COURSE STRUCTURE and SYLLABI FOR B. TECH. (CE) 2020

First Semester

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load/ week	Marks
			L	T	P			
1.	Mathematics – I		3	1	0	4	4	100
2.	Chemistry/Physics		3/4	0	0	3/4	3/4	100
3.	Intro to Computing/Basic Electrical Engineering		3/4	0	0	3/4	3/4	100
4.	Mechanics/Environment and Ecology		4/3	0	0	4/3	4/3	100
5.	English/Sociology & Professional Ethics		3	0	0	3	3	100
	Theory Sub-total		**16/17**	**1**	**0**	**17/18**	**17/18**	**500**
6.	Chemistry Lab/Physics Lab		0	0	3	2	3	50
7.	Computer Lab/ Electrical Lab		0	0	3	2	3	50
8.	Drawing/Workshop		0	1/0	3	3/2	4/3	50
9.	NSS/NCC/PT/Yoga					R*		
	Practical Sub-total		**0**	**1/0**	**9**	**7/6**	**10/9**	**200**
	First Semester Total					**24**	**27**	**700**

*R: Required (Non-credit but with grade)

Second Semester

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load/ week	Marks
			L	T	P			
1.	Mathematics – II		3	1	0	4	4	100
2.	Physics/Chemistry		4/3	0	0	4/3	4/3	100
3.	Basic Electrical Engineering/ Intro to Computing		4/3	0	0	4/3	4/3	100
4.	Environment & Ecology/ Mechanics		3/4	0	0	3/4	3/4	100
5.	Sociology & Professional Ethics/ English		3	0	0	3	3	100
	Theory Sub-total		**17/16**	**1**	**0**	**18/17**	**18/17**	**500**
6.	Physics Lab/Chemistry Lab		0	0	3	2	3	50
7.	Electrical Lab/Computer Lab		0	0	3	2	3	50
8.	Workshop/Drawing		0	0/1	3	2/3	3/4	50
9.	NSS/NCC/PT/Yoga					R*		
	Practical Sub-total		**0**	**0/1**	**9**	**6/7**	**9/10**	**200**
	Second Semester Total					**24**	**27**	**700**

*R: Required (Non-credit but with grade)

Third Semester

Sl. No.	Course Name	Course Code	Class Load /Week			Credit	Class load /week	Marks
			L	T	P			
1.	Surveying	CE2101	4	0	0	4	4	100
2.	Civil Engineering Materials	CE2102	4	0	0	4	4	100
3.	Mathematics – III	MA2101	3	0	0	3	3	100
4.	Solid Mechanics	AM2103	4	0	0	4	4	100
5.	Hydraulics	AM2104	4	0	0	4	4	100
	Theory Sub-total		16	0	NIL	19	19	500
6.	Civil Engineering Drawing	CE2171	0	0	3	2	3	50
7.	Introduction to Civil Engineering	CE2172	0	0	3	2	3	50
8.	Solid Mechanics Laboratory	AM2174	0	0	3	2	3	50
9.	Hydraulics Laboratory	AM2175	0	0	3	2	3	50
	Practical Sub-total		NIL	NIL	12	8	12	200
	Third Semester Total					**27**	**31**	**700**

Fourth Semester

Sl. No.	Course Name	Course Code	Class Load/Week			Credit	Class load/ week	Marks
			L	T	P			
1.	Structural Analysis I	CE2201	4	0	0	4	4	100
2.	Geotechnical Engineering - I	CE2202	4	0	0	4	4	100
3.	Environmental Engineering - I	CE2203	4	0	0	4	4	100
4.	Water Resources Engineering– I	CE2204	4	0	0	4	4	100
5.	Geology for Civil Engineering	ES2201	3	0	0	3	3	100
	Theory Sub-total		19	0	NIL	19	19	500
6.	Water Resources Engineering Laboratory	CE2271	0	0	3	2	3	50
7.	CE Materials Laboratory	CE2272	0	0	3	2	3	50
8.	Surveying Laboratory	CE2273	0	0	3	2	3	50
9.	General Civil Engineering Problems (Minor Project)	CE2274	0	0	2	2	2	50
	Practical Sub-total		NIL	NIL	11	8	11	200
	Fourth Semester Total					**27**	**30**	**700**

Fifth Semester

Sl. No.	Course Name	Course Code	Class Load/Week			Credit	Class load/ week	Marks
			L	T	P			
1.	Structural Analysis II	CE3101	3	0	0	3	3	100
2.	Design of RC Structures	CE3102	4	0	0	4	4	100
3.	Transportation Engineering I	CE3103	4	0	0	4	4	100
4.	Environmental Engineering II	CE3104	3	0	0	3	3	100
5.	Water Resources Engineering II	CE3105	3	0	0	3	3	100
	Theory Sub-total		17	0	NIL	17	17	500
6.	Structural Engineering Laboratory	CE3171	0	0	3	2	3	50
7.	RC Structures Design Project	CE3172	0	0	3	2	3	50
8.	Geotechnical Engineering Laboratory	CE3173	0	0	3	2	3	50
9.	Environmental Engineering Laboratory	CE3174	0	0	3	2	3	50
	Practical Sub-total		NIL	NIL	9	8	12	200
	Fifth Semester Total					**25**	**29**	**700**

Sixth Semester

Sl. No.	Course Name	Course Code	Class Load/Week			Credit	Class load/ week	Marks
			L	T	P			
1.	Design of Steel Structures	CE3201	4	0	0	4	4	100
2.	Geotechnical Engineering II	CE3202	3	0	0	3	3	100
3.	Transportation Engineering II	CE3203	3	0	0	3	3	100
4.	Construction Technology and Project Management	CE3204	4	0	0	4	4	100
5.	Numerical Methods in Civil Engineering	CE3205	3	0	0	3	3	100
	Theory Sub-total		17	0	NIL	17	17	500
6.	Steel Structures Design Project	CE3271	0	0	3	2	3	50
7.	Transportation Engineering Laboratory	CE3272	0	0	3	2	3	50
8.	Estimation Practice	CE3273	0	0	3	2	3	50
	Practical Sub-total		NIL	NIL	12	6	9	200
	Sixth Semester Total					**23**	**26**	**700**

Seventh Semester

Sl. No.	Course Name	Course Code	Class Load/Week			Credit	Class load/ week	Marks
			L	T	P			
1.	Advanced Design of Structures	CE4101	3	0	0	3	3	100
2.	Advanced Design of Foundation	CE4102	3	0	0	3	3	100
3.	Core Elective – I		3	0	0	3	3	100
4.	Open Elective (HSS)		3	0	0	3	3	100
	Theory Sub-total		12	0	NIL	12	12	400
5.	Advanced Structures Design Project	CE4171	0	0	3	2	3	50
6.	Advanced Foundation Design Project	CE4172	0	0	3	2	3	50
7.	Infrastructure Design	CE4173	0	0	3	2	2	50
8.	B. Tech Project/Part – I	CE4191	0	0	0	4	2	100
9.	Internship (Evaluation)	CE4192	0	0	0	2	0	50
	Practical Sub-total		NIL	NIL	9	12	10	300
	Seventh Semester Total					**24**	**22**	**700**

Eighth Semester

Sl. No.	Course Name	Course Code	Class Load/Week			Credit	Class load / week	Marks
			L	T	P			
1.	GIS and Remote Sensing	CE4201	3	1	0	4	4	100
2.	Core Elective-II		3	0	0	3	3	100
3.	Open Elective II		3	0	0	3	3	100
	Theory Sub-total		9	1	NIL	10	10	300
4.	B. Tech Project /Part – II	CE4291	0	0	0	8	2	200
5.	Seminar	CE4292	0	0	0	2	0	50
6.	Comprehensive Viva	CE4293	0	0	0	2	0	100
	Practical Sub-total		NIL	NIL	0	12	2	350
	Eighth Semester Total					**22**	**12**	**650**

Total Credit: 24 + 24 + 27 + 27 + 25 + 23 + 24 + 22 = 196

Syllabus of Undergraduate Subjects - B. Tech. (CE)

1st/2nd Semester

CE 1101/CE1201: Environment and Ecology

Weekly Contact: 3 – 0 – 0 (L – T – P) **Marks: 100** **Credit: 3**

Course Objective: To provide the students with basic understanding about the environment and its allied problems, and identify and solve environmental problems.

Course Outcome: At the end of the course, the students will be able to:

- Understand the different components of the environment and functional and structural attributes of the ecosystem.
- Correlate the effects of environmental pollution with the changes in the ecosystem.
- Understand the reasons of environmental pollution
- Acquire the knowledge solving the environmental problems
- To understand the pollution pathways and assess the risk
- Acquire the knowledge about conducting environmental impact assessment

Syllabus: Introduction, ecology, water and wastewater, basics of air pollution, solid waste management, noise pollution, pollutant pathway, exposure, risk assessment, environmental impact assessment.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction: Environment-Human interaction, Sustainability – Definition/Goals, Sustainable Development, Case studies	3
2.	Ecology: Ecosystem and its Components, ecosystem functions, Anthropogenic impact on aquatic and terrestrial ecosystem, Biodiversity,	6
3.	Water and Wastewater – Sources, Quality, Treatment standards, conservation and recycling water crisis and related issues	6
4.	Basics of Air Pollution – Global and Local, Air Quality Standards, Energy and Climate Change, Energy and Sustainability	6
5.	Solid Waste Management, Hazardous Waste Management, recycling/reuse	6
6.	Basics of Noise Pollution, Noise Standards	3
7.	Pollutant pathway, exposure, risk assessment	3
8.	Environmental Management: Environmental Impact Assessment, Life Cycle Analysis, Pollution Control Acts, Legal aspects, role of Governments and NGOs, Environmental Education.	6

Total	39

Suggested readings:

1. Peavy, H. S., Rowe, D. R., and Tchobanoglous, G. (1985), "Environmental Engineering", McGraw Hill Book Company, Singapore.
2. Masters, G.M. (1995), "Introduction to Environmental Engineering and Science", Second Indian Reprint, Prentice Hall, New Delhi.
3. Edward J. Kormondy (1999), "Concepts of Ecology", Prentice –Hall
4. Rajagopalan, R. (2011), "Environmental Studies – from Crisis to Cure", 2nd Ed. Oxford University Press.

3rd Semester

CE 2101: Surveying

Weekly Contact: 4 – 0 – 0 (L – T – P) **Full Marks: 100** **Credit: 4**

Course Objective: To provide the students with a basic understanding of principles of field surveying procedures and practices for civil engineering applications. The course also intends to impart basic knowledge on various topics of advanced surveying.: for example, photogrammetry, Global Positioning Systems (GPS), land use mapping and hydrographic survey.

Course Outcome: In this course, students will gain a theoretical and applied understanding of surveying principles and practices. The course learning outcomes are:

- Measurement of distance using tape or EDM and angle using compass and theodolite
- Profile levelling and contouring using levelling instruments
- Principles and practices used in triangulation, traversing and plane table surveying
- Surveying through Total Station equipment
- Land use mapping using aerial survey
- Principles of hydrographic surveying, measurements and applications

Syllabus: Basic concepts of surveying, distance measurement, angle measurement, levelling, conventional surveys, plane table surveying, total station surveying, geomatics engineering, engineering survey, hydrographic survey.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Basic concepts of surveying: Principles – Basic measurements – Control networks – Locating position - Errors in measurement	3
2.	Distance measurement: Principles and methods – Errors in taping and chaining – Electromagnetic Distance measurement (EDM) – measuring principles – errors, checking and calibration.	5

3.	Angle measurement: Measurement with compass and theodolite – methods of measurements – instrument adjustment – sources of error.	4
4.	Levelling: Principles of levelling – equipment – effect of curvature and refraction – simple and differential levelling - adjustments – Contouring - Tacheometry – Different types of tacheometric measurements - fixed hair and tangential method	9
5.	Conventional surveys: traversing – plane rectangular coordinates – development of triangulation network – method of triangulation – traversing	3
6.	Plane table surveying: different methods - two and three-point problems	2
7.	Total station surveying: principles – classification – salient features of total station – adjustments	6
8.	Geomatics Engineering: the concept of GPS - principles – errors – GPS survey methods - planning of GPS survey - aerial surveying – photogrammetry – stereoscopy - land use mapping	9
9.	Engineering survey: computation of area and volume – Trapezoidal rule, Simpson's rule etc. – the concept of horizontal and vertical curves – practical applications – setting out of circular and transition curve	7
10.	Hydrographic Survey: Introduction - principles of hydrographic surveying - water levels and tidal datums - tidal observations - depth measurement - applications of hydrographic surveying	4
	Total	52

Suggested Readings:

1. Ghosh, J. K. (2010), "Elementary Engineering Surveying", Studium Press (India) Pvt Ltd.
2. Duggal, S. K. (2013), "Surveying (Vol. 1, Vol 2)", Tata McGraw-Hill Education India
3. Subramanian, R. (2013), "Surveying and Leveling", Oxford University Press
4. Roy, S. K. (2010), "Fundamentals of Surveying", Prentice Hall India Learning Private Limited
5. Bossler, J.D. (2010), "Manual of Geospatial Science and Technology", Taylor and Francis.

3rd Semester

CE 2102: Civil Engineering Materials

Weekly contact: 4 – 0 – 0 (L – T – P) **Full Marks: 100** **Credit : 4**

Course Objective: To introduce the students with various materials used in civil engineering applications, why and where they are used and what are their properties that are important.

Course Outcome: At the end of the course, the students will be able to:

- Identify and characterize building materials with the help of latest IS codes
- Understand the manufacturing process of bricks and cement
- Learn to perform Mix Design of concrete
- Identify the methods for preservation of timber
- Understand the use of non-conventional civil engineering materials

Syllabus: Physical properties and uses of bricks, cement, mortar, timber, bitumen, metals.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Physical properties of building materials	2
2.	a. Bricks: classification, testing, ingredients, defects, manufacturing. b. Brick masonry: Definitions, Rules for bonding, Type of bonds – stretcher bond, Header bond, English bond, Flemish Bond	6
3.	Rocks and stones: classification, characteristics of good building stone, testing, preservation and application of stones	2
4.	Wood and wood products: classification of trees. Structure, seasoning, conversion, defects and preservation of timber. Market forms of timber	4
5.	Building mortars: classification, characteristics of good mortar, functions of ingredients, cement mortar, lime mortar, testing of mortar. Grout	4
6.	Ferrous materials: Structure of ferrous materials, iron, Pig iron, cast iron, steel: properties and uses, heat treatment, rolled steel sections, reinforcing steel bars, rusting and corrosion, tensile testing	4
7.	Non-ferrous materials: aluminium, ceramics, glass, polymer, FRP, SMA	2
8.	Tar, bitumen, asphalt, paints, enamels and varnishes	2
9.	Cements: OPC, PPC, PSC, chemical composition, hydration, setting time, manufacturing and testing of cement.	8

10.	Aggregates: coarse and fine aggregates, impurities of aggregates, classification and tests	6
11.	a. Concrete: Types, ingredients, water cement ratio, workability, durability, defects and strength of concrete. Tests on cement concrete. b. Concrete mix design: principles, ingredients, acceptance criteria, proportioning the ingredients using IS10262:2019	6 6
	Total	52

Suggested Readings

1. Duggal, S.K. (2012), "Building materials", New Age International Publishers.
2. Neville, A.M. (2011), "Properties of concrete" Pearson.
3. Setty, M.S. (latest edition), "Concrete Technology", S.Chand & Co**.**

3rd Semester

MA2101: Mathematics-III

Weekly contact: 3 - 0 - 0 (L – T - P) Full Marks: 100 Credit : 3

Sl. No	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Probability: Axiomatic approach to probability theory, Univariate probability distributions – discrete and continuous. Standard distributions: Binomial, Poisson, Geometric, Exponential, Normal, Uniform and Gamma. Bivariate distributions – concepts of joint and conditional distributions, Mathematical expectation, variance and covariance. Correlation coefficient. Tchebycheff's inequality. Concept of convergence in probability and convergence almost sure. Laws of Large Numbers (statement only).	15
2.	Statistics: Concept of Statistics, Idea of sample correlation coefficients, curve fitting: Method of Least Square, Simple Regression models, Elements of the theory of Point Estimation: Unbiasedness and Mean Squared Error - bias-variance decomposition. Minimum Variance Unbiased Estimators. Maximum Likelihood Estimation. Consistent Estimators.	8

3.	Laplace Transform: Definition, Laplace transform of elementary functions, basic operational properties, Inverse Laplace transform, Convolution theorem, applications to initial value problems involving Ordinary Differential Equations.	6
4.	Linear Programming Problem: Basic solution, reduction of feasible solution to basic feasible solution, convex combination, convex set, extreme points, hyperplanes, slack and surplus variables, Simplex Method, Charnes' Big-M method.	10
	First half: Sl. No. 1,2 Second half: Sl. No. 3, 4	39

Suggested Readings:

Latest editions of

1. Mood, Graybiii& Boes, Introduction to the theory of statistics
2. Hoel, Port & Stone, Introduction to probability Theory
3. S.M. Ross A first course in probability
4. Amritava Gupta, Groundwork of Mathematical Probability and Statistics
5. P. M. Karak, Linear programming
6. J.G. Chakraborty & P.R. Ghosh Linear programming and Game theory
7. R.V. Churchill, Operational Mathematics

3rd Semester

AM 2103 Solid Mechanics

Weekly Contact: 3 – 1 - 0 (L – T - P) **Full Marks: 100** **Credit: 4**

Sl No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Introduction and concept of elastic behaviour, Concept of stress and strain : normal stress, shear stress, state of stress at a point, normal strain, shear strain, Hooke's law, Poisson's ratio, analysis of axially loaded members, Thermal stress	06
2.	Flexural loading: shear and moment in beams, load-shear-moment relationship, shear and moment diagrams	08
3.	Flexure and shear stress in beam	04

4.	Torsion: Torsion of cylindrical bars, torsional stress, modulus of rigidity and deformation	03
5.	Transformation of stress and strain, principal stresses, principal strains, Mohr's circle for stress and strain, introduction to theories of failure	09
6.	Combined loading: axial and torsional; axial and bending; axial, torsional and bending.	05
7.	Bending of non-symmetric sections, curved beams, shear flow, shear centre un thin walled section,	06
8.	Strain energy due to axial forces, bending and torsion, Castigliano's theorem and simple applications	04
	Total	45

Text Book: 1. Elements of Strength of Materials - S.P. Timoshenko and D.H. Young.

Reference Books:

1. E. Popov, Mechanics of Materials
2. R K Bansal, A Text Book of Strength of Materials
3. F.P. Beer and E.R. Johnston Jr., Strength of Materials
4. D.S. Prakash Rao, Strength of Materials (Vol. 1)

3rd Semester

AM2104: Hydraulics

Contact Period: 3-1-0 (L-T-P) **Full Marks: 100** **Credit : 4**

Sl No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Dimensions and SI units of physical quantities relevant to fluid mechanics. Fluid pressure: absolute and gauge pressures, measurement of pressure by piezometer, different types of manometers and pressure gauges. Hydrostatic pressure forces on flat and curved surfaces, concept of pressure prism. Centre of pressure.	05

2.	Fluid kinematics & basic equations of fluid flow: steady flow, uniform flow, laminar flow, turbulent flow, streamline, stream tube, streak line, path line, concept of one/two/three-dimensional analysis of flow. Continuity equation for unidirectional flow, local & convective accelerations, Euler's equation of motion along a streamline, Bernoulli's energy equation, momentum equation, KE correction factor and momentum correction factor.	06
3.	Flow measurements: flow through orifices, orifice coefficients, mouthpieces attached to orifices, velocity measurement by Pitot tube, measurement of discharge by venturimeter, orificemeter, notches & weirs of different shapes and corresponding formulae.	06
4.	Basic hydrodynamics [ideal fluid flow]: three-dimensional continuity equation, rotational & irrotational flows, velocity potential function & stream function, equipotential line & stream line, flow net, circulation & vorticity.	04
5.	Dimensional analysis: dimensional homogeneity of an equation, Buckingham π theorem and their application to fluid flow problems. Geometric, kinematic and dynamic similitude. Reynolds law & Froude's law, corresponding dimensionless parameters applicable to various flow situations.	05
6.	Viscous flow through pipes: derivation of Navier-Stokes equations and its application to viscous flow through circular pipes, Hagen-Poiseuille velocity distribution, average velocity, discharge, pressure drop, wall shear stress and friction factor. Critical Reynold's number.	08

7.	Turbulent flow through pipes: concept of turbulence, effects of turbulence on velocity distribution, Prandtl mixing length and universal velocity distribution. Hydraulically smooth & rough pipes. Average velocities derived from velocity distributions. Friction factors given by Karman-Prandtl equation and Colebrook & White equation. Derivation of Darcy-Weisbach equation for major head loss, friction factor & Moody diagram, different types of minor losses, hydraulic & energy grade lines, flow through pipes connected in series and/or parallel. Transmission of hydraulic power through pipes and pipe economics. Analysis of pipe network. Three reservoir problems.	14
	Total	48

Suggested Readings:

Latest editions of

1. R W Fox and A T McDonald, Introduction to Fluid Mechanics, Wiley India
2. F M White, Fluid Mechanics, McGraw-Hill International

3rd Semester

CE 2171: Civil Engineering Drawing

Weekly contact: 0 – 0 – 3 (L – T – P) **Full Marks: 50** **Credit : 2**

Course Objective: To impart the knowledge of civil engineering and building components, their functionalities, etc. as per municipal and code provisions. The course intends to enable students to learn drawing various building units in different views, on paper using drawing tools, as well as to familiarize usage of computer-aided drawing software for the same.

Course Outcome: At the end of this course, the students shall be able to-

- Identify various components of a building and know their functionalities.
- Know various building planning concepts such as various areas, spaces and coverages as well as the municipal and codal provisions.
- Draw a detailed plan, elevation and section of a building on drawing sheets with all its components including doors, windows, arches
- Know drawing of buildings in computer-aided drawing software

Syllabus: Drawing of plan, elevation and section of a building as per various building planning concepts of Area Height Limitations, Covered Area, Plinth Area, Ground Coverage, Open Spaces and Parking Space. Introduction and drawing of building plans, elevation in AutoCAD software.

Description of module and lecture plan:

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Section I Building drawing	
	1. Different components of a typical building.	3
	2. Drawing detailed plan, elevation and sectional elevation of a small building by measurement and foundation details, including DPC, roof, parapet and plumbing.	6
	3. Various types of arches, doors and wall junctions of various thickness.	3
2.	Section II Building planning	
	4. Principles of building planning	1
	5. Building planning concepts - Area Height Limitations, Covered Area, Plinth Area, Ground Coverage, Open Spaces and Parking Space as per regulation of Municipal Corporation	2
	6. Preparation of plan (sketch) of a typical apartment building as per provisions in (4) and Municipal Regulations.	3
3.	Section III Building drawing using software	
	7. Introduction to AutoCAD software- tool bars, modes, units and layouts.	3
	8. Creation of layers, dimensioning and hatching.	3
	9. 2D drawing of an apartment building (plan, elevation, section, foundation, water supply and sanitary system) in AutoCAD software.	12
	10. Presentation / Viva	3
	Total	39

Suggested Readings:

1. Bhavikatti, S.S., and Chitawadagi, M.V. "Building Planning and Drawing", I K International Publishing House Pvt. Ltd, Delhi.
2. Jeyapooran, T. (2000), "Engineering Drawing with AutoCAD", Vikas Publishing House, Delhi.
3. Shrock, C.R. (2005). "Exercise workbook for beginning AutoCAD", Industrial Press, New York, USA.

3rd Semester

CE 2172: Introduction to Civil Engineering

Weekly Contact: 0 – 0 – 3 (L – T – P) **Full Marks: 50** **Credit: 2**

Course Objective: To provide an overall idea of Civil Engineering discipline and scope of Civil Engineering profession.

Course Outcome:

- Understanding the essence of Civil Engineering.
- Get idea about the different specialized areas of Civil Engineering
- To know about the emerging fields of Civil Engineering
- Know about the scope and opportunities of Civil Engineering

Syllabus: Introduction to Civil Engineering; Specialized areas of Civil Engineering; Concept about Civil Engineering projects and emerging fields.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction to Civil Engineering	3
2.	Specialized areas of Civil Engineering	9
3.	Concepts about different projects and case studies	15
4.	Concepts about different emerging fields	9
5.	Evaluation	3
	Total	39

Suggested Readings:

1. Gopi, S. (2009) Basic Civil Engineering, Pearson Publisher.
2. Kandya, A. A. (2015) Elements of Civil Engineering, Charotar Publishing House.

3rd Semester

AM2174: Solid Mechanics Laboratory

Contact Period: 0-0-3 (L-T-P) **Full Marks : 50** **Credit: 2**

Sl. No.	Name of experiments	No. of Classes
1.	Rockwell Hardness Test	03
2.	Brinell Hardness Test	03
3.	Tension Test of Metals	03
4.	Experiment on Strain Hardening of Metals	03
5.	Torsion Test of Circular Shaft	03
6.	Experiment on Impact Test	03
7.	Buckling or Critical Load for Long Column	03
8.	Testing of wood	03
9.	Measurement of Beam Deflection Using Dial Gauge	03
Viva voce		03
	Total	30

3rd Semester

AM2175: Hydraulics Laboratory

Contact Period: 0-0-3 (L-T-P) **Full Marks : 50** **Credit: 2**

Sl No.	Name of experiments	No of Classes
1.	Friction losses in pipe and pipe fittings	03
2.	Verification of Bernoulli's theorem	03
3.	Determination of orifice coefficients	03
4.	Reynolds experiment	03
5.	Velocity measurement using pitot static tube	03
6.	Determination of metacentric height	03
7.	Force of impact of jet on vanes	03
8.	Determination of Manning's roughness coefficient	03
9.	Friction losses in commercial pipes	03
10.	Calibration of a rectangular weir	03
11.	Calibration of an orifice meter	03
	Viva Voce	03
	Total	36

4th Semester

CE 2201: Structural Analysis - I

Class Load/week: 4 -0 – 0 (L – T – P) **Full Marks: 100** **Credit: 4**

Course Objective: To introduce students to basic structural concepts and familiarize them with various types of structural forms. The course intends to enable students to comprehend redundancy in a structure and provide means to analyse statically determinate and indeterminate structures utilizing different techniques.

Course Outcome: At the end of the course, the students will be able to: [Maximum 5/6 bulleted points]

- Understand the basic characteristics of different structural forms and identify instability and redundancy in a structure.
- Analyse the deflection in statically determinate beams, frames and trusses.
- Obtain the bending moment and shear force diagrams for statically indeterminate beams and frames.

- Analyse cable and arch structures.

Syllabus: Introduction to structural forms, stability and determinacy; analysis of statically determinate and statically indeterminate beams, frames and trusses; analysis of arch and cable structures.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction: Structure and its various forms; Stability and Determinacy of structures	4
2.	Analysis of Statically Determinate Structures: a) Deflection of beams and frames by Macaulay's method, Moment-Area method, Conjugate Beam method, Unit load method b) Deflection of trusses by Unit load method	 10 4
3.	Analysis of Statically Indeterminate Structures: a) Concepts of Force and Displacement methods b) Consistent Deformation/Compatibility Method c) Three Moment theorem for continuous beams	 4 4 4 8

	d) Slope Deflection and Moment Distribution methods for beams and frames e) Castigliano's theorems and theory of least work.	6
4.	Analysis of Arch structures	4
5.	Analysis of Cable structures	4
	Total	52

Suggested Readings:

Latest editions of

1. Sack R L, Structural Analysis, McGraw Hill.
2. Hibbler R C, Structural Analysis, Pearson.
3. Smith J C, Structural Analysis, Harper and Row, New York.
4. Wang C K, Intermediate Structural Analysis, McGraw Hill.
5. Reddy C S, Basic Structural Analysis, Tata McGraw Hill.
6. Pandit G, Gupta S, Gupta R, Theory of Structure, Vol. 1., McGraw Hill Education India Pvt Ltd.
7. Roy S K, Chakraborty S, Fundamentals of Structural Analysis, S Chand.

4th Semester

CE 2202: Geotechnical Engineering I

Weekly Contact: 4 - 0 - 0 (L-T-P) **Full Marks: 100** **Credit: 4**

Course Objective: To introduce the basic understanding of physical and mechanical properties of soil, together with the knowledge of engineering procedures used to classify soils. The course also intends to familiarize the students with permeability and seepage phenomena, stress distribution in soils, consolidation, shear strength and earth pressure concepts.

Course Outcome: At the end of the course, the students will be able to:

- Characterize and classify soils based on formation and engineering properties

- Analyse the phenomena of seepage through soils, and the factors governing soil permeability
- Compute the stress generated in soils due to various loading conditions
- Compute and analyse the consolidation settlements
- Identify the shear strength parameters of soil through laboratory tests and field investigations
- Understand the principles of earth pressure theories and its application to retaining walls
- Familiar with advanced geotechnical testing facilities

Syllabus: Formation of soil, phase relation, index properties, classification of soils, soil-water, permeability and seepage, stresses in soils, compressibility and consolidation, shear strength of soil, earth pressure.

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Formation of soil	2
2.	Phase relation: Soil phases, Definitions, Specific gravity of soils, Weight volume relationships	2
3.	Index properties: Shape and size of particles, Stoke's Law, Determination of grain size distribution of soils, Limits and indices, Plasticity chart, Identification of soils, Relative density	4
4.	Classification of soils: Indian Standard Classification System, Unified soil classification system	3
5.	Soil water: Structural water, adsorbed water, capillary water, free water, concept of effective and pore water pressure	2
6.	Permeability and Seepage: Head , Gradient and potential, Darcy's Law, Factor affecting permeability, permeability of stratified deposits, laboratory and field determination of permeability, Laplace equation, seepage, quick sand condition, flow net	8
7.	Stresses in soils: Boussinesq and Westergaard equations, concept of pressure bulb. Vertical stresses in soils under concentrated load, line load, strip load and uniformly distributed loads over limited areas of different shapes, Newmark's chart.	6

8.	Compressibility and consolidation: Compressibility parameters, consolidation, Terzaghi's one dimensional consolidation, determination of coefficient of consolidation, normally consolidated and over consolidated soils, computation of consolidation settlement.	8
9.	Shear strength of soil: Concept of shear strength, Mohr-Coulomb failure criteria, Mohr circle, Determination of shear strength parameters – laboratory and field methods, pore pressure parameters, sensitivity and thixotropy	7
10.	Earth pressure: Concept of earth pressure. Rankine and Coulomb's earth pressure theories, Different types of backfill, Analytical and graphical methods for determination of earth pressure against retaining walls	10
	Total	52

Suggested Readings:

1. Tayler, D.W. (1948), "Fundamentals of Soil Mechanics", Asia Publishing Hall.
2. Sing, A. (1967), "Soil engineering in theory and practices", Asia Publishing Hall.
3. Murthy, V.N.S. (2010), "Geotechnical engineering", CRC Press.
4. Craig, R.F. (2004), "Craig's Soil Mechanics", Taylor & Francis.
5. Lambe, T.W., and Whiteman, R.V. (1969), "Soil Mechanics", John Wiley & Sons.

4th Semester

CE 2203: Environmental Engineering I

Weekly Contact: 4-0-0 (L-T-P) **Full Marks:100** **Credit: 4**

Pre requisite: CE1201, AM-303/1

Course Objective: The course Environmental Engineering I is designed for the UG Civil Engineering students to focus on water and wastewater quality parameters, its effect on the water environment and different aspects of water and wastewater treatment**.** It was aimed to foster the young minds towards the importance of efficient use of water and wastewater treatment, disposal and the factors that govern the process. To grasp the idea as the beginners, five different modules were designed.

Course Outcome: At the end of the course, the students will be able to:

- Differentiate between water and wastewater and will know about its characters and prevailing guidelines and standards.
- Understand the conventional water treatment and the unit operations associated with it and factors governing the process.
- Know the wastewater conveyance system and appurtenances
- Know the conventional wastewater treatment system, treatment (on-site, off-site) and disposal of wastewater efficiently
- Understand the sludge disposal and reuse of treated wastewater.

Syllabus: Water and wastewater quality, water abstraction, water and wastewater treatment, sludge disposal, on-site wastewater treatment and wastewater reuse

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Water and Wastewater Quality: Physical, chemical and biological water and wastewater quality parameters, river water quality, water quality requirements, Indian Standards, Standards of disposal into natural water courses and on land.	8
2.	Water Demand, Abstraction of Ground and Surface Water and Water Distribution Network: Population forecasting, Water demand, Aquifer and its types, Well: open well and tube well, Sinking of tube well, Intake and its types, factors governing the location of an intake, Hydraulics of pipe flow – Hazen Williams equation, Water distribution network analysis.	10
3.	Water Treatment: Historical overview of water treatment, Water treatment processes: aeration and types of aerators, solids separation: coagulation and flocculation-influencing factors, settling operation-Clariflocculators, filtration-slow and rapid sand filters-Gravity and Pressure filters-filter operation and maintenance, disinfection-Criteria of good disinfectant, mechanism of disinfection, influencing factors-breakpoint chlorination-other disinfecting chemicals in use, softening, iron and manganese removal.	14
4.	Wastewater Collection and Conveyance: Conservancy system, Water carriage system, Types of sewerage system, Layouts of sewers, Sewer and drain-sewer appurtenances, Estimation of sewage quantity, Hydraulics and design of sewer.	8

5.	Wastewater Treatment: Preliminary treatment: Screening, grit removal units, oil and grease removal, primary treatment, secondary treatment: suspended growth and attached growth systems, sludge digestion and drying beds, stabilization ponds, Septic tank, Soakage systems, and wastewater reuse.	12
	Total	52

Suggested Readings:

1. Peavy, S. P., Rowe, D.R. and Tchobanoglous, G. (1985), "Environmental Engineering", McGraw-Hill Book Company, Singapore.
2. Punmia, B. C., Jain, A. K., and Jain, A. K. (2006), "Wastewater Engineering", Laxmi Publications (P) Ltd., New Delhi.
3. Punmia, B. C., Jain, A.K. and Jain, A.K. (1995), "Water Supply Engineering", Laxmi Publications (P) Ltd., New Delhi.
4. Garg, S. K. and Garg, R. (1979), "Sewage Disposal and Air Pollution Engineering", Khanna Publishers, Delhi.

4th Semester

CE 2204: Water Resources Engineering– I

Weekly Contact: 4-0-0 (L-T-P) **Full Marks: 100** **Credit: 4**

Course Objective: The objective of the course is to impart knowledge to the students about the basic concepts of hydrology. This will help them to understand the different components of the hydrological cycle along with an idea of computation or estimation of the components. The principle of open channel flow will also be introduced.

Course outcome: At the end of the course, the students will be able to:

- Understand the principle of flow through open channel
- Know about the hydrologic unit- catchment and water budget
- Compute average precipitation over a catchment along with computer application of gridded data for raingauge stations
- Estimate the different losses from precipitation
- Estimate the surface runoff using different methods along with handling the water scarcity situation
- Understand different methods of measurement of streamflow and generate flood hydrographs
- Apply statistical methods in frequency analysis of hydrologic events

Syllabus: Open Channel flow, Introduction to Hydrology, Precipitation, Losses from Precipitation, Runoff, Streamflow Measurement, Hydrographs, Statistical Preliminaries

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Open Channel Flow: Channel Characteristics and parameters, Uniform flow, Critical flow, Specific Energy concepts, Gradually Varied Flows	06
2.	Introduction to Hydrology: Catchment and its physical characteristics, Hydrologic Cycle, Hydrologic Budget, use of DEM data for Catchment Delineation.	04
2.	Precipitation: Types and Forms, Southwest Monsoon, Measurement: Rain Gauges, Data Processing: Rainfall Mass Curve, Hyetograph, Average Rainfall, Computer Applications with Gridded Data	07
3.	Losses from Precipitation: Evaporation, Evapotranspiration and Infiltration: Processes, Measurement and Estimation, Computer applications.	06
4.	Runoff: Factors affecting Runoff, Estimation of Runoff, SCS method, Watershed Models, Flow-duration curve, Surface Water Resources of India, Water Scarcity, Drought Analysis, Computer Applications with HEC-HMS.	06
5.	Streamflow Measurement: Different Direct and Indirect Methods, Stage-Discharge Curve; Unsteady Flow and Backwater Effects, Computer Applications.	07
6.	Hydrographs: Definition and Characteristics, Baseflow Separation, Unit Hydrographs, S-Curve, Synthetic Unit Hydrograph, Distribution Graph, Computer Applications.	06
7.	Statistical Preliminaries: Statistical Terminology, Probability of Discrete and Continuous Random variables, Distribution Functions, Reliability of Estimates of Distribution Characteristics, Point Rainfall frequency analysis, Intensity Duration Curve, DAD curve	10
	TOTAL:	52

Suggested Readings: Latest editions of

1. Subramanya, K, “Engineering Hydrology”, Tata McGraw-Hill.
2. Reddy, P. J., “A Textbook of Hydrology”, University Science Press.
3. Singh, V. P., “Engineering Hydrology”, Prentice Hall of India.
4. Subramanya, K, “Flow in Open Channels”, Tata McGraw-Hill.

ES2201: Geology for Civil Engineering

Weekly Contact: 3 – 0 - 0 (L-T-P) **Full Marks: 100** **Credit: 3**

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lecture
1	Physical Geology-Weathering, Erosion, Transportation, Deposition, Geological Agents. Overall ideas about the work done by Geological Agents. The Earth-Origin, age, internal constitution. Geological timescale-a brief introduction.	5
2	Mineralogy -Definition of Minerals, Non-crystalline, Crystalline matter and -Crystals. Physical Properties of Minerals in general. An Introduction to physical properties of Cornmon Rock Forming Minerals and Economic Minerals.	6
3	Petrology- Definition of Rocks. Brief idea on different types of Rocks. Igneous Rocks-, forms, Structures and Textures. Sedimentary Rocks- Genesis, Texture, Classification. Metamorphic Rocks -Factors controlling Metamorphism, Textures and Structures of Metamorphic Rocks. Petrography of common Igneous, Sedimentary and Metamorphic rocks	5
4	Structural Geology -Brief idea about fold, fault, unconformity, lineation, foliation	6
5	Seismology: An introduction to Earthquake. Elastic Rebound Theory. Different types of seismic waves. Global distribution of seismic zones.	6
6	Geohydrology -Sources of Ground water, Hydrological Zones below the surface, porosity, permeability, aquifer-confined and unconfined, engineering importance of ground water study	6
7	Engineering Geology –Importance of geological investigation in engineering projects, site selection for dam, bridge, tunnel & reservoir, stability of hill slopes along road and railway cuttings.	5
	Total	39

Suggested Readings:

1. Understanding earth (2004) by Press, Frank, Raymond Siever, John Grotzinger, and Thomas H. Jordan. Macmillan,
2. P. K. Mukherjee, A Textbook of Geology, compiled by and published by World Press
3. GB Mahapatra, A Textbook of Geology, published by CBS Publishers & Distributors
4. Holmes' Principles of Physical Geology edited by Peter MacLaren Donald Duff, Donald Duff published by Taylor & Francis, 1993

4th Semester

CE 2271: Water Resources Engineering Laboratory

Class Load/week: 0 - 0 – 3 (L – T – P) **Full Marks: 50** **Credit : 2**

Course Objective: To provide the students with basic understanding of how to determine the various hydrological parameters practically and develop a deeper understanding about hydrological processes as well as flow in the open channel.

Course Outcome: At the end of the course, the students will be able to:

- Delineate catchment boundary from contour map as well as from DEM data.
- Calculating average rainfall over a catchment area
- Determination of Infiltration and Evaporation Characteristics
- Measure velocity distribution in Open Channels
- Analyse rainfall data and develop IDF curves
- Measure streamflow using current meter and ADCP

Syllabus: Delineation of catchment, Determination of average rainfall. Different types of climatic measurement devices, Infiltration and Evaporation loss, Current meter, Flow in open channel

Sl. No	Description of Course Modules and Lecture Plan	Contact hours
1.	Delineation of Catchment Boundary from contour map and Measurement of Catchment Area	6
2.	Delineation of Catchment Boundary from Digital Elevation Model	3
3.	Thiessen Polygon and Average Rainfall	3
4.	Measurement of Evaporation Loss	3

5.	Use of Hygrometers, Min-max Thermometers, Sunshine Recorder	3
6.	Use of Infiltrometer and measurement of infiltration capacity	3
7.	Demonstration of Current Meters and ADCP	6
8.	Experiments on flow in open channels	9
9.	Viva-voce	3
	Total	39

Suggested Readings:

1. Subramanya, K. (2017), "Engineering Hydrology", McGraw Hill Education.
2. Reddy, P. J. R. (2016), "A Textbook of Hydrology", Laxmi Publications.
3. Subramanya, K. (2015), "Flow in Open Channels", McGraw Hill Education.

4th Semester

CE 2272: CE Materials Laboratory

Weekly contact: 0 – 0 – 3 (L – T – P) **Full Marks:** **Credit: 2**

Course Objective: Introduce the students to hands-on training of testing of various materials used in civil engineering applications.

Course Outcome: At the end of the course, the students will:

- Understand the suitability of building materials with the help of latest IS codes
- Become conversant with the testing process of bricks, cement, fine aggregate and coarse aggregate.
- Learn to test cement-sand mortar samples
- Know the testing procedure of concrete paver blocks.

Syllabus: Testing procedures of bricks, cement, fine aggregate, coarse aggregate, mortar, steel bars and paver blocks.

Sl. No.	Description of Course Modules and Lecture Plan	Contact hours

1	a. Sieve analysis of coarse aggregate and determination of fineness modulus. b. Sieve analysis of fine aggregate and determination of fineness modulus.	3
2	Determination of specific gravity and water absorption of coarse aggregates	3
3	Determination of crushing value of coarse aggregates.	3
4	Determination of bulking factor and silt factor of fine aggregates.	3
5	Determination of specific gravity and water absorption of fine aggregates	3
6	a. Determination of standard consistency of cement b. Determination of fineness of cement by Sieve analysis & Blaine apparatus	3
7	a. Determination of Initial and Final setting time of cement. b. Determination of specific gravity of cement	3
8	Casting of cement- sand mortar cubes with standard sand for determination of compressive strength of cement	3
9	Testing of cement-sand mortar cube samples b. Determination of soundness of cement by Le-Chatelier method and Autoclave method.	3
10	Testing of bricks and blocks a. Dimensioning b. Unit weight/density c. Compressive strength d. Water absorption e. Efflorescence	3
11	Testing of Steel bars a. Tensile strength (Yield Stress and Ultimate Tensile Stress) b. Elongation tests (% of elongation)	3

12	Testing of precast concrete paver blocks a. Dimensioning b. Compressive strength c. Flexural strength d. Water absorption	3
13	Submission of final reports and viva voce	3
	Total classes	39

Suggested Readings:

1. Duggal, S. K. (2012), "Building materials", New Age International Publishers.
2. Neville, A. M. (2011), "Properties of concrete", Pearson.

IS Codes: (latest versions to be considered):

1. IS. 383, IS 2386: (coarse & fine aggregates)
2. IS. 456, IS 455, IS 269, IS 4031 (cement)
3. IS. 15658 (paver block)
4. IS. 800 (steel)
5. IS. 3495 (brick)

4th Semester

CE2273: Surveying Laboratory

Weekly contact: 0 – 0 – 3 (L – T – P) **Full Marks: 50** **Credit: 2**
Prerequisite: Surveying (CE 2101)

Course Objective: To provide the students with a basic understanding of principles of field surveying procedures and practices for civil engineering applications.

Course Outcome: In this course, students will gain applied understanding of surveying principles and practices. The course learning outcome are:

- Measurement of distance using tape or EDM and angle using compass and theodolite
- Profile levelling and contouring using levelling instruments
- Principles and practices used in triangulation, traversing and surveying through Total Station equipment

Syllabus: Introduction, chain triangulation, traversing with prismatic compass, profile levelling with dumpy level, contouring, theodolite traverse, total station and measurements, setting out buildings, setting out highway curves.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction - surveying equipment - basic measurement	3
2.	Chain Triangulation - Plotting the chain triangulation of a given area	3
3.	Traversing with Prismatic Compass - Plotting the compass traverse of a given area and graphical adjustments	3
4.	Profile levelling with Dumpy level - Longitudinal sectioning and cross-sectioning	6
5.	Contouring - preparation of contour map of a given area	6
6.	Theodolite traverse – theodolite traversing and plotting the results graphically	6
7.	Total station and measurements - Surveying through Total Station equipment	6
8.	Setting out buildings	3
9.	Setting out highway curves	3
	Total	39

Suggested Readings:

1. Ghosh, J. K. (2010), “Elementary Engineering Surveying”, Studium Press (India) Pvt Ltd.
2. Duggal, S. K. (2013), “Surveying (Vol. 1, Vol 2)”, Tata McGraw-Hill Education India
3. Subramanian, R. (2013), “Surveying and Leveling”, Oxford University Press
4. Roy, S. K. (2010), “Fundamentals of Surveying”, Prentice Hall India Learning Private Limited

5th Semester

CE 3101: Structural Analysis - II

Class Load/week: 3 - 0 – 0 (L – T – P) **Full Marks: 100** **Credit: 3**

Course Objective: The objective of the course is to provide the students the detailed knowledge of structural analysis by both static and dynamic method. This will help them to determine the structural response for the design of various structural components.

Course outcome: At the end of the course, the students will be able to:

- Understand the basic concepts of Influence line diagrams for different types of loads
- Learn the analysis of structures by matrix method.
- Learn the analysis of structures by Plastic method.
- Understand the fundamentals concept of structural dynamics .
- Learn free and forced vibration of single-degree-of freedom systems

Syllabus: Basic Concepts. Influence line diagrams for different types of loads, Matrix method of structural analysis, Plastic analysis of structures, structural dynamics, single-degree-of freedom systems

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Influence line diagrams for different types of moving loads, Muller Breslau's Principle, Application to beams, trusses and arches	10
2.	Matrix method of structural analysis: Stiffness method – application to beams, trusses and frames	15
3.	Plastic analysis of beams and frames	4
4.	Introduction to structural dynamics: Free and Forced vibration of single-degree-of freedom systems	10
	Total	39

Suggested Readings:

Latest editions of

1. Ghali, A and Neville, A. M., "Structural Analysis (Unified Classical and Matrix Approach)", Chapman and Hall, Ltd.
2. Weaver, W. Jr. and Gere, J. M, "Matrix Analysis of Framed Structures", CBS Publishers
3. Sack, R. L., "Matrix Structural Analysis", Waveland Press
4. Reddy, C. S., "Basic Structural Analysis", Tata McGraw Hill
5. Roy, S. K., and Chakraborty, S., "Fundamentals of Structural Analysis", S Chand
6. Mukhopadhyay, M., "Structural Dynamics-vibrations and systems", Ane Books India
7. Chopra, A. K., "Dynamics of structures", Pearson

5th Semester

CE 3102: Design of RC Structures

Class Load/week: 4 - 0 – 0 (L – T – P) **Full Marks: 100** **Credit : 4**

Course Objective: To provide the students with basic understanding of design philosophies and fundamentals of Reinforced concrete structures. The course intends to familiarize the students with the Working Stress Method of design and the Limit State Method of design.

Course Outcome: At the end of the course, the students will be able to:

- Understand the fundamentals of Reinforced concrete structures.

- Design the structural members using Working Stress Method
- Design the structural members using Limit State Method
- Provide reinforcement details as per IS Code of practice.

Syllabus: Introduction - Design philosophies and fundamentals. Working Stress Method of design for one-way slab, singly reinforced beam, doubly reinforced beam, T-beams, Axially loaded column and Isolated column foundation. Limit State Method of design for two-way slabs, beams, columns, staircase, Isolated and combined footings, Pile and Pile cap.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Design philosophies of reinforced concrete structures and fundamentals of working stress method and limit state method of design.	4
2.	Working stress method of design & detailing of one-way slab	4
3.	Singly reinforced beam, doubly reinforced beam using working stress method. Introduction to T-beams	10

4.	Limit state method of design and detailing for two way slab.	4
5.	Design and detailing of singly reinforced, doubly reinforced and T-beams using limit state method	8
6.	Design and detailing of axially loaded column, axial load with uni-axial bending and axial load with biaxial bending for columns using limit state method	8
7.	Design and detailing of stair cases using limit state method.	4
8.	Design and detailing of isolated footing and combined footing using limit state method	6
9.	Design and detailing of pile and pile cap using limit state method	4
	Total	52

Suggested Readings:

1. Pillai, S. U., and Menon, D. (latest edition), "Reinforced Concrete Design", McGraw Hill Education
2. Subramanian, N. (latest edition), "Design of Reinforced Concrete Structures", Oxford Higher Education.

5th Semester

CE 3103: Transportation Engineering I

Class Load/week: 4 -0 – 0 (L – T – P) **Full Marks: 100** **Credit : 4**

Course Objective: The objective of the course is to teach students the essential components of transportation engineering, interactions between different modes of transportation, basic elements of highway engineering and geometric design. The course aims to provide students with a fundamental design concept of roadway pavement components and to understand various transportation structures. The course will try to introduce the basic engineering principles that help in the planning and design of airports

Course outcome: Upon completion of the course, Students are expected to attain the following outcome:

- Knowledge of the basic principles of transportation engineering, modal classification
- Understand the principles of highway geometrics design as per state of art design standards

- Understand types of pavements & materials required for highway construction
- Basic concept of Pavement design and fundamentals of transportation structures
- Knowledge of airport classification, planning, layout and components of airport systems, orientation and geometric design of runway and taxiway.

Syllabus: Basics of transportation engineering, highway engineering, pavement engineering, transportation structures and airport engineering

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Basics of transportation:	2
	Introduction to Transportation and Transportation Engineering, Role of Transportation	1
	Forms and Modes of Transportation and their Characteristics	1
2.	Highway Engineering	15
	History of Road Transportation in India	1
	Functional classification of roads; Cross sectional elements	2
	Road Planning & Route Survey	2
	Roadway Alignment : Geometric Design of Roads; sight distances; horizontal and vertical alignments	10
3.	Pavement Engineering	23
	Pavement Types and components	2
	Pavement materials – Subgrade soil, Granular material, aggregates, Bitumen, non-conventional material	5
	Construction of Roads – Embankment, Subgrade, Subbase, Base and Bituminous layers, Cement Concrete Pavements, Drainage	6

	Pavement Design– Flexible and Rigid pavement by IRC methods	8
	Road Maintenance -various type of failures, evaluation and remedial measures	2
4.	Transportation Structures: Bridges & Culverts	2
5.	Airport Engineering	10
	Functional areas of airports – Runways, Taxiways, Aprons, Terminal buildings	2
	Classifications of Airports	1
	Airport site selection	1
	Design of Runway, Runway orientation, Wind Rose diagram	3
	Runway capacity	1
	Design of Taxiway and Terminal Building	2
	Total	52

Suggested Readings:

Latest editions of

1. Khanna, S. K., Justo, C. E. G., and Veeraraghavan, A., "Highway Engineering", Nem Chand & Bros
2. Kumar, R.N., "A Textbook of Highway Engineering", Universities Press
3. Chakroborty, P., and Das, A., "Principles of Transportation Engineering", PHI Learning
4. Huang, Y. H., "Pavement Analysis and Design", Pearson Education, India
5. Horonjeff, R., McKelvey, F. X., Sproule, W. J., and Young, S. B., "Planning and Design of Airports", McGraw Hill
6. Kumar, V., and Chandra, S., "Air Transportation Planning & Design", Galgotia Publications
7. Bindra, S. P., "Principles and Practices of Bridge Engineering", Dhanpat Rai Publications

5th Semester

CE 3104: Environmental Engineering-II

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Pre-requisite: CE 2203

Course Objective: The course Environmental Engineering II was designed for the UG Civil Engineering students to focus on some major area of environmental concerns: solid waste management, air pollution, noise pollution and environmental impact assessment and management. It describes the sources, character and management of above pollution aspects. It was aimed to foster the young minds towards the importance of pollution potential of solid waste, air and noise. The air pollution aspects and global concerns, solid waste disposal and the factors that govern the efficient treatment are of prime importance and the students will acquire basic knowledge in this increasingly important issue of environmental pollution.

Course Outcome: At the end of the course, the students will be able to:

- Understand source, composition, character of different types of municipal solid waste.
- Acquire knowledge on different disposal techniques and the factors that govern the process.
- Understand the air pollutant and its sources, character, health effect and control system and global issues
- Acquire knowledge on noise pollution, health effects and control mechanisms.
- Know the various aspects of environmental impact assessment and management issues.

Syllabus: Solid waste management, air pollution and control, noise pollution and control, environmental impact assessment and management.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures

1.	Municipal Solid Waste: Characteristics (Physical, Biological and Chemical); Generation of waste, Waste Reduction at the Source, Collection techniques, Materials and Resources Recovery / Recycling. Transport of Municipal Solid Waste, Treatment, Transformations and Disposal Techniques (Composting, Vermi-Composting, Incineration, Refuse Derived fuels, Landfilling). Rules and Regulations, Economics of the on-site v/s off site waste management options.	10
2.	Air Quality: Classification of pollutants-Primary and secondary pollutants, types of air pollutants-particulate and gaseous and its sources, Air quality management concepts-air quality indexes, Effects of air pollution: Global effects of Air Pollution: Greenhouse effect, Acid rain, Ozone layer disruption Ambient and Emission Standards.	10
3.	Air Pollution and Meteorology: Air pollution episodes, Wind Profiles, Turbulent Diffusion, Stability of atmosphere, Inversion, Plume behaviour, Plume rise.	6
4.	Control of Air Pollution: Particulates: Terminology, Size distribution, removal mechanism, particulate collection devices, Sulphur Oxides: SO_x, Nitrogen Oxides: NO_X, Control techniques, control of vehicular emissions-catalytic converter.	6
5.	Noise Pollution: Definitions; noise levels and noise measurement; standards; continuous, intermittent and impulsive noise; noise criteria; noise propagation; health effect, noise control.	3
6.	Environmental Management: Environmental impact assessment, environmental audit, Pollution control acts, International protocols.	4
	Total	39

Suggested Readings:

1. Davis, M. L. and Cornwell, D. A. (2015), "Introduction to Environmental Engineering", 5th Ed. McGraw Hill Education (India) Private Limited, New Delhi.
2. Peavy, S. P., Rowe, D.R. and Tchobanoglous, G. (1985), "Environmental Engineering", McGraw-Hill Book Company, Singapore.
3. Punmia, B. C., Jain, A. K., and Jain, A. K. (2006), "Wastewater Engineering", Laxmi Publications (P) Ltd., New Delhi.
4. Garg, S. K. and Garg, R. (1979), "Sewage Disposal and Air Pollution Engineering", Khanna Publishers, Delhi.

5th Semester

CE 3105: Water Resources Engineering II

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Pre-requisite: CE 2204

Course Objective: The objective of the course Water Resources Engineering II is to introduce the students to the basic concepts of irrigation, soil, water, plants and their interactions, as well as irrigation and drainage systems design, planning and management. The course will also impart knowledge about estimation of design flood and flood routing and concepts related to flood management.

Course Outcome: At the end of the course, the students will be able to:

- Plan and design irrigation projects. Design the frequency and amount of irrigation water required
- Estimate the quantity of water required by crops.
- Design channels and other irrigation structures required for irrigation, drainage, flood control and other water-management projects.
- Design the water retaining structures considering the sub-surface seepage failure
- Apply the concepts of flood routing and statistical flood analysis for managing the flood.

Syllabus: Irrigation, Water requirement of crops, Canal irrigation, Storage for irrigation, Diversion headworks, Control structures, Land drainage, Floods. Flood frequency analysis, Flood routing

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Irrigation: Necessity, Types, Techniques, Quality of Irrigation water, Soil-water-plant relationship.	3
2.	Water requirement of crops: Base period, Duty, Delta, Commanded area, Intensity of irrigation, Consumptive use of water, ETO, estimation of ETO, Modified Penman's equations, CropWAT software – examples, Irrigation efficiencies, Frequency of irrigation.	5
3.	Canal Irrigation: Classification of canals, types, layout of irrigation canals, lined canals and unlined canals, design of unlined canals: Kennedy's method, Lacey's method, design of	6

	lined canals, typical sections, advantages of lining, materials used, economics of canal lining.	
4.	Storage for Irrigation: Flow mass curve, estimation of storage required for irrigation and other demands.	3
5.	Diversion Headworks: Necessity and uses, different types, Layout and different components, weirs on permeable foundation, Creep theories, Khosla's method.	5
6.	Control Structures: Head- regulators, Cross-regulators, falls.	2
7.	Land Drainage: Design and maintenance of open drains, closed drains, discharge and spacing of closed drains.	3
8.	Floods: Introduction, definitions, flood scenario in India, concept of flood hazard mitigation – structural and non-structural measures, flood plain zoning and management	3
9.	Flood Frequency Analysis: Frequency studies using different distributions, Risk analysis, Design flood.	4
10.	Flood Routing: Passage of flood through reservoir and streams, hydraulics of flood wave propagation, hydrologic storage routing, channel routing.	5
	Total	39

Suggested Readings:

1. Modi, P.N., "Irrigation Water Resources and WaterPower Engineering", Standard Book House.
2. Asawa, G.L., "Irrigation and Water Resources Engineering", New Age International.
3. Subramanya, K. (2017), "Engineering Hydrology", McGraw Hill Education.
4. Garg, S.K. (latest edition), "Irrigation Engineering and Hydraulic Structures", Khanna Publishers, New Delhi.
5. Punmia, B. C., and Pande, B.B. (latest edition), "Irrigation and Water Power Engineering", Laxmi Publication Pvt. Ltd., New Delhi

5th Semester

CE 3171: Structural Engineering Laboratory

Class Load/week: 0 - 0 – 3 (L – T – P) **Full Marks: 50** **Credit : 2**

Course Objectives:
The aim of the course is to develop a sound understanding of experimental verification of some well-known theories in structural engineering and verification of material properties of two important materials namely steel and concrete which are the most widely used materials in the civil engineering field.

Course Outcome: At the end of the course, the students will learn

- To perform Mix Design of concrete
- To verify concrete compressive and tensile strength of concrete, load deflection behaviour of simple reinforced concrete beam
- To verify Maxwell's Reciprocal Theorem and testing of Elastically Supported Beams, determination of Influence Lines for Beams, Arches and Portals, measurement of Strain
- Non-destructive Testing of concrete & Steel
- Free Vibration Testing for identification of natural frequency and damping ratio

Syllabus:
Mix Design of concrete, Casting and testing of RCC Beam, Concrete cubes, Cylinder and M.R. Beam, Verification of Maxwell's Reciprocal Theorem, Test on Elastically Supported Beams, Determination of Influence Lines for Beams, Arches and Portals, Non-destructive Testing of concrete including evaluation of rebar in concrete, Non-destructive Testing of Steel, Measurement of Strain, Free Vibration Test for identification of natural frequency and damping ratio.

Sl. No.	Description of Course Modules and Lecture Plan	Contact hours
1	Design of Concrete Mix as per IS10262-2019 - Introduction of calculation procedure for various types of concrete	3
2	Casting of RCC Beam, Concrete cubes, Cylinder and M.R. Beam	3
3	Verification of Maxwell's Reciprocal Theorem	3
4	Test on Elastically Supported Beam No. -1 (cross beam support)	3
5	Test on Elastically Supported Beam No. -2 (spring support)	3
6	Determination of Influence Lines for Beams, Arches and Portals	3

7	Testing of RCC Beam, Concrete cubes, Cylinder and M.R. Beam	3
8	Non-destructive Testing of concrete structure including evaluation of rebar in concrete	3
9	Non-destructive Testing of Steel structure	3
10	Non-destructive Testing of Masonry structure	3
11	Measurement of Strain	3
12	Free Vibration Test for identification of natural frequency and damping ratio	3
13	Submission of final reports and viva voce	3
	Total	39

5th Semester

CE 3172: RC Structures Design Project

Class Load/week: 0 - 0 – 3 (L – T – P) **Full Marks: 50** **Credit: 2**

Course Objective: To provide the students with basic understanding of loads and factors as per IS 875 & IS 456 codes. The course intends to familiarize the students with design handbooks SP16 & reinforcement detailing handbook of SP34.

Course Outcome: At the end of the course, the students will be able to:

- Familiarize with different IS codes for loads and design guidelines.
- Design the Reinforced concrete members as per IS 456.

- Design the structural members using SP-16
- Provide reinforcement details as per SP-34.

Syllabus: Estimation of loads and factors as per IS codes. Project on design and detailing of reinforced concrete members for two storeyed buildings. Hands-on experience for Limit State Method of design for two way slabs, beams, columns, staircase, Isolated and combined footings.

Sl. No.	Description of Course Modules and Lecture Plan	Contact hours
1.	Estimation of loads and factors as per IS codes (IS 875 & IS 456) for limit state method	3
2.	Design and detailing of two-way slabs using IS 456 & as per design handbooks SP 16 & SP 34 using limit state method	9
3.	Design of RC beams using IS 456 and SP 16. Detailing for provision of reinforcement as per SP 34	6
4.	Design and detailing of RC columns using IS codes and design hand books	6
5.	Design and detailing of foundations using IS codes and design handbooks	6
6.	Design and detailing of staircase using IS codes and design hand books	6
7.	Submission of sessional project including drawing sheets and viva voce	3
	Total classes	39

Suggested Readings:

Latest editions of

1. Pillai, S. U., and Menon, D., "Reinforced Concrete Design", McGraw Hill Education
2. Subramanian, N., "Design of Reinforced Concrete Structures", Oxford Higher Education
3. IS codes: IS 456, IS 875, SP 16 and SP 34.

5th Semester

CE 3173: Geotechnical Engineering Laboratory

Class Load/week: 0 - 0 – 3 (L – T – P) **Full Marks: 50** **Credit: 2**

Course Objective: The basic knowledge of soil mechanics applied for identifying and characterizing soils through field tests and laboratory investigations. The course intends to acquaint the students with the art of geotechnical engineering practice through evaluation of engineering properties of soil.

Course Outcome: At the end of the course, the students will be able to:

- Determine the index properties of soils
- Characterize and classify soils based on engineering properties
- Determine shear strength parameters of soil
- Determine compaction and consolidation characteristics of soil

Syllabus: Introduction and Field Identification of Soils, Grain size Analysis, Atterberg Limits and Indices, Direct shear test, Triaxial compression test, Unconfined compression test, Vane shear test, Determination of Void ratio, Consolidation test, Compaction test, Permeability test, California Bearing Ratio test, Field density, Demonstration of selected advanced tests.

Sl. No.	Description of Course Modules and Lecture Plan	Contact hours
1.	Introduction and Field Identification of Soils	3
2.	Grain size Analysis: Sieve analysis	3
3.	Grain size Analysis: Hydrometer analysis, Specific gravity of soil solids	3
4.	Atterberg Limits and Indices	3
5.	Direct shear test	3
6.	Triaxial compression test (UU), Unconfined compression test,	3
7.	Vane shear test, Determination of Void ratio	3
8.	Consolidation test (One dimensional)	3
9.	Compaction test, Permeability tests	3

10.	California Bearing Ratio test	3
11.	Field density: Core cutter method and Sand replacement method,	3
12.	Demonstration of a few Advance tests.	3
13.	Viva Voce	3
	Total	39

Suggested Readings:

1. SP 36: Compendium of Indian Standards on Soil Engineering, Part 1 – Laboratory Testing.
2. Tayler, D.W. (1948), "Fundamentals of Soil Mechanics", Asia Publishing Hall.
3. Bowles, J.E., (1992), "Engineering properties of soils and their measurements", McGraw-Hill.
4. Lambe, T. W. (1951), "Soil testing for engineers", Wiley Eastern Limited.
5. Murthy, V.N.S. (2010), "Geotechnical engineering", CRC Press.

5th Semester

CE 3174: Environmental Engineering Laboratory

Class Load/week: 0 - 0 – 3 (L – T – P) **Full Marks: 50** **Credit : 2**

Course Objective: To provide the students with basic understanding of how to determine the important water quality parameters, air pollutants and noise level.

Course Outcome: At the end of the course, the students will be able to:

- Perform the tests to determine the physical, chemical and biological water quality parameters
- Determine the alum dose and chlorine dose for treatment of drinking water
- Determine the SPM in ambient and indoor air
- Determine the different types of noise levels.

Syllabus: Sample collection procedure; determination of physicochemical and biological water quality parameters such as pH, alkalinity, hardness, chlorides, solids, iron, turbidity, sodium,

potassium, calcium, lithium, indicator pathogen, BOD, COD; jar test; chlorine demand test; determination of SPM in air; Determination of noise level.

Sl. No.	Description of Course Modules and Lecture Plan	Contact hours
1.	Introduction: laboratory safety, sampling procedure, preservation of sample, IS codes for drinking water, effluent discharge standards, writing laboratory reports	3
2.	Determination of Hardness & Alkalinity and pH of an Aqueous Sample.	3
3.	Determination of Chlorides, different types of Solids and Conductivity of an Aqueous Sample.	3
4.	Determination of Total Iron & Turbidity of an Aqueous Sample.	3
5.	Determination of Members of the Coliform Group (MPN) by Multiple Tube Fermentation Technique.	3
6.	Determination of Biochemical Oxygen Demand (B.O.D) of water.	3
7.	Determination of Chemical Oxygen Demand (C.O.D) of water.	3
8.	Determination of Optimum Coagulant dose (Jar Test).	3
9.	Determination of Chlorine Demand of an Aqueous Sample.	3
10.	Determination of sodium, potassium, calcium and lithium by flame photometer.	3
11.	Determination of SPM in ambient air and noise Level	3
12.	Demonstration of atomic absorption spectrophotometer	3
13.	Examination and viva voce	3

Total	39

Suggested Readings:

Latest editions of

1. Standard Methods for the Examination of Water and Wastewater. A.P.H. A.; A.W. W.A.; W.E.F.
2. IS: 10500-2012 DRINKING WATER — SPECIFICATION
3. Peavy, S. P., Rowe, D.R. and Tchobanoglous, G., "Environmental Engineering. McGraw-Hill Book Company, Singapore.
4. Garg, S.K., and Garg, R., "Water Supply Engineering", Khanna Publishers, Delhi.

6th Semester

CE 3201: Design of Steel Structures

Class Load/week: 4 - 0 – 0 (L – T – P) **Full Marks: 100** **Credit: 4**

Course Objective: The objective of the course is to impart the students a basic knowledge of design of steel structure elements in Limit State Method. This will help them to design industrial steel structures or other applications in steel design problems

Course outcome: At the end of the course, the students will be able to:

- Understand the basic concepts of Limit State Method along with the structural properties of steel
- Learn the Design of tension and compression members, struts and columns. built up columns.
- Learn the simple and moment resistant connections both bolted and welded.
- Learn the Design of Beams, Purlin, Gantry Girder etc.
- Learn the Design of Beam-column.
- Learn the Design of Foundation/Column Base

Syllabus: Basic Concepts. Limit State Design, Properties of Structural Steel, Design of members, Struts, Beams and Columns. Built up columns, Design of Gantry Girder, Design of Beam-column, Design of Column Base.

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures

1.	Introduction to steel structure elements, properties of structural steel, I.S. rolled sections, I.S. specifications.	03
2.	Design approach, limit state design.	04
3.	Design of tension and compression members, struts and columns. built up columns.	12
4.	Design of connections, simple and moment resistant bolted and welded connections	09
5.	Design of Beams (laterally supported and unsupported), Design of purlins	09
6.	Design of Gantry Girder	06
7.	Design of Beam-column	05
8.	Design of Column Base	04
	Total	52

Suggested Readings:

1. Subramanian, N. (latest edition), "Design of Steel Structures (Limit States Method)".
2. Duggal, S.K. (latest edition), "Limit State Design of Steel Structures", Tata McGraw Hill.
3. IS: 800, 2007: General Construction in Steel-Code of Practice
4. IS: 875 (Part-1), 1987: Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures
5. IS: 875 (Part-2), 1987: Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures
6. IS: 875 (Part-3), 2015: Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures
7. IS: 875 (Part-5), 1987: Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures
8. SP:6(1)

6th Semester

CE 3202: Geotechnical Engineering II

Class Load/week: 3 - 0 – 0 (L – T – P) **Full Marks: 100** **Credit: 3**

Course Objective: To develop an understanding of earth pressure theory and its application to retaining walls and sheet pile walls. The course intends to familiarize the students with various methods of improvement of engineering properties of soil with compaction and stabilization. soil compaction, as well as to develop the concepts of slope stability and foundation analysis and design.

Course Outcome: At the end of the course, the students will be able to:

- Understand the principles of earth pressure theories and its application to retaining walls and sheet pile walls
- Understand the various methods of soil stabilization and soil compaction
- Analyse the stability of slopes using limit-equilibrium methods
- Understand the concepts of bearing capacity and soil settlement
- Design, analyse and proportion shallow foundations in cohesionless and cohesive soils
- Design and analyse pile foundations and well foundations

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Introduction: Brief review of earth pressure and other topics of Geotech Engg.-I Retaining Walls: Stability checks for gravity, cantilever, and counterfort walls. Sheet pile walls: Types of sheet pile wall, depth of embedment of cantilever sheet pile walls in cohesionless and cohesive soils; depth of embedment and anchor rod force for anchored sheet pile walls using Free earth support method (in both cohesionless and cohesive soils) and Fixed earth support method (in cohesionless soils).	6
2.	Soil Stabilization: Brief introduction to different types of soil stabilization Compaction: Introduction, difference between compaction and consolidation, Methods of laboratory and Field compactions.	3

3.	Stability of Slopes: Infinite and finite slopes - modes of failure, factor of safety based on Swedish circle method and method of slices, critical slip surface, stability number, remedial measures.	4
4.	Shallow Foundation: Introduction– shallow and deep foundations, modes of shear failure. Bearing capacity: various definitions, Terzaghi's analysis, factors influencing bearing capacity– effect of water table and eccentric load., methods of estimation (IS 6403 recommendations) including field test. Settlement: methods of estimation in cohesionless and cohesive soils, Permissible settlement (IS: 1904) and allowable bearing pressure. Proportioning of Isolated and combined footings, and Raft foundations.	14
5.	Deep Foundation: Introduction, classification of piles, suitability and uses. Determination of types and length of pile, pile capacity, spacing and group action. Pile load test-IS 2911 recommendations. Negative skin friction. Settlement analysis of pile and pile group. Well foundation – types, loadings, salient components, criteria for horizontal cross-section and depth of foundation, tilts and shifts.	12
	Total	39

Suggested Readings:

1. Das, B.M. (2009), "Shallow Foundations Bearing Capacity and Settlement", CRC Press.
2. Tomlinson, M.J. (2004), "Pile Design and Construction Practice", E & FN SPON.
3. Murthy, V.N.S, (2007), "Advanced Foundation Engineering", CBS Publishers and Distributers.
4. Poulos H.G. and Davis E.H, (1980), "Pile Foundation, Analysis and Design", Rainbow-Bridge Book Co.
5. Ranjan, G. and Rao, A.S.R. (2003), "Basic and Applied Soil Mechanics", New Age International (P) Limited, Publishers.
6. Bowles, J.E. (2000), "Foundation Analysis and Design", McGraw-Hill.

6th Semester

CE 3203: Transportation Engineering II

Weekly Contact: 3 - 0 – 0 (L – T – P) **Full Marks: 100** **Credit: 3**

Course Objective: To provide knowledge of principles of traffic engineering, assessment of traffic characteristics and related problems, transportation planning and management, the fundamentals of railway engineering, geometric design, Signalling & interlocking systems. The course impart the knowledge and understanding on port and harbour engineering and its design principles

Course outcome: At the end of the course, students will be able to:

- Explain the characteristics of traffic flow, traffic studies, capacity analysis and LOS, principles of traffic control devices and road accident study
- Explain the principles of transportation planning, design of public transportation system
- Understand the planning, design, construction, operation and maintenance of railway facilities used for the movement of people and goods
- Understand the principles of port and harbour engineering, different components and layout of port, dock, harbour and jetty, brake water design.

Syllabus: Principles of traffic engineering and transportation planning, railway engineering and port & harbour engineering.

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Traffic Engineering	14
	Traffic flow parameters	1
	Traffic studies and surveys: volume, speed and delays, origin and destination; analysis and interpretation of survey data	2
	Capacity and level-of-service	3
	Traffic operation and management	2
	Intersection: traffic signal design, traffic signs and markings	3
	Parking space design	2

	Road accidents and safety measures	1
2.	Transportation Planning	7
	Basic of Transportation planning, Urban Transportation Planning	1
	Transport Demand Analysis.	5
	Public Transport System	1
3.	Railway Engineering	14
	History of railway development in India	1
	Location surveys and alignment	1
	Permanent way and its components	1
	Track layout, Geometric design of track	2
	Resistances and Stresses in Track; coning of wheels; Joints and Fastenings	2
	Track junctions: points and crossings	2
	Railway stations and yards	1
	Signals and interlocking; Signals classification and their functions	2
	High speed tracks - track requirements, speed limitations, high speed technologies	2
4.	Port & Harbour Engineering	4
	Planning layout of port, dock, harbour& jetties	1
	Different components of port, dock harbour and jetty	1

	Design of Breakwater	1
	Inland water Transportation	1
	Total	39

Suggested Readings:

Latest editions of

1. Khisty, C. J. and Lall, B. K., "Transportation Engineering: an introduction", Prentice Hall India
2. Garber, N. J., and Hoel, L. A., "Traffic and Highway Engineering', Cengage Learning
3. Papacostas, C. S., and Prevedouros, P. D., "Transportation Engineering & Planning", Pearson
4. Kadiyali, L. R., "Traffic Engineering and Transportation Planning", Khanna Publishers
5. Chandra, S., and Agarwal, M. M., "Railway Engineering", Oxford University Press.
6. Mundrey, J. S., "Railway Track Engineering", Tata McGraw Hill.
7. Bindra, S. P., "A course in Docks and Harbour Engineering', Dhanpat Rai Publications

6th Semester

CE 3204: Construction Technology and Project Management

Class Load/week: 4 - 0 – 0 (L – T – P) **Full Marks: 100** **Credit: 4**

Course objective: To introduce students to various techniques and practices commonly used in construction of different civil engineering structures. Also to ignite the concept of management of civil engineering projects among the students.

Course Outcome: At the end of the course the students will develop the understanding on:

- construction techniques of foundations and superstructure of different types of civil engineering structures
- types and use of important construction equipment
- methods of construction quality control
- civil engineering project types and characteristics
- various techniques of project management
- resource management as well as financial planning and their interrelation with project management
- steps involved in preparation of Detailed Project Report and Tendering process

Syllabus: Construction phases; Construction of foundation, Construction of RCC and steel structures; Construction of Tunnels, Bridges, Towers, Chimneys, High-Rise Building; Roadway, dams, Water Treatment Plant, Sewage Treatment Plants; Construction Equipment, Construction site safety measures, Quality Control and Assurance, Concept of Engineering Project; Role of construction project manager; Characteristics of civil construction project; Construction planning, sequencing, scheduling; Bar Charts; Network analysis, resource management as well as financial planning; DPR preparation, contract agreement types, Tendering process

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Construction phases; Construction of foundation– types and problems; Construction of RCC and steel structures; Concrete making, transporting, pouring, and curing, formwork and scaffolding, Steel work fabrication, erection, fasteners.	8
2.	Construction of Tunnels, Bridges, Towers, Chimneys, High-Rise Building; Construction of Roadway, dams, Construction of Water Treatment Plant, Sewage treatment plants.	10
3.	Construction equipment for major projects.	6
4.	Construction site safety measures: Protection, Accident prevention.	3
5.	Quality Control and Assurance.	3
6.	Concept of engineering project; Types of projects; characteristics of civil construction project; Importance of construction project management; Role of construction project manager; Stakeholders in construction project; Ethical issues in civil construction	6
7.	Construction planning, sequencing, scheduling; Bar Charts; Network analysis, elements of PERT and CPM, upgrading; Cash flow diagram; Resource levelling and resource allocation; Construction material management;	10
8.	DPR preparation, contract agreement types, Tendering process	6
	Total	52

Suggested Readings:

Latest editions of

1. Sarkar, S.K. and Saraswati, S., "Construction Technology", Oxford University Press.
2. Chudley, R., "Construction Technology", Longman Group Limited, London.
3. Holt, A. S. J., "Principles of Construction Safety", Blackwell Publishers.
4. Punmia, B. C., and Khandelwal, K. K., "Project Planning & Control with PERT & CPM", Laxmi Publications (P) Ltd.
5. Jha, K. N. "Construction Project Management: Theory and Practice"; Pearson
6. Patrick, C. "Construction Project Planning & Scheduling", Pearson

6th Semester

CE 3205: Numerical Methods in Civil Engineering

Class Load/week: 3 - 0 – 0 (L – T – P) **Full Marks: 100** **Credit: 3**

Course Objective: The basic premise to introduce the Civil engineering graduate students to this course is that it can serve as the basis for a wide range of courses that discuss numerical methods used in Civil Engineering. Specifically, the aim of the course is to develop a sound understanding of the various numerical techniques, principles and their application to Civil engineering problems.

Course Outcome: At the end of the course, the students will be able to:

- Understand the fundamental principles and basics of various numerical methods.
- Acquire knowledge of various common numerical methods (e.g. interpolation, differentiation, integration, solution of linear and nonlinear equations, solution of differential and integral equations.
- Apply those numerical methods to obtain approximate solutions to mathematical problems in Civil Engineering.
- Analyse, to evaluate accuracy and coding of various numerical methods
- Conversant with the applications of numerical methods to solve problems related to civil engineering.

Syllabus: Introduction, Numerical Methods for Linear Equations and Matrices, Introduction to matrix eigenvalue problems, Numerical Methods for Nonlinear Equations, Polynomial approximation, curve fitting, interpolation and extrapolation, Numerical Evaluation of Derivatives, Numerical Solution of Differential Equations, Numerical Evaluation of Integrals, Linear and nonlinear regression, Correlation Analysis. Introduction to Numerical Solution of integral equations.

The elucidation of the various numerical techniques will be through example problems from the Civil Engineering field as far as possible. Also, the course module is expected to cover coding in suitable programming platforms.

Course Module

Sl. No	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Introduction: Numerical Methods, error in computation, error bound, convergence and stability	2
2.	Numerical Methods for Linear Equations and Matrices Direct Methods for the Solution of Linear Algebraic Equations Solution of Linear Equations by Iterative Methods Introduction to matrix eigenvalue problems	6
3.	Numerical Methods for Nonlinear Equations Transcendental and Polynomial Equation; simple and multiple roots, system of nonlinear equations	4
4.	Polynomial approximation, curve fitting, interpolation and extrapolation	4
5.	Numerical Evaluation of Derivatives: Various finite difference schemes, implicit and explicit methods, Richards Extrapolation for derivatives	4
6.	Numerical Solution of Differential Equations: One Step Methods, Multi-Step and Predictor-Corrector Methods, Partial Differential Equations	6
7.	Numerical Evaluation of Integrals: The Trapezoid Rule, Simpson's Rule, Gaussian Quadrature Schemes, Romberg Quadrature and Richardson Extrapolation, Monte Carlo Integration Schemes	6
8.	Linear and nonlinear regression, Correlation Analysis	4

9.	Introduction to Numerical Solution of integral equations	3
	Total	39

Suggested Readings:

Latest editions of

1. Collins, G.W., "Fundamental Numerical Methods and Data Analysis", II available electronically by the NASA Astrophysics Data System (ADS).
2. Griffiths, D.V., and Smith, I.M., "Numerical Methods for Engineers: A Programming approach", Blackwell Scientific Publications.
3. Jain, M.K., Iyengar, S.R.K., and Jain, R.K., "Numerical Methods (Problems and Solution)", New Age International.
4. Yang, W.Y., Cao, W., Chung, T.S., and Morris, J., "Applied Numerical Methods using MATLAB", Wiley Interscience.

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6th Semester

CE 3271: Steel Structures Design Project

Class Load/week: 0 – 0 – 3 (L – T – P) **Full Marks: 50** **Credit: 2**

Course Objective: The objective of the course is to impart the students a basic knowledge of analysis and design of steel structure elements in Limit State Method. This will help them to analyze and design industrial steel structures or other steel design elements.

Course outcome: At the end of the course, the students will be able to:

- Understand the evaluation and application of various types of loads on the structures.
- Learn the analysis of structures by any suitable method or computer-aided structural analysis.
- Understand the basic concepts of Limit State Method along with the structural properties of steel
- Learn the manual and computer-aided structural design
- Learn the detailing of structural components

Syllabus: Evaluation and Analysis of loads**,** Computer-aided structural analysis, Basic Concepts. Limit State Design, Properties of Structural Steel, Manual and Computer-aided structural design, Detailing of structural components.

Sl. No.	Description of Course Modules and Lecture Plan	Contact hour

1.	Estimation of load	09
2.	Computer-aided structural analysis	09
3.	Manual and Computer-aided structural design	10
4.	Detailing	08
5.	Viva-Voce	03
	Total	39

Suggested Readings:

1. Subramanian, N., "Design of Steel Structures (Limit States Method)".
2. Duggal, S.K., "Limit State Design of Steel Structures", Tata McGraw Hill.
3. IS: 800, 2007: General Construction in Steel -Code of Practice
4. IS: 875 (Part-1), 1987: Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures
5. IS: 875 (Part-2), 1987: Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures
6. IS: 875 (Part-3), 2015: Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures
7. IS: 875 (Part-5), 1987: Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures
8. SP:6(1)
9. Bentley STAAD. Pro user manual

6th Semester

CE 3272: Transportation Engineering Laboratory

Weekly Contact: 0 - 0 – 3 (L – T – P) **Full Marks: 50** **Credit : 2**

Course objective: To introduce the concept of quality control in roadway construction, estimate the engineering properties of aggregate and bitumen, design of bituminous mix, measurement of road unevenness for functional evaluation of roadway pavement, study and analysis of traffic facilities

Course outcome: At the end of the course, students will be able to:

- Identify engineering properties of aggregate, bitumen and its application in quality control of road construction
- Design the bituminous course for roadway pavement construction
- Identify the functional condition of roadway pavement
- Find out peak hour traffic & peak time for a given location on the road.
- Calculate design speed, maximum speed & minimum speed limits of a location through speed data collection.
- Draw the parking accumulation curve and find out the parking duration & turnover of on street/off street parking facilities.

Syllabus: Introduction to quality control test, tests on aggregate and bitumen, design of bituminous course, functional evaluation of roadway pavement through road roughness test, study and analysis of traffic facility by traffic data collection

Sl. No.	Description of Course Modules and Lecture Plan	Contact hour
1.	Tests on aggregates, viscosity grade bitumen, emulsion, cutback	12
2.	Bituminous mix design - Marshall method, Design of emulsified mixes	12
3.	Pavement roughness – measurements and evaluation	03
4.	Traffic data collection and analysis - speed, headway and capacity studies on highways, parking surveys.	09
5.	Viva-Voce	03
	Total	39

Suggested Readings:

Latest readings of

1. Rao, G. V., Rao, K. R., Pahari, K., and Rao, D.V.B., ‘Highway Material Testing & Quality Control’, I. K. International.

2. Garber, N.J., and Hoel, L.A., "Traffic and Highway Engineering', Cengage Learning
3. Khanna, S. K., Justo, C. E. G., and Veeraraghavan, A., "Highway Engineering", Nem Chand & Bros
4. ASTM D6927-15,'Standard Test Method for Marshall Stability and Flow of Asphalt Mixtures.
5. MORTH (Ministry of Road Transport and Highways). (2013). "Specifications or road and bridge works." Indian Roads Congress, New Delhi, India.

6th Semester

CE 3273: Estimation Practice

Class Load/week: 0 - 0 – 3 (L – T – P) **Full Marks: 50** **Credit: 2**

Course objective: To impart knowledge in estimation of Civil Engineering works.

Course Outcome: After completion of the course the students primary knowledge on:

- the basic concept on process of quantity estimation for building, and roads
- preparation of bill of quantities
- analysis of rate and preparation of cost estimate
- Software application in estimation

Syllabus: Introduction of Estimate Practice, Concept of Detailed Estimate, Preliminary Estimate, Approximate Estimate; Revised Estimate; Preparation of Bill of Quantities of a residential building; Analysis of Rate and Preparation of Cost Estimate of a residential building; Preparation of Bill of Quantities and Cost Estimate of a typical rural road; Software application in estimation.

Sl. No.	Description of Course Modules and Lecture Plan	Contact hour
1.	Introduction of Estimate Practice, Concept of Detailed Estimate, Preliminary Estimate, Approximate Estimate; Revised Estimate,	6
2.	Preparation of Bill of Quantities of a residential building considering all major items of work including sanitary works	12
3.	Analysis of Rate and Preparation of Cost Estimate of the same building	9
4.	Preparation of Bill of Quantities and Cost Estimate of a typical rural road	6

5	Introduction to software application in estimation	3
6	Viva-Voce / Assessment	3
	Total	39

Suggested Readings:

Latest editions of

1. Chakraborti, M., "Estimating Costing Specification and Valuation in Civil Engineering".
2. Dutta B.N., and Dutta S., "Estimating and Costing in Civil Engineering".
3. Schedule of rates from Public Works Department, Government of West Bengal

7th Semester

CE 4101: Advanced Design of Structures

Class Load/week: 3 - 0 – 0 (L – T – P) **Full Marks: 100** **Credit: 3**

Prerequisite: Design of Steel and RC Structures (CE3102 & CE3201)

Course Objective: Design methodology of typical industrial and community structures.

Course Outcome: Conversant with design of standard community and industrial structures.

Syllabus:

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Steel design requirements for seismic load and fatigue	3
2.	Design philosophy and methodology of steel plate girder	6
3.	Design philosophy and specifications for RC building under seismic load.	6
4.	Design specifications and methodology of RC water tank	3

5.	Design specifications and methodology of RC deep beam	3
6.	Design specifications and methodology of RC flat slab	3
7.	Design specifications and methodology of RC silo	3
8.	Design specifications and methodology of RC beam curved in plan.	3
9.	Design specification and methodology of RC chimney	3
10.	Introduction to PSC design.	6

Suggested Readings:

Latest editions of

1. Latest publication of IS:456, IS:800, IS:1893(1), IS:13920, IS:3370(1, 2, 4), IS:4995(1, 2) and IS:1343.
2. Duggal, S.K., "Limit State Design of Steel Structures", Tata McGraw Hill.
3. Subramanian, N., "Design of Steel Structures (Limit States Method)".
4. Pillai & Menon, RC Design
5. Punmia, Jain & Jain RCC Design

7th Semester

CE 4102: Advanced Design of Foundation

Class Load/week: 3 - 0 – 0 (L – T – P) **Full Marks: 100** **Credit : 3**

Course Objective: To develop the knowledge of foundation design. The course intends to acquaint the students with design and proportioning of pile foundations, design of well foundation, design of foundations for reciprocating and impact type machines, design of sheeting and bracing systems, cellular cofferdams and principles of drainage and dewatering.

Course Outcome: At the end of the course, the students will be able to:

- Design, analyse and proportion pile foundations
- Design and analyse well foundations and machine foundations
- Understand the design of braced excavation systems
- Understand the design of cellular cofferdams
- Understand the methods of drainage and dewatering techniques applied in field

Syllabus: Pile foundations, well foundation, machine foundations, braced excavation, cellular cofferdams, drainage and dewatering.

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Pile foundations - Analytical estimation of load-settlement behaviour of piles, pile group capacity and settlement, laterally loaded piles, pile load tests, proportioning of pile foundations, lateral and uplift capacity of piles. Structural design of pile and pile cap.	10
2.	Well foundation - IS and IRC codal provisions, elastic theory and ultimate resistance methods, analysis and design.	4
3.	Machine Foundations - Types and basic requirements of machine foundations, mathematical models, response of foundation – soil system to machine excitation, block resonance test, criteria for design. Analysis and design of foundations for reciprocating and impact type machines, introduction to the design of T.G. Foundations.	9
4.	Braced excavation - Sheeting and bracing systems in shallow and deep open cuts in different soil types	6
5.	Cellular coffer dams - Various types, analysis and design.	5
6.	Drainage and dewatering – Methods and design principle.	5
	Total	39

Suggested Readings:

1. Das, B.M. (1998), “Principles of Foundation Engineering”, PWS Publishing.
2. Poulos, H. G. and Davis, E. H, (1980), “Pile Foundation, Analysis and Design”, Wiley and Sons.
3. Ranjan, G. and Rao, A. S. R, (2003), “Basic and Applied Soil Mechanics”, New Age International (P) Limited, Publishers.
4. Bowles, J. E. (2000), “Foundation Analysis and Design”, McGraw-Hill.
5. Murthy, V. N. S, (2007), “Advanced Foundation Engineering”, CBS Publishers and Distributers.

7th Semester

CE 4171: Advanced Structures Design Project

Class Load/week: 0 - 0 – 3 (L – T – P) **Full Marks: 50** **Credit: 2**

Prerequisite: Advanced Design of Structures.

Course Objective: Design practice on important structural elements.

Course Outcome: Conversant as practising structural designer.

Sl No.	Description of Course Modules and Lecture Plan	Contact hour
1.	Design of a multi-storeyed RC building under wind and earthquake load	15
2.	Design of a stiffened plate girder	12
3.	Design of a PSC bridge girder.	12

Suggested Readings: As stated for CE 4101

Suggested Training**:** On structural Analysis and Design Softwares.

7th Semester

CE 4172: Advanced Foundation Design Project

Class Load/week: 0 - 0 – 3 (L – T – P) **Full Marks: 50** **Credit: 2**

Course Objective: To create the ability to identify, formulates, and solve foundation engineering problems. The course intends to make students understand the art of geotechnical engineering practice through computation and calculation of field design problems related to special types of shallow foundations, pile foundations, well foundations, machine foundations and deep excavations.

Course Outcome: At the end of the course, the students will be able to:

- Solve problems on design of special types of shallow foundations, combined footing and raft foundation
- Solve problems on analysis and design of pile foundation and well foundation
- Solve problems on analysis and design of machine foundation
- Solve problems on analysis and design of deep excavation

Syllabus: Problems on Design of special types of shallow foundation, problems on design of pile foundation, problems on design of well foundation, problems on design of machine foundation, Problems on design of deep excavation.

Sl. No.	Description of Course Modules and Lecture Plan	Contact hour
1.	Problems on Design of Special types of Shallow foundation– Rectangular combined footing, Trapezoidal combined footing, Strap footings, Mat or Raft foundation, Coefficient of subgrade reaction, Floating Foundation etc.	6
2.	Problems on design of pile foundation – Calculation of load-bearing capacity of single pile by static and dynamic formula, group action of piles in sand and clay, group efficiency of piles, settlement of piles, negative skin friction, laterally loaded piles, under reamed piles etc.	15
3.	Problems on design of well foundation – Analysis and design principles of well foundation, drilled piers, caissons etc.	6
4.	Problems on design of machine foundation – Degrees of freedom of a block foundation, determination of natural frequency, computation of dynamic soil properties for use in foundation design, design of foundations for reciprocating and impact type machines, vibration isolation etc.	6
5.	Problems on design of deep excavation – Sheeting and bracing systems used in deep excavation in different soil types, related field examples.	6
	Total	39

Suggested Readings:

1. Das, B.M. (1998), "Principles of Foundation Engineering", PWS Publishing.
2. Poulos, H. G. and Davis, E. H, (1980), "Pile Foundation, Analysis and Design", Wiley and Sons.
3. Different IS Code of Practices related to foundation Engineering.
4. Bowles, J. E. (2000), "Foundation Analysis and Design", McGraw-Hill.
5. Murthy, V. N. S, (2007), "Advanced Foundation Engineering", CBS Publishers and Distributers.

7th Semester

CE 4173: Infrastructure Design

Class Load/week: 0 - 0 – 3 (L – T – P) **Full Marks: 50** **Credit: 2**

Prerequisite: Environmental Engineering I & II, Transportation Engineering I & II and Water Resources Engineering I & II

Course Objective: To provide the students with basic understanding for design of procedure for water supply and sanitation system; pavement and traffic system and different hydraulic structures design.

Course Outcome: At the end of the course, the students will be able to:

- Design water supply network and sewerage network
- Design of road geometry and pavement
- Design of Traffic & Level of Service
- Design of hydraulic structures

Syllabus: Water supply network; Sewage system and network design; Road geometry, traffic system and pavement design; Design of hydraulic structures.

Sl. No.	Description of Course Modules and Lecture Plan	Contact hour
1.	Module I: • Design of water supply line: population forecasting; calculation of water demand; hydraulics of pipe flow; Hardy Cross method of pipe network analysis; pipe network analysis by EPANET.	12

	• Design of sewer: wastewater quantity estimation for a city; hydraulic elements of sewer; design of sewers • Design of clariflocculator and rapid sand filter for conventional water treatment plant	
2.	Module II • Geometric design and pavement design of highways. • Traffic & Level of Service: estimation of traffic volume on the links of road networks, turning movements at intersections, LOS calculations • Travel Demand/Mode Choice/Route Choice	12
3.	Module III • Design of flow through open channels: Uniform flow – Regular and Irregular sections • Flow through weirs • Design of Flow through pressure pipes • Application of the hydraulics software 'Flowmaster' to solve the problems	12
4.	Examination and viva voce	3
	Total	39

Suggested Readings:

Latest editions of

1. Peavy, S. P., Rowe, D. R. and Tchobanoglous, G., "Environmental Engineering", McGraw-Hill Book Company, Singapore.
2. Huang, Y. H., "Pavement analysis and design", Pearson Education India.
3. Chakraborty, P., and Das, A., "Principles of transportation engineering", PHI Learning Pvt. Ltd.
4. Mannering, F. L., Kilareski, W. P., and Washburn, S. S., "Principles of Highway Engineering and Traffic Analysis", Willey India
5. Subramanya, K., "Flow in Open Channels", Tata McGraw-Hill.
6. Computer Applications in Hydraulic Engineering by Bentley Systems

8th Semester

CE 4201: GIS and Remote Sensing

Class Load/week: 3 – 1 – 0 (L – T – P) **Full Marks: 100** **Credit: 4**

Course Objective: The objective of the course is to impart the students a basic knowledge of GIS and Remote Sensing along with its application to Civil Engineering problems. This will help them to solve the problems with the help of geospatial technique using satellite data and other ancillary data.

Course outcome: At the end of the course, the students will be able to:

- Understand the basic concepts of GIS
- Prepare the digital map with attribute database and learn basic concepts of database management
- Learn the processing of GIS data for proximity analysis, network analysis etc.
- Apply GIS in different fields of Civil Engineering
- Understand the basic concepts of Remote Sensing and gather knowledge on platforms and sensors
- Process the digital remote sensing data to extract information required for analysis
- Learn the basics of advanced remote sensing techniques

Syllabus: Basic Concepts. GIS Data, GIS Model Development, Basic GIS Processing, Application of GIS, Remote Sensing – Introduction, Electromagnetic Radiation, Platforms and Sensors, Advanced Remote Sensing

Sl. No.	Description of Course Modules and Lecture Plan	Lectures	Tutorial
	Geographical Information System		
1.	Basic Concepts: Definition of GIS, components of GIS; Variables – points, lines, polygon, functionality of GIS, Areas of GIS application.	4	
2.	GIS Data: Spatial and attribute Data, information organization and data structures; Raster and vector data structures, data file and database; Introduction to GIS software.	4	1

3.	GIS Model Development: Preparation of digital map – sources, geo-registration of images, scanning and digitization, building topology, errors and corrections, preparation of attribute database; basic concepts of database management – relational model, relationship, query.	5	2
4.	Basic GIS Processing: Buffering, neighbourhood analysis, network analysis, thematic maps, spatial statistics.	5	1
5.	Application of GIS: Concept of GIS as a processing platform; Integrating GIS with other engineering analysis software – examples. Programming with GIS. GIS as a decision making platform – applications to Disaster Management, Natural Resources Management, Transport Systems Planning, Infrastructural Planning, Water Supply Operation and Management, Stormwater management, Catchment Modelling, Runoff & Soil Loss estimation, Groundwater studies, Environmental management – examples.	8	4
	Remote Sensing		
6.	Introduction: Definitions, Process and characteristics of remote sensing systems, fields of applications of remote sensing techniques, advantages and limitations, remote sensing scenario in India.	3	
7.	Electromagnetic Radiation (EMR): Wavelength-frequency-energy relationship of EMR, EMR Spectrum and its properties, EMR wavelength regions and their applications, atmospheric windows, interaction of EMR with matter, spectral reflectance curve, spectral signatures.	3	
8.	Platforms and Sensors: Airborne and Space-borne platforms; Remote sensing satellites – types and functions, specification of some widely used satellites – IRS, Landsat, IKONOS, Cartosat, Quickbird, WorldView, etc.; Sensor systems – Framing and Scanning System, Whiskbroom scanners, Push-broom scanners, Side looking scanners, imaging and non-imaging sensors, active and passive sensors; Resolution of sensors – spectral, spatial, radiometric and temporal,	3	

	Scale, Multi-band concepts and False Colour Composites.		
9.	Digital Image Processing: Definition of digital image, sources of data, data formats; Sources of errors and corrections; Image registration and geoprocessing; Contrast manipulation, filtering, edge enhancements; Band ratioing and differencing; NDVI analyses; Image classification – Ground truth, parametric and non-parametric classifiers, unsupervised classification, supervised classification, spectral, spatial and temporal pattern recognition; Accuracy assessment; Applications of classification techniques with examples.	4	4
10.	Advanced Remote Sensing: Introduction to Thermal, Microwave, Lidar and Hyperspectral remote sensing.	1	
	Total	40	12

Suggested Readings:

1. Heywood, I., Cornelius, S, and Carver, S. (2006), "An Introduction to Geographical Information Systems", Pearson Education.
2. Burrough, P. A, Rachael A., McDonnell, R. A., and Lloyd, C. D. (2016), "Principles of Geographical Information Systems", Oxford University Press.
3. Chandra, A. M, and Ghosh, S. K. (2005), "Remote Sensing and Geographical Information System", Alpha Science International Ltd.
4. Reddy, M. A. (2012), "Geoinformatics for Environmental Management", B.S. Publications.
5. Brimicombe, A. (2010), "GIS, Environmental Modelling and Engineering", CRC Press.

Civil Engineering Department, Indian Institute of Engineering Science and Technology, Shibpur

Proposed UG Departmental Electives and Syllabi

7th Semester: Core Elective-I

1. CE 4121: Reliability Analysis of Structures
2. CE 4122: Advanced Mathematics and Computing in Structural Engineering
3. CE 4123: Damage Assessment, Repair and Retrofitting of Structures
4. CE 4124: Earthquake Engineering
5. CE 4126: Principles of Slope Stability Analysis
6. CE 4127: Ground Improvement Methods
7. CE 4128: Earth and Earth Retaining Structures
8. CE 4130: Design of Pavement Structure
9. CE 4131: Industrial and Hazardous Waste Management
10. CE 4133: Water Resources System
11. CE 4134: Hydropower Engineering

8th Semester: Core Elective-II

1. CE 4221: Bridge Engineering
2. CE 4222: Structures under extreme events
3. CE 4223: Tall Structures
4. CE 4224: Behavior of metal structures
5. CE 4226: Probabilistic Methods in Geotechnical Engineering
6. CE 4227: Environmental Geomechanics
7. CE 4228: Geotechnical Investigations and Instrumentation
8. CE 4229: Materials and Construction of Roadway Pavement
9. CE 4230: Road Safety Engineering
10. CE 4231: Rural Water Supply and Sanitation
11. CE 4233: Advanced Hydraulic Structures
12. CE 4234: Statistics in Hydrology

Open Elective - II

1. CE 4261: Environmental Management
2. CE 4262: Modelling and Simulation
3. CE 4263: Transportation in Logistics and Supply Chain Management

7th Semester: Core Elective-I

CE 4121: Reliability Analysis of Structures

Weekly contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course objective: 1. To equip students with various reliability analysis methods for safety assessment of structures, 2. To offer a broader perspective of structural analysis and design in light of uncertainty analysis fundamentals, 3. To impart basic knowledge of modern reliability engineering so that the candidate can conveniently pursue research in this field.

Course outcome: At the end of the course, the students will be able to:

- Students will learn fundamental methods to estimate structural reliability.
- Students will be able to analyze the theories and design methodologies of structure in light of uncertainty analysis principles. They will be in a position to estimate partial safety factors for new code calibrations.
- Students will learn various methods frequently used in reliability analysis of structure (e.g. metamodeling, Monte Carlo simulation).
- The students will learn how to design safe and economic structure directly considering uncertainty effects.

Syllabus: Probabilistic models of load and resistance parameters, Basic structural reliability analysis method, metamodeling and Monte Carlo Simulation, Partial safety factor calculation, optimization under uncertainty.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction to the concept of structural reliability, basic statistics and probability theory, probabilistic models for loads and resistance parameters	5
2.	Structural reliability methods: FORM and SORM, Hasofer-Lind and Rackwitz-Fissler methods, application to structural engineering problems	9
3.	Reliability based design-determination of partial safety factors, code calibration	5
4.	Reliability of structural systems	6
5.	Simulation methods for structural safety, Variance reduction techniques, Importance sampling	6

6.	Application of metamodeling approaches in reliability analysis	4
7.	Introduction to Reliability based and robust design optimization	4
	Total	39

Suggested Readings:

1. Haldar, A., and Mahadevan, S. (2000), "Reliability Assessment Using Stochastic Finite Element Analysis", John-Wiely & Sons Inc., New York, USA.
2. Nowak, A.S., and Collins, K.R. (2012), "Reliability of Structures", CRC press.
3. Madsen, H.O., Krenk, S., and Lind, N.C. (1986), "Methods of Structural Safety", Prentice-Hall Inc, Englewood Cliffs, USA.
4. Melchers, R.E. (1987), "Structural Reliability Analysis and Prediction", Ellis Horwood, Chisester, England.
5. Cristensen, P.T., and Murotsu, Y. (1986), "Applications of Structural Systems Reliability Theory", Springer-Verlag, Berlin.

CE 4122: Advanced Mathematics and Computing in Structural Engineering

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: The basic objective of the course is to introduce the concept of Mathematical modeling for various structural engineering problems like truss, beam, frame, plate etc. and to develop an understanding of the fundamental theories of finite difference, finite element and finite strip methods.

Course outcome: At the end of the course, the students will be able to learn:

- Development and solution of one, dimensional and two-dimensional structural engineering problems
- The application of finite element method in Structural analysis
- Use of finite element softwares for structural engineering problems

Syllabus: Linear Differential Equations; Partial Differential Equations; Finite Difference Method; Variational Principle; Finite element method; Finite strip method.

Sl. No.	Description of Module and Lecture Plan	No. of lectures

1.	Linear Differential Equations: Concept of Mathematical modelling in Civil Engineering Problems; Solution of Linear Differential Equation and application to Structural Engineering Problems	2
2.	Partial Differential Equations: Development and solution of Partial Differential Equation for Structural Engineering Problems; Governing Equations; Discrete and Continuous models; Boundary, Initial and Eigenvalue problems	4
3.	Finite Difference Method: Finite Difference representation of derivatives; One dimensional problems- Static and Dynamic analysis of Beams; Buckling analysis of Columns; Two dimensional problems -Analysis of Plates	6
4.	Variational Principle: Strong form and weak form of governing partial differential equation; Galerkin's Weighted Residual Method with example of bar under axial load and beam bending problem; Ritz method; Variational formulation of Boundary Value Problems; Basic concepts of Finite Element Method	4
5	Finite Element Method: Introduction to Finite Element Method and its Application in Civil Engineering Problems; One Dimensional Elements-Finite Element Formulation of axially loaded Bar, Truss, Beam, Frame and Grillage; Two Dimensional Elements-CST element, Rectangular linear and higher order elements; Derivation of Shape Functions, Stiffness Matrix and Load Vector; Incorporation of Boundary Conditions; Finite Element Analysis-Application to Truss and Frame, Static and Dynamic Analysis of Beam, Torsion of circular shaft, Buckling of Column, Static and Dynamic Analysis of Plate; Introduction to Three Dimensional and Axisymmetric Problems; Use of Finite Element Softwares in Structural Engineering Problems	19
6	Finite Strip Method: Introduction to Finite Strip Method; Formulation of Beam and Plate problems by Finite Strip Method	4
	Total	39

Suggested Readings:

Latest editions of

1. Cheung, Y. K., and Tham, L. G., “Finite strip method”, CRC Press, Taylor and Francis
2. Bathe, K. J., “Finite element procedures”, Prentics Hall
3. Cook, R. D., “Concepts and applications of Finite element analysis”, John Wiley
4. Belegundu, C., “Finite element analysis”, Pearson (International edition)
5. Rao, K. S., “Introduction to Partial Differential equations”, PHI

CE 4123: Damage Assessment, Repair and Retrofitting of Structures

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course objective: 1. To equip students with various methods of damage assessment of structures by visual inspection, Non-destructive and semi- destructive testing and other load tests.

2. To offer a broader perspective of reasons for distress e.g. wear and tear, support settlement, foundation sinking, overloading and aggressive environmental effects etc..

3. To impart basic knowledge of different techniques for repairing and retrofitting for Masonry structures, RCC structures and Steel structures.

Course outcome: At the end of the course, the students will be able to:

- Students will learn fundamental methods to evaluate the condition of structures by Non-destructive and semi- destructive testing,
- 2. Students will be able to analyze the reasons for distress e.g. wear and tear, support settlement, foundation sinking, overloading and aggressive environmental effects,
- Students will learn different techniques for repairing and retrofitting for Masonry structures, RCC structures and Steel structures.
- The students will learn the importance of maintenance of structures.

Syllabus: Evaluation of condition of structures, Reasons for distress in structures, Introduction to Structural Health monitoring, Different techniques for repairing and retrofitting for Masonry structures, RCC structures and Steel structures, Case studies for repairing, restoration, rehabilitation and retrofitting of buildings, Bridges and other types of structures.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures

1.	Evaluation of condition of structures: visual inspection, Non-destructive and semi- destructive testing, load tests and others. Reasons for distress: wear and tear, support settlement, foundation sinking, overloading and aggressive environmental effects, Defects in construction: materials and workmanship, Effect of earthquake, wind, flood, blast and fire, Consideration of Erection loads.	12
2.	Introduction to System Identification and Structural Health monitoring using static and vibration based data	8
3.	Change of requirement or utility, Insufficiency of original designs, Rectification of defects, strengthening of structures, Replacement of defective portions, Remedial construction techniques. Importance of maintenance of structures, Differentiation among repairing, restoration, rehabilitation and retrofitting of structures.	10
4.	Different techniques for repairing and retrofitting for Masonry structures, RCC structures and Steel structures. Case studies for buildings, Bridges and other types of structures.	9
	Total	39

Suggested Readings:

Latest editions of

1. Mohamed, A., and Reedy, E.I., "Concrete and steel construction- Quality control and assurance", CRC Press.
2. Whittle, R., "Failures in concrete structures – Case studies in reinforced and prestressed concrete", CRC Press.
3. Malhotra, V. M., and Carino, N. J., "Hand Book on Non-destructive Testing of Concrete", CRC Press.
4. CPWD Handbook on Repair and rehabilitation of RCC structures, CPWD, Govt. of India.

CE 4124: Earthquake Engineering

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: To provide a thorough understanding of the basic principles of earthquake resistant design of structures, from ground motion seismology, structure and seismic load models, design, detailing and supplemental protective systems.

Course Outcome: At the end of the course, the students will be able to:

- Understand the basics of engineering seismology, including ground motion characteristics.
- Adopt suitable models for different structures and determine the seismic loads on the same following codal provisions.
- Design and detail aseismic structures.
- Identify common causes of damages in structures subjected to earthquake shaking.
- Comprehend the tenets of seismic protective systems such as base isolation and passive energy dissipation systems.

Syllabus: Engineering seismology; strong motion characteristics; response spectrum; various methods and philosophies of earthquake resistant design of structures; sources of seismic damage in RC structures; ductile detailing in RC structures; structural seismic protective systems.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Basics of Engineering Seismology	2
2.	Strong Motion Characteristics - accelerogram, peak acceleration, Fourier spectrum, Response spectrum, seismic demand, spatial variation of earthquake ground motion, damage potential of earthquake, measurements of severity	4
3.	Response Spectrum – construction, PSV, PSA, SD, characteristics, tripartite plot, design spectrum	4

4.	Basic elements of earthquake resistant design of structures – structural modeling, shear building idealization, code-based procedures for seismic analysis - equivalent lateral force method, response spectrum method, elastic time history analysis, seismic design methods – lateral strength based design, displacement or ductility based design, capacity based design, energy based design	14
5.	Identification of Seismic Damages in R.C. buildings – soft storey failure, floating columns, effect of other structural irregularities	4
6.	Ductile detailing considerations as per IS 13920	6
7.	Overview of Earthquake protective systems	2
	Total	36

Suggested Readings:

Latest editions of

1. Chopra, A. K., "Dynamics of Structures, Theory and Applications to Earthquake Engineering".
2. Agarwal, P., and Shrikhande, M., "Earthquake Resistant Design of Structures".
3. Duggal, S.K., "Earthquake Resistant Design of Structures".
4. Murty, C.V.R. et al., "Some Concepts in Earthquake Behaviour of Buildings".

CE 4126: Principles of Slope Stability Analysis

Weekly contact 3-0-0 (L -T -P) **Full Marks: 100** **Credit: 3**

Course Objective: To develop the ability to apply knowledge of soil mechanics to identify the types of slopes, causes of slope failures. The course intends to provide sound knowledge to analyze slope stability problems.

Course Outcome: At the end of the course, the students will be able to:

- Identify the types of slopes
- Analysis the finite slope using different methods (Methods of slices, Bishop methods etc.
- Uses of Slope Stability Charts (Taylor's charts, Bishop and Morgenstern Charts) to design the slopes
- Analysis of Geotextile Reinforced Soil Slopes based on Limit Equilibrium Principles.

Syllabus: Introduction, natural and man-made slopes, causes of slope failures, Infinite slopes, Finite slopes, Different methods for analysis of finite slopes, Stability Analysis of Geotextile Reinforced Soil Slopes based on Limit Equilibrium Principles.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction, natural and man-made slopes, causes of slope failures	3
2.	Infinite slopes – Definition, mode of failure, limit equilibrium, analysis of cohesionless and cohesive slopes with and without seepage occurring	3
3.	Finite slopes – Modes of failure, slip surfaces of specific shapes, general slip surfaces	3
4.	Analysis of finite slopes based on limit equilibrium principles - Methods of Slices – Unknowns and Equations,	3
5.	Ordinary method of slices, Bishop simplified method, Spencer method for circular slip surfaces	5
6.	Methods of slices valid for general slip surfaces – Spencer method	3
7.	Stability Analyses for Critical stages in the life of an earth dam	4

8.	Pseudo-static approach of slope stability analysis under seismic loading	3
9.	Determination of Critical slip surfaces using optimization techniques	4
10.	Use of Slope Stability Charts – Taylor's charts, Bishop and Morgenstern Charts	3
11.	Stability Analysis of Geotextile Reinforced Soil Slopes based on Limit Equilibrium Principles.	5
	Total	39

Suggested Readings:

Latest edition of

1. Taylor, D. W., "Fundamentals of Soil Mechanics", John Wiley & Sons.
2. Lambe, T.W., and Whitman, R.V., "Soil Mechanics", John Wiley & Sons.
3. Craig, R.F., "Soil Mechanics", Taylor & Francis group.
4. Kramer, S.L., "Geotechnical Earthquake Engineering", Prentice Hall.
5. Chowdhury, R., Flentje, P., and Bhattacharya, G., "Geotechnical Slope Analysis", CRC press.
6. Koerner, R.M., "Designing with Geosynthetics", Xlibris.

CE 4127: Ground Improvement Methods

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: To provide the students with basic understanding of ground improvement techniques. The course intends to familiarize the students with different ground improvement methods such as compaction, vibroflotation, grouting, reinforced earth etc.

Course Outcome: At the end of the course, the students will be able to:

- Identify the different ground improvement methods
- Familiarization with poor soil condition and identify the solutions of the respective soil conditions

Syllabus: Introduction, Economic considerations, preloading and sand drains; strengthening by granular columns, Stone columns; lime columns etc. Ground anchors and soil nailing, Problems and case histories

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction, Economic considerations	2
2.	Consolidation by preloading and sand drains; strengthening by granular columns, Stone columns; lime columns	9
3.	Compaction by vibro floatation, blasting and dynamic consolidation	4
4.	Improvement of deep strata of fine soils by vacuum dewatering, PVD, electro osmosis, ground freezing and thermal stabilization	8
5.	Grouting technique	4
6.	Reinforced earth and applications of geo synthetics; retaining walls, slopes, roads, erosion	8
7.	Ground anchors and soil nailing	2
8.	Problems and case histories	2
	Total	39

Suggested Readings:

1. Bowles, J.E. (1997), "Foundation Analysis and Design", McGraw-Hill International Edition.
2. Hausmann, M.R. (1990), "Engineering Principles of Ground Modification", McGraw-Hill International Editions.
3. Yonekura, R., Terashi, M. and Shibazaki, M. (Eds.). (1966), "Grouting and Deep Mixing", A.A. Balkema.
4. Moseley, M.P. (1993), "Ground Improvement", Blackie Academic & Professional.
5. Xanthakos, P.P., Abramson, L.W. and Bruce, D.A. (1994), "Ground Control and Improvement", John Wiley & Sons.
6. Korner, R. M. (2002), "Design with Geosynthetics", Prentice Hall, New Jersey, 3rd Edn.
7. Rao, G. V., and Rao, G. V. S. (latest edition), "Text Book On Engineering with Geotextiles", Tata McGraw Hill.
8. Ingold, T. S. and Miller, K. S. (latest edition), "Geotextile Hand Book", Thomas Telford, London.

CE 4128: Earth and Earth Retaining Structures

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: To create an ability to apply knowledge of geotechnical engineering. To design and analyze the problems related to the earth retaining of soils as a part of geotechnical engineering. To develop an ability to analyze and design of earth retaining structures such as retaining walls, sheet pile walls etc.

Course Outcome: At the end of the course, the students will be able to:

- Develop the basic knowledge of calculation of lateral earth pressure
- Get the knowledge of calculation of stresses in soil mass due to different kinds of loads
- To develop the basic idea of design of earth retaining structures such as retaining walls, sheet pile walls etc.
- Get the knowledge of drainage and dewatering
- Get the idea about application of geosynthetics in the geotechnical field

Syllabus: Introduction and a brief review of previous knowledge of soil mechanics, stresses in soil mass due to different kinds of loads, Earth pressure against retaining structures, Diaphragm Walls, Earth Structures, Drainage and dewatering, Application of Geosynthetics.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction and a brief review of previous knowledge of soil mechanics.	2
2.	Stresses in soil mass due to different kinds of loads – vertical, inclined, horizontal, concentrated, triangular and trapezoidal earthfill. Pore water pressure developed due to seepage.	7
3.	Earth pressure against retaining structures – analytical and graphical methods – different conditions. Stability analysis and design of retaining walls, sheet piles, anchored bulkheads, cofferdam, braced cofferdam.	10
4.	Diaphragm Walls – description and trench stability	4

5.	Earth Structures - Stability analysis based on limit equilibrium principles – methods of slices, stability charts and their use—Taylor's stability charts, determination of critical slip surfaces, stability of earth dams.	10
6.	Drainage and dewatering –brief description of various methods	2
7.	Application of Geosynthetics	4
	Total	39

Suggested Readings:

Latest edition of

1. Das, B. M., "Principles of Geotechnical Engineering", Thomson Brooks/Cole, 6th Edition.
2. Craig, R. F., "Soil Mechanics", Taylor & Francis, 7th Edition.
3. Singh, A., "Soil Engineering in Theory and Practice", Vol. I, CBS.
4. Huntington, W.C., "Earth Pressure and Retaining Walls", W.C. John Wiley & Sons Inc.
5. Lambe, T. W, and Whitman, R.V., "Soil Mechanics", John Wiley & Sons Inc.

CE 4130: Design of Pavement Structure

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: Gain knowledge about principle factors affecting pavement design, and maintenance of pavement. Excel in the path of analysis of stress, strain and deflection in pavement, design concepts of flexible and rigid pavement by various design methods, design concept of embankment and subgrade. Develop skills to design runway pavement.

Course Outcome: At the end of the course, the students will be able to:

- Understand the characteristics of flexible and rigid pavement and factors govern the design criteria
- Analyze stress, strain and deflection of flexible and rigid pavement
- Design flexible pavement and rigid pavement conforming to IRC, AASTHO and other design guidelines
- Design the runway pavement

Syllabus: Elements of pavement structures and its design criteria, stresses in flexible and rigid pavement, road embankment and subgrade design, flexible and rigid pavement design, and design of runway pavement

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Pavement Structure Elements; Performance Criteria; Roadway and Runway pavements, Characteristics of Traffic Load; Estimation of Design Traffic	6
2.	Analysis of Stresses in Flexible and Rigid Pavement	6
3.	Design of Embankment and Subgrade	6
4.	Design of Flexible and Rigid Pavements by IRC, AASHTO and Other Methods	15
5.	Design of overlay	6
	Total	39

Suggested Readings:

Latest editions of

1. Kumar, R.S., “Pavement Design”, Universities Press
2. Khanna, S.K., Justo, C.E.G., and Veeraraghavan, A., “Highway Engineering”, Nem Chand & Bros.
3. Chakroborty, P., and Das, A., “Principles of Transportation Engineering”, Prentice Hall of India Pvt. Ltd.
4. Graber, N.J., and Hoel, L.A., “Traffic & Highway Engineering”, Brooks/Cole
5. Yoder, E. J. and Witczak, M. W., “Principles of Pavement Design”, John Wiley and Sons.
6. Mallick, R.B., and Ei-Korchi, T., “Pavement Engineering: Principles and Practice”, CRC Press.

CE 4131: Industrial and Hazardous Waste Management

Weekly Contact: 3-0-0 (L-T-P)……..Full Marks:100 Credit: 3

Course Objective: To provide the students with basic understanding about the generation of industrial wastes, its minimization and treatment methods for its safe disposal.

Course Outcome: At the end of the course, the students will be able to:

- Understand the sources and composition of different industrial wastes
- Apply the waste source reduction methods
- Know about the different methods for waste treatment and management
- Acquire knowledge about the waste composition and treatment methods for specific industries.

Syllabus: Effluent characterization; approach towards minimization; treatment of Industrial wastes, treatment of specific industrial wastewater**.**

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Effluents from industries – sampling, characterization. Effect of discharge of industrial wastewaters on streams, land and environment, Indian Standards for discharge of wastewaters	5
2.	Approach towards minimization - good housekeeping, equalization and neutralization by mixing of different effluent streams, recycling of wastewater streams, process modification in terms of raw materials and chemicals used	5
3.	Treatment of Industrial wastes, equalization and proportioning, neutralization, Removal of dissolved and suspended solids, Organic waste treatment process, Sludge treatment and handling	8
4.	Treating different effluent streams separately, Treating different streams jointly after mixing them partly or fully including/ excluding domestic wastewater	5
5.	Approaches for treating wastes having shock loads, colours, toxic metal ions, refractory substances, growth inhibition substances such as insecticides, oil and grease, acidic and alkaline waste, alkalinity, etc.	8

6.	Process flow Diagrams for treatment of various Industrial Wastes	8
	Total	39

Suggested Readings:

Latest editions of

1. Eckenfelder Jr., W. W., "Industrial water pollution Control", McGraw-Hill
2. LaGrega, M. D., Buckingham, P. L., Evans, J. C., "Hazardous waste management", Environmental Resource Management, 2nd Edition, McGraw-Hill
3. Birdie, G. S., and Birdie, J. S., "Water Supply and Sanitary Engineering", Dhanpat Rai Publishing Co.

CE 4133: Water Resources System

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Pre-requisite: CE 2204

Course Objective: The objective of this course is to develop an understanding of systems analysis and various optimization techniques like calculus, linear and dynamic programming and to prepare them for applying the knowledge to real life problem solving with an emphasis on water resources. It also aims to introduce and prepare them to apply various methods of economic analysis to problems in Water Resources Engineering.

Course Outcome: At the end of the course, the students will be able to:

- Plan and design water resources projects by applying the general principles of systems analysis
- Optimise the performance of the various objective of a water resources project like multi-purpose reservoir operation
- Understand how to distribute irrigation water optimally among different stakeholders
- Analyze the economic feasibility of water resources development projects
- Identify and evaluate the costs and benefits of water resources projects

Syllabus: Introduction about the system concepts, Optimization using calculus, Linear programming, Dynamic programming, Water resources system modelling, Economic analysis of water resources project.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction: Concept of a system, , System Components, Advantages and limitations of systems approach, Modeling of Water Resources Systems, Simulation and optimization, Economics in water resources, Challenges in water sector	3
2.	Optimization using Calculus: Objective function, Maxima, minima and saddle points, convex and concave functions, Constrained and unconstrained optimization using calculus, Lagrange multipliers, Kuhn-Tucker conditions.	7
3.	Linear Programming: General form of LP, Standard and Canonical forms of LP, Elementary transformations, Graphical method, Feasible and infeasible solutions, Simplex method, Dual and sensitivity analysis, LP problem formulation, Reservoir sizing and Reservoir operation using LP	9
4.	Dynamic Programming: Introduction, multistage decision problem, Recursive Equations, Principle of optimality, Discrete DP, Curse of Dimensionality, Water allocation problem, Capacity expansion problem, Reservoir operation	7
5.	Water Resources System Modelling: Multipurpose reservoir operation, Water distribution systems, Urban storm water management, Water quality modelling, Floodplain management	6
6.	Economic Analysis of Water Resources Projects: Basics of Engineering Economics, Discount Factors, Amortization, Present worth, Economic Analysis, Supply and Demand, Benefit Cost Analysis	7
	Total	39

Suggested Readings:

1. Loucks D.P, Stedinger J.R., and Haith D.A. (1981), “Water Resources Systems Planning and Analysis”, Prentice Hall, USA.
2. Mays L.W., and Tung, Y.K. (1992), “Hydrosystems Engineering and Management”, McGraw Hill, USA.

3. Vedula, S., and Mujumdar, P.P. (2005). "Water Resources Systems: Modelling Techniques and Analysis", Tata-McGraw Hill.
4. Jain, S.K., and Singh, V.P. (2003). "Water Resources Systems Planning and Management", Elsevier, The Netherlands.

CE 4134: Hydropower Engineering

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**
Pre-requisite: CE 2204

Course Objective: The objective of this course is to stress the importance of hydropower as a sustainable energy source. In this regard, to help them to estimate the hydropower potential of our country. It also aims to develop an understanding of planning a hydroelectric power plant and design its different components and to enable students to develop independent problem-solving skills in this field.

Course Outcome: At the end of the course, the students will be able to:

- Understand the importance of hydropower as a sustainable energy source.
- Know how to plan and implement a hydropower project
- Know about the different types of power plants and their layout and components
- Understand how to design different components of the power plants

Syllabus: Introduction to Hydro Power Energy, Planning and Management of hydro power projects, Power Plants, Design of Components, Water hammer pressure, case studies

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction to Hydro Power Energy: Introduction to non-conventional energy. Types of energy – solar energy, wind energy, biomass energy, ocean and geothermal energy etc. Need for hydropower energy and its power estimation. Law of conservation of energy. Climate change and hydropower	3
2.	Planning and Management: Government Hydropower policies, environmental issues, SWOT-(Strength weakness opportunity threatening) of hydropower projects, type of clearance required for Hydropower project, Survey & investigation, PFR-(Pre-feasibility report), DPR (Detailed Project Report), Process of development of site (announcement, allotment, clearance, agreement, commissioning).Types of survey- Topographical, metrological, hydrological, ecological, geological.	8

3.	Power Plants: Sources and forms of energy, types of power plants, and elements of hydropower scheme, hydropower development in India. Power house structures-substructure and superstructure Layout and dimensions, deign considerations. Hydropower plants classification: Surface and underground power stations, Low medium-high head plants-layout and components, pumped storage plants, tidal power plants, micro-tidal units. Load and power studies: load curve, load factor, load duration curve, firm capacity, reservoir capacity, capacity factor.	7
4.	Design of Components: Classification of penstocks, Design of Penstocks, economic diameter, bends, anchor blocks, surges in canals design criteria of power canals. Intake structures: Location function and types of intakes, energy losses at intake trash rock, design of intakes.	12
5.	Water hammer pressure: Behaviour of surge tanks, types of surge tanks, Hydraulic turbines and types and classification, constructional features, hydraulic analysis, selection, characteristic curves	5
6.	Case studies	4
	Total	39

Suggested Readings:

Latest editions of

1. Varshiray, R.S., "Hydropower structures", Nem Chand and Bros. Roorkee
2. Desmukh, M.M., "Water Power Engineering", Dhanpat Rai and Sons.
3. Punmia, B.C., and Pande, B.B., "Irrigation and water power Engineering", Laxmi Publications Private Limited
4. Dandekar, M.M., and Sharma, K.N., "Water Power Engineering", Vani Educational Books

8th Semester: Core Elective - II

CE 4221: Bridge Engineering

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Prerequisite: Structural Analysis and Design

Course Objective: Analytical methodologies in detail, Design perspective in Indian condition and Construction cum Maintenance in brief.

Course Outcome: Conversant with Design of Indian Bridges.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction, Overview, Classification and Terminology	3
2.	Site Selection, Planning, Bridge Hydraulics, Loads and Forces. Introduction to Indian Code Provisions for Design of Steel and Concrete Bridges	6
3.	Methods of Analysis and Design of Superstructure.	6
4.	Methods of Analysis and Design of Foundations	6
5.	Methods of Analysis and Design of Abutments and Piers. Methods of Analysis and Design of Bearings.	6
6.	Construction and Maintenance of Bridges. Health Monitoring and Evaluation of Existing Bridges	9
7.	Introduction to the world's magnificent bridges.	3
	Total	39

Suggested Readings:

Latest editions of

1. Ponnuswamy, S., “Bridge Engineering”.
2. Krishnaraju, N., “Design of Bridges”.
3. Victor, D.J., “Essentials of Bridge Engineering”.
4. Rakshit, K.S., “Design and construction of Highway Bridges”.

CE 4222: Structures under Extreme Events

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: The objective of this course is to understand proper evaluation, modelling, and assessment of the effects of extreme events to ensure the desired performance of structures.

Course Outcome: At the end of the course, the students will be able to:

- Knowledge of various natural and manmade extreme effects, special considerations for analysis under such loads.
- Know to describe and modelling of Various Extreme loads i.e. wind, earthquake,blast, explosion, projectile impact, fire etc.
- Learn dynamics of structures under extreme transient loads including high strain considerations and the effect of combined extreme transient loadings on a structure.
- Know the basics of safety assessment under extreme loads

Syllabus: Introduction: various natural and manmade extreme effects, special considerations for analysis under such loads. Description and modelling of various extreme loads i.e. wind, earthquake, blast, explosion, projectile impact, fire etc. Dynamics of structures under extreme transient loads: the effects of strong earthquake motion, and the impact and long-duration effects of strong stormy winds, explosion induced impact loading. High Strain Rate Response under extreme Dynamic Loading. The effect of combined extreme transient loadings on structure. Introduction to safety assessment under extreme loads.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction: various natural and manmade extreme effects, special considerations for analysis under such loads	3
2.	Description and modelling of Various Extreme loads i.e. wind, earthquake, blast, explosion, projectile impact, fire etc.	16
3.	Dynamics of Structures Under Extreme Transient Loads: the effects of strong earthquake motion, and the impact and long-duration effects of strong stormy winds, explosion induced impact loading	8
4.	High Strain Rate Response under extreme Dynamic Loading	3

5.	The effect of combined extreme transient loadings on a structure	3
6.	Introduction to safety assessment under extreme loads	6
	Total	39

Suggested Readings:

1. Kappos A. J. (2002), "Dynamic Loading and Design of Structures", Spon Press, Taylor and Francis group.
2. Ibrahimbegovic, A., and Kozar, I. (edited) (2006), "Extreme Man-Made and Natural Hazards in Dynamics of Structures", NATO Security through Science Series, Springer
3. Nigam, N.C., and Narayanan, S. (1994), "Applications of Random Vibrations", Narosa
4. Ibrahimbegovic, A., and Ademovic, N. (2019), "Nonlinear Dynamics of Structures Under Extreme Transient Loads", CRC Press Taylor & Francis Group.

CE 4223: Tall Structures

Weekly contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: The objective of the course is to impart the students a vast knowledge of analysis and design of tall structures subjected to all possible gravity and lateral loads as per relevant standards. This will help them to design various industrial tall buildings or other applications in design problems.

Course outcome: At the end of the course, the students will be able to:

- Understand the basic concepts of various structural systems and configurations
- Understand the analysis and design concepts of multi-storied tall structure: building, chimneys, towers etc.
- Learn the design and detailing of various members and joints, shear walls for ductility.
- Learn to check the stability of tall buildings.
- Learn the design of foundations of tall structures.

Syllabus: Introduction to high rise structures, Analysis and design concepts of multi-storied tall structure, detailing of various members and beam-column joints, Design of shear walls and coupled shear walls, Stability of tall buildings, Design of foundation.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction to high rise structures, Behavior of Various Structural Systems and configurations, effect of aerodynamic modifications.	9
2.	Analysis and design concepts of multi-storied tall structure: building, chimneys, towers under gravity and lateral loads. Introduction to IS and foreign codes for design of tall structures	12
3.	Design and detailing of various members and beam-column joints, shear walls and coupled shear walls for ductility. The capacity design principle. Performance based design philosophy	6
4.	Stability of Tall Buildings: Overall buckling analysis of frames, wall frames, approximate methods, second order effects of gravity of loading, P-Delta analysis, Transnational, Torsional instability,	6
5.	Design of foundation of tall structures	6
	Total	39

Suggested Readings:

Latest editions of

1. Taranath, B. S., "Structural Analysis and Design of Tall Buildings", Mc-Graw Hill.
2. Smith, B.S., and Coull, A., "Tall Building Structures", Wiley India.
3. Schueller, W., "High Rise Building Structures", Wiley.
4. Varyani, U.H., "Structural Design of Multi-storeyed Buildings", 2nd Ed., South Asian Publishers, New Delhi.

IS: codes:

1. IS:16700-2017, "Criteria for structural safety of tall concrete buildings", BIS, New Delhi, India.
2. IS:4998(I):1992, "Criteria for design of reinforced concrete chimneys", BIS, New Delhi, India.

CE 4224: Behavior of Metal Structures

Weekly contact 3-0-0 (L -T -P) **Full Marks:100** **Credit: 3**

Course Objective: 1. To equip the candidate with a detailed knowledge on behvaiour of metal structures (mainly hot rolled steel, cold formed steel and aluminium structures) and their failure modes. 2. To train the candidate with behaviour and design of modern steel structural systems, like reticulated system, cable suspended systems, 3. To impart a deeper insight of connection behaviour - semi rigid connections, HSFG bolts., 4. To introduce the concept of LRFD-based advanced design approach, 5. To provide a deeper perspective of fatigue and earthquake resistant design of steel structure.

Course Outcome: At the end of the course, the students will be able to:

- Students will be able to gain a deeper insight (than the basic course on steel structure design) of behvaiour and design of metal structures and their connection,
- Students will be able to analyze and design against various failure modes of metal structure
- Students will be able to design light gauge steel structure, alumium structures and modern structural systems of cable and reticulated structures,
- Students will be able to apply the concept of LRFD design for design of structure using foreign codes.

Syllabus: Various forms of buckling, Design and behaviour of Aluminium, metal hot rolled, and metal cold formed structure, LRFD steel design, effect of fatigue, earthquake resistant design, design of modern structural system like reticulated structures, cable suspended structures, etc, Critical analysis and design of connections - semi-rigid joints, HSFG bolts.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Mechanical properties of metals, hysteresis, ductility; Concept of inelastic behavior of beam and frames, residual stresses, estimation of fatigue life	6
2.	Effect of buckling on member design: local buckling, elastic and inelastic buckling, post-buckling of plate elements, torsional buckling, design for torsion, P-Δ effects	9
3.	High strength friction grip (HSFG) bolted connections, Semi-rigid and rigid beam to column connections	6
4.	Behavior and design of reticulated plate, shell and cable supported roof system	6

5.	Earthquake resistant design of metal structures	3
6.	Introduction to design of light gauge steel structural members	3
7.	Introduction to design of Aluminum Structure	3
8.	Introduction of LRFD steel design	3
	Total	39

Suggested Readings:

1. Salmon C.G. and Johnson J. E. (1996), "Steel structures: Design and Behavior", HarperCollins Publishing.
2. Subramanian, N. (2011), "Design of Steel Structures", Oxford Univ Pres.
3. Trahir N. S., and Nethercot, D. A. (2007), "The Behaviour and Design of Steel Structures to EC3", Taylor and Francis.
4. Timoshenko, S. P., and Gere, J. M. (1961), "Theory of Elastic Stability", Mc-Graw Hill Book Company, New York.
5. Segui, W. T. (2007), "LRFD Steel Design", Cengage Learning.

CE 4226: Probabilistic methods in Geotechnical Engineering

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: The objective of the course is to introduce the basic concepts of probability and statistics in solving various geotechnical engineering problems.

Course outcome: At the end of the course, the students will be able to:

- Understand the basic concepts of statistics and probability in engineering
- Understand the probability distribution and functions of a random variable
- Perform regression and correlation Analysis
- Perform reliability and reliability-based design and sensitivity analysis

Syllabus: Role of Statistics and Probability in Engineering, Fundamentals of Probability Models, Analytical Models of Random Phenomena, Functions of Random Variables, Estimating

Parameters from Observational Data, Regression and Correlation Analysis, Reliability and Reliability-Based Design, Methods of reliability analysis.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Role of Statistics and Probability in Engineering, Fundamentals of Probability Models--Events and probability, estimating probabilities, mathematics of probability-theorem of total probability, Bayes' theorem	5
2.	Analytical Models of Random Phenomena--Random variables, probability distribution of a random variable, main descriptors of a random variable, useful probability distributions, multiple random variables, joint and conditional probability distributions, covariance and correlation. Functions of Random Variables--Derived probability distributions, functions of multiple random variables, moments of functions mean and variance of a general function, central limit theorem.	12
3.	Estimating Parameters from Observational Data, Regression and Correlation Analysis--Basic formulation of linear regression, multiple linear regression, nonlinear regression, correlation analysis	8
4.	Reliability and Reliability-Based Design--Concept of reliability, Analysis and assessment of reliability—Reliability index, Methods of reliability analysis--Mean-Value First-Order Second-Moment method based on Taylor series expansion, Hasofer-Lind FOSM method, First Order Reliability Method (FORM), Probability-based Design criteria, Sensitivity analysis	14
	Total	39

Suggested Readings:

1. Baecher, G.B., and Christian, J.T. (2005), "Reliability and Statistics in Geotechnical Engineering", John Wiley & Sons.
2. Probabilistic characterization of soil properties: bridge between theory and practice : Proceedings of a symposium, David S. Bowles, Hon-Yim Ko, American Society of Civil Engineers. Geotechnical Engineering Division

3. Gordon, D., Fenton, A., and Griffiths, D. V. (2007), "Probabilistic Methods in Geotechnical Engineering", A. Fenton (eds.), Springer -Verlag Wien New York.
4. Ang, A.H.S., and Tang. W.H. (latest edition), "Probability Concepts in Engineering Planning and Design", Vol. I & II., John Wiley & Sons, Inc.
5. Chernoff, H., and Moses. L. E. (latest edition), "Elementary Decision Theory", Dover Publications, Inc.
6. Elishakoff, I. (latest edition), "Probabilistic Theory of Structures", Dover Publications, Inc, 2nd edition.
7. Lin, Y.K. (latest edition), "Probabilistic Theory of Structural Dynamics", McGraw Hill, New York.

CE 4227: Environmental Geomechanics

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: To develop the knowledge of the effect of contaminants on engineering properties of soil. Identify the different remedial methods of contaminant soils and waste utilization methods. To know the design procedure of liner, cover, cut off walls, leachate collection and removal system etc.

Course Outcome: At the end of the course, the students will be able to:

- Develop the basic knowledge of engineering properties of contaminated soils
- Develop the skills to mitigate the problems of contaminant transport through soil.
- Sound knowledge regarding design aspects of liner, cover, cut off walls.
- Develop concepts of waste utilization.

Syllabus: Fundamental issues of waste problem, Effects of contaminants on engineering properties of soil, Remediation and stabilization of contaminated ground, Contaminant transport, Design of liner, cover, cut off walls, leachate collection and removal system, waste utilization.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Fundamental issues of waste problem; regulations, waste generation and disposal, composition and engineering properties of waste soils	4
2.	Effects of contaminants on engineering properties of soil; clay mineralogy, clay – water –electrolyte system, soil - water – contaminant interaction	6
3.	Remediation and stabilization of contaminated ground; bioremediation, soil washing, thermal treatment, solidification, ground improvement application	7

4.	Contaminant transport, advection, diffusion, dispersion, chemical reactions, dispersion coefficient, distribution coefficient, retardation factor, contaminant transport modeling	10
5.	Design of liner, cover, cut off walls, leachate collection and removal system	8
6.	Waste utilization; stability, settlement, seismic consideration, field quality control	4
Total		39

Suggested Readings:

1. Mitchell, J.K and Soga, K. (2005), "Fundamentals of Soil Behavior", John Wiley and Sons Inc.
2. Fang, H.Y. (1997), "Introduction to Environmental Geotechnology", CRC Press.
3. Daniel, D.E. (1993), "Geotechnical Practice for Waste Disposal", Chapman and Hall.
4. Rowe, R.K., Quigley, R.M. and Booker, J.R. (1995), "Clay Barrier Systems for Waste Disposal Facilities", E & FN Spon.
5. Rowe, R.K. (2001), "Geotechnical and Geoenvironmental Engineering Handbook", Kluwer Academic Publishers.
6. Reddi, L.N. and Inyang, H.F. (2000), "Geoenvironmental Engineering - Principles and Applications", Marcel Dekker Inc.
7. Sharma, H.D., and Lewis, S.P. (1994), "Waste Containment Systems, Waste Stabilization and Landfills: Design and Evaluation", John Wiley & Sons Inc.

CE 4228: Geotechnical Investigations and Instrumentation

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: To develop the basic knowledge about soil exploration. Planning and design of soil exploration programme. To have an idea regarding the choice of sampler, sampling of soil and rock in the field. To know the various methods of determining the engineering properties of soils. Basic understanding of the methods of geotechnical investigations used in civil engineering design and constructions.

Course Outcome: At the end of the course, the students will be able to:

- Develop the basic idea about planning and design of subsurface exploration.
- Develop an idea about the types of sampler, sampling methods etc..
- Sound knowledge regarding preparation of soil investigation report

Syllabus: Methods of Geophysical exploration: seismic refraction and electrical resistivity methods, Methods of boring, sampling, In-situ method of determination of different soil properties, Laboratory methods for determining the various properties and behaviour of soils. Exploration methods in rocks, Preparation of necessary report.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Methods of Geophysical exploration: seismic refraction and electrical resistivity methods. Field soil exploration – planning and exploration programme. Methods of boring, sampling – samplers. Spacing, number, extent and location of bore holes. Bore logs. Stabilization of bore holes.	12
2.	In-situ method of determination of different soil properties like shear strength, permeability etc. Soundings, pressure meter. Determination of water table. Under water exploration. Technique of ground water exploration	8
3.	Exploration methods in rocks – investigation, sequence, drilling, sampling and bore hole inspection. Stresses in rocks, and properties of rocks.	8
4.	Laboratory methods for determining the various properties and behaviour of soils. Dynamic testing of soils. Methods of geotechnical study for various civil engineering design and construction	8
5.	Preparation of necessary report	3
	Total	39

Suggested Readings:

1. Bowles, J.E. (1985), "Physical and Geotechnical Properties of Soil", McGraw-Hill Book Company.
2. Bowles, J.E. (1997), "Foundation Analysis and Design", McGraw-Hill International edition.
3. Dunnicliff, J. and Green, G.E. (1982), "Geotechnical Instrumentation for Monitoring Field Performance", John Wiley & Sons.

4. Ranjan, G., and Rao, A.S.R. (1991), "Basic and Applied Soil Mechanics", Wiley Eastern Limited.
5. Lunne, T., Robertson, P.K., and Powell, J. J. M. (1997), "Cone Penetration Testing in Geotechnical Practice", Blackie Academic & Professional.
6. Compendium of Indian Standards on Soil Engineering Parts 1 and II 1987 - 1988.

CE 4229: Materials and Construction of Roadway Pavement

Weekly Contact: 3 – 0 – 0 (L – T – P) **Full Marks: 100** **Credit: 3**

Pre-requisite: Transportation Engineering - I

Course Objective: To provide the students with a basic understanding of pavement materials and construction procedures and practices for road engineering applications. The course also intends to impart knowledge on various emerging topics of pavement engineering: for example, non-conventional and new pavement materials, modern construction equipment and quality assurance and control.

Course Outcome: In this course, students will gain a theoretical and applied understanding of the use of pavement materials and construction procedures and practices for road engineering. The course learning outcome are:

- Component of pavement structures, materials used for different layers and testing procedure
- Construction of plain jointed, roller compacted and continuously reinforced cement concrete pavement
- Utilisation of non-conventional materials for pavement construction
- Construction methodology and selection of equipment for different activities
- Quality assurance and quality control during construction

Syllabus: Introduction, materials used in pavement construction, components of the pavement structure, cement concrete pavements, non-conventional and new pavement materials, construction equipment, quality control.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction: History of road construction - the basic structure of roadway pavement	3

2.	Materials used in pavement construction: Aggregates – cement - bituminous materials - cement concrete - bituminous concrete - soil characteristics - testing procedure	7
3.	Components of pavement structure: Embankments – subgrade - granular sub-base - base - surface course of flexible pavement	3
4.	Cement concrete pavements: Materials - constructions of plain jointed concrete pavement including different types of joints - roller compacted concrete pavement (RCCP) construction - continuously reinforced concrete pavement (CRCP) - low-cost concrete pavement	9
5.	Non-conventional and new pavement materials: Use of non-conventional Materials including waste materials - stabilization - Super pave	7
6.	Construction equipment: Construction methods - selection of equipment - characteristics and performances of equipment for different activities such as material transport, concreting, pavement construction	6
7.	Quality control: Introduction to quality, assurance, control - techniques in quality control - quality assurance during construction	4
	Total	39

Suggested Readings:

1. Justo, C. E. G., Khanna, S. K., and Veeraraghavan, A. (2015), "Highway Engineering", Nem Chand & Bros.
2. Chakraborty, P. & Das, A. (2017), "Principles of Transportation Engineering", PHI Publication
3. Rao, G. V. (2000), "Principles of Transportation and Highway Engineering", Tata Mc. Graw Hill.
4. Ministry of Road Transport and Highways (2013), "Specifications for Road and Bridge Works", New Delhi
5. Indian Roads Congress (2005), "Manual for Construction and Supervision of Bituminous works", New Delhi

CE 4230: Road Safety Engineering

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: Highlighting the need for road safety and identification of various factors contributing to road crashes, Exposing students about road crash data collection procedure, its

analysis, prioritization, management and derivation of preventive countermeasures. Explaining the procedure for evaluation of planned/existing roadway facilities from a safety point of view as well as emphasis on the need for consistent data collection standards (crash data, geometric features, traffic characteristics, environmental conditions and surrogate data)

Course Outcome: At the end of the course students will able to:

- Analyze the present scenario about transport safety and environment with a multidisciplinary approach
- Examine factors affecting road safety engineering and crash investigation, human factors relating to crashes/accidents, crash/accident.
- Predict hazard identification related to the transport safety and environment and take management measures for improving road safety
- Create awareness about empathetic and improving the present practices related to the Road Safety Audit

Syllabus: Road traffic environment including vehicle and driver behavior, traffic safety planning and design for urban and rural roads, crush investigation and modeling, accident study and accident cost evaluation and road safety audit.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Vehicle, Roadway, Driver characteristics	6
2.	Planning for traffic safety in urban streets, highways and rural roads	3
3.	Roadway geometric and traffic system design for safety; Traffic operation and management	12
4.	Crash and Injury causations; Crash models; Accident investigation and prevention Accident cost, Accident analysis	12
5.	Enforcement and education aspects for safety; Road Safety Audit	6
	Total	39

Suggested Readings:

Latest editions of

1. Kadiyali, L.R., “Traffic Engineering and Transportation Planning”, Khanna Publishers

2. Papacostas, C.S., and Prevedouros, P. D., “Transportation Engineering & Planning”, Prentice-Hall India
3. Graber, N.J., and Hoel, L.A., “Traffic & Highway Engineering”, Brooks/Cole
4. Khisty, C.J., and Lal, B. K., “Transportation Engineering; An Introduction”, Prentice-Hall India
5. Mannering, F.L., Kilareski, W.P., and Washburn, S.S., “Principles of Highway Engineering and Traffic Analysis”, Willey India

CE 4231: Rural Water Supply and Sanitation

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course Objective: To provide the students with basic understanding about the methods of rural water supply, treatment requirements, management of liquid waste and solid waste.

Course Outcome: At the end of the course, the students will be able to:

- Identify the sources of rural water supply
- Decide the methods of treatment requirements for rural water supply
- Know about the management of night soil and liquid waste
- Know about the methods to manage the solid waste.

Syllabus: General concept and scope of water supply and sanitation in rural areas; water quality aspects; water demand; sources of water; treatment methods for individuals and community; collection, treatment and disposal on night soil and liquid waste; disposal methods of solid waste; case studies.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	General Concept and scope of environmental sanitation in rural areas, Magnitude and problems of water supply and sanitation in rural areas in India, National policy.	6
2.	Water Supply Quality aspects: Specific impurities and their significance, Design population, Demand and variations	9

3.	Planning of water supply schemes in rural areas: individual village and group schemes, Source of water supply: Springs, wells, infiltration wells, radial wells, infiltration galleries and surface water intake, Treatment of water for rural water supply, Compact system: multibottom settler, horizontal roughing filter, slow sand filter, cloth filter, chlorine diffuse cartridges, pumps, pipe, materials, appurtenances and improved device for use in rural water supply schemes, Distribution system for rural water supply	9
4.	Disposal of Night Soil and Wastewater, Various methods of collection and disposal of night–soil: sanitary latrines, community latrines, septic tanks, soakage system, anaerobic filter, Imhoff tank, compact and simple wastewater treatment units: stabilization ponds, revolving biological surfaces. Biogas Plants, Quantity of cow dung, required capacity and design	9
5.	Disposal of Solid Wastes Composting, landfilling, incineration, recycling	3
6.	Case studies	3
	Total	39

Suggested Readings:

Latest editions of

1. Gupta, S., “Rural Water Supply and Sanitation”, VAYU Education of India
2. Wright, F.B., “Rural Water Supply and sanitation”, Kruger Publishing Company
3. Birdie, G.S., and Birdie, J.S., “Water Supply & Sanitary Engineering”, Dhanpat Rai Publishing Co. Pvt. Ltd.
4. Husain, S.K., “Textbook of Water Supply and Sanitary Engineering”, Oxford & IBH Publishers

CE 4233: Advanced Hydraulic Structures

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Syllabus

Introduction: Definition, types, and necessity of hydraulic structues; Dams, Barrages and River/Canal regulation structures. Names, location, purposes, and characteristics of some famous hydraulic structures.

Site Selection: Investigation survey, Selection of dam site, Selection of type of dam, Classification, Geological Investigation, Field Exploration.

Earth and Rockfill Dams: Introduction, Types. Causes of failures and remedial measures, Selection of earth dams, Criteria for safe design of an earth dam, Section of an earth dam, Phreatic lines, Seepage loss through earth dams, Stability analysis, Control of seepage through earth dams, Slope Protection, Design considerations in Earthquake Regions, Rockfill dams, Design considerations.

Gravity Dams: Forces acting on gravity dams, Modes of failures, Load combination for design, Elementary profile, Stability analysis, Control of cracking, Galleries.

Structures of Permeable Foundation: Types, characteristics. Modes of failures, Bligh's Creep theory, Lanes weighted creep theory, Potential flow theory, Khosla's method of independent variables, Design of barrages.

Sl. No	Description of Course Modules and Lecture Plan	No. of Lectures
1.	Introduction: Definition, types, and necessity of hydraulic structues; Dams, Barrages and River/Canal regulation structures.	2
2.	Site Selection: Investigation survey, Selection of dam site, Selection of type of dam, Classification, Geological Investigation, Field Exploration.	4
3.	Earth and Rockfill Dams: Introduction, Types. Causes of failures and remedial measures, Selection of earth dams, Criteria for safe design of an earth dam, Section of an earth dam, Phreatic lines, Seepage loss through earth dams, Stability analysis, Control of seepage through earth dams, Slope Protection, Design considerations in Earthquake Regions, Rockfill dams, Design considerations.	8

4	Gravity Dams: Forces acting on gravity dams, Modes of failures, Load combination for design, Elementary profile, Stability analysis, Control of cracking, Galleries.	20
5	Structures of Permeable Foundation: Types, characteristics. Modes of failures, Bligh's Creep theory, Lanes weighted creep theory, Potential flow theory, Khosla's method of independent variables, Design of barrages.	5
	Total	39

Suggested readings:

1. Garg, S.K. (2016), "Irrigation Engineering and Hydraulic Structures", Khanna Publishers
2. Sharma, S.K. (2017), "Irrigation Engineering and Hydraulic Structures", S. Chand Publishing
3. Jain, R.K. (2019), "Design of Hydraulic Structures", Mahajan Publishing House
4. James, C.S. (2019), "Hydraulic Structures", Springer

CE4234: Statistics in Hydrology

Weekly Contact: 3-0-0 (L-T-P) **Full Marks100** **Credit: 3**

Course Objective: Statistics is an evitable tool for solving problems related to Water Resources Engineering. In this context, the course is designed in such a way that the students will get a basic knowledge of statistics with the context of its application to hydrology. This will enable them to solve the real-life problems related to hydrological events, particularly for extreme events like flood and drought.

Course outcome: At the end of the course, the students will be able to:

- Understand the basic concepts of probability and statistics
- Apply the different probability distributions for problems related to hydrology
- Determining the design magnitude of the structures within its expected life to withstand different hydrologic events by applying risk analysis
- Analyze the time-series data with different models

Syllabus: Concepts of probability and statistics, Basic statistical properties of data, Probability Distributions and their applications, Frequency analysis, Hydrologic Design, Hypothesis testing and non-parametric test, Time-series analysis

Sl. No.	Description of Course Modules and Lecture Plan	No. of Lectures

1.	Concepts of probability and statistics – Random variable, probability, Conditional Probability Theorem, Total Probability Theorem and Bayes' Rule, Univariate and Bivariate Probability Distribution, Marginal and Conditional Probability Distribution Basic statistical properties of data - Descriptive Statistics: Measures of Central Tendency, Measures of Dispersion, Measures of Symmetry, Moments and Expectations, Moment generating functions Parameter Estimation - Method of moment, Method of maximum likelihood, Example problems in hydrology	8
2.	Probability Distributions and their applications – Discrete probability distributions – Binomial Distribution, Poisson Distribution, Continuous probability distributions – Extreme value distribution, Normal distribution, Log-normal distribution, Gamma Distribution, Pearson Distribution, Log-Pearson Type-III Distribution Important distributions of sample statistic – Chi-square Distribution, T Distribution, F Distribution Frequency analysis - Concept of Return Period, Probability Plotting and Plotting Positions Formulae, Frequency Analysis of Hydrologic Extremes using Different Distributions	10
3.	Hydrologic Design: Risk and reliability in hydrologic design, Reliability, resilience and vulnerability of hydrologic time-series	4
4.	Hypothesis testing and non-parametric test – Populations, Samples, Sampling distribution, Statistical Inference – Point Estimation, Interval Estimation, Hypothesis testing, Goodness of fit test, Non-parametric test Regression analysis – Simple linear regression, Multiple linear regression, Correlation and regression, confidence interval Multivariate analysis – Principal component analysis, Analysis of variance	9
5.	Time-series analysis – Data representation, stationary and non-stationary time-series, trend analysis, analysis of periodicity, Time-series modelling– measures of linear association in time-series, statistical operators on time-series, properties of time-	8

	series models, Autoregressive models, Moving-average models, Forecasting with different models	
	Total	39

Suggested Readings:

Latest editions of

1. Haan, C.T., "Statistical Methods in Hydrology", Iowa State University Press.
2. Maity, R., "Statistical Methods in Hydrology and Hydroclimatology", Springer Transaction in Civil and Environmental Engineering.
3. Chow, V.T., Maidment, D.R., and Mays, L. W., "Applied Hydrology", Mc-Graw Hill International Editions.

Open Elective - II

CE 4261: Environmental Management

Weekly contact 3-0-0 (L -T -P) **Full Marks: 100** **Credit: 3**

Course objective:

1. To familiarize students about various different industrial activities and associated environmental problems.
2. To impart the basic idea about environmental regulations, LCA, EIA, EA and EMS.
3. To impart knowledge about sustainability.

Course outcome:

1. Students will be able to learn the sources of industrial pollution and prepare its management options.
2. Students will be able to conduct LCA, EIA, AU and EMS.
3. The students will be able to learn to design environment.
4. Students will be able to design environmental systems for sustainable development.

Syllabus: Industrial activity and the environment; environmental regulations; life cycle assessment (LCA); environmental impact assessment (EIA); Environmental audit (AU); Environmental management system (EMS); Environmental design and sustainable development.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Industrial activity and the environment – air pollution, solid waste, hazardous waste, water pollution, energy usage, resource depletion	5
2.	Environmental Regulations and International Protocols	4
3.	Life cycle assessment – stages in product LCA, LCA methodology, application of LCA	4
4.	Environmental Impact Assessment – purpose of EIA, steps in EIA, Environmental impact statement, impact indicators	5
5.	Environmental Audit – types of environmental audit, EA methodology	4
6.	Pollution prevention planning and Improved manufacturing operations	4
7.	Design for the environment – benefits, ED for manufactured products, ED for buildings, ED for developmental planning	4
8.	Environmental Management System – core elements of EMS, documentation for EMS, implementation of EMS	4
9.	Toward a sustainable society – what is sustainability, hurdles to sustainability, a framework for sustainability, achieving sustainable development	5
	Total	39

Suggested readings:

Latest editions of

1. Bishop, P. L., “Pollution Prevention: Fundamentals and Practice”. McGraw-Hill. ISBN 0-07-366147-3.
2. Kulkarni, V. and Ramachandra, T.V., “Environmental Management”. TERI Press. ISBN 978-81-7993-184-4.

CE 4262: Modelling and Simulation

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credit: 3**

Course objective:

1. To familiarize students about various modeling and simulation techniques of engineering systems.
2. To solve governing differential equations of systems by numerical techniques.
3. To impart the basic idea of preparing models for experiments and analyze the similitude requirements and results.

Course outcome:

1. Students will be able to learn preparation of numerical and experimental modeling philosophies.
2. Students will be able to solve differential equations of systems by numerical techniques.
3. Students will be able to prepare models based on similitude requirements, and analyse results therefrom.

Syllabus: Concept of System, its boundary, components and interaction, classifications; System modelling; differential Equations for modelling of engineering system and phenomena; Concept of Simulation of System; Stochastic Simulation; Curve Fitting; Metamodeling Approaches Concepts of probability and statistics; Introduction to Optimization concept.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction to concept of System, its boundary, components and interaction, classifications	4
2.	System Modelling: introduction, need and classification, concept of mathematical modelling of physical systems and phenomena with examples, concept of model building	10
3.	Differential Equations for modelling of engineering system and phenomena, introduction to computational approach of solution	9
4.	Concept of Simulation of System, Stochastic Simulation	6
5.	Curve Fitting, Metamodeling Approaches	6
6.	Introduction to Optimization concept, Model Updating	4
	Total	39

Suggested Readings:

Latest editions of

1. Chaturvedi, D.K., "Chaturvedi Modelling and Simulation of System using MATLAB and Simulink", CRC Press.
2. Dym, C.L., "Principles of Mathematical Modelling", Elsevier Academic Press.
3. Rubinstein, R.Y., Kroese, D.P., "Simulation and The Monte Carlo Method", Wiley-Interscience Press.

CE 4263: Transportation in Logistics and Supply Chain Management

Weekly contact 3-0-0 (L -T -P) **Full Marks: 100** **Credit: 3**

Course Objective: To describe the increasing significance of logistics and its impact on both costs and services and to incorporate and learn the critical elements of transportation logistics and supply-chain management processes based on the most relevant applications. Introducing concepts of transportation network analysis and design application for meaningful focus on the rate of change occurring in business logistics

Course Outcome: At the end of the course students will able to:

1. Understand the fundamental concepts of business logistics, operation and supply chain management
2. Apply transportation models in business operation freight transport cost analysis for supply chain management.
3. Understand how the logistic performance cycles and inventory management plays predominant roll in supply chain management
4. To analyze and design sustainable transportation network for optimizing the total logistics and supply-chain process

Syllabus: Introduction to Business Logistics and Supply Chain Management, Role of Transportation in Logistics and Supply Chain Management, Logistics Performance Cycles, Inventory Management in Supply chain Management, Transportation Cost in Distribution Cycle, Transportation Network Analysis and design.

Sl. No.	Description of Course Modules and Lecture Plan	No. of lectures
1.	Introduction to Business Logistics and Supply Chain Management: Objective of Logistics Management; Evolution of Concepts of Business Logistics; Modern Concept of Business Logistics; Fundamentals of Business Operation; Objective of Supply Chain Management; Inventory Flow, Information Flow and Cash Flow.	6

2.	Role of Transportation in Logistics and Supply Chain Management: Role of Transportation in Business Operation; Transportation Modes – Freight Transport Industry structure in India; Participants in Transport Operation; Road Freight Transport Industry Problem; Freight Transport Cost - the Factors and the Cost Elements, Fixing the Rate of Freight.	6
3.	Logistics Performance Cycles: Introduction; Procurement Performance Cycle; Production Performance Cycle; Distribution Performance Cycle.	6
4.	Inventory Management in Supply chain Management: Role of Inventory in the Supply Chain Management; Cycle Inventory, Economies of Scale; Safety Inventory, Appropriate Level of Safety Inventory Determination; Managing Uncertainty	6
5.	Transportation Cost in Distribution Cycle: Introduction, Distribution Function Components, Warehousing and Distribution Centres; Transportation Consolidation; Factors Governing Distribution Pattern; Market Boundary and Laid Down Cost; Total Physical Distribution Cost.	6
6.	Transportation Network Analysis and Design: Concept of Network; Shortest Path Problem; Maximum flow Problem; Minimum Cost Flow Problem, Network Optimization Models, Direct Shipment Network, Tradeoff in Transportation Design	9
	Total	39

Suggested Readings:

Latest editions of

1. Chopra, S., Meindy, P., and Kalra, D.V., “Supply Chain Management – Strategy, Planning and Operation”, Pearson
2. Chandrasekaran, N., “Supply Chain Management-Process, System and Practice”, Oxford University Press
3. Bowersox, D.J., and Closs, D.J., “Logistical Management – The Integrated Supply Chain Process”, MCGraw Hill, International Edition