sleepers, timber, metal and concrete sleeper, comparison of different types of sleepers, spacing of sleepers and sleeper density.

Ballast: Function and requirements of ballast, types, comparison of ballast materials.
Geometric design: alignment, horizontal curves, super elevation, equilibrium, cant and cant deficiency, length of transition curve, gradients and grade compensation. Stations and yards, and their classification

Points and crossings: introduction, necessity of points and crossings, turnouts, points and crossings, design of a simple turnout.

Track Recording: Equipment, Mechanized Maintenance, High Speed Trans, Present & Future.
Signaling and interlocking: objects of signaling, engineering principle of signaling, classification of signaling, control of train movements, interlocking definition, necessity and function of interlocking, methods of interlocking, mechanical devices for inter locking. Traction and tractive resistance, stresses in track, modernization of railway track.

Airport Engineering: Airport site selection, various surveys for site selection. Classifications of obstructions, Imaginary surfaces, Approach zone and turning zone.Runway orientation, basic runway length, corrections for elevation, temperature & gradient, airport classification.

Runway & Taxiway Design: Geometric design of runway, airport capacity, factors controlling taxiway layout, geometric design standards for taxiway holding aprons, Wind-rose diagram, Structural design of runway pavements LCN/PCN method of rigid pavement design, Pavement Evaluation for runway & taxiway, design of overlay, Terminal area, building area, parking area, apron, hanger typical airport layouts. Design of flexible and rigid runways as per FAA procedure, Specifications for the different layers of runway and taxiway pavements, Pavement management systems for runway pavements.

Experimental Project/assignment/Micro Project
1. To design the flexible & rigid runway & apron pavements.
2. To design the turnout as per the Indian Railway specifications.
3. To perform the data analysis for developing management systems for airport pavements.

Course learning Outcomes (CLO):
Upon completion of this course, the students will be able to:

1. Determine the runway orientation and the runway length as per FAA & ICAO guidelines
2. Design the airport pavements including air-side marking & lighting as per ICAO & FAA guidelines
3. Evaluate pavement and learn the concept of pavement maintenance management system.
4. Employ Railway Track specifications and perform geometric design of the railway track.
5. Design turnout and crossings as per the Indian Railways

Text Books
1. *Arora and Saxena, Railway Engineering, Dhanpat Rai & Sons, New Delhi (2006).*
2. *Khanna, Arora & Jain, Airport Planning and Design, Nem Chand & Brothers, Roorkee (1999).*

Reference Books
1. *Rangawala, Railway Engineering, Charotar Publishing House, Anan (1989).*
2. *Aggarwal M.M., and Satish Chandra Railway Engineering, Oxford University Press (2002).*
3. *Horenjeff Robert, Airport Engineering, McGraw Hill International Publisher (2010).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	40
3	Sessional (include Assignments/Projects/Tutorials/Quizzes)	30

	L	**T**	**P**	**Cr**
	1	**0**	**2**	**5**

Course Objectives: The main objective of the project is to gain hands-on experience in tackling the planning, analysis and design issues in open-ended structural design projects while performing the analysis and design of representative structural system and components. This project work covers various aspects including planning, architectural design, geotechnical constraints, structural analysis and design and construction planning & scheduling.

During the project, various experts from industry/academics/public body are invited to deliver talks on relevant issues like:-
- Planning & preparation of architectural drawings of the building.
- Design of building frames: Load pattern, design of continuous beams/slabs and detailing of various structural components as per the relevant Indian codal guidelines.
- Preparation of detailed structural drawings.
- Design of various allied services for the building project.
- Preparation of general & special conditions of the contract for the project including specifications of the building based upon utility & functional aspects.
- Preparation of the detailed cost estimation for the project.

    The final project report should include the following
- Description of the General Design Problem, Constraints, Functions, Design Life, and Other Relevant Considerations.
- Design Assumptions, Analysis Methodologies Employed, and a Flowchart of the Design Process
- Specific Design Considerations and Architectural Considerations
- Design Details Including:
    - Load Types, Loads, and Load Cases
    - Analysis and Design Computations
    - Deformed Shapes
    - Member Dimensions and Reinforcement Details.
- Written and Illustrated Descriptions of the Architectural, Structural Designs including the services and bill of quantities.
- Conclusion

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Function as a member of the design team.
2. Develop the general arrangement drawings.
3. Produce detailed structural design & drawings and viable construction sequence.
4. Produce a bill of quantities and calculate approximate construction cost.

Reference Books:
1. *Varghese, P. C., Limit State Design of Reinforced Concrete, PHI Publishers(2000)*
2. *Jain, A.K., Reinforced Concrete-Limit State Design, Nem Chand & Bros (2014)*

3.   *Pillai & Menon, Reinforced Concrete Design, Tata McGraw Hill Publishers(2014)*

Evaluation Scheme:

Activity	Submission time line	Weightage
Problem Formulation & Design Flow Chart	End of week 4th of fifth semester	5%
Midway report-1	End of fifth semester (Before the start of EST of 5th Semester)	20%
Midway report-2	Before the start of MST of 6th Semester	30%
Final Assessment & Final Report & Presentation	End of Sixth semester	45% (Report = 20%) (Presentation & Viva Voce = 25%)

UCE794: PROJECT SEMESTER

	L	T	P	Cr
	0	0	0	20

Course Objective: The objective of the six month industrial training is to expose the final year civil engineering students to the competency, knowledge and skills needed to succeed at the workplace. By undergoing industrial training, they will be able to relate the theory that they learnt and applied them practically. Industrial Training is essential for students to develop the practical skills that they will need to be effective professional engineers.

Course Introduction: The project semester is aimed at developing the undergraduate education programme in engineering to include a practical training in a professional engineering setting (a company, top educational institution, research institute etc.) hereafter referred to as host "organization" as deemed appropriate. The participating organizations are selected that are either already visiting Thapar University for placement or are forming new relationships of mutual benefit. The project semester gives the student the opportunity to translate engineering theory into practice in a professional engineering environment. A central requirement of the project semester is that it must be based around significant engineering work and is principally assessed on that basis. The technical activity should be related to both the student's engineering studies and to the host organization's activities, and it should constitute a significant body of engineering work at the appropriate level. It should involve tasks and methods that are more appropriately completed in a professional engineering environment and should, where possible, make use of human and technology resources provided by the organization. It consolidates the student's prior learning and provides a context for later research studies.

The student remains a full time registered student at Thapar University during the project semester and this activity is therefore wholly distinct from any industrial interactions which may occur over vacation periods.

Course learning Outcomes:

The project work undertaken as part of the project semester is diverse. As a result, the Learning Outcomes will vary, but on completion of the module, students will have achieved several learning outcomes from the following list:

1. Able to identify and use appropriate mathematical methods, numerical techniques and software tools for application to new and ill-defined engineering problems;
2. Be able to integrate knowledge, handle complexity and formulate judgements with incomplete or limited information;
3. Have the ability to redesign products, processes or systems in order to improve productivity, quality, safety and other desired needs;
4. Have the ability to apply design methods, processes and techniques to unfamiliar, ill-defined problems, involving other disciplines;
5. Be able to design according to codes of practice and industry standards; to identify limitations of codes of practice and the need for their application

6. Have the ability to investigate and define a need and identify constraints including health, safety and legal issues and the impact of engineering solutions in a societal and environmental context;

7. Be able to make engineering judgements that take cognisance of the social, environmental, ethical, economic, financial, institutional and commercial considerations affecting the exercise of their engineering discipline;

8. Have the ability to consult and work with experts in various fields in the realisation of a product or system;

9. Have knowledge and understanding of concepts from a range of areas outside engineering;

10. Be able, via knowledge and understanding of group dynamics, to exercise leadership;

11. Be able to select and apply appropriate communication tools and write technical papers and reports;

12. Be able to describe the relevant advantages and disadvantages of various technologies to an audience, and to communicate effectively in public.

Evaluation Scheme:

Each student is assigned a faculty supervisor who is responsible for managing and assessment of the project semester. This includes a Reflective Diary which is updated throughout the project semester, an Interim Project Report, a Final Report with Learning Agreement/Outcomes and a Final Presentation & Viva which involves the faculty Supervisor and some other members from the department. A hard copy and electronic copy of all reports are required. The mentor from the host organization will be asked to provide his assessment on the designated form. A suggested weighting for the assessments is as follows:

Activity	Submission time line	Marks awarded by	Weighting
Reflective Diary	End of Project Semester	Faculty Supervisor	10%
Goals Report	End of week 4 of project semester	Faculty Supervisor	5%
Midway report	End of week 10 of project semester	Faculty Supervisor	15%
Final Assessment	End of project semester	Host Mentor	20%
Final Report	End of project semester	Committee assessment	20%
Oral and poster presentation and viva	End of project semester		30%

UCE701: GROUND IMPROVEMENT

L	**T**	**P**	**Cr**
3	**1**	**0**	**3.5**

Course Objective: To expose the students to various ground improvement techniques that can be used to enhance the engineering properties of soil mass.

Introduction: Necessity and importance of ground improvement, classification of ground improvement methods and their suitability, Emerging trends in ground Improvement

Modification by admixtures: Premixing, Cement stabilization and cement columns, Lime stabilization and lime columns.Stabilization using bitumen and emulsions, Stabilization using industrial wastes, Proportioning of aggregates - Triangular chart method and Rothfuch's method.

Mechanical stabilization: Shallow and deep compaction methods, compaction piles, vibro-compaction and vibro-replacement, stone columns, dynamic compaction

Hydraulic and electrical modification: Ground Improvement by drainage, De-watering methods. Design of dewatering systems, Preloading, Vertical drains, vacuum consolidation, Electro-kinetic dewatering, design and construction methods.Electro-osmosis and Electrochemical stabilization.

Thermal modification: Ground freezing methods, Hydrogeology of frozen soils, Strength and behaviour of frozen soils. Ground heating methods and its effect on soil properties.

In-situ soil treatment: Grouts, properties, penetration, clay, cement clay, cement, clay-chemical, chemical and Bituminous grouts, grouting methods viz penetration, claquage, compaction & jet.

Reinforcement techniques: Introduction, load transfer mechanism, strength development, anchored earth, soil nailing, micropiles, soil dowels and anchors, reinforced earth.

Exclusion techniques: Sheet piles, contiguous bored piles, secant piles, slurry trenches, Diaphragm walls.

Course learning Outcomes:
Upon completion of this course, the students will be able to:
1. Apply the concept of soil reinforcement
2. Perform ground improvement based on grouting and exclusion techniques
3. Design earth retaining structures, diaphragm walls and stone columns

Text Books:
1. *Raj Parshotham; Geotechnical Engineering, Pearson Education(2009).*
2. *F.G. Bell; Engineering Treatment of Soils, E & FN Spon Publishers, UK (2004).*

Reference Books:
1. *Moseley M.P.; Ground Improvement, Blackie A&P (2000).*
2. *Saran Swami; Reinforced Soil and its Engineering Applications, I.K. International(2010).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

<div align="center">**UCE795: PROJECT**</div>

<div align="right">

L	T	P	Cr
1	**-**	**10**	**9.0**

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Course Objectives: To expose students to a design problem related to various disciplines of civil engineering.

The project work shall consist of various components related to design of structures, geotechnical investigations, water supply distribution system, irrigation engineering and highway design. The student is supposed to take up any three of these projects. They shall be evaluated on the basis of project report and viva-voce examination.

Course learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Apply principles of geotechnical investigations in designing super structures
2. Use design codes
3. Solve design problems related to structure, highway, water supply, and irrigation
4. Function as a member of the design team
5. Write effective reports and improve presentation skills

UCE796: PRACTICAL TRAINING

	L	T	P	Cr
	-	-	-	4.0

Course Objectives: To have extensive on-site exposure to various civil engineering aspects.
The students of the alternate scheme shall have to undergo a six weeks industrial training in the summer vacations. They can take up the training at a design office, construction or related sites etc. After completion of their training they have to submit a project report and also make a presentation in front of a panel of internal faculty members only.

Course learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Employ technical knowledge and state-of-the art practice related to the chosen topic.
2. Enumerate modern construction materials and techniques.
3. Improve presentation skills.

UCE805: DESIGN OF STEEL STRUCTURES – II

	L	T	P	Cr
	3	2	0	4.0

Course Objective: The objective of this course is to expose students to design of various industrial structures and steel bridges.

Plate Girders: Introduction, weight and economic depth, design of flanges, design of web, curtailment of flange plates, intermediate and bearing stiffeners, design of a riveted and welded plate girders, web and flange splice.

Tubular Structures: Permissible stresses, tube columns and compression members, tube tension members, tubular roof trusses, joints in tubular trusses, tubular beams and purlins

Industrial Buildings (Steel Structures)*:* Design of roof trusses and supporting system, Industrial building frames, bracing, crane girders and columns, design of crane girders, analysis of trussed bents.

Steel Bridges: Introduction to suspension bridges, cantilever bridges, cable-stayed bridges. Standard specifications for railway bridges, Railway bridge code. General arrangement of single-track broad-gauge railway bridge with open floor, design of stringers, cross girders, main trusses, top and bottom lateral bracing, complete design of through type truss bridge

Steel Towers: Introduction to steel towers and tower foundations and multistorey steel building frames.

Introduction to Pre-engineered steel buildings

Course learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Analyze and design plate girder bridges and truss bridges
2. Analyze and design different components of industrial buildings
3. Design tubular and aluminum structures
4. Analyze and design transmission line towers

Experimental Project/assignment/Micro Project
Students will have to submit reports on the design of various structural elements of a steel building.

Text Books:
1. *Subramanian, N., Design of Steel Structures, Oxford University Press (2008).*
2. *Ajmani, J. L. and Arya, A. S., Design of Steel Structures, Nem Chand and Brothers (2000).*

Reference Books:
1. *Dunham, C.W., Planning of Industrial Structures, John Wiley and Sons (2001).*
2. *Gary, W., Steel Designer's Manual, Prentice Hall (2008).*
3. *S. M. A. Kazimi and R. S. Jindal, "Design of Steel Structures", Prentice Hall of IndiaPvt Ltd (1988).*
4. *M. Edwin, J. Gaylord and J. E. Stallmeyer, "Design of Steel Structures", Mc Graw Hill(2006).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

UCE804: SEISMIC ANALYSIS AND DESIGN

	L	T	P	Cr
	3	1	2	4.5

Course Objective: To expose students to the basic concepts of dynamic analysis of single degree and multiple degree of freedom system. Using these dynamic properties, students will further analyze and design structures subjected to seismic loading as per IS codes.

Introduction: Nature of dynamic loads, earthquake, wind and blast loads, characteristics of dynamic problems, method of discretization etc.

Theory of Vibrations: Formulation of Equation of Motions: Free and forced vibrations of single degree of freedom systems, damping and its effects, transient vibration, response spectrum theory. Analysis of SDOF structures subjected harmonic and impulse loading.

Multi-degree of freedom systems: Review of formulation of flexibility and stiffness matrices of framed structures, Mode shapes and frequencies, Rayleigh method for determination of fundamental frequency , Stodola-vianello method for finding modes shapes and corresponding frequencies, orthogonality relationship of modes of vibration, normal mode theory for free vibration

Introduction to Structural Failures due to Earthquake, Case histories of failures.

Introduction to IS: 1893 - 2002: Seismic analysis and design of framed structures by equivalent lateral load procedure and dynamic analysis.

Introduction to IS: 13920 – 1993 : Introduction to Ductile Detailing of Structures, Concept of Soft Story, Design of Shear Walls using IS-13920-1993.

Masonry Buildings : Use of Codes with reference to Masonry Buildings like IS: 4326, IS: 13828, IS: 13827

Laboratory Work: Perform some basic test on vibration of helical spring, compound pendulum, bifilar suspension. Torsional vibrations of single mass and two mass system. Evaluation of damping properties of materials using free vibration test and to study the various responses (frequency and time response) through a Real time FFT analyzer.

Experimental Project/assignment/Micro Project
Evaluation of seismic loads for the given RCC framed building as per IS 1893-2002.

Course learning Outcome (CLO):
Upon completion of this course, the students will be able to:
1. Evaluate the dynamic properties of single and multi-degree of freedom systems.
2. Evaluate the dynamic properties for SDOF system subjected to harmonic, impulse and arbitrary loading.
3. Evaluate   seismic load for a building using equivalent static load procedure as per IS codes.
4. Evaluate seismic load for a building using dynamic analysis as per IS codes
5. Perform ductile detailing of buildings, and design of shear walls as per IS code.

Text Books:

1. *Mario Paz, Structural Dynamics (Theory and Computation), CBS Publishers and Distributors (2004).*
2. *Agarwal, Pankaj and Shrikhande, Manish, Earthquake Resistant Design of Structures, PHI (2006).*

Reference Books:

Chopra A.K., Dynamics of structures, Perason Education (2012).

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

UCE806: DESIGN OF HYDRAULIC STRUCTURES

L	**T**	**P**	**Cr**
3	**1**	**0**	**3.5**

Course Objective: The objective of this subject is to focus on estimation of crop water requirement, designing of various hydraulic structures like canal, weir/barrage, canal fall, canal head regulator, canal outlet and cross drainage works.

Crop Water Requirement: Soil-moisture-irrigation relationship, depth and frequency of irrigation, irrigation efficiencies, consumptive use and its determination, duty and delta relationship

Canal Irrigation: canal distribution system, design of stable channels by Lacey's and Kennedy's theory, design of lined channels

Design of Impervious floor: Creep theories, Khosla seepage theory, hydraulic jump

Diversion Headworks: component, design of a weir or barrage and canal head regulator, river protection measures

Canal Regulation Works: Canal falls, design of a vertical drop fall and a glacis fall, roughening measures for energy dissipation, cross regulators and distributary's head regulators, canal escape.

Cross Drainage Works: Need, types, selection of suitable CD work, design of CD works

Outlets: types, design principle of open flume outlet and A. P. M. outlet

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Work out water requirement of crops.
2. Design lined and unlined channels for distribution water
3. Learn the function, components and design of headworks
4. Learn the function, components and design of canal regulation works and related hydraulic structures.
5. Learn different types of cross drainage works and their design aspects

Text Book:

1. *S.K. Garg, Irrigation Engineering and Hydraulic Structures, Khanna Publishers, New Delhi(2014)*

2. *P.N.Modi, Irrigation Water Resources and Water Power Engineering, Standard Book House, New Delhi(2014)*

Reference Book:

1. *Bharat Singh, Fundamentals of Irrigation Engineering, Nem Chand, Roorkee(1988)*
2. *S.R. Sahasrabudhe, Irrigation Engineering and Hydraulic Structures, S K Kataria & Sons, New Delhi(2014)*
3. *P Novak, A I BMoffat, C Nalluri& R Narayanan, Hydraulic Structures, Taylor & Francis(2014)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE892: CAPSTONE PROJECT

	L	T	P	Cr
	0	0	3	8.0

Project Objectives: The main objective of the project is to encourage students to think critically, solve challenging problems, and develop skills through experimental/analytical projects. The idea is to provide an opportunity to the students so that they are able to apply what they have learned throughout the course of their graduate program by undertaking a specific idea.

Project Details: A capstone project will be a multifaceted assignment that will serve as a culminating academic experience for students during their final semester of graduate program. The projects will be of interdisciplinary nature that will require students to apply skills or investigate issues across many different subject areas that they would have studied in all previous semesters.

While undertaking the project, students will have go through a step wise procedure:
Step 1: Students in a team of 5-7 will be asked to select a topic that interests them and discuss it with the faculty who will be assigned to mentor the given team of students. At this stage, the students will give a brief note of problem or question being investigated such as what is the problem, why is it important and what is to be done and how including preliminary bibliography or literature review.

Step 2: Once the topic is decided, the student will start working on the subject and would regularly update the mentor on his/her progress.

Step 3: Students will create a final product/results, demonstrating their learning acquisition or conclusions in the form of a report. The student will be asked to give an oral presentation on the project to a panel of experts who will collectively evaluate its quality. Typically, no grades will be awarded to students until the panel of experts approve of the project.

Project Outcomes (PO):
Upon completion of this course, the students will be able to:
1. Inculcate the spirit of teamwork while synthesizing all aspects of problem including technology and information
2. Develop oral and writing skills, while preparing for the project report
3. Procure in depth knowledge of recent advancements in the chosen area of the project.
4. Develop research skills that will prepare them for further studies

Reference Books:
1. *Ajmani, J. L. and Arya, A. S., Design of Steel Structures, Nem Chand and Brothers.(2000)*
2. *Duggal, S.K. Limit State Design of Steel structures, McGraw Hill(2014)*
3. *Gambhir, M. L., Reinforced Concrete Design, Prentice Hall of India.(20103)*
4. *GopalRanjan& A.S.R. Rao, Basic and Applied Soil mechanics, New Age Publisher, New Delhi(1998)*
5. *Kohli D. D.; A Text book on Estimating and Costing and Accounts, S. Chand & Company New Delhi(2004)*
6. *Peavy, Rowe and Tchobanglous, Environmental Engineering, McGraw Hill.(2013)*
7. *Reddy, Jaya Rami., A textbook of Hydrology, University Science Press, New Delhi (2015)*
8. *P.N.Modi, Irrigation Water Resources and Water Power Engineering, Standard Book House, New Delhi(2014)*
9. *B. Sengupta and H. Guha; Construction Management and Planning, Tata McGraw Hill.(1999)*

Evaluation Scheme:

Internal Evaluation (by Faculty Advisor)		External Evaluation (Presentation/viva)	
Component	**Max. Marks**	**Component**	**Max. Marks**
Work output/Quality + Individual member contribution/Interaction	20+20	Technical content	25
		Questionnaire	20
Final report	10	Presentation quality	05
Total	**50**	**Total**	**50**

UCE831: BRIDGE ENGINEERING

L	**T**	**P**	**Cr**
3	**1**	**0**	**3.5**

Course Objectives: The course introduces various components of bridges and their various types and hydraulic design requirements of bridges. Standard loading standards developed by IRC which form a consistent basis for design are introduced. The course provides a lucid exposition of the theory and design of pipe culverts, RC slab culverts, T- Beam Bridges and introduction to pre-stressed concrete bridges. The course covers the theory and design of substructures (piers and abutments), foundations, bearings and joints and introduces construction and maintenance as an important part of bridge engineering.

Introduction: Definition, components of a bridge, classifications, importance of bridges.

Investigation of Bridges: Need for investigations, selection of bridge site, preliminary data to be collected, design discharge and its determination, linear waterway, economical span, vertical clearance above HFL, scour depth, choice of bridge type

Standard Specifications: Road bridges, I.R.C. loadings, code provisions on width of carriageway, clearances, loads considered etc.

Slab type Bridges: Design of R.C.C. Orthogonal and Skew Culverts

Reinforced Concrete Bridges: T-Beam Bridge, Courbon's theory for load distribution. Balanced cantilever bridges, Pre-stressed concrete bridges (General discussions)

Sub Structure: Types of piers and abutments, design forces, design of piers and abutments.

Bearing and Joints: Various types of expansion bearing and fixed bearings, elastomeric bearings, joints and their types, design of bearings

Construction, inspection and maintenance of bridges including case studies

Introduction to suspension bridges, cantilever bridges, cable-stayed bridges

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Specify various sub-surface investigations required for bridge construction and further use them to calculate the hydraulic design requirements of different bridges.
2. Implement standard loading specifications for bridge design followed by IRC codes.
3. Analyze and perform design of RC slab culverts and RC T-Beam Bridges
4. Analyze and design various elements of sub-structures of a bridge
5. Design various types of bearings and joints in bridge structures.

Text Books:

1. *Victor, D. Johnson, Elements of Bridge Engineering, Oxford and IBH Publishers, New Delhi(2009)*
2. *Vazirani&Ratwani, Design of Concrete Bridges, Khanna Publishers, New Delhi(2010)*

Reference Books:

1. *Raina, V.K., Analysis, Design and Construction of Bridges, Tata McGraw Hill(2010)*
2. *Raju, N. Krishna, Design of Bridges, Oxford and IBH .(2004)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weights (%)
1.	Mid Semester Test	30
2.	End Semester Test	50
3.	Sessionals (May include assignments, project and quizes)	20

UCE834: ADVANCED TRANSPORTATION ENGINEERING

	L	T/P	Cr
	3	1	3.5

Course Objectives: To expose students to various concepts of pavement design & traffic engineering.

Design of bituminous mixes: Requirement of bitumen mixes, design of bituminous mixes as per Marshall Stability & flow method, parametric evaluation of bituminous mixes, I.R.C & MORTH recommendations for the design mix of various layers of flexible pavements.

Structural design of Flexible Pavements: Stresses in flexible pavements, theories of stress distribution, Boussinesq's Elastic theory, Burmister's theory, considerations for flexible pavement design, IRC method & other countries method for the design of flexible pavements, AASHTO method of Pavement design, Analytical methods of pavement design, overlay design.

Structural design of Rigid Pavements: Stresses in rigid pavements,Westergaard method of rigid pavement design, IRC method of rigid pavement design for plain dowel jointed slabs, design of joints and load transfer devices; design of tie bars, joint fillers and sealers, design of continuously reinforced concrete pavements, design of thin & ultra-thin white toppings as overlay.

Soil Stabilized Roads: Methods of soil stabilization, mechanical stabilization, stabilization with additives/admixtures like lime, cement and bitumen. Stabilization of problematic soils like desert sand & black cotton soils.

Traffic Planning& control: Fundamental principles of Traffic Flow, Traffic flow Elements, Flow Density Relationships, Traffic signs, Road markings, traffic signals, type's i.e. simultaneous system, alternate system, simple progressive system and flexible progressive system, general principles of signal design, Roadway delineations, object markers, guard rails, Barriers.

Highway capacity& Intersection design: PCU, Level of service concepts, factors affecting capacity, capacity of urban highways, capacity of rotary intersection, Design of intersection, grade separated intersection, Need for rotary intersection, principles of design, design of rotary intersection.

Pavement Management Systems: Concepts of Pavement life cycle, Pavement performance assesement, evaluation of pavement structural capacity and safety, combined measures of pavement quality, development of models for pavement deterioration, rehabilitation and maintenance strategies, Future directions and need for innovations in pavement management, HDM applications.

Laboratory Work:
1. Plate bearing test.
2. Stability and Flow value test of bituminous mix as per Marshall Criteria.
3. Evaluation of pavement by Benkelman beam.
4. Evaluation of pavement roughness by Bump Integrator.
5. Introduction to highway engineering softwares(HEADS, MX Road and HDM4)
6. To conduct Pavement Deterioration tests.

Course learning Outcomes:
Upon completion of this course, the students will be able to:
1. Design the bituminous mixes as per IRC standards.
2. Design rigid and flexible pavements using various methods.
3. Apply the concepts of traffic engineering including traffic control, control aids, regulations, highway capacity, and design of intersections.
4. Design pavement maintenance management systems for the road networks.

Text Books:
1. Khanna S.K. and C.E.G. Justo, "Highway Engineering", Nemchand Bros, (2002)
2. Kadyali L. R.; Highway Engineering, Nem Chand & Brothers, Roorkee(2002)

Reference Books:
1. *Sharma & Sharma; Principle and Practice of Highway Engineering, Asia Publishing House, New Delhi (1980).*
2. *Road Development plan for India (1981-2001), IRC, New Delhi, (1984).*
3. *Rao G. V.; Transportation Engineering, Tata McGraw Hill Publisher, New Delhi*
4. *Highway Materials, H.M.S.O.(London).*
5. *Yoder E. J.; Principles of Pavement Design, John Wiley & Sons, (October 1975)*
6. *Haas R.C.G. , Hudson W. Ronald., Zaniewski John P., Modern Pavement Management, Krieger Publishing Company, 1994.*
7. *Susan Brown, Pavement Managaement Systems, Transportation Research Board, 1993.*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE833: WATER RESOURCES PLANNING AND MANAGEMENT

	L	T	P	Cr
	3	1	0	3.5

Course Objective: To expose students to gain the knowledge on planning and economics of water resources project. Various aspects of water resource planning such as single and multipurpose projects, their feasibility based on cost allocation and comparison of alternatives will be taught along with application of optimization techniques to water resource problems.

Introduction: Role of water in development of water resources, Assessment of water resources of the country, Requirement for various uses, Future of water resources engineering.

Planning and Management: Issues in planning, Water resources planning process, Planning for single purpose and multipurpose projects, Principles of multipurpose development; Functional requirement of multipurpose uses, Compatibility of multipurpose uses, Cost allocations in multipurpose projects, Comparison of alternatives, Inter-basin transfer of water, Conjunctive use of surface and ground water.

Project Economics: Basic principles, Tangible and intangible values, Selection of interest rate, Cash flow diagrams Discounting factors, Discounting techniques - present-worth method, annual-cost method, benefit-cost ratio method, rate of return method, Risk and uncertainty, Application to water resources problems.

Optimization Techniques: Linear and Dynamic programming, Application to water resources problems.

Dams: Types, classification, factors governing the selection of a dam, Design of gravity dams: Analysis of forces, combination of forces for design, modes of failure and criteria for structural stability, principal and shear stresses, methods of analysis (detailed description of gravity method only).

Spillways: Location, types, design considerations of ogee spillway, energy dissipation below spillways, design of stilling basins.

Reservoir Planning: Types of reservoirs, storage zones, selection of reservoir site, mass curve analysis for reservoir capacity, reservoir yield and its determination, reservoir sedimentation and its control, reservoir evaporation and methods for its reduction.

Course learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Perform economic analysis of water resource project.
2. Apply optimization techniques to water resources problems
3. Analyze the criteria of stability of gravity dams and its design features
4. Evaluate the capacity of reservoir based on site specific data

Text Books:
1. *Chaturvedi, M. C., Water resources Planning and Management, Tata MC Graw Hill, New Delhi (1997)*
2. *Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers, New Delhi(1993)*

Reference Books:
1. *James, L. D., and Lee, R. R., Economics of Water Resources Planning. McGraw Hill Publishing Company, New York(1971)*
2. *Chow, V. T. et. al., Applied Hydrology, McGrawHill Publishing Company, New York.(1988)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE612: ENVIRONMENT LEGISLATION AND IMPACT ASSESSMENT

	L	T	P	Cr
	3	1	0	3.5

Course Objectives: The basic objective of the course is to provide the students with an overview on environmental legislation and acts and role of pollution control boards and their procedures, provide understanding of various aspects related to EIA processes and Inculcate capabilities to interpret environmental management plans and EIA documents

Definition of Terms: Conventions and protocols; Policy; law; acts and rules; Administrative and legal interpretations; Codes and specifications.

Overview of environmental Legislation: International environmental Conventions and protocols, History of development, Overview of Indian environmental law; Review of Environment and Forest policies of Government of India; Pollution control boards – Powers; functions and Procedures. Judgements on Environment and pollution.

Provisions of Water Act; Water-cess Act; Air Act; Environmental Protection Act; Public Liability Insurance Act as Applicable to Industry: Provisions relating to Environmental clearance; Consents from SPCB; Environmental sampling; analysis and Environmental standards; Overview of other key environmental regulations- Municipal solid waste rules; Biomedical waste rules; Hazardous waste rules, Chemical accident rules, Batteries rules, flyash rules, construction and demolition waste rules.

Legal Aspects of EIA: EIA notification; Environmental clearance process - Screening; scoping; public consultation and appraisal; Objectives and scope of EIA; EIA process flow chart.

Project and the Environment Description: Environmental feasibility analysis; Identification of key issues; Baseline studies; environmental monitoring and environmental data collection- air, water, noise, socioeconomics: Methods of Impact analysis and evaluation- checklists; matrices; networks; overlays and GIS; and professional judgements etc.

EMP (Environmental Management Plan) and EIA Documentation: Principles; anticipated environmental impacts; mitigation measures: Preparation of EIA documents.
Case Studies: EIA of highway, infrastructure and hydel power projects.

Course Learning Outcomes:
Upon completion of this course, the students will be able to:
1. Be aware of the environmental legislations, policies of the country and of international environmental conventions and protocols.
2. Know the environmental regulations applicable to the industry and other organizations with significant environmental aspects

3. Know about the environmental requirements applicable to the environmental impact assessment, and about the environmental clearance process of developmental projects.
4. Understand the methods and tools of identification, prediction and evaluation of environmental impacts of developmental projects.

Recommended Books:
1. *CPCB, Pollution Control Law Series - PCL/2/2001; Central Pollution Control Board (http://envfor.nic.in/cpcb/cpcb.html)*
2. *L.W Canter, Environmental impact assessment, McGraw Hill (1989)*
3. *EIA notification, Gazette Notification: SO 1533 dated 14-09-2006; MOEF. GOI (2006).*
4. *Krishan Keshav, Law and environment, Singhal Law Publication, New Delhi (2015)*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Assignments/Tutorials/Quizes)	25

UCE725: ADVANCED CONSTRUCTION MATERIALS AND TECHNIQUES

L T P Cr
3 1 0 3.5

Course Objectives The basic objective of the course is to expose the students to the latest and advanced construction materials used for thermal and sound insulation and special concretes used for specific field applications. The students will also be introduced to newer and latest construction techniques followed in construction industry.

Advanced Construction Materials: Plastics, Timber products and Preservation, materials for thermal insulation, materials for sound insulation. Smart Materials and their applications.

Special Concretes: Light Weight Concrete, Vaccuum Concrete, Waste Material Based Concrete, Fiber reinforced concrete, Polymer Concrete Composites, Ferrocement, Concreting at High and Low Temperatures, Self- Compacting Concrete (SCC), Ready Mixed Concrete (RMC) and its characteristics and advantages, Shotcrete and concreting in tunnels.

Techniques for Tunneling and Formwork*:* Earthwork including cut and cover method, TBM, EBM and trenchless technology, Slip Form Shuttering, Latest type of Formwork, e.g. DOKA.

High Rise Structures: Construction techniques for high rise buildings, chimneys, dams. Special problems of high-rise construction & optimization of space,

Fire Resistance in Structures*:* Fire hazards in buildings and preventive measures,

Low Cost Housing: Types, Design and advantages.

Special Constructions: Pre-Cast and Pre-Fabricated Construction and Modular Construction, production and utilization in various types of structures, Environmental and Economic Benefits.

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Characterize and specify advanced construction materials for thermal and sound insulation, smart materials and plastic and timber products.
2. Identify Special Concretes used in construction industry for specific applications.
3. Identify and Specify construction techniques for earthwork, tunneling and formwork.
4. Identify the various construction techniques for High Rise Buildings.
5. Know how to Design Low Cost Housing and cost analysis of In- Situ Pre-Cast, Pre-Fabricated and Modular construction.

Text Books

1. *M.L. Gambhir , Neha Jamwal, Building Materials, Products, properties and systems, Mc Graw Hill(2011)*

2. *M.L. Gambhir, Concrete Technology, Mc Graw Hill(2013)*

3. *Subir Sarkar, Subhajit Sarawati, Construction Technology, Oxford University Press (2008).*

Reference Books/Journals:

1. *Low Cost Houses, Publications by HUDCO, India Habitat Centre, Lodhi Road, New Delhi(1982)*

2. *F. Glower, Structural Pre-cast Concrete, Oxford Publishers.(1974)*

3. *Neil Jackson and R. K. Dhir, Civil Engineering materials, Macmillan Fourth edition.(1996)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weights (%)
1.	Mid Semester Test	30
2.	End Semester Test	50
3.	Sessionals (Includes Assignments and Quiz Evaluations)	20

UCE723: GROUND WATER ENGINEERING

L	T	P	Cr
3	1	0	3.5

Course Objective: The objective of this subject is to get exposure on engineering aspects of groundwater such as groundwater hydraulics, an introduction to groundwater quality and groundwater exploration.

Principles of Ground water flow: Definition and occurrence of ground water flow, Role of ground water in a hydrologic cycle, Mechanical energy and fluid potential, Hydraulic head, Darcy's law, Heterogeneity and anisotropy, Range and validity of Darcy's law, Types of aquifer and its properties, Compressibility, Specific storage, Storativity, Ground water flow equation, Solution of flow equation, Analytical solutions, Steady flow in a confined and unconfined aquifer, Graphical solutions, Flow lines and Equipotential lines, Flow net, Refraction of flow lines.

Well Hydraulics: Introduction, Drawdown due to abstraction from well, Steady and unsteady abstraction from well, Well interference, Pumping test analysis, Infiltration wells and gallery.

Well Construction: Method of construction of shallow and deep well, well log, well completion, horizontal well

Groundwater Conservation: Regional groundwater budget, Resource assessment, Estimation of recharge, artificial recharge.

Groundwater quality: Indian and international standards, Pollution of groundwater sources, Advection and dispersion, sorption and diffusive mass transfer, remedial and preventive measures.

Exploration: Geophysical, Electric resistivity method, Seismic refraction method, Saline water intrusion in aquifers, Groundwater levels fluctuation.

Course Learning Outcome (CLO):
Upon completion of this course, the students will be able to:
1. Learn the principles of groundwater flow and its representation in mathematical equation.
2. Estimate the discharge in well for different aquifers.
3. Learn the method of well construction
4. Learn the source and mechanism of contaminant transport in groundwater
5. Learn the methods of groundwater of exploration and the reasons of groundwater fluctuation.

Text Books:

1. *Raghunath H M, Groundwater, New Age International(2007).*

2. *Franklin W. Schwartz and Hubao Zhang, Fundamentals of Groundwater, John Wiley(2003).*

Reference Books:

1. *David Keith Todd, Groundwater Hydrology, Wiley India Edition(2007).*

2. *Bear, J. Hydraulics of Groundwater, McGraw-Hill(1979).*

3. *Freeze, R.A. and Chery, J.A, Groundwater. Prentice Hall,Inc, Englewood Cliffs, New Jersey(1979).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weights (%)
1.	Mid Semester Test	30
2.	End Semester Test	50
3.	Sessionals (Includes Assignments and Quiz Evaluations)	20

UCE724: SITE ORGANIZATION AND SAFETY MANAGEMENT IN CONSTRUCTION

	L	T	P	Cr
	3	1	0	3.5

Course Objective: To purpose of this course is to expose the students to various aspects of construction site starting from preparation of site to various safety management measures.

Preparation of Site: Site Clearance, Layout, infra-structural facilities, organizing utilities, site grading legal frame-work, liaison with local authorities, acquisition of land Various levels, job description, role of consultants, contractor and client and their responsibilities, training, Job layout, placement of material equipment on site. Documentation, inspection, Machinery, stores equipment, contractor, Quarries, vendors

Supervision: Procedure for quality assurance, Controlling and reporting system, Labour laws, legislation.

Safety Management: Safety management function, line versus staff authority, safety responsibility and accountability in construction industry. Safety and its importance in construction industry, hazards in construction projects, causes of accidents, cost of an accident. Experience Modification Rating, Workers insurance, general safety programs in construction industry, construction safety problems, Systems safety analysis, faulty tree analysis, failure modes and effects analysis in construction industry. Introduction to Risk assessment and management, Health and safety legislation and regulations and, Safety management systems.

Course learning Outcome (CLO):
Upon completion of this course, the students will be able to:
1. Execute various preparatory steps involved in construction project execution at site
2. Perform various organizational activities involved in project management at site
3. Work out safety provisions to be adopted at a construction site

Text Books

1. *B. Sengupta and H. Guha; Construction Management and Planning, Tata McGraw Hill.(1999)*
2. *R.L. Peurifoy, W.B. Ledbetter and C.J. Schexnayder, Construction planning and methods, McGraw Hill International edition.(1996)*

Reference Books

1. *P.K. Joy; Total Project Management – The Indian Context, McMillan India Ltd.(2010)*
2. *P.K. Joy; Hand Book for Construction Management, MacMillan India Ltd. (1991)*
3. *Hand Book on Labour Contract Legislation, ILO(2015)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May includeAssignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE848: TRANSPORTATION PLANNING AND MANAGEMENT

	L	T	P	Cr
	3	1	0	3.5

Course Objective: To expose the students to various concepts of transportation planning on urban platform, Land use planning, use of transportation modelling in travel demand management and public transit studies.

Overview of Metropolitan Transportation Planning: History of urban transportation planning, early concepts and approaches (Pre 1964 Era); Contemporary Urban Transportation Planning and Apex bodies that constitute the framework of the planning process in India; Legislative measures regarding transportation planning in India.

The Transportation Planning Process and Problems: Terminology of Transportation Planning, Functional Components, Brief Overview of Models used in Transportation Planning, Stakeholder input in the planning process, Environmental concerns, Smart growth and sustainable alternatives, Energy based planning, Intelligent Transportation Systems, Global Positioning Systems.

Transportation System Impacts: Travel Facilities, Origin and Destination, Transit Surveys, Decision making Process, Transportation Demand Management (TDM).

Modeling: Transportation system characteristics and interrelationships, User costs and Human Activities, Travel Demand Forecasting, Trip Generation, Trip Distribution, Modal Choice, Trip Assignment.

Land Use Transportation System: Urban system components, Urban Spatial Structure, Location Theory, Land use planning, Land use Models, Land use transport models – (Lowry and Garin), Lowry Models, Transit Oriented Development(TOD).

Urban Public Transportation: Urban Growth and Public Transport needs, Transit mode characteristics, transit characteristics, Fleet size and capacity estimation, Smart cities bases Transit Planning

Project assignment/ Micro project:
1. Study area delineation
2. Travel Survey Design
3. Home interview survey
4. Data analysis
5. Use of Transportation Simulation Software like VISUM/ TransCAD.
6. Case study: Planning for transportation systems of a specific location.

Course Learning Outcome (CLO):
Upon completion of this course, the students will be able to:
1. Understand the concept of Transportation Planning in the Regional and City level Planning
2. Design Travel Demand and Transit based Surveys.
3. Estimate Travel Demand of a particular corridor, city or area
4. Perform Four Stage Modelling for Travel demand and further Design transportation alternatives for the same.
5. Suggest mass transit alternatives for a given conditions on the base of its characteristics and capacity estimate.

Text Books:
1. Kadiali, L.R.; *Traffic Engineering and Transportation Planning, Khanna Publications, 2011.*
2. Sarkar, P.K., Maitri Vinay., Joshi, G.J.; *Transportation Planning: Principles, Practices and Policies, PHI, New Delhi, 2014.*

Reference Books:
1. Bowmen, J. and M. Ben-Akiva;*Activity based travel forecasting; in Activity based travel forecasting. Washington, DC: U.S. Department of transportation, Report DOT-97-17.*
2. Bruton M.J.; *Introduction to Transportation Planning, Hutchinson of London, 1988.*
3. *Chakraborty P. and Das N.; Principles of transportation Engineering, PHI, New Delhi, 2003.*
4. Dickey J.W.; *Metropolitan Transportation Planning, Tata Mc-Graw Hill 1980.*
5. *Hutchinson B.G.; Principals of Urban Transportation System Planning, Mc-Graw Hill, 1974.*
6. Khisty C.J., Lall B. Kent, *Transportation Engineering- An Introduction, Prentice- Hall, NJ, 2005.*
7. Ortuzar, J.D., Willumsen, L.G., *Modeling Transport, John Wiley and Sons, 1994.*
8. Papacostas C.S. and Prevedouros, P.D., *Transportation Engineering and Planning, PHI, New Delhi, 2002.*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE832: GEO-TECHNIQUES

L T P Cr
3 1 0 3.5

Course Objectives: This subjects aims to develop the understanding for design of earth retaining structures, open cuts, and introduce the concepts of earth dam and foundations on expansive soils.

Sheet Piles and Cofferdams: Types of sheet piles, principal advantages of sheet piles, analysis of cantilever wall in sands, simplified approach in clays ($\phi= 0$), Anchored bulk head stability, Free earth support method, fixed earth support method Types of cofferdams, relative merits and their advantages as compared to other types, comparison between circular and diaphragm types, failure modes of cells, stability analysis of cofferdams by TVA method.

Design of Bracing in Open cut: Open cuts, necessity of bracing and strutting in open cuts, pressure distribution diagram under various cases, deep open cut in loose and dense sands, deep open cut in normally loaded and stiff clays. Heaving of vertical cuts in clay, Design of anchors.

Earth Dams: Criteria for selection of dams, material required in earth dam construction, types of Earth dams, compaction control during construction of dams, method of measuring field density and moisture content. Control of seepage, through body of dam and through its foundations.

Arching Action in Soils: Arching in soil, theory of arching in soils, practical utility of arching in various field problems.

Foundation on expansive soils: Introduction mineralogy, identification testing techniques, swelling pressure, types, practice, methods of foundation in expensive soils, CNS Concepts. Design of shallow and deep foundation in swelling soils. Design of under reamed piles

Dewatering: Approximate computation for flow quantity to dewater an excavation, slurry wall and safety factor.Simple sketches to illustrate the principles of dewatering by different methods and their relative suitability. Ditches and sumps, well point system, deep well drainage installation, vacuum method Bleeder wells, sand drain installation, electro-osmosis. Design of well point system for dewatering.

Course learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Design the cantilever and anchored sheet pile
2. Design the bracing system in open cuts and anchoring
3. Apply design aspects of earth dams.
4. Design the foundations on expansive soils.
5. Design the well point system for deep excavations.

Text Books:
1. *Murthy,VNS., Advanced Foundation Engineering, CBS, New Delhi (2007)*
2. *Ranjan,Gopal & ASR Rao; Basic and Applied Soil Mechanics, New Age Publishers, New Delhi (2004)*

Reference Books:
1. *Bell, F., Engineering Treatment of Soils, Chapman and Hall, UK (2001)*
2. *Saran, Swami; Analysis and Design of Substructures, Oxford and IBH, New Delhi(2005)*
3. *Bowles, Foundation Analysis & Design, McGraw Hill Publishing Co., New Delhi (1996)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE849: AIR QUALITY AND CONTROL ENGINEERING

	L	T	P	Cr
	3	1	0	4.0

Course Objectives

This course facilitates understanding of the sources, dispersion and effects of air pollutants. Principles underlying designing of mechanical devices used for particulate and gaseous emission control from various sources. To understand the management strategies in the control of air pollution from stationary and mobile sources.

Sources and Effects of Air Pollutants: Classification of air pollutants Particulates and gaseous pollutants, Sources of air pollution, Source inventory, Air Pollution Index, Effects of air pollution, Climate Change, Ozone layer depletion, Sampling and Analysis –Source and ambient sampling, Principles of analysis of pollutants.

Dispersion of Pollutants: Elements of atmosphere, Meteorological factors, Wind roses, Lapse rate, Atmospheric stability and turbulence, Plume rise, Dispersion of pollutants, Dispersion model (Gaussian plume model) & its applications, Stack height calculations.

Emission Control: Basic principles of fluid flow, Dynamics of particles in fluid, Properties of particles, Collection efficiencies of particles, Design and operation of settling chambers, Cyclone and multiclones, Scrubbers, Bag houses and Electrostatic precipitators, Collection efficiency and Pressure drop calculations, Selection criteria for equipment, Gaseous pollutant control by adsorption, absorption, condensation, combustion, Automobile emission control.

Air Quality Management: Air quality standards, Source reduction (Fuel substitution, Fuel pretreatment, Process modifications), Management strategies for air pollution abatement, Green belt design.

Course Learning Outcomes:
Upon completion of this course, the students will be able to:
1. identify, formulate and solve air pollution problems
2. demonstrate a detailed knowledge of study the effect of meteorological parameters in the dispersion of air pollutants
3. design and evaluate efficiency of various air pollution control devices used for particulate removal
4. design, operate and control the devices used for gaseous emission control
5. examine the management strategies for air pollution abatement

Text Books:
1. *De Nevers N, Air Pollution Control and Engineering, Mc Graw Hill 1993.*
2. *Rao, C.S. Environmental Pollution Control Engineering, Wiley Eastern Ltd., New Delhi, 1996.*

3. *Boubel RW, Fox DL, Turner B and Stern AC, Fundamental of Air Pollution, Academic Press 1994.*
4. *Rao M.N., and Rao H. V. N., Air Pollution Control, Tata McGraw Hill, New Delhi, 1996.*

Reference Books:
1. *Perkins HC, Air Pollution, McGraw Hill (2004).*
2. *Heumann. W.L., Industrial Air Pollution Control Systems, McGraw Hill, New Yark, 1997.*
3. *Mahajan S.P., Pollution Control in Process Industries, Tata McGraw Hill Publishing Company, New Delhi, 1991.*
4. *Peavy S.W., Rowe D.R. and Tchobanoglous G. "Environmental Engineering", McGraw Hill, New Delhi, 1985.*
5. *Flagan RC and Seinfeld JH, Fundamentals of Air Pollution Engineering, Prentice Hall 1988.*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Assignments/ Projects/ Tutorials/ Quizes/Lab Evaluations)	25

UCE844: REMOTE SENSING AND GIS

	L	T	P	Cr
	3	1	0	3.5

Course Objective: The purpose of this course is to expose students to the principles of remote sensing, sources of errors in raw data before its application, including data handling in GIS and to be able to learn the application of remote sensing in Civil and Environmental Engineering.

Principles and Fundamentals of Remote Sensing: Sources of Energy – Active and Passive radiation – Electromagnetic Radiation – Nomenclature, Reflectance, Transmission and Absorption, Thermal Emission – Plank's formula, Stefan – Boltzman Law, Wein's Displacement Law; Emissivity – Kirchoff's Law, Characteristics of Solar Radiant Energy.

Sensors and Platforms: Types of sensors, Multispectral, hyperspectral, thermal, orbital characteristics, working principles and instrumentation. Storage and Retrieval of data. IRS and ERS satellite systems – Introduction, Stages of development, Sensory Characteristics, Orbit and Coverage's, various types of data product and its uses.

Data Processing: Initial data statistics. Pre-processing – Atmospheric, Radiometric and Geometric corrections.

Data analysis: Image Interpretation Elements, Keys and Aids. Basic Instrumentation.Visual analysis of data in application of remote sensing to various engineering fields.

Digital Elevation Model: Principles of data collections; Application to various fields: Contours, profiles, watersheds, stream networks etc.

Principles of Geographical Information Systems (GIS): Geographic information and spatial data types, Hardware and software; GIS; Steps of spatial data handling, database management systems, Spatial referencing.

Data*:* Quality, measures of location errors on maps, Satellite-based positioning, Spatial data input, data preparation, Point data transformation.

Analytical GIS capabilities: classification; overlay analysis

Map Projections: System of map projections.

Lab Assignments:
1.   Prepare land use and land cover map.
2.   Generate contours and sectional profile from a DEM data
3.   Delineate watersheds and stream networks from DEM data
4.   Projects of Maps
5.   Geometric corrections of satellite data
6.   Spatial data processing through GIS.

Course learning Outcomes (CLO):

Upon completion of this course, the students will be able to:
1. Process the remotely sensed data for various field applications.
2. Interpret and classify the remotely sensed data and prepare the land use and land cover maps.
3. Handle DEM data and be able to prepare contours and topographical maps.
4. Delineate the watershed and prepare the stream network of an area.
5. Use spatial information, collected through remote sensing, for the benefits of end users.

Text Books:

1. *Lillesand, T.M. and R.W. Kiefer, Remote Sensing and Image Interpretation, John Wiley & Sons, New York(1994).*
2. *Campbell, J.B, Introduction to Remote Sensing, Taylor & Francis, London (1996).*
3. *Joseph, G., Fundamentals of Remote Sensing, Universities Press, New Delhi (2003).*

Reference Books:

1. *Colwell, R.N. (Editor-in-Chief), Manual of Remote Sensing, Vols I & II, American Society of Photogrammetry, Falls Church, Virginia(1983).*
2. *Jensen, J. R., Remote Sensing of the Environment an Earth Resource Perspective, Pearson Education. Delhi(2007).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
4.	MST	30
5.	EST	45
6.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE845: PRESTRESSED CONCRETE

	L	T	P	Cr.
	3	1	0	3.5

Course Objectives: To expose students about various design aspects of prestressed and post tensioned concrete**.**

Introduction: Basic concepts of prestressing, terminology, advantages and applications of prestressed concrete.

Materials for Prestressed Concrete: High strength Concrete, permissible stresses in concrete, high strength steel, permissible stresses in steel.

Prestressing Systems: Pretensioning and post tensioning systems, various types of tensioning devices, Lec-Macall systems, MagnelBlaton post tensioning, Freyssinet systems, Gifford Udal system.

Losses of Prestress : Types of losses of prestress, loss due to elastic deformation of concrete, loss due to shrinkage of concrete, loss due to creep of concrete, loss due to relaxation of stress in steel, loss due to friction, loss due to anchorage slip, total loss in pretensioned and post tensioned members.

Analysis of Prestress and Bending stresses: Basic assumptions, resultant stresses at a section, concept of load balancing, cracking moment.

Deflections: Factors influencing deflections, short term deflections of un-cracked members, deflections of cracked members, prediction of long term deflections.
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Shear and Torsional Resistance: Ultimate shear resistance of prestressed concrete members, prestressed concrete members in torsion, design of reinforcements for torsion, shear and bending.

Design of Flexural Members : Dimensioning of flexural members, design of pre-tensioned and post tensioned beams, design of partially prestressed members, design of one way and two way slabs, continuous beams.

Design for axial tension, compression and bending, bond and bearing.

Limit State Design: Review of limit state design concepts, design loads and strengths, crack widths in prestressed members, principles of dimensioning prestressed concrete members.

Course learning Outcomes:

Upon completion of this course, the students will be able to:

1. Specify and characterize the materials required for prestressed concrete structures and various methods of prestressing.
2. Calculate losses in various pre-stressed members.
3. Analyze prestressed concrete members for flexure and their flexural strength.
4. Design various prestressed concrete structures for bending, axial tension, bond and bearing.
5. Evaluate shear and torsional resistance of pre-stressed concrete members and perform check for deflection criteria.

Text Books

1.   Raju, N. Krishna,   Prestressed Concrete by, TMH Publishing Company, New Delhi (2006).

Reference books

1.   Dayartnam,, P., Prestressed Concrete , Oxford and IBH Publication, New Delhi.(1991)

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE846: SOIL DYNAMICS AND MACHINE FOUNDATION

	L	T	P	Cr
	3	1	0	3.5

Course Objective: This subjects aims to develop an understanding of behavior of soil mass when subjected to vibratory loads. Further they will also develop an understanding of liquefaction of soil.

Dynamic properties of soils: Nature of dynamic loads, Stress conditions during earthquake loading, strain levels, Determination of dynamic properties – in-situ and laboratory methods, Block vibration tests, Cyclic plate load test, Cyclic resonant column test, Cyclic triaxial test, Cyclic simple shear test, Wave propagation tests, Interpretation of test results.

Dynamic Earth Pressure: Earth pressure problem and retaining walls, Behavior of retaining walls during earthquakes, Modification of Coulomb's theory, Indian standard code of practice, Culmann's modified graphical constructions for lateral earth pressure, Simplified analytical solution for c-ϕ backfill.

Liquefaction of Soils: Basic concept, Liquefaction related phenomena, Factors influencing liquefaction susceptibility of soils, factor of safety against liquefaction, Cyclic shear stress ratio, Cyclic resistance ratio and its determination from SPT, CPT and shear wave velocity, Laboratory studies on liquefaction, Liquefaction behavior of loose and dense sands; silt and clayey silts, Methods of liquefaction remediation.

Machine Foundations: Theory of vibrations, Single degree and multi-degree of freedom system, Criteria for satisfactory functioning of machine foundation, Methods of analysis, Degrees of freedom of a block foundation, Vibrations of a block, Design procedure for block foundation. I.S. method for foundation design of reciprocating machines, Vibration isolation.

Introduction to the dynamics of dams and reservoirs

Course learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Know theoretically how to evaluate dynamic properties of soils by geotechnical and geophysical methods.
2. Understand the stress-strain behaviour of cyclically loaded soils.
3. Evaluate the liquefaction potential of soil deposits.
4. Perform analysis and design of retaining walls and dynamic loading.
5. Perform analysis and design of machine foundations.

Text Books:
1. Saran, Swami, Soil Dynamics and Machine Foundations, Galgotia, New Delhi (2008).
2. Kramer, S. L.,Geotechnical Earthquake Engineering, Pearson Education, Inc, India(1996).
3. Prasad B.B., Soil Dynamics and Earthquake Engineering, PHI Learning Private Ltd (2009).

Reference Books:
1. *Prakash, S., Soil Dynamics, McGraw Hill International Edition, New York. Publishing, New Delhi (1994).*
2. *Barken, D.D., Dynamics of Bases and Foundations, McGraw Hill Book Company, New York (1995).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UCE850: HYDRO POWER ENGINEERING

L	T	P	Cr
3	1	0	3.5

Course objective: To get an overview of hydropower systems along with its various units.

Introduction:

Power resources, Conventional and Nonconventional, Need & advantages, Hydropower development in India, Hydropower potential.

Hydropower Plants

Types of hydropower plants, Storage power plant, Runoff River plant, Pumped storage plant, Reversible pump turbines, types of turbines, hydraulics of turbines, cavitation in turbine, efficiency of pumped storage plants.

Electrical load on hydro turbines:

Load curve, Load factor, power factor, capacity factor, utilization factor, Diversity factor, Load duration curve, Firm power, Secondary power, Prediction of load

Water conveyance system:

Intakes, location and types, losses in intakes, air entrainment at intake, inlet aeration, fore bay, canals, Tunnels and Penstocks, classification of penstocks, design criteria of penstock, economical diameter of penstock, Anchor blocks, Conduit valves, types of valves, bends and manifolds, Water hammer, channel surges, surge tanks types and design consideration.

Planning of power house:

Powerhouse structure, location and types of underground power stations, Components of an underground power house, Advantages and limitation of underground power house.
Environmental impact of hydel project

Course learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. Analyze various processes involved in the planning and designing of hydropower projects.
2. Define and describe various types of hydropower plants
3. Understand various terms associated with running of hydro turbines
4. Describe components of underground power stations

5. Design various components of the hydropower systems.

Text Books:

1. *Varshney, R. S., Hydro Power Structures, Nem Chand Brothers, Roorkee (2001).*

2. *Modi, P N. Irrigation Water Resources and Water Power Engineering, Standard Book House (2008)*

Reference Books:

1. *Dandekar, M. M. and Sharma, K. H., Water Power Engineering, Vikas Publishing House, New Delhi. (2013).*

2. *Warnick, C C, Hydropower Engineering, Prentice-Hall (1984)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
4.	MST	30
5.	EST	45
6.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25