CURRICULUM & SYLLABI

B.Tech. CIVIL ENGINEERING

Effective from AY: 2024-25



NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

WARANGAL, TELANGANA

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Vision and Mission of the Institute
National Institute of Technology Warangal

VISION
Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION
- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department
CIVIL Engineering

VISION
To be a knowledge nerve centre in civil engineering education, research, entrepreneurship and industry outreach services for creating sustainable infrastructure and enhancing quality of life.

MISSION
- Generate a specialized cadre of civil engineers by imparting quality education and training
- Attain international standards in teaching, research and consultancy with global linkages

Program: B.Tech. Civil Engineering

Program Educational Objectives

PEO-1	Apply principles of basic and engineering sciences in analysis, design and operation of civil engineering systems
PEO-2	Assess societal needs and plan suitable infrastructure
PEO-3	Analyze and design components of civil engineering projects
PEO-4	Develop team spirit and inter personal dynamics for effective execution and management of projects
PEO-5	Engage in lifelong learning and adapt to changing professional and societal needs

Program Articulation Matrix

PEO / Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
Generate a specialized cadre of civil engineers by imparting quality education and training	3	3	3	2	2
Attain international standards in teaching, research and consultancy with global linkages	2	2	2	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Program: B.Tech. Civil Engineering

Program Outcomes

PO-1	**Engineering knowledge**: Apply the knowledge of mathematics, science, Engineering fundamentals, and civil engineering to the solution of complex engineering problems.
PO-2	**Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO-3	**Design/Development of solutions:** Design solutions for complex civil engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex civil engineering activities and comprehend the limitations.
PO-6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO-7	**Environment and sustainability:** Comprehend the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO-10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO-11	**Project management and Finance**: Demonstrate knowledge and comprehend the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO-12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

PSO-1	Survey, map, measure and analyze earth surface features and natural resources
PSO-2	Characterize and evaluate materials for adoptability in civil engineering projects
PSO-3	Analyze, design and execute infrastructural facilities needed for the society and apply best management practices for construction and maintenance of these facilities
PSO-4	Predict, forecast and take measures for mitigation of natural and man made

CURRICULUM
B.Tech. Civil Engineering

1st Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1161	Linear Algebra, Calculus, and Ordinary Differential Equations	3-0-0	3
2	CY1161	Engineering Chemistry	3-0-2	4
3	HS1161	English for Technical Communication	2-0-2	3
4	CS1101	Programming and Data Structures	3-0-0	3
5	CE1101	Design Thinking	0-1-4	3
6	CS1103	Programming and Data Structures Lab	0-1-2	2
7	IC1101	EAA – I (Games &Sports / Yoga & Wellness)	0-0-0	0
Total Credits				**18**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1162	Integral and Vector Calculus, Laplace Transforms	3-0-0	3
2	PH1161	Engineering Physics	3-0-2	4
3	CE1102	Engineering Mechanics	3-0-0	3
4	CE1104	Building Planning & Drawing	1-1-2	3
5	BT1161	Biology for Engineers	2-0-0	2
6	ME1165	Engineering Workshop Practice	0-1-2	2
7	CE1108	Civil Engineering Materials	3-0-0	3
8	IC1102	EAA – II (Games &Sports / Yoga & Wellness)	0-0-0	0
Total Credits				**20**

3rd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MS1261	Business Essentials for Engineers	3-0-0	3
2	CE1201	Surveying	3-1-0	4
3	CE1203	Fluid Mechanics & Hydraulic Engineering	3-1-0	4
4	CE1205	Strength of Materials	3-0-0	3
5	CE1207	Geotechnical Engineering	3-0-0	3
6	CE1209	Surveying Laboratory	0-1-2	2
7	CE1211	Geotechnical Engineering Laboratory	0-1-2	2
Total Credits				**21**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1363	Fourier Series, Partial Differential Equations and Complex Variables	3-0-0	3
2	CE1202	Structural Mechanics	3-1-0	4
3	CE1204	Hydrology and Irrigation Engineering	3-1-0	4
4	CE1206	Design of Steel Structures	3-0-0	3
5	CE1208	Foundation Engineering	3-0-0	3
6	CE1210	Fluid Mechanics Laboratory	0-1-2	2
7	CE1212	Strength of Materials Laboratory	0-1-2	2
Total Credits				**21**

5th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CE1301	Environmental Engineering	3-1-0	4
2	CE1303	Theory of Structures	3-1-0	4
3	CE1305	Design of Concrete Structures	3-0-0	3
4	CE1307	Highway Engineering	3-0-0	3
5	CE13XX	Professional Elective – I	3-0-0	3
6	CE1381	Fractal Course - I	1-0-0	0.5
7	CE1309	Environmental Engineering Laboratory	0-1-2	2
8	CE1311	Concrete Laboratory	0-1-2	2
Total Credits				**21.5**

6th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CE1302	Construction Technology & Project Management	3-1-0	4
2	CE1304	Airport and Railway Engineering	3-0-0	3
3	CE13XX	Professional Elective -II:	3-0-0	3
4	CE13XX	Professional Elective -III:	3-0-0	3
5	CE1306	Product development	0-1-4	3
6	CE1382	Fractal Course - II	1-0-0	0.5
7	CE1308	Civil Engineering Software Lab	0-1-2	2
8	CE1310	Transportation Engineering Laboratory	0-1-2	2
Total Credits				**20.5**

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CE1401	Hydraulic structures	3-0-0	3
2	CE14XX	Professional Elective – IV	3-0-0	3
3	CE14XX	Professional Elective – V	3-0-0	3
4	CE14XX	Open Elective – I	2-0-0	2
5	CE1403	Quantity Surveying & Public works Laboratory	0-1-2	1
6	CE1405	RS & GIS Lab	0-1-2	1
7	CE1489	Seminar & Technical Writing	0-0-0	2
8	CE1491	Short Term Industrial / Research Experience*	0-0-0	2
9	CE1495	Minor Project	0-0-0	2
Total Credits				**19**

18th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CE14XX	Professional Elective – VI	3-0-0	3
2	CE14XX	Professional Elective – VII	3-0-0	3
3	CE14XX	Professional Elective – VIII	3-0-0	3
4	CE1498	Major Project	0-0-0	6
Total Credits				**15**

Professional Elective Courses:

Professional Elective-I		
S.No.	**Code**	**Course Title**
1	CE1321	Concrete Technology
2	CE1323	Ground Water Development
3	CE1325	Industrial Wastewater Treatment
4	CE1327	Remote Sensing
5	CE1329	Construction Geotechniques

Professional Elective-II		
S.No.	**Code**	**Course Title**
1	CE1322	Prestressed Concrete
2	CE1324	Geosynthetic Applications
3	CE1326	Travel Demand Analysis
4	CE1328	Systems Analysis in Civil Engineering
5	CE1330	GIS for Civil Engineering Applications

Professional Elective-III		
S.No.	**Code**	**Course Title**
1	CE1332	Foundation Analysis and Design
2	CE1334	Highway Construction
3	CE1336	Municipal solid waste management
4	CE1338	Watershed Management
5	CE1340	Applied Stress Analysis

Professional Elective-IV		
S.No.	**Code**	**Course Title**
1	CE1421	Advanced Reinforced Concrete Design
2	CE1423	Geological Engineering
3	CE1425	Traffic Engineering Design
4	CE1427	Water Quality Modeling and Management
5	CE1429	Air Pollution

Professional Elective-V		
S.No.	**Code**	**Course Title**
1	CE1431	Earthquake Resistant Design
2	CE1433	Ground Improvement Techniques
3	CE1435	Pavement Forensics and Rehabilitation
4	CE1437	Conservation of Heritage Structures

Professional Elective-VI		
S.No.	**Code**	**Course Title**
1	CE1422	Rock Engineering
2	CE1424	Land and Water Management
3	CE1426	Highway Safety
4	CE1428	Design of Bridges
5	CE1430	Low Carbon Materials and Green Buildings

Professional Elective-VII		
S.No.	**Code**	**Course Title**
1	CE1432	Seismic Hazard Analysis
2	CE1434	Advanced Structural Analysis
3	CE1436	Pedestrian and Bicycle Facility Design
4	CE1438	Hydro Power Engineering
5	CE1440	Photogrammetry and UAV

Professional Elective-VIII		
S.No.	**Code**	**Course Title**
1	CE1442	River Hydraulics
2	CE1444	Pavement Management System
3	CE1446	Repair & Rehabilitation of Structures

Open Electives		
S.No.	**Code**	**Course Title**
1	CE1473	Building Technology
2	CE1475	Environmental Management

Basic Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	MA1161	Linear Algebra, Calculus, and Ordinary Differential Equations	3-0-0	3
2	CY1161	Engineering Chemistry	3-0-2	4
3	MA1162	Integral and Vector Calculus, Laplace Transforms	3-0-0	3
4	PH1161	Engineering Physics	3-0-2	4
5	MA1363	Fourier Series, Partial Differential Equations and Complex Variables	3-0-0	3

Engineering Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	CS1101	Programming and Data Structures	3-0-0	3
2	CE1101	Design Thinking	0-1-4	3
3	CS1103	Programming and Data Structures Lab	0-1-2	2
4	CE1104	Building Planning & Drawing	1-1-2	3
5	BT1161	Biology for Engineers	2-0-0	2
6	ME1165	Engineering Workshop Practice	0-1-2	2

Humanities and Social Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	HS1161	English for Technical Communication	2-0-2	3
2	MS1261	Business Essentials for Engineers	3-0-0	3

The Overall Credit Structure

Course Category	Credits
Basic Science	17
Engineering Science	15
Humanities and Social Sciences	6
Program Core	79
Professional Elective	24
Open Elective	2
Seminar and Technical Writing	2
Fractal Course	1
Short Term Industrial / Research Experience	2
Minor Project	2
Major Project	6
Total Graded Credit Requirement	156

Minor in Civil Engineering:

Code	Course Title	L-T-P	Credits
CEM101	Building Construction Practices	3-0-0	3
CEM102	Elements of Structural Engineering	3-0-0	3
CEM103	Hydrology and Environmental Engineering	3-0-0	3
CEM104	Soil and Foundation Engineering	3-0-0	3
CEM105	Transportation Engineering	3-0-0	3
Total			**15**

Honors in Construction Technology and Management:

Code	Course Title	L-T-P	Credits
CE16001	Construction Techniques	3-0-0	3
CE16003	Lean Construction	3-0-0	3
MS16061	Construction Economics and Finance	3-0-0	3
CE16002	Contract Management and Arbitration	3-0-0	3
CE16004	Construction Equipment Management	3-0-0	3
Total			**15**

Honors in Engineering Structures:

Code	Course Title	L-T-P	Credits
CE 26001	Theory of Elasticity	3-0-0	3
CE 26003	Behaviour of Concrete Structures	3-0-0	3
CE 26005	Structural Dynamics	3-0-0	3
CE 26002	Structural Stability	3-0-0	3
CE 26004	Finite Element Analysis of Structures	3-0-0	3
Total			**15**

Honors in Environmental Engineering:

Code	Course Title	L-T-P	Credits
CE36001	Environmental Chemistry and Microbiology	3-0-0	3
CE36003	Water Supply Systems	3-0-0	3
CE36005	Solid Waste Management	3-0-0	3
CE36002	Air Pollution and Control	3-0-0	3
CE36004	Wastewater Treatment Systems	3-0-0	3
Total			**15**

Honors in Geoinformatics:

Code	Course Title	L-T-P	Credits
CE46001	Principles of Remote Sensing	3-0-0	3
CE46003	Geographical Information Systems	3-0-0	3
CE46005	Programming Methods for Geospatial Systems	3-0-0	3
CE46002	Global Navigation Satellite System	3-0-0	3
CE46004	Geospatial Data Processing and Modeling	3-0-0	3
Total			**15**

Honors in Geotechnical Engineering:

Code	Course Title	L-T-P	Credits
CE56001	Advanced Soil Mechanics	3-1-0	4
CE56003	Ground Improvement Methods	3-1-0	4
CE56005	Geotechnical Exploration and Instrumentation	3-0-0	3
CE56002	Advanced Foundation Engineering	3-1-0	4
CE56004	Soil Dynamics and Machine Foundations	3-0-0	3
Total			**18**

Honors in Transportation Engineering:

Code	Course Title	L-T-P	Credits
CE66001	Urban Transportation Planning	3-1-0	4
CE66003	Traffic Analysis and Design	3-0-0	3
CE66005	Pavement Analysis and Design	3-1-0	4
CE66002	Advanced Travel Demand Modelling	3-1-0	4
CE66004	Geometric Design of Transportation Facilities	3-1-0	4
Total			**19**

Honors in Water Resources Engineering:

Code	Course Title	L-T-P	Credits
CE76001	Applied Hydrology	3-0-0	3
CE76003	Stochastic Hydrology	3-1-0	4
CE76005	Advances in Fluid Mechanics & Hydraulic Engineering	3-1-0	4
CE76002	Water Resources Systems Planning and Management	3-1-0	4
CE76004	Groundwater Hydrology	3-0-0	3
Total			**18**

SYLLABI

B.Tech. Civil Engineering

1st Semester

MA1161 **3-0-0 (3)**

Linear Algebra, Calculus, and Ordinary Differential Equations

Pre-Requisites: **None**

Course Outcomes:

CO-1	Solve the consistent system of linear equations
CO-2	Apply orthogonal transformations to a quadratic form
CO-3	Determine the series expansion of a given function
CO-4	Explore the properties of functions of several variables
CO-5	Solve arbitrary order linear differential equations

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	2	1	–	–	–	–	–	–	–	1	1	1	1
CO-2	3	3	1	2	1	–	–	–	–	–	–	–	-	-	1	-
CO-3	3	3	1	2	1	–	–	–	–	–	–	–	1	-	1	1
CO-4	3	3	1	2	1	–	–	–	–	–	–	–	-	-	-	1
CO-5	3	3	1	2	1	–	–	–	–	–	–	–	2	1	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Linear Algebra: Vector space, Subspace, Examples, Linear span, Linear independence and dependence, Basis, Dimension, Extension of a basis of a subspace, Intersection and sum of two subspace, Examples. Linear transformation, Kernel and Range of a linear map, Rank-Nullity Theorem (without proof). Rank of a matrix, Row, and column spaces, Solvability of the system of linear equations, Inner product spaces, Orthogonal basis, Gram-Schmidt orthogonalization process. Eigenvalues, Eigenvectors, and properties Caley-Hamilton Theorem (without proof) and applications, diagonalization of a matrix, diagonalization by similarity, and orthogonal transformations.

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions; Functions of several variables – continuity, differentiability, partial derivatives, Euler's theorem, change of variables, Jacobians, Functional dependence; Maxima and minima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

Ordinary Differential Equations: First order differential equations - Basic definitions, Geometric interpretation of solutions of first-order ODE $y' = f(x, y)$, Exact differential equations, Integrating factors, Linear equation, Reducible to linear form: Bernoulli's equations; Orthogonal trajectories; Higher order linear differential equations with constant coefficients - Cauchy-Euler and Legendre's differential equations, Method of variation of parameters - System of linear differential equations; Applications to physical problems.

Learning Resources:

Text Books:

1. Howard Anton and Chris Rorres, Elementary Linear Algebra with Supplementary Applications, John Wiley & Sons, 2014, Eleventh Edition.
2. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, Ninth Edition.

Reference Books:

1. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, Sixth Edition.
2. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, Fifth Edition.

CY1161 **3-0-2 (4)**

Engineering Chemistry

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the basic concepts of chemistry relevant to materials.
CO-2	Apply electrochemical concepts for energy harvesting, conversion and storage.
CO-3	Analyze the properties of materials for various applications.
CO-4	Comprehend the concepts of instrumentation principles, Spectroscopy and procedures involved in characterization of materials
CO-5	To analyze the metal contents from the ores by understanding the redox process
CO-6	To determine the rate of corrosion by a redox reaction and understand the concept of adsorption

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2	3	-	-	-	-	-	-	-	-	-	-	-	2	2	1	-
CO-3	3	2	-	-	-	-	-	-	-	-	-	-	2	2	1	-
CO-4	3	-	-	-	-	-	-	-	-	-	-	-	2	2	1	-
CO-5	3	3	3	-	2	-	2	-	-	-	-	-	1	1	-	-
CO-6	3	3	3	-	2	-	2	-	-	-	-	-	-	1	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Chemical Kinetics and Thermodynamics: Order of a Reaction, Theories of Reaction Rates. Homogeneous and Heterogeneous Catalysis. Laws of Thermodynamics, Thermodynamic functions (A, G, U, and H). Maxwell Relationships.

Electrochemistry and Energy Systems: Introduction to Electrochemistry, Nernst's law and its applications. Batteries, fuel cell and photoelectrochemical systems. Corrosion and its prevention.

Transition Metal Chemistry and Organometallic Chemistry: Bonding in transition metal complexes; Crystal field and MO Theories, Jahn-Teller effect. Properties of Coordination complexes; Metal Carbonyls, EAN and 18-electron rule, Ligands and hapticity; Type of reactions: Oxidative addition, Reductive elimination, Migratory insertion, Hydrogenation, Hydroformylation, Monsanto process and Wacker process.

Engineering Materials: Inorganic and Organic Semiconductors, Magnetic materials, Liquid crystals, Super conductors, Photo conducting Materials and conducting polymers.

Chromatographic and Spectroscopic Methods: Liquid Chromatographic and Gas Chromatographic methods. UV-VIS spectroscopy, Infrared spectroscopy, NMR spectroscopy.

Chemistry Lab:

1. Standardization $KMnO_4$ solution

2. Estimation of metal content in an ore

3. Estimation of Calcium in milk powder by complexometry

4. Extraction and identification of DNA from green peas/onions

5. Estimation of iodine in iodized common salt

6. Blue printing of an object by photochemical reaction

7. Kinetics of acid hydrolysis of methyl acetate

8. Determination of acid strength in citrus fruit

9. Verification of Beer-Lambert Law and estimation of concentration of food color

10. Evaluation of Eo values of $Zn|Zn^{2+}$ and $Cu|Cu^{2+}$ Electrodes and measure the emf by constructing the Daniel cell

11. Estimation of phosphoric acid in soft drinks by pH metry

12. Separation of natural pigments from mixture using paper chromatography

13. Determination of efficiency of a corrosion inhibitor

14. Verification of Freundlich adsorption isotherm

15. Preparation of a polymer and its analysis

16. Estimation of active pharmaceutical ingredient in a drug

Learning Resources:

Text Books:

1. Shashi Chawla, A Text Book of Engineering Chemistry, Danpathrao & Co. Publications, 6th India reprint edition, 2007
2. Ashutosh Kar, Text Book of Engineering Chemistry, ED-Tech Publications, 2018

Reference Books:

1. William Kemp, Organic Spectroscopy, Macmillan Education, Limited, 2017
2. Michael F. Ashby/David R.H. Jones, Engineering Materials, Elsevier Science, 2012
3. V. Raghava, Material Science and Engineering, PHI Learning, 2015
4. J.M. Martin, Materials for Engineering, Elsevier Science, 2006
5. Peter Atkins, Julio de Paula, James Keeler, Physical Chemistry, Oxford University Press, 2018
6. Charles Corwin, Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Pearson Education, 2012.
7. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 2006.

HS1161 **2-0-2 (3)**

English for Technical Communication

Pre-Requisites: **None**

Course Outcomes:

CO-1	Appreciate and apply principles of technical communication to interact effectively in diverse environments.
CO-2	Analyze complex technical documents to extract and synthesize key information.
CO-3	Employ reported speech, active and passive voice in engineering and scientific contexts to compile technical reports.
CO-4	Demonstrate use of English speech sounds, stress, and intonation in day-to-day situations, conversations, and interactions.
CO-5	Interpret technical data presented in the form of graphs, pie charts, and diagrams.
CO-6	Criticize & provide constructive feedback on peer communication performances and written works.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–
CO-2	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–
CO-3	–	1	–	–	2	–	–	–	–	3	–	–	–	–	–	–
CO-4	–	–	–	–	2	–	–	–	–	3	–	–	–	–	–	–
CO-5	–	–	–	–	–	2	–	–	–	3	–	–	–	–	–	–
CO-6	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Grammar Principles & Effective Sentence Construction: Correction of Sentences and Concord, - Vocabulary Building, - Synonyms and Antonyms, - Idioms and Phrasal Verbs: Patterns of Use and Suggestions for Effective Employment in Varied Contexts, - Technical Vocabulary (Jargons and Registers),- Strategies for Bringing Variety and Clarity in Sentences, - Removing Ambiguity, - Editing Long Sentences for Brevity and Clarity, - Reported Speech, - Contexts for Use of Reported Speech, - Impact on Audiences and Readers, - Active and Passive Voice, - Reasons for Preference for Passive Voice in Scientific English

Reading Techniques: Definition and Importance, - Skills and Sub-Skills of Reading, - Skimming and Scanning: Uses and Purposes, Examples and Exercises, - Reading Comprehension, - Reading Silently and with Understanding, - Process of Comprehension, - Types of Comprehension Questions

Writing- Paragraph and Letter: Definition of Paragraph and Types, - Features of a Good Paragraph, - Unity of Theme, - Coherence, - Linking Devices, - Direction, - Patterns of Development. - Importance in the Context of Other Channels of Communication, - Qualities of Effective Letters, - Types of Letters, - Official Letters, - Letters for Various Purposes, - Letters of Application for Jobs, - Cover Letter and Resume Types, - Letters for Internship/Fellowship, - Writing Statements of Purpose (SOPs), - Examples and Exercises

Mechanics of Writing: Principles of a Technical Report, - Know Your Audience, Purpose, and Length of Report, - Understand the Cornerstones of a Presentation, - Define Various Purposes of Presentations and Plan the Correct Structure, - Writing Clear Sentences and Paragraphs, - Removing Jargon, Redundancy,

and Wordiness, - Kinds of Graphics and their Messages, - Suitability for Placement in Graphic Representation.

Reviews: Oral and Written Review of a Chosen Novel/Play/Movie, - Review of Scientific Articles and Science Fiction, - Focus on Appropriate Vocabulary and Structure, - Use of Special Vocabulary and Idioms.

Language laboratory

English Sound System -vowels, consonants, Diphthongs, phonetic symbols- using dictionary to decode phonetic transcription-- Received Pronunciation, its value and relevance- transcription.

Stress and Intonation –word and sentence stress - their role and importance in spoken English- Intonation in spoken English -definition, -use of intonation in daily life-exercises

Introducing oneself in formal and social contexts- Role plays. - their uses in developing fluency and communication in general.

Oral presentation - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids.

Listening Comprehension- Challenges in listening, good listening traits, some standard listening tests- practice and exercises.

Debate/ Group Discussions-concepts, types, Do's and don'ts- intensive practice, Guided writing practice with examples, drafting – the mindset to avoid writer's block, checking your own reports and presentations, Giving and receiving constructive feedback.

Learning Resources:

Text Books:

1. English for Engineers and Technologists, Orient Blackswan 2010 (Combined edition, Vol. 1 & 2).
2. Ashraf, M Rizvi. Effective Technical Communication. Tata McGraw-Hill, 2006

Reference Books:

1. Markel, Mike, and Stuart A. Selber. Technical Communication. Bedford/St. Martin's, 2017.
2. Strunk, William, Jr., and E.B. White. The Elements of Style. Longman, 2000, 4th edition.
3. Meenakshi Raman and Sangeetha Sharma. Technical Communication: Principles and Practice Oxford University Press, 2011, 2nd Edition.
4. Tan, Zhongchao. Academic Writing for Engineering Publications: A Guide for Non-native English Speakers. Springer, 2022
5. Olsen, L. A., and T N. Huckin. Technical Writing and Professional Communication, McGraw-Hill, 1991. 2nd Edition.
6. Turabian, Kate L. A Manual for Writers of Research Papers, Theses, and Dissertations, University of Chicago Press, 2018. 9th edition.
7. Seely, John. The Oxford Guide to Writing and Speaking. Oxford University Press, 2004.
8. Murphy, Raymond. English Grammar in Use. 5th ed., Cambridge University Press, 2019.
9. P. Steven. The Sense of Style: The Thinking Person's Guide to Writing in the 21st Century. Viking, 2014.

Other Suggested Readings:

1. Zinsser, William. On Writing Well: The Classic Guide to Writing Nonfiction. HarperCollins, 2006. 7th edition.
2. Williams, Joseph M., and Joseph Bizup. Style: Lessons in Clarity and Grace. Pearson, 2016. 12th edition.
3. Einsohn, Amy, and Marilyn Schwartz. The Copyeditor's Handbook: A Guide for Book Publishing and Corporate Communications. University of California Press, 2019, 4th edition.
4. Alley, Michael. The Craft of Scientific Writing. Springer, 2018, 4th edition.
5. Hofmann, Angelika H. Scientific Writing and Communication: Papers, Proposals, and Presentations. Oxford University Press, 2016, 3rd edition.

CS1101 **3-0-0 (3)**

Programming and Data Structures

Pre-Requisites: **Nil**

Course Outcomes:

CO-1	Design algorithms for solving simple mathematical problems including computing, searching and sorting
CO-2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems
CO-3	Explore the internals of computing systems to suitably develop efficient algorithms
CO-4	Examine the suitability of data types and structures to solve specific problems
CO-5	Apply control structures to develop modular programs to solve mathematical problems
CO-6	Comprehend the concept of Abstract Data Types and use in real time applications.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	1	1	2	1	-	-	-	-	-	3	3	3	3	3
CO-2	2	1	2	1	2	3	-	-	-	-	-	3	3	2	2	2
CO-3	1	2	2	2	2	1	-	-	-	-	-	3	3	2	2	1
CO-4	2	2	2	2	2	2	-	-	-	-	-	2	3	2	1	2
CO-5	2	2	3	1	2	2	-	-	-	-	-	2	3	2	2	2
CO-6	2	2	3	2	2	2	-	-	-	-	-	2	3	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Fundamentals of Computers: Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques: Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Number systems and data representation

Elements of C++ programming language: Data types, constants, and variables, expressions and assignment statements, input and output statements, conditional and branch statements: If-else, Switch-case constructs, iteration statements: while, do-while, for, Arrays – Single and Multi-Dimensional Arrays, strings. Bit-wise operations.

Functions and Recursion: Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, passing arrays as parameters to functions Recursion.

Structures and Classes: Declaration, member variables, member functions, access modifiers, function overloading, Problems on Complex numbers, Date, Time, Large Numbers.

Pointers and Files: Introduction to pointers and dynamic allocation, String processing, File operations-create, read and write.

Searching and sorting: Linear and binary search, selection sort, bubble sort, insertion sort, merge sort, quick sort.

Data structures: Abstract Data Types (ADTs) - Stack ADT- Array-Based Implementation of Stack - Applications, Queue ADT - Array-Based Implementation – Applications.

Learning Resources:

Text Books:

1. Walter Savitch, "Problem Solving with C++", Tenth Edition, Pearson, 2018.
2. Cay Horstmann, Timothy Budd, "Big C++", Wiley, 2nd Edition, 2009.

Reference Books:

1. R.G. Dromey, "How to solve it by Computer", Pearson, 2008.
2. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", Third Edition, Pearson Education, 2006

CE1101 **0-1-4 (3)**

Design Thinking

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify user needs
CO-2	Define problems to stimulate ideation
CO-3	Ideate on problems to propose solutions by working collaboratively
CO-4	Test aspects of proposed solutions and improve solutions by gaining user feedback
CO-5	To comprehend the role of standardization for sustainable development

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	3	3	3	2	2	3	3	2	3	-	-	-	-
CO-2	2	2	2	3	3	3	2	2	3	3	2	3	-	-	-	-
CO-3	2	2	2	3	3	3	2	2	3	3	2	3	-	-	-	-
CO-4	2	2	2	3	3	3	2	2	3	3	2	3	-	-	-	-
CO-5	2	2	2	3	3	3	2	2	3	3	2	3	-	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Engineering: "Engineering" for social and economic development; the impact of science/engineering on our day-to-day lives; the process of engineering a product; various career options.

Introduction and identifying the need: Understanding the unique needs of the user - empathize - define - ideate - prototype - test. Case Studies - Develop an appreciation for the design process and its application in specific settings (Guest lectures, Videos, Field visits, Interplay lectures of design-based movies).

Problem Formulation: Framing a problem statement neutrally using adequate checks. Case studies.

Concept Generation: Generate multiple concepts using various creativity tools and thinking styles.

Prototyping: Select from ideas and make quick prototypes (mock-ups) using available material.

Evaluation: Iterative process of ideation, prototyping and testing-Take the mock-ups to users for feedback and iterate the process till users feel delighted.

Activities: Field Visits, Case Studies on innovation, failures etc, Guest lectures, Group Discussions, Presentation by student, Experiential learning workshops.

Standardization: Purpose of Standardisation; marking and certification of articles and processes, Importance of Standards to Industry; policy makers; trade; sustainability and innovation; Introduction to Bureau of Indian Standards (BIS); Objectives, roles and functions of BIS; Bureau of Indian Standards Act.; Case discussion through expert lectures.

Learning Resources:

Text Books:

1. Design Thinking: A guide to creative problem solving for everyone, Andrew Pressman, Routledge Taylor and Francis group, 2019, 1st Edition.
2. Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation
3. SO/IEC Guide 59, BIS Standards Formulation Manual, 2022.

Reference Books:

1. George E. Dieter, Linda C. Schmidt Engineering Design 5th edition (2019)
2. Ulrich, K., Eppinger, S. and Yang, M., Product Design and development, 7th edition (2020)

CS1103 **0-1-2 (2)**

Programming and Data Structures Lab

Pre-Requisites: **Nil**

Course Outcomes:

CO-1	Design and test programs to solve mathematical and scientific problems
CO-2	Develop and test programs using control structures
CO-3	Implement modular programs using functions
CO-4	Develop programs using classes
CO-5	Develop ADT for stack and queue applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	1	2	1	-	-	-	-	-	-	3	3	3	3
CO-2	1	1	2	1	2	2	-	-	-	-	-	-	3	3	2	2
CO-3	1	2	3	2	2	1	-	-	-	-	-	-	3	3	2	2
CO-4	2	2	2	2	2	3	-	-	-	-	-	-	2	3	2	1
CO-5	2	2	2	2	2	3	-	-	-	-	-	-	2	3	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. **Programs on** conditional control constructs.
2. **Programs on loops** (while, do-while, for).
3. **Programs using** user defined functions and library functions.
4. **Programs on arrays**, matrices (single and multi-dimensional arrays).
5. **Programs using pointers** (int pointers, char pointers).
6. **Programs on structures.**
7. **Programs on classes and objects.**
8. **Programs of Stack and Queue.**

Learning Resources:

Text Books:

1. Walter Savitch, "Problem Solving with C++", Ninth Edition, Pearson, 2014.
2. Cay Horstmann, Timothy Budd, "Big C++", Wiley, 2nd Edition, 2009.

Reference Books:

1. R.G. Dromey, "How to solve it by Computer", Pearson, 2008.
2. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", Third Edition, Pearson Education, 2006

2nd Semester

MA1162 **3-0-0 (3)**

Integral and Vector Calculus, Laplace Transforms

Pre-requisites: MA1161

Course Outcomes:

CO-1	Analyze improper integrals for extracting certain properties of beta and gamma integrals.
CO-2	Evaluate multiple integrals in different coordinate systems.
CO-3	Apply the concepts of gradient, divergence and curl of scalar and vector point functions to formulate engineering problems.
CO-4	Convert line integrals into area integrals and surface integrals into volume integrals.
CO-5	Apply Laplace transforms to solve physical problems arising in engineering.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-2	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-3	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-4	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-5	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Integral Calculus: Improper integrals; Beta and Gamma functions, and their properties; Differentiation under integral sign, Evaluation of double and triple integrals; Areas and Volumes, Change of order of integration; Change of variables in double and triple integrals.

Vector Calculus: Scalar and vector fields; Vector differentiation; Level surfaces; Directional derivative; Gradient of a scalar field; Divergence and curl of a vector field; Laplacian operator; Parametrization of curves and surfaces; Line, surface and volume integrals; Green's theorem in a plane; Stoke's theorem; Gauss divergence theorem.

Laplace Transforms: Laplace transforms; Inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step, impulse and periodic functions; Convolution theorem; Applications of Laplace transforms - solving certain initial value problems - solving system of linear differential equations - finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses.

Learning Resources:

Text Books:

1. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, 9th Edition
2. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, 6th Edition

Reference Books:

1. Maurice D. Weir, Joel Hass and Christopher Heil, Thomas' Calculus: Early Transcendentals, Pearson, 2014, 13th Edition.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, 8th Edition.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, 5th Edition.

PH1161 **3-0-2 (4)**

Engineering Physics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Examine the concepts of Interference, diffraction, polarisation to solve engineering problems
CO-2	Assess the technological applications of lasers and optical fibers
CO-3	Apply the quantum mechanical principles for solving engineering problems
CO-4	Comprehend the basics of nanomaterials and their engineering applications
CO-5	Demonstrate the production, detection and applications of ultrasonics

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	2	–	–	–	–	–	–	–	–	3	2	–	–
CO-2	3	3	2	2	–	–	–	–	–	–	–	–	3	2	–	–
CO-3	3	3	2	2	–	–	–	–	–	–	–	–	3	2	–	–
CO-4	3	3	2	2	–	–	–	–	–	–	–	–	3	2	–	–
CO-5	3	3	2	2	–	–	–	–	–	–	–	–	3	2	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Interference: Principle of Superposition, Coherence and Coherent Sources, Production of Coherent Light, Young's Double Slit Experiment, Concept of interference, Newton's Rings, working of Michelson Interferometer, Fabry-Perot Interferometer, and its application as wavelength filter.

Diffraction: Definition and types of Diffractions, Huygen's Principle and types of wave fronts, types of Diffraction, Single Slit Diffraction, Double Slit Diffraction, Diffraction Grating, Derivation of Resolving Power and Dispersive Power, Rayleigh's Criterion and applications.

Polarization: Introduction to Polarization, Production of Polarized Light by Reflection and Refraction, Phenomenon of Double Refraction, Construction and Working of Nicol's Prism, Half-Wave and Quarter Waveplates, Representation of Different Polarized Lights, Optical Activity, Practical Applications of Polarized Light, Construction and Working of Laurent's Half Shade Polarimeter and Engineering Applications.

Lasers & Optical Fibers: Basic theory of Laser, Fundamentals of lasers, Einstein Coefficients, Characteristics of Laser Pumping Mechanisms; Basic Components of Laser System, 2-Level, 3-Level and 4-Level Systems, Construction and working of He-Ne, Nd-YAG, and semiconductor diode Lasers and Engineering Applications of Lasers. Basic Principle of Optical Fiber, Derivation-Numerical Aperture and Acceptance Angle, Types of Optical Fibers (Step and Graded Index, Single Mode and Multimode), Applications in Communications and Sensors.

Quantum Mechanics: Concepts and experiments that led to the discovery of Quantum Nature, de Broglie hypothesis of matter waves, Heisenberg uncertainty principle, Schrodinger time independent and time dependent wave equations, the free particle problem, Particle in an infinite and finite potential well, Quantum mechanical tunnelling and applications.

Nanomaterials: Introduction and importance of Nanomaterials, classification (0D, 1D, 2D and 3D) of nanomaterials, properties of nanomaterials, carbon-based nanomaterials, synthesis of nanomaterials, top-

down and bottom-up approaches, characterization of nanomaterials, Engineering Applications of Nanomaterials:

Ultrasonics: Production, detection, and applications of ultrasonics

List of Experiments:

1. Determination of Wavelength of Sodium light using Newton's Rings.
2. Determination of Wavelength of He-Ne laser - Metal Scale.
3. Measurement of Width of a narrow slit using He- Ne Laser.
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of Numerical aperture, loss, Acceptance angle of optical fiber.
6. Determination of plank constant by photo electric effect.
7. Determination of I – V characteristics of photo diode.
8. Diffraction grating by normal incidence method.
9. Determination of capacitance by using R-C circuit.
10. Determination of resonating frequency and bandwidth by LCR circuit
11. Strain Gauge
12. Dielectric constant measurements
13. Determination of carrier concentration, charge by using Hall effect experiment
14. Study of I-V characteristics of Solar Cell
15. Determination of velocity of ultrasonic waves and adiabatic compressibility of liquids using ultrasonic interferometer.

Learning Resources:

Text Books:

1. Fundamentals of Physics by Halliday, Resnic and Walker, John Wiley, 2011, 9th Edition.
2. Concepts of Modern Physics by Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, McGraw Hill Publications, 2009, 6th Edition.

Reference Books:

1. Shatendra Sharma, Jyotnsa Sharma, Engineering Physics, Pearson Education,2018.
2. Nanotechnology: principles and practices by Sulabha K. Kulkarnl. Springer publications, 2018, 3rd Edition.
3. G.L. Squire, Practical Physics, Cambridge University press, 2001, 4th edition.

Other Suggested Readings:

1. Ajoy K. Ghatak, Optics, Tata McGraw Hill, 2017, 6th edition.
2. Jeff Hecht, Understanding Lasers An Entry-Level Guide, Wiley Publications, 2018, 4th edition.
3. M.N. Avadhanulu, P.G. Khirsagar, A Textbook of Engineering Physics,2011, 9th edition.
4. Hugh D. Young, Roger A. Freedman, University Physics with modern physics, Pearson Education,2014.
5. B. Rogers, J Adams and S. Pennathur, Nanotechnology the whole story, CRC Press. 2013.
6. S.K. Gupta Krishna, Engineering Physics Practical, Prakashan Publications, 2010, 9th edition.
7. https://nptel.ac.in/courses/122/107/122107035/

CE1102 **3-0-0 (3)**

Engineering Mechanics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Determine the resultant force and moment for a given system of forces
CO-2	Analyze planar and spatial systems to determine the forces in members of trusses, frames and problems related to friction
CO-3	Calculate the motion characteristics of a body subjected to a given force system
CO-4	Determine the deformation of a shaft and recognize the relationship between different material constants
CO-5	Determine the centroid and second moment of area

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	-	-	1	-	-	-	-	-	-	-	-	3	-
CO-2	3	3	2	-	-	1	-	-	-	-	-	-	-	-	3	-
CO-3	3	3	2	-	-	1	-	-	-	-	-	-	-	-	3	-
CO-4	3	3	2	-	-	1	-	-	-	-	-	-	-	1	2	-
CO-5	3	3	2	-	-	1	-	-	-	-	-	-	-	1	2	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space, Degrees of freedom - Equilibrium Equations, Kinematics – Kinetics – De' Alemberts principle, Degree of Constraints – Free body diagrams.

Spatial Force systems: Types of spatial force systems, Equilibrium equations, Vector approach, Tension Coefficient method, Parallel force systems.

Coplanar Force Systems: Introduction – Equilibrium equations – All systems, Problems on Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Method of joints, Method of sections, Method of members, Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Centroid & Moment of Inertia: Centroid and M.I – Arial – Radius of Gyration, Parallel axis– Perpendicular axis theorem – Simple Problems.

Dynamics of Particles: Rectilinear Motion – Kinematics, Kinetics, Work & Energy – Impulse Moment, Curvilinear Motion – Normal and tangential components.

Mechanics of Deformable Bodies: Stress & Strain at a point- Normal and shear stresses, Stress-strain diagrams for brittle and ductile materials-working stress-Axial deformations – Problems on prismatic shaft, tapered shaft and deformation due to self- weight, Deformation of Stepped shaft due to axial loading, Poisson's Ratio – Bulk Modulus - Problems, change in dimensions and volume-Thermal Stresses

Learning Resources:

Text Books:

1. S. Timoshenko, D.H. Young, J.V. Rao and Sukumar Pati, Engineering Mechanics (In SI Units), McGraw Hill Publishers, 2017, 5th Edition.
2. Ferdinand P. Beer, E. Russell Johnston Jr., et al., Vector Mechanics for Engineers - Statics and Dynamics, McGraw Hill Publishers, 2019, 12th Edition.

Reference Books:

1. Gere and Timoshenko, Mechanics of Materials, CBS Publishers, 2011, 2nd Edition.
2. R. C. Hibbeler, Mechanics of Materials (SI Edition), Pearson publication, 2018.
3. J. L. Meriam, L. G. Kraige, et al., Engineering Mechanics: Statics, SI Version, Wiley India Edition, 2017

Other Suggested Readings:

1. https://nptel.ac.in/courses/122/104/122104015/
2. https://nptel.ac.in/courses/112/106/112106180/

CE1104 **1-1-2 (3)**

Building Planning and Drawing

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend multiple factors to be considered in planning and construction of buildings
CO-2	Identify various components of the building, their functionality, and construction techniques
CO-3	Plan various service and safety requirements of the building, their functionality, and construction techniques
CO-4	Create and draw plan for different buildings in different views using computer aided graphic tool

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	1	2	-	-	3	3	2	-	2	2	2	2	-	1	2
CO-2	1	1	2	-	-	3	2	-	-	2	1	1	1	1	1	1
CO-3	1	1	2	-	-	3	2	-	-	2	2	2	1	1	2	2
CO-4	1	1	2	-	2	3	2	2	2	2	2	2	2	-	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Functional planning of Buildings: Types of Buildings, Aspects and Principles of Building Planning, Building By-laws and Regulations, Site Selection criteria, Orientation of Building and its relation to surrounding environment, Sustainability and Green Buildings.

Components of Buildings: Foundation and its requirements, Soil characteristics, Construction of Foundation; Masonry construction and Materials used; Construction of Floors and Roofs; Functional requirements and planning of a stair case

Service and Safety requirements of Buildings: Damping causes, its effects, and Proofing techniques; Fire hazards, protection, and grading rules; Methods of thermal insulation and materials used

Building Drawing Lab: Planning a building according to the rules and requirements, Drawing the plan, section, and elevation of the building, Drawing various components of the building, Bar bending schedule for steel and RCC, Notations used in various civil engineering drawings

Learning Resources:

Text Books:

1. Punmia B. C., Jain A.J., and Jain A.J., Building Construction, Laxmi Publication, 2016, 11th Edition.
2. Arora S. P., and Bindra S. P., The Text book for Building Construction, Dhanpat Rai Pubications, 2010

Reference Books:

1. Varghese P.C., Building Construction, PHI Learning Pvt. Ltd., 2017, 2nd Edition.
2. National Building Code of India, Bureau of Indian Standards, 2016.
3. S. Tickoo, Auto CAD 2017 for Engineers & Designers, Dreamtech, 2016, 23rd Edition
4. N. D. Bhatt. and V. M. Panchal, Engineering Graphics, Charotar Publishers, 2016, 53rd Edition
5. B. Agarwal, Engineering Drawing, 2015, McGraw Hill Education, 2015, 2nd Edition
6. AutoCAD Manual. (https://knowledge.autodesk.com/)
7. https://nptel.ac.in/courses/105/106/105106197/
8. https://nptel.ac.in/courses/105/102/105102175/

BT1161 **2-0-0 (2)**

Biology for Engineers

Pre-Requisites: **None**

Course Outcomes:

CO-1	Realize the significance of biomolecules for sustaining life
CO-2	Identify the difference between unicellular to multi-cellular organisms
CO-3	Understand heredity, variation and central dogma of life
CO-4	Apply the concepts of biology for engineering the cell

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	-	-	2	2	-	-	2	-	3	1	1	-	-
CO-2	3	2	2	-	-	2	-	-	-	-	-	3	1	1	-	-
CO-3	3	2	2	-	-	2	-	-	-	-	-	3	1	1	-	-
CO-4	3	3	2	2	1	2	2	1	-	2	-	3	1	1	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Molecules of Life: Chemical basis of life, Proteins, Nucleic acids, Carbohydrates, Lipids, Membranes and First cell, Inside the cell, Cell cycle and Division.

Information processing in living system: Central dogma, Concept of Gene, Genetic code, Transcription, Translation, Biological signal transduction, Quorum sensing and Biofilm formation.

Biomolecular machines and motors: Cytoskeletal motor proteins, ATP synthase, Cell motility.

Applied Biotechnology: Biocomputing, Synthetic biology, Biosensors, Biomedical instrumentation in disease diagnosis, Biomimicry, Biomechanics, Biomaterials, Nanobiotechnology, Industrial and Environmental Biotechnology, Biosafety and Bioethics.

Learning Resources:

Text Books:

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016.
2. Reinhard Renneberg, Viola Berkling and Vanya Loroch, Biotechnology for Beginners, Academic Press, 2017.

ME1165 **0-1-2(2)**

Engineering Workshop Practice

Pre-Requisites: None

Course Outcomes:

CO-1	Identify workshop tools and their operational capabilities Credits
CO-2	Practice on manufacturing of components using workshop trades including fitting, foundry and welding
CO-3	Apply suitable tools for machining processes including turning, facing, thread cutting and tapping
CO-4	Apply basic electrical engineering knowledge for House Wiring Practice

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	–	–	1	–	–	2	2	–	–	2	–	–	–
CO-2	3	3	1	–	2	1	–	–	2	2	–	–	2	–	–	–
CO-3	3	3	1	–	2	1	–	–	2	2	–	–	2	–	–	–
CO-4	3	3	1	–	2	1	–	–	2	2	–	–	2	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Demonstration: Safety practices and precautions to be observed in workshop.

Fitting Trade: Demonstration and practice of fitting tools, Preparation of T-Shape, Dovetail Joint. Carpentry: Demonstration and practice of carpentry tools, Preparation of Cross Half lap joint and Mortise Tenon Joint.

Machine shop: Demonstration and practice on Lathe Machine, Preparation of work pieces involving Facing, Plane Turning, step turning, knurling and parting operations.

House Wiring: Demonstration and practice on Electrical tools, wiring and earthing, Exercises on Staircase Wiring & Godown wiring.

Power Tools: Demonstration and practice on Power tools (Bosch Power Tools) and Safety Practices.

Foundry Trade: Demonstration and practice on Moulding tools and processes, Preparation of Green Sand Moulds for given Patterns.

Welding Shop: Demonstration and practice on Arc Welding and Gas welding. Preparation of Lap joint and Butt joint.

Learning Resources

Text Books:

1. Felix W., Basic Workshop Technology: Manufacturing Process, Independently Published, 2019.
2. Bruce J. Black, Workshop Processes, Practices and Materials, Routledge publishers, 2015, 5th Edition.

Reference Books:

1. B.S. Raghuwanshi, A Course in Workshop Technology Vol I. & II, Dhanpat Rai & Co., 2015 & 2017.
2. S. K. Hajra Choudhury, and Nirjahar Roy, Elements of Workshop Technology, Vol. I, Media Promoters and Publishers, Mumbai. 2007, 14th Edition.
3. S. K. Hajra Choudhury and Nirjahar Roy, Elements of Workshop Technology, Vol. II, Media Promoters and Publishers, Mumbai. 2007, 12th edition
4. H. S. Bawa, Workshop Practice Tata-McGraw Hill, 2009, 2nd Edition
5. Arthur R. Gill, Peter Smid, Steve F. Krar, Technology of Machine Tools, McGraw Hill Education,2010, 7th Edition.
6. Ramesh Babu.V., Engineering Practices Laboratory Manual, VRB Publishers, Chennai, 2019-20, Revised Edition
7. T.Jeyapoovan, Engineering Practices Lab Manual; Vikas Publishers, 2008, 4th Edition
8. John K.C.,Mechanical Workshop Practice; PHI, 2010, 2nd Edition
9. Soni P.M. & Upadhyay P.A.; Atul Prakashan, Wiring Estimating, Costing and Contracting; 2021-22

Other Suggested Readings:

1. Different Trade E-Books (Fitting, Plumbing, Welding, Carpentry, Foundryman, Turner and House Wiring etc.) developed by National Instructional Media Institute, Chennai. Directorate General of Training, Ministry of Skill Development & Entrepreneurship, Govt. of India. (https://bharatskills.gov.in).

CE1108 **3-0-0 (3)**

Civil Engineering Materials

Pre-Requisites: **None**

Course Outcomes:

CO-1	Classify and characterize building stones, lime and cement
CO-2	Recognize the preservation methods of timber, metals, and other building components
CO-3	Comprehend the behaviour of cement and concrete
CO-4	Recognize the advanced civil engineering materials

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	-	-	-	-	2	-	1	2	2	3	2	3	2	1	-
CO-2	1	2	3	3	1	2	2	2	2	2	2	3	2	2	3	2
CO-3	2	2	2	-	-	2	2	2	2	2	2	2	-	3	1	-
CO-4	2	3	2	3	3	3	2	1	2	2	3	3	-	3	3	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Construction Materials: Classification of stones- Characteristics of good building stones and their uses; Brick and other Clay Products: Composition of brick-earth, manufacturing process of bricks, characteristics of good building bricks and their uses, testing of bricks, Types of tiles and their use in buildings. Concrete Making Materials: Cement, Fine and Coarse aggregate, Water, Chemical & Mineral admixtures, Tests on aggregates as per Indian standards, Bulking of sand. Bitumen and additives

Timber and Metals: Classification of timber trees, cross section of exogenous tree, hard wood and soft wood, seasoning of timber, ply wood and its uses. Compressed and industrial wood, wood finishes and surface protection, PVC, WPC, WPVC panels. Steel and Aluminium: Types of steel-mild steel, high carbon steel, high strength steel- properties and uses, light Guage steel, commercial forms of steel and aluminium and their uses, UPVC, Railings and fittings.

Lime, Cement, and Concrete: IS classification of lime and uses, chemical composition of cement, IS specifications and tests on Portland cement, different types of cements and their uses, Mortar and Concrete: Preparation of cement mortar and concrete for different types of works, Hydration of Cement: Bogue's compounds, Hydration, Gel formation, pore & capillary water, factors affecting strength of concrete, durability, types of concrete and their specific use. Different methods of mix design – factors affecting mix design, Ready mix concrete.

Introduction to Advanced Materials: Ferro cement, FRP, Gypsum boards, FAL-G brick, fly ash, GGBS, super plasticizers, plastics, paints, and geotextiles, Admixtures and Stabilisers

Learning Resources:

Text Books:

1. Duggal, S.K, Building Materials, New Age International (P) Limited Publishers., 2008, 3rd Edition
2. M. S. Shetty and A. K. Jain, Concrete Technology: Theory and Practice, S Chand Co., Publishers, 2018.

Reference Books:

1. Peter A. Claisse, Butterworth- Heinemann, Civil Engineering Materials, 2016, 1st Edition
2. Kathryn E. Schulte Grahame, Steven W. Cranford, Craig M. Shillaber, and Matthew J. Eckelman. Cognella Essentials of Civil Engineering Materials. Academic Publishing, San Diego, 2020, 1st Edition.
3. Haimei Zhang Building Materials in Civil Engineering, Woodhead Publishing Limited and Science Press, 2011, 1st Edition.
4. AM Nevelli, Properties of Concrete, Prentice Hall Publishers, 2012, 5th Edition.

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc21_ar11/preview
2. https://nptel.ac.in/courses/105/102/105102088/
3. https://nptel.ac.in/courses/105/106/105106053/
4. https://nptel.ac.in/courses/105/102/105102012/

3rd Semester

MS 1261 **3-0-0 (3)**

Business Essentials for Engineers

Pre-Requisites: **None**

Course Outcomes:

CO-1	Recognize the basic concepts of management and its functions
CO-2	Apply the functions of management for taking effective decisions
CO-3	Analyze factors influencing management in competitive business environment
CO-4	Identify business opportunities and challenges
CO-5	Integrate functions of management for building a better organization

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	–	–	–	–	–	–	–	3	–	3	3	–	–	–	–
CO-2	–	–	–	–	–	–	–	–	2	–	3	3	–	–	–	–
CO-3	–	–	–	–	–	–	–	–	1	–	3	3	–	–	–	–
CO-4	–	–	–	–	–	–	–	–	1	–	2	2	–	–	–	–
CO-5	–	–	–	–	–	–	–	–	1	–	1	2	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: The evolution of management theory, Business functions and their roles, Organizations and types, Levels of management, Types of markets and pillars of management- planning, organizing, leading and controlling.

People Management: Catalysts for organizational performance – Motivation & Leadership, Organization culture & Change, Human resource functions in a dynamic business environment and evolving dynamics in Industrial Relations.

Marketing Management: Nature and scope of marketing, Company's orientation towards market place, Importance of marketing concept, Marketing environment, 4p's of marketing, market segmentation, target market selection and positioning.

Financial Management: Financial accounting, Financial statements and analysis for decisions, Financial planning, Capital, Working capital, Capital structure and Sources of corporate finance, Investment decisions.

Project Management: Project screening and Selection, Techniques, Structuring concepts and Tools (WBS, OBS, and LRC, RACE). Project life cycle analysis. Appraisal of a project, Project Planning: Techniques, CPM, PERT- GAN - Time Cost Trade-off and Crashing Procedure, Project Monitoring: Monitoring Techniques and time control System, EVA Analysis

Quality & Strategy: Quality, Principles, Quality Awards, Standards of Quality culture, Quality metrics programs, Strategy, Vision and Mission, Porter's 5–forces, McKinsey's 7S Model, BCG Matrix, Competitive advantage - Value chain analysis & Resource based view.

Learning Resources:

Text Books:

1. Ronald J. Ebert, Ricky W. Griffin, Business Essentials, Pearson, 2019, 12th Edition
2. Harold Koontz, Heinz Weihrich, Mark V. Cannice, Essentials of Management, McGraw hill, 2020, 11th Edition

Reference Books:

1. G. Shainesh Philip Kotler, Kevin lane Keller, Alexander Chernev, Jagdish N. Sheth, Marketing Management, Pearson, 2022, 16th Edition
2. Dessler, G., & Varkkey, B, Human Resource Management, Pearson Education, 2024, 17th Edition
3. Prasanna Chandra, Financial Management: Theory & Practice, Mc Graw Hill, 2022, 11th Edition
4. Poornima M Charantimath, Total Quality Management, Pearson, 2022, 4th Edition
5. IM Pandey, Financial Management, Vikas Publications, 2021, 12th Edition
6. Jack R. Meredith, Mantel, Project Management - A Managerial Approach, John Wiley, 2021,11th Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/110106050
2. https://nptel.ac.in/courses/110105146
3. https://nptel.ac.in/courses/110105069
4. https://nptel.ac.in/courses/110104068
5. https://ocw.mit.edu/courses/15-535-business-analysis-using-financial-statements-spring-2003/
6. https://ocw.mit.edu/courses/15-810-marketing-management-fall-2010/

CE1201 **3-1-0 (4)**

Surveying

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply the basic principles of Surveying
CO-2	Operate and use different instruments and techniques to determine the positions
CO-3	Prepare maps/plans from the collected field data
CO-4	Apply the techniques for setting out curves and other layouts etc

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	1	3	3	3	3	1	1	1	1	-	3	-
CO-2	3	2	3	3	2	2	2	1	1	2	3	2	1	-	1	-
CO-3	3	1	2	1	1	3	1	1	2	3	2	2	2	2	-	2
CO-4	3	3	2	2	3	2	3	2	3	2	3	2	2	-	2	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Surveying objectives, plane surveying principles and classification, scales, Errors and Mistakes, Types of tapes and chains, offsets, Errors and Corrections

Compass Surveying: Measurement of directions and angles, types of compass, meridians and bearings, local attraction, magnetic declination, traversing, plotting of traverse, adjustment of closing error

Plane Table Surveying: Principle and instruments used in plane table surveying, working operations, methods of plane table surveying

Levelling and Contouring: Description of a point (position) on the earth's surface, instruments for leveling, principle and classification of leveling, bench marks, leveling staff, readings and booking of levels, field work, longitudinal section and cross section, plotting the profile, height (level) computations, contours, characteristics of contours, methods of contouring, interpolation, contour gradient, contour maps, calculation of areas of a closed traverse, measurements from cross sections, earth work calculations

Theodolite and Tacheometric Surveying: Principle of theodolite survey, Theodolite component parts, observations, Traversing, traverse computations, Trigonometrical Surveying, Tacheometry, principle of tacheometry, methods of tacheometry

Curve Setting: Types of curves, elements of a curve, setting out a simple curve, setting out a compound curve, checks on field work, reverse curve, transition curves, super elevation, deflection angles, transition curves, characteristics of transition curves, method of setting out a compound curve, types of vertical curves, setting out vertical curves

Advanced Surveying: Principle of EDM, Features and Functions of Total Station, GNSS – Segments, IRNSS, GAGAN

Learning Resources:

Text Books:

1. B.C. Punmia, Ashok Kumar Jain, Ashok Kr. Jain, Arun Kr. Jain., Surveying I & II, Laxmi Publications, 2015
2. Chandra A. M., Higher Surveying, New Age International Publishers, 2015

Reference Books:

1. James, M Anderson & Edward M., Surveying Theory and Practice, Tata Mc Graw Hill, 2012
2. Charles D Ghilani, Paul R Wolf., Elementary Surveying, Prentice Hall, 2012

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/107/105107122/
2. https://nptel.ac.in/courses/105/104/105104101/
3. http://sl-iitr.vlabs.ac.in/sl-iitr/

CE1203 **3-1-0 (4)**

Fluid Mechanics & Hydraulic Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply conservation laws to derive governing equations of fluid flow
CO-2	Compute hydrostatic and hydrodynamic forces
CO-3	Analyze the flow profiles in open channel flow and design channels
CO-4	Analyze and design simple pipe systems
CO-5	Apply principles of dimensional analysis to design experiments

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	1	–	–	–	–	–	–	–	1	–	–	3	–
CO-2	3	3	2	1	–	–	–	–	–	–	–	1	–	–	3	–
CO-3	3	3	2	2	2	–	–	–	–	–	–	1	–	–	3	–
CO-4	3	3	3	2	-	–	–	–	–	–	–	1	–	–	3	–
CO-5	3	3	3	3	2	–	–	–	–	–	–	1	–	–	3	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Introduction to fluid mechanics and hydraulic engineering for Civil Engineering, Fundamental difference between a solid and a fluid, Constituent relationships for solids and fluids, Conservation principles applied in fluid mechanics.

Properties of Fluids: Density, specific weight, pressure, viscosity, compressibility, surface tension and capillarity. Variation of pressure with elevation in fluids, Pressure measurement, piezometers and manometers Hydrostatic forces exerted on submerged surfaces.

Description of fluid flow: Concept of continuum, control mass & control volume approach, Reynolds transport theorem. Steady flow and uniform flow for flows along streamlines. Concept and application of stream functions and velocity potential functions.

Forces exerted in a fluid flow: Derivation of Continuity equation and Euler's equation, Bernoulli's equation and its applications, Momentum equation and its applications.

Dimensional Analysis: Basic concepts, design of experiments, identification of non-dimensional numbers and their significance, dimensional analysis methods.

Flow Measurement: Measurement of flow in pipes and open channels, orifice, mouthpiece, orificemeter and venturimeter, weirs and notches.

Laminar and Turbulent Flow: Laminar flow and turbulent flow in pipes, Navier-Stokes equations, Laminar flow between parallel plates, Laminar flow through pipes, Hazen-Poiseuille equation, creeping flows, boundary layer flows, Drag force on flat plates using boundary layer theory, head loss in flow through pipes, Darcy Weisbach equation, losses in pipe transitions, Turbulence, Reynolds turbulent stresses, Velocity distribution in turbulent flow, Pipe networks.

Flow in Open Channels: Uniform and Non-Uniform Flows in open channel, Specific energy, Critical flow, Channel transitions, Uniform flow formulae, best hydraulic sections.

Steady Gradually Varied Flow: Gradually varied flow equation, Type of GVF profiles, Computation of GVF profiles.

Steady Rapidly Varied Flow: Hydraulic jump in a horizontal rectangular channel, Specific force, Computation of energy loss.

Unsteady Flow: Celerity of a gravity wave, Monoclonal rising wave, Positive and negative surges, St. Venant's equations, Method of characteristics, Hydraulic routing.

Hydraulic Machinery: Classification of hydraulic machines, Euler's equation of turbo machines, one dimensional flow analysis and velocity triangles, Pump efficiency curves, selection of pumps, Different turbines.

Learning Resources:

Text Books:

1. Robert W. Fox, Philip J. Pritchard, and Alan T. McDonald, Introduction to Fluid Mechanics, Wiley, 2011, 7th Edition.
2. Subramanya K., Flow in Open Channels, McGraw Hill Publications, 2016, 4th Edition.

Reference Books:

1. Ojha C. S. P., Chandramouli P. N., Berndtsson R., Fluid Mechanics and Machinery, Oxford University Press, 2010, 2nd edition
2. Chow V.T., Open Channel Hydrualics. The Blackburn Press, 2009, 1st Edition
3. Roberson J.A., Cassidy J.J., Chaudhry M.H., Hydraulic Engineering, 2013, 2nd Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/112/105/112105218/
2. https://nptel.ac.in/courses/105/103/105103192/

CE1205 **3-0-0 (3)**

Strength of Materials

Pre-Requisites: **CE1102**

Course Outcomes:

CO-1	Obtain the Fourier series for a given function
CO-2	Find the Fourier transform of a function
CO-3	Determine the solution of a PDE by variable separable method
CO-4	Know the use of complex variables
CO-5	Evaluate a real definite integral

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	**2**	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-2	**3**	2	1	2	1	–	–	–	–	–	–	–	–	1	3	–
CO-3	**2**	3	1	3	1	–	–	–	–	–	–	–	–	1	2	–
CO-4	**3**	2	1	2	1	–	–	–	–	–	–	–	–	1	3	–
CO-5	**3**	3	1	3	1	–	–	–	–	–	–	–	–	1	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Strain Energy, Resilience and Impact Loading Strain energy in axial tension and compression- bars with varying section-proof resilience – stress due to gradual, sudden and Impact loading.

Shear Force and Bending Moment: Types of supports - Types of determinate beams – Simply supported, Cantilever, Overhanging and compound beams with articulations -Shear Force and Bending Moment diagrams - Principles of Superposition.

Theory of Simple Bending: Assumptions - Theory of Simple Bending - Bending stresses in beams - Discussion of efficiency of various shapes of cross sections.

Shear Stress Distribution: Flexural shear stress distribution in various shapes of cross sections of beams.

Deflection of Beams: Double Integration method, Macaulay's method, Moment area method, Conjugate Beam method - Calculation of Slope and deflections of statically determinate beams.

Torsion of Circular Shafts: Theory of Pure Torsion in Solid and Hollow Circular Shafts – Torsional Shear Stresses and angle of twist - transmission of Power.

Springs: Types and classification of springs – Analysis of Close and Open coiled helical springs subjected to axial load and axial twist – Compound springs - Leaf springs.

Thin Cylinders and spherical shells: Internal fluid pressure – Volumetric strain-Wire wound thin cylinders.

Strain Energy in Flexure and Castigliano's Theorem: Strain Energy of Beams in bending-Deflection of beams from Strain Energy. Castigliano's Theorem I - application to statically determinate beams for determining slopes and deflections.

Learning Resources:

Text Books:

1. Mechanics of Materials, Timoshenko and Gere, CBS Publishers, New Delhi, 2004, 2nd Edition.
2. Mechanics of Materials, Beer and Johnston, McGraw Hill India Pvt. Ltd., 2020, 8th Edition

Reference Books:

1. S. B. Junarkar and H. J. Shah, Mechanics of Structures Vol 1 (Strength of Material), Charotar Publishing House Pvt. Ltd., 2012.
2. L.S Srinath, Advanced Mechanics of Solids, McGraw Hill Education, 2017, 3rd Edition.
3. E.P.Popov, Engineering Mechanics of Solids, Pearson, 2015, 2nd Edition.
4. Pytel & Singer, Strength of Materials - Harper & Row Publishers, 2018, 4th Edition.
5. T.D.Gunneswara Rao and Mudimby Andal, Strength of Materials - Fundamentals and Applications, Cambridge University Press, 2018, 1st Edition
6. B.C. Punmia, Ashok Kumar Jain, Arun Kumar Jain, Mechanics of Materials, by Laxmi publications(p) Limited.

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/105/105/105105108/
2. https://archive.nptel.ac.in/courses/112/107/112107147/

CE1207 **3-0-0 (3)**

Geotechnical Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Characterize and classify the soils.
CO-2	Calculate the stress distribution and effective stress under various field conditions and estimate the consolidation settlements.
CO-3	Select the suitable shear strength parameters for different field conditions and evaluate the stability of slopes.
CO-4	Determine the compaction parameters and exercise field compaction control. Comprehend the principles of compaction and its control.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	-	3	-	-	-	1	-	-	-	-	1	3	-	-
CO-2	3	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	3	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	3	3	-	3	-	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Rocks: Formation of rocks, Rock minerals, Structure of earth, Classification of rocks, Defects in rock mass, Rock as a construction material.

Soils: Soil formation- Development of soil mechanics- Importance of soil engineering- Major soil deposits of India.

Basic Definitions and Relationships: 3-phase soil system, Volumetric relationships and weight -volume relationships.

Determination of Index Properties: Water content, Specific gravity, Grain size distribution by sieve and hydrometer analysis, Relative density, Atterberg limits and indices.

Classification of Soils: Classification of soil systems – Particle size classification, Textural classification, AASHTO classification, Unified soil classification and Indian soil classification- Field identification of soils, Relative suitability of soils for engineering works based on soil classification.

Soil Water: Types of soil water, Capillarity in soils, Permeability of soils, Darcy's law, Determination of permeability of soils, Permeability of stratified soils, Field permeability determination, Seepage velocity, Absolute coefficient of permeability, Factors affecting permeability- Effective stress principle- Effective stress under different field conditions- Seepage pressure-Quick sand condition.

Compaction of Soils: Definition and importance of compaction – Standard Proctor compaction test, Modified compaction test- Factors affecting compaction- Influence of compaction on soil properties – Field compaction and its control, Relative compaction.

Stress distribution in Soils: Importance of estimation of stresses in soils – Boussinesq's and Westergaard's theories for point loads, uniformly loaded circular and rectangular areas, pressure bulb, variation of vertical stress under point load along the vertical and horizontal planes – Newmark's influence chart, Contact pressure distribution in sands and clays.

Consolidation: Types of compressibility – Immediate settlement – Primary consolidation and secondary consolidation – Stress history of clay, Normally consolidated soil, Over consolidated soil and under consolidated soil- preconsolidation pressure and its determination- Consolidation test, Estimation of settlements -Terzaghi's 1-D consolidation theory – Coefficient of consolidation and its determination - Spring analogy.

Shear Strength: Definition and use of shear strength - Source of shear strength- Normal and Shear stresses on a plane – Mohr's stress circle- Mohr-Coulomb failure theory- Measurement of shear strength, Drainage conditions -Direct shear test, Triaxial shear test, Unconfined compression test and vane shear test – Factors affecting shear strength of granular soils and cohesive soils.

Stability of Soil Slopes: Types of slopes – Types of slope failures – Slip circle method, Determination of centre of most critical slip circle – Taylor's stability charts and their use. Stabilization of soil slopes.

Learning Resources:

Text Books:

1. Gopal Ranjan and A.S.R. Rao Basic and Applied Soil Mechanics, New Age Int. Publishers,2023, 5th Edition.
2. V.N.S. Murthy, Geotechnical Engineering, CBS Publishers, 2018, 1st Edition.

Reference Books:

1. Nagaratnam Sivakugan, Soil Mechanics and Foundation Engineering: Fundamental and Applications, McGraw Hill Publishers, 2021, First Edition.
2. Braja M. Das and N. Sivakugan, Introduction to Geotechnical Engineering, Cengage Learning, 2015, 2nd Edition.
3. David F.McCarthy, Essentials of Soil Mechanics and Foundations – Basic Geotechnics, Pearson Education Ltd., 2014, 7th Edition.
4. Muni Budhu, Soil Mechanics and Foundations, Wiley Publishers, 2016, 3rd Edition.
5. William A. Kitch, Geotechnical Engineering Lab Manual, 2011.
6. SP 36(Part-1)-1987 "Compendium of Indian Standards on soil Engineering" Bureau of Indian Standards, New Delhi.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/101/105101201/
2. https://nptel.ac.in/courses/105/105/105105168/
3. https://nptel.ac.in/courses/105/101/105101160/

CE1209 **0-1-2 (2)**

Surveying Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Operate and use different instruments and techniques to determine the positions
CO-2	Apply the techniques for setting out curves and other layouts etc
CO-3	Demonstrate advanced equipment in preparing maps

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	3	2	2	2	1	1	2	3	2	1	-	1	-
CO-2	3	3	2	2	3	2	3	2	3	2	3	2	2	-	2	-
CO-3	3	2	2	3	3	3	3	3	3	2	3	2	3	-	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Measurement of a line using a chain taking offsets on both sides
2. Traversing using compass.
3. Measurement of horizontal angle using Theodolite by Repetition/ Reiteration method.
4. Differential Levelling.
5. Profile Levelling and Cross sectioning.
6. Grid Contouring
7. Plane table traversing
8. Direct contouring using plane tabling
9. Setting out simple curve using theodolite.
10. Introduction to Total Station.
11. Total station traversing.
12. Introduction to GPS

Learning Resources:

Text Books:

1. Surveying I & II, B.C. Punmia, Ashok Kumar Jain, Ashok Kr. Jain, Arun Kr. Jain., Laxmi Publications, 2015
2. M Anderson & Edward M., Surveying Theory and Practice, James, Tata Mc Graw Hill, 2012

Other Suggested Readings:

1. http://sl-iitr.vlabs.ac.in/sl-iitr/

CE1211 **0-1-2 (2)**

Geotechnical Engineering Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend properties of different soils
CO-2	Characterize and classify the soils.
CO-3	Carryout the laboratory testing on soil samples to determine their index and engineering properties.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	-	3	-	-	-	1	-	-	-	-	1	3	-	-
CO-2	3	1	-	3	-	-	-	1	-	-	-	-	1	3	-	-
CO-3	1	-	-	2	-	-	-	-	2	2	-	-	1	3	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Basic Soil Properties: Specific Gravity of soil particles, Sieve Analysis, Atterberg Limits (Liquid Limit, Plastic Limit & Shrinkage Limit), Proctor's Standard Compaction Test, Determination of Field Density.

Engineering Properties of soil: Constant Head Permeameter Test, Variable Head Permeameter Test, Unconfined Compression Test, Triaxial Compression Test (U.U Test), Consolidation Test, Direct Shear Test

Learning Resources:

Text Books:

1. William A. Kitch, Geotechnical Engineering Lab Manual, 2011.

Reference Books:

1. SP 36(Part-1)-1987 "Compendium of Indian Standards on soil Engineering" Bureau of Indian Standards, New Delhi.
2. IS2720 "Indian standard for testing materials" Bureau of Indian Standards, New Delhi.
3. Sivakugan, Arulrajah and Bo, Laboratory Testing of Soils, Rocks and Aggregates, J. Ross Publishing, 2011.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/101/105101201/
2. https://nptel.ac.in/courses/105/105/105105168/
3. https://nptel.ac.in/courses/105/101/105101160/

4th Semester

MA1363 **3-0-0 (3)**

Fourier Series, Partial Differential Equations and Complex Variables

Pre-Requisites: **None**

Course Outcomes:

CO-1	Obtain the Fourier series for a given function
CO-2	Find the Fourier transform of a function
CO-3	Determine the solution of a PDE by variable separable method
CO-4	Know the use of complex variables
CO-5	Evaluate a real definite integral

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-2	3	2	1	2	1	–	–	–	–	–	–	–	–	1	3	–
CO-3	2	3	1	3	1	–	–	–	–	–	–	–	–	1	2	–
CO-4	3	2	1	2	1	–	–	–	–	–	–	–	–	1	3	–
CO-5	3	3	1	3	1	–	–	–	–	–	–	–	–	1	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Fourier Series: Introduction and basic definitions; Expansion of a function in Fourier series for a given range; Half range sine and cosine expansions.

Partial Differential Equations: Classification of higher order partial differential equations; Method of separation of variables - Solution of one-dimensional wave equation, one-dimensional heat conduction equation and two-dimensional steady state heat conduction equation with illustrations.

Complex Variables: Analytic function – Cauchy-Riemann equations, Harmonic functions, Conjugate functions; Complex integration - Line integrals in complex plane, Cauchy's theorem (simple proof only) and Cauchy's integral formula; Taylor's and Laurent's series expansions; Zeros and singularities; Residues - Residue theorem, Use of residue theorem to evaluate the real definite integral of the type $\int_0^{2\pi} f(cos\theta,\ sin\theta)d\theta$ and $\int_{-\infty}^{\infty} f(x)dx$. Concept of conformal mapping with simple illustrations.

Learning Resources:

Text Books:

1. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, 6th Edition.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, 8th Edition.

Reference Books:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, McGraw Hill Education, 2009, 9th Edition
2. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, 5th Edition.
3. M.D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand and Co., 2024, 20th Edition.

CE1202 **3-1-0 (4)**

Structural Mechanics

Pre-Requisites: **CE1205**

Course Outcomes:

CO-1	Determine the principal stresses and strains in structural members
CO-2	Analyze columns and struts
CO-3	Apply the concept of failure theories
CO-4	Analyze indeterminate problems using classical methods
CO-5	Analyze structures for gravity loads and moving loads

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	-	1	-	1	1	-	-	-	-	3	1	1
CO-2	2	3	3	2	-	1	-	1	1	-	-	-	-	3	1	1
CO-3	1	3	1	1	-	1	-	1	1	-	1	-	-	3	1	1
CO-4	3	-	-	3	-	-	-	1	-	-	-	-	-	-	1	-
CO-5	3	-	-	3	-	-	-	1	-	-	-	-	-	-	1	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Columns and Struts: Direct and Bending stresses - Kernel of a section - Euler's critical load for columns with ordinary end conditions - Slenderness ratio and effective length of a column -Rankine's Formula - IS Code formula - Critical load of eccentrically loaded columns.

Principal Stresses and Strains at a Point: Analysis of Biaxial state of stress at a point- Principal Planes - Principal stresses and strains - Mohr's Circle and its application to different cases - combined bending and torsion with or without end thrust - Equivalent Bending Moment and Equivalent Twisting Moment.

Failure Theories: (1) Maximum Principal Stress Theory (2) Maximum Principal Strain Theory (3) Maximum Shear Stress Theory (4) Strain Energy Theory (5) Distortion energy theory -Applications.

Indeterminate beams: Propped cantilever, Fixed and Continuous beams - Analysis for shear force and bending moment - Clapeyron's theorem of three moments - Slope and deflection - effect of sinking of supports.

Slope - Deflection Method: Analysis and application to continuous beams - portal frames (single bay - Single storey).

Moving Loads: Maximum bending moment and shear force diagrams for simply supported spans traversed by single point load - two concentrated loads - Uniformly distributed load, shorter and longer than the span-enveloping parabola and equivalent uniformly distributed load, determination of maximum bending moment and shear force for a system of concentrated loads on simply supported girders - focal length of a girder - counter bracing.

Influence Lines: Influence lines for reaction bending moment and shear force diagrams for simply supported beams - stresses in members of statically determinate pin-jointed plane frames due to moving loads.

Learning Resources:

Text Books:

1. Timoshenko and Gere, Mechanics of Materials, CBS Publishers, New Delhi, 2004, 2nd Edition.
2. H. J. Shah and S. B. Junarkar, Mechanics of Structures Vol.II, Charotar Publishers, 2017, 23rd Edition.

Reference Books:

1. Pytel & Singer, Strength of Materials, Harper & Row Publishers, 2018, 4th Edition.
2. R. C. Hibbeler, Mechanics of Materials (SI Edition), Pearson Publications, 2018.
3. L. S Srinath, Advanced Mechanics of Solids, McGraw Hill Education, 2017, 3rd Edition.
4. N. Krishna Raju, Advanced Mechanics of Solids and Structures, McGraw Hill Education, 2018.
5. B. C. Punmia, Ashok Kumar Jain, Arun Kumar Jain, Mechanics of Materials, by Laxmi publications(p) Limited.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/106/105106172/

CE1204 **3-1-0 (4)**

Hydrology and Irrigation Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze hydro-meteorological data
CO-2	Estimation of yield from the basin
CO-3	Estimate the Irrigation Requirements of Crops
CO-4	Formulate and solve hydrologic flood routing models
CO-5	Plan and design a Canal System

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	1	3	2	–	–	–	–	–	–	1	3	–	1	2
CO-2	3	3	3	2	2	–	–	–	–	–	–	1	3	–	1	–
CO-3	2	3	1	2	2	–	–	–	–	–	–	1	3	–	1	–
CO-4	3	3	2	2	3	–	–	–	–	–	–	1	1	–	2	3
CO-5	3	3	3	1	2	1	1	–	–	–	–	1	2	–	3	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Description of Hydrologic Cycle, Overview of application of hydrology in engineering, Forms and types of precipitation, basic concepts of weather systems, characteristics of precipitation in India. Need for irrigation, Types of irrigation systems, Gravity irrigation, Lift irrigation, Well irrigation.

Precipitation: Measurement of precipitation, types of rain gauges, rain gauge network, collection and presentation of rainfall data, Test for consistency and continuity of data, analysis of rainfall data, average precipitation over an area, intensity-duration-frequency analysis and depth-area-duration analysis.

Evaporation: Evaporation and Evaporation Process, measurement, estimation and control of evaporation.

Evapotranspiration: Evapotranspiration, measurement and estimation of evapotranspiration, Consumptive use of water, Factors affecting evapotranspiration, Penman-Monteith method, Potential evapotranspiration and Reference crop evapotranspiration, Duty and Delta, Frequency of irrigation, Irrigation efficiencies, Irrigation water quality, Cropping pattern.

Infiltration: Soil classification, Soil moisture, Field capacity, Permanent, and temporary wilting point, Available moisture, Measurement of soil moisture, Soil moisture tension, Infiltration process, measurement of infiltration, infiltration models and infiltration indices and effective rainfall.

Runoff: Methods of measurement of stream flow, stage-discharge relationship, Runoff characteristics, catchment characteristics effecting the runoff, yield from a catchment, flow duration curve and flow mass curve.

Hydrograph Theory: Components of hydrograph, base flow separation, direct runoff hydrograph, Unit hydrograph theory, derivation of unit hydrograph, S-hydrograph and instantaneous unit hydrograph, Derivation of unit hydrograph for ungauged catchments, conceptual models, synthetic unit hydrograph and its derivation.

Floods: Estimation of peak discharge, rational method, SCS method and unit hydrograph method, Design flood, return period, flood frequency analysis, probabilistic and statistical concepts. Gumbel's and log Pearson Type III methods.

Flood Routing: Concepts of flow routing, hydraulic and hydrologic routing, Reservoir routing, Channel routing, Muskingum and Muskingum-Cunge methods of channel routing and flood forecasting.

Methods of Irrigation: Surface irrigation – controlled flooding methods, contour farming, Subsurface irrigation – drip irrigation, Sprinkler irrigation.

Canal Systems: Types of canals, Principles of design of stable irrigation canals, Silt theories – Kennedy's and Lacey's theory, Tractive force theory, Design of lined canal, Design of longitudinal section.

Groundwater: Occurrence of groundwater, types of aquifers, aquifer properties, Groundwater movement, Darcy's law, Conductivity and Transmissivity, Steady Groundwater Flow Analysis.

Learning Resources:

Text Books:

1. Chow V.T., Maidment D., Mays L.W., Applied Hydrology, Tata McGraw Hill Publications, 2010, Second Edition.
2. Modi P.M., Irrigation Water Resources and Hydropower Engineering, Standard Book Publishing, 2014, Ninth Edition.

Reference Books:

1. Subramanya K., Engineering Hydrology, Tata McGraw Hill Publications, 2018, Fifth Edition.
2. Mays L.W., Water Resources Engineering, Wiley Publications, 2012, Second Edition.
3. Asawa G.L., Irrigation and Water Resources Engineering, New Age International Publishers, 2006, Second Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/105/105105110/

CE1206 **3-0-0 (3)**

Design of Steel Structures

Pre-Requisites: CE1205

Course Outcomes:

CO-1	Design bolt and weld connections
CO-2	Design tension and compression members
CO-3	Design beams and beam columns
CO-4	Design built up members and column base

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	-	1	-	-	-	-	-	-	-	-	-	2	-
CO-2	3	3	3	-	1	-	-	-	-	-	-	-	-	-	2	-
CO-3	3	3	3	-	1	-	-	-	-	-	-	-	-	-	2	-
CO-4	3	3	3	-	1	-	-	-	-	-	-	-	-	-	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: General- Types of Steel – Mechanical behaviour of steel – Measures of Yielding – Measures of Ductility – Types of Structures – Structural Steel Sections.

Methods of Structural design: Introduction-Design Philosophies-Working Stress method- Ultimate Strength method-Load and Resistant factor- Limit State Method-Partial safety factor-Load-Load combinations-Classification of Cross sections- General aspects in the design.

Design of Steel fasteners: Types of fasteners – Riveted connections- Bolted connections- Assumptions-Failure of bolted joints – Strength of bolted joints – Design examples – Design of Welded connections – Butt weld- fillet weld – Design examples.

Design of Tension Members: General – Modes of Failure of Tension member- Analysis of Tension members- Example - Design steps – Design examples – Lug angles – Design.

Design of Compression Members: General – Strength of Compression members- Design Compressive strength- Example on analysis of Compression members – Design of Angle struts – Design Examples-Built up Columns- Design of Lacing – Design of Battens- Design Examples- Design of Roof members.

Design of Beams: General- Lateral Stability of Beams- Bending Strength of Beams – Plastic Section Modulus - Design Examples.

Design of Beam Columns: Behaviour of members under combined loading – Modes of Failures – Design Examples.

Design of Column Splices and Column Base: Design of Column Splice-Design Examples- Design of Column Base- Slab Base- Gusseted Base- Design Examples.

Design of Eccentric Connections: Design of Brackets- Type-1 and Type 2 – Moment Resistant connections - Design Examples.

Design of Plate Girder: General- Components of Plate Girder- Optimum depth – Bending Strength – Shear Strength – Shear Buckling- Simple Post critical method- Tension Field method- Stiffeners-Bearing-Transverse stiffeners - Design Examples.

Introduction to Gantry Girders

Learning Resources:

Text Books:

1. N.Subramanian, Steel Structures: Design and Practice, Oxford Publishers, 2018.
2. S.S. Bhavikatti, Design of Steel Structures: By Limit State Method as per IS:800 – 2007, 2019, 5th Edition.

Reference Books:

1. V. N. Vazirani and M. M. Ratwani, Design and Analysis of Steel Structures, Khanna Publishers, 1988.
2. P Dayaratnam, Design of Steel Structures, S. Chand Publishers, 2012
3. L S Negi, Design of Steel Structures, Tata Mc Graw Hill Publishers, 2017
4. S K Duggal, Limit State Design of Steel Structures, Tata Mc Graw Hill Publishers, 2019, 3rd Edition.
5. IS-800-2007, BIS Publication

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/105/105105162/

CE1208 **3-0-0 (3)**

Foundation Engineering

Pre-Requisites: **CE1207**

Course Outcomes:

CO-1	Determine the earth pressures on foundations and retaining structures
CO-2	Analyze shallow and deep foundations
CO-3	Calculate the bearing capacity of soils and foundation settlements
CO-4	Conduct soil exploration for engineering works

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	-	1	-	-	-	-	-	-	-	-	-	-	-	2
CO-2	2	1	-	3	-	-	-	2	-	-	-	2	-	2	2	2
CO-3	3	3	-	1	-	-	-	-	-	1	-	-	-	-	2	2
CO-4	2	2	-	3	-	-	-	2	2	2	-	2	-	3	-	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Lateral Earth Pressures: Lateral earth pressure theory, Different types of earth pressures, Rankine's active and passive earth pressures, Pressure distribution diagram for lateral earth pressures against retaining walls for different conditions in cohesionless and cohesive soils, Coulomb's active and passive earth pressure theory, Culmann's graphical construction, Stability check, Problems.

Bearing Capacity of Foundation: Bearing capacity – Basic Definitions, Factors affecting bearing capacity, Estimation of Bearing capacity by different methods, Analytical measures – Terzaghi's and Meyerhof methods and calculations, Field measures – SPT, CPT and Plate load tests.

Settlement of Foundation: Settlement analysis – Types of foundation settlement, Components of settlements - their estimation, Allowable settlement values, Effects, Causes and remedial measures of total and differential settlements.

Shallow Foundations: Types of shallow foundations and choice, Basic requirements, Significance of these foundations.

Pile Foundations: Classification and uses, Load carrying capacity calculations by different methods - static methods, dynamic methods, in-situ penetration tests, piles load test, Negative skin friction, Under reamed pile foundations, Pile groups - necessity, efficiency, Group capacity and settlements.

Well Foundations: Types of caissons and their construction, Different shapes of wells, component parts and forces, Estimation of bearing capacity, Sinking of wells and remedial measures for tilts and shifts.

Soil Exploration: Introduction, Different methods - direct methods, semi-direct and indirect methods, Sampling in soils and rocks, Subsurface exploration program - Preparation of bore logs and preparation of exploration report.

Learning Resources:

Text Books:

1. Textbook of Soil Mechanics and Foundation Engineering Geotechnical Engineering Series, V.N.S. Murthy, CBS, 2018.
2. Principles of Foundation Engineering, Braja.M. Das, Cengage Learning India Private Limited, 2011, Seventh Edition

Reference Books:

1. Basic and Applied Soil Mechanics, Gopal Ranjan, ASR Rao, New Age International Pvt Ltd, 2016.
2. Textbook of Geotechnical Engineering, Iqbal H. Khan, PHI Learning, 2020.
3. Soil Mechanics and Foundation Engineering, K. R. Arora, Standard Publisher Dist., 2020.
4. Foundation Analysis and Design, Bowles,J.E, Mc.Graw Hill Company limited, England, 1988

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc21_ce39/preview
2. https://nptel.ac.in/courses/105/105/105105168/

CE1210 **0-1-2 (2)**

Fluid Mechanics Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Calibrate flow measuring devices
CO-2	Characterize laminar and turbulent flows
CO-3	Determine Manning's and Chezy's coefficients for smooth and rough channels
CO-4	Determine energy loss in hydraulic jump
CO-5	Performance analysis of pumps

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	2	2	3	–	1	–	–	1	–	–	1	2	–	2	–
CO-2	1	2	1	3	–	1	–	–	1	–	–	1	2	–	–	–
CO-3	1	2	1	3	–	1	–	–	1	–	–	1	2	–	3	–
CO-4	1	2	2	3	–	1	–	–	1	–	–	1	2	–	3	–
CO-5	1	1	1	3	–	1	–	–	1	–	–	1	2	–	3	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Calibration of Venturimeter, Orifice meter (discharge measuring device in pipes)
2. Calibration of Orifice and mouthpiece (discharge measuring device in Tanks)
3. Calibration of triangular notch and rectangular notch (discharge measuring device in Channels)
4. Measurement of viscosity by Hazen- Poiseuille method and Stokes method
5. Determination of Darcy's friction factor, relative roughness for laminar and turbulent flows
6. Determination of impact of jets on flat and curved blades
7. Determination of Manning's and Chezy's coefficients for smooth and rough channels
8. Determination of energy loss in hydraulic jump
9. Performance Characteristics of centrifugal pumps
10. Determination Velocity distributions in open channels
11. Estimation of infiltration rate in soils

Learning Resources:

Text Books:

1. Textbook of Soil Mechanics and Foundation Engineering Geotechnical Engineering Series, V.N.S. Murthy, CBS, 2018.
2. Principles of Foundation Engineering, Braja.M. Das, Cengage Learning India Private Limited, 2011, Seventh Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/112/105/112105218/
2. https://nptel.ac.in/courses/105/103/105103192/

CE1212 **0-1-2 (2)**

Strength of Materials Laboratory

Pre-Requisites: **CE1102**

Course Outcomes:

CO-1	Evaluate the strength of steel members
CO-2	Analyze the behavior of steel beams loaded differently

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	2	-	1	-	-	1	-	-	-	-	3	1	1
CO-2	1	3	1	1	-	1	-	1	1	-	-	-	-	3	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. To study the stress -strain characteristics of (a) Mild Steel and (b) Tor steel by conducting tension test on U.T.M.

2. To find the Brinnell's and Vicker's hardness numbers of (a) Steel (b) Brass (c) Aluminium (d) Copper by conducting hardness test.

3. To determine the Modulus of rigidity by conducting Torsion test on (a) Solid shaft (b) Hollow shaft.

4. To find the Modulus of rigidity of the material of a spring by conducting Compression test.

5. To determine the Young's modulus of the material by conducting deflection test on a simply supported beam.

6. To determine the Modulus of elasticity of the material by conducting deflection test on a Propped Cantilever beam.

7. To determine the Modulus of elasticity of the material by conducting deflection test on a continuous beam.

8. To determine the impact resistance of mild steel and cast iron specimen by conducting Charpy Impact test.

9. Shear test on Mild Steel rods

Learning Resources:

Text Books:

1. L.S Srinath, Advanced Mechanics of Solids, McGraw Hill Education, 2017, 3rd Edition.
2. N. Krishna Raju, Advanced Mechanics of Solids and Structures, McGraw Hill Education, 2018

5th Semester

CE1301 **3-1-0 (4)**

Environmental Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Plan and design water treatment units
CO-2	Design components of water distribution systems
CO-3	Design conveyance elements of wastewater collection systems
CO-4	Plan and design components of wastewater treatment systems
CO-5	Design sludge treatment and disposal systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	1	3	1	1	–	–	–	1	2	–	3	2
CO-2	3	3	3	3	2	3	1	1	–	–	–	1	2	–	2	2
CO-3	3	3	3	3	2	3	3	2	–	–	–	1	1	–	2	1
CO-4	3	3	3	3	2	3	3	2	–	–	–	1	1	–	2	1
CO-5	3	3	3	3	1	3	2	2	–	–	–	1	1	–	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Water Pollution: Sources, types of pollutants and their effects, water quality issues, contaminant transport, self-purification capacity of streams and water bodies, water quality standards, principles of water and wastewater treatment. Surface sources, subsurface sources, physical, chemical and biological characteristics, Estimation of water demand, water consumption rate, fluctuations in rate of demand, design period. Physical, chemical and biological characteristics of wastewater, analysis of wastewater, Importance of BOD and COD, Effluent standards, impacts of disposal

Collection and Conveyance of Water: Intakes, types of Intakes, factors governing location of intakes, pumps, types of conduits, types of pipes, pipe appurtenances

Water Treatment: Working principles and design of water treatment units, screening, plain sedimentation, sedimentation aided with coagulation, filtration, disinfection, water softening, miscellaneous treatments.

Distribution System: Requirements of a good distribution system, methods of distribution, systems of supply of water, Distribution reservoirs, layout of distribution system, design of distribution system, analysis of pipe networks, appurtenances in distribution system, detection and prevention of wastage of water in distribution system.

Sewers and sewer appurtenances: Wastewater Collection, Estimation of dry weather flow and storm water flow, Hydraulic design of sewers, Limiting velocities, effect of variation in flow of sewage on velocity of flow in sewers, types of sewers, design of storm water drains.

Construction of sewers: factors affecting the selection of material for sewer construction, materials for sewers, joints in sewers, shapes of sewers, maintenance, cleaning & ventilation of sewers. Sewer appurtenances.

Primary Treatment of wastewater: Preliminary & primary treatment of wastewater: screening, grit removal basins, removal of oil and grease, sedimentation, sedimentation aided with coagulation.

Secondary Treatment of wastewater: Secondary treatment of Wastewater: Principles and classification of secondary treatment, activated sludge process, trickling filters, miscellaneous methods such as oxidation ditch, oxidation ponds, aerated lagoons, rotating biological contractors. Disposal of wastewater, self-purification of streams, sewage irrigation, Treatment and disposal of sludge, On-site disposal methods

Tertiary Treatment of wastewater: Tertiary wastewater treatment, necessity and principles, Industrial wastewaters and effluent treatment plants including institutional and industrial waste management.

Learning Resources:

Text Books:

1. Peavy H.S, Rowe, D.R., and Tchobanoglous, G., Environmental Engineering, McGraw Hill Education, 2017 1st Indian Edition
2. Mackenzie L. Davis, Water and Wastewater Engineering: Design Principles and Practice, McGraw Hill Education, 2017,1st Edition

Reference Books:

1. S.K. Garg, Environmental Engineering (Vol. I): Water supply Engineering, Khanna Publishers, 2017, 34th Edition.
2. John C. Crittenden, R. Rhodes Trussell, David W. Hand, Kerry J. Howe, George Tchobanoglous, MWH's Water Treatment: Principles and Design, John Wiley & Sons, Inc., 2012, 3rd Edition
3. Mackenzie L. Davis, Water and Wastewater Engineering: Design Principles and Practice, McGraw Hill Education, 2017,1st Edition.
4. Terence Mcghee,Water Supply and Sewerage, McGraw-Hill Education, 1991, 6th edition.
5. Masters, G.M., Ela W.P.,Introduction to Environmental Engineering and Science, Prentice Hall of India, 1994, 3rd Edition

Other Suggested Readings:

1. http://cpheeo.gov.in/cms/manual-on-water-supply-and-treatment.php
2. https://nptel.ac.in/courses/105/104/105104102/
3. http://cpheeo.gov.in/cms/manual-on-operation--and-maintenance-of-water-supply-system 2005.php
4. http://cpheeo.gov.in/cms/manual-on-storm-water-drainage-systems---2019.php
5. https://nptel.ac.in/courses/105/105/105105201/
6. https://nptel.ac.in/courses/105/106/105106119/

CE1303 **3-1-0 (4)**

Theory of Structures

Pre-Requisites: **None**

Course Outcomes:

CO-1	Formulate Equilibrium and Compatibility equations for structural members
CO-2	Analyze one dimensional indeterminate problem using classical methods
CO-3	Analyze Indeterminate structures using energy methods
CO-4	Analyze structures for gravity loads and moving loads

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	-	-	3	-	-	-	1	-	-	-	-	-	-	1	-
CO-2	3	-	-	3	-	-	-	1	-	-	-	-	-	-	1	-
CO-3	3	-	-	3	-	-	-	1	-	-	-	-	-	-	1	-
CO-4	3	-	-	3	-	-	-	1	-	-	-	-	-	-	1	-
CO-5	3	-	-	3	-	-	-	1	-	-	-	-	-	-	1	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Three-Hinged and Two-Hinged Arches: Action of an arch - eddy's theorem - Three-hinged and two-hinged, parabolic and segmental arches - determination of horizontal thrust, bending moment, normal thrust and radial shear, Influence lines for three and two hinged arches- effect of rib shortening - temperature effects - tied arches.

Cables and Suspension Bridges: Force in loaded cable and hanging cables - length of cables for different support conditions - simple suspension bridges with three hinged and two hinged stiffening girders - bending moments and shear force diagrams, influence lines - temperature effects on cables and stiffening girders.

Moment-Distribution Method: Analysis of continuous beams and portal frames (single storey - single bay).

Introduction to Matrix Methods: Static and Kinematic indeterminacy- flexibility and stiffness influence coefficients – Flexibility and stiffness Matrix- inversion- MAT Lab applications.

Flexibility Method: Basic principles - choice of redundants - released structure - application of fixed beams, continuous beams and frames (jointed) up to two degree static indeterminacy, portal frames higher degree static indeterminacy- verification by computer aided analysis.

Stiffness Method: Concept of stiffness method - restrained structure - applications to continuous beams and portal frames up to two degree of kinematic indeterminacy portal frames higher degree static indeterminacy- verification by computer aided analysis.

Learning Resources:

Text Books:

1. R L Jindal, Indeterminate Structures, S.Chand & Co. , New Delhi,
2. C S Reddy, Basic Structural Analysis, Tata McGraw Hill Publishers, 2017

Reference Books:

1. Intermediate Structural Analysis, Chu-Kia Wang, Tata McGraw Hill Publishers, 2017.
2. Computational Structural Mechanics, Rajasekaran & Sankara Subramanian, PHI, 2003.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/105/105105109/

CE1305 **3-0-0 (3)**

Design of Concrete Structures

Pre-Requisites: **None**

Course Outcomes:

CO1	Design Reinforced Concrete beams using limit state and working stress methods
CO2	Design Reinforced Concrete slabs
CO3	Design Reinforced Concrete columns and footings
CO4	Design structures for serviceability
CO5	Design stair cases, canopy, retaining wall and water tanks

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	-	1	-	-	-	-	-	-	-	-	-	3	-
CO2	3	3	3	-	1	-	-	-	-	-	-	-	-	-	3	-
CO3	3	3	3	-	1	-	-	-	-	-	-	-	-	-	3	-
CO4	3	3	3	-	1	-	-	-	-	-	-	-	-	-	3	-
CO5	3	3	3	-	1	-	-	-	-	-	-	-	-	-	3	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Review of Concrete making materials- Structural concrete- Grades- properties of Concrete- Modulus of elasticity-flexural strength-Characteristic and Design values-Partialsafety factor.

Methods of design: Aims of design- RCC- Limit State method- Assumptions- Stress-Strain behavior of Steel and Concrete- Stress block parameters- Working stress method- comparison of design process.

Analysis and Design of Singly Reinforced Beams: Analysis of Singly Reinforced RC Section-Neutral axis-Balanced-Under Reinforced-Over Reinforced Sections- Moment of Resistance- Design parameters- Design examples.

Analysis and Design of Doubly Reinforced Beams: Necessity of Doubly Reinforced sections-Analysis of Doubly Reinforced RC Section-Moment of Resistance- Design parameters- Design.

Shear and Bond design of RCC: Shear forces in RC-Shear Resistance of RC- Truss analogy- design of Vertical stirrups-Bent-up bars- Limitation- Bond failure in RC- Check for bond resistance-Development length-Design for shear and bond.

Analysis and Design of Flanged Beams: Analysis of flanged RC section- Singly and Doubly reinforced-Effective flange width- Moment of Resistance- design examples.

Design of RCC Slabs: Concept of yield line theory - Design of One and Two way slabs- Effect of edge conditions- Moment of resistance-Torsion reinforcement at corners- Design examples.

Design of Continuous Slab and Beams: Effect of continuity- analysis of continuous beam/slab-Moment and shear coefficients for continuous beam/slab- Critical sections.

Design of RC Columns: Design principles of RC columns- Assumptions- Rectangular and Circular columns- Helical reinforcement- Minimum eccentricity-Use of Interaction diagrams for Axial load and Moment.

Design of RC Footings: RC footings-Minimum depth of footing- Safe bearing capacity- Design for Bending-Shear in One way and Shear in Two way- Transfer of load at base of column.

Design for Serviceability: Concept of Serviceability- Deflection- Span to depth ratio- Short term-Long term deflection due to Shrinkage, Creep- Cracking-Crack width calculation.

Design of Miscellaneous RC Structures: Design of Stair case – Design of Canopy Slab and Beam – Design of cantilever Retaining walls- Design of RC Circular Water tank- Design of single story RC Building.

Learning Resources:

Text Books:

1. B. C. Punmia, Ashok. K. Jain and Arun. K. Jain, Limit State Design of Reinforced Concrete Structures, Laxmi Pub. Pvt Ltd, 2016.
2. N. Krishnaraju, Design Of Reinforced Concrete Structures, IS:456-2000, CBS Publications, 2019, 4th Edition.

Reference Books:

1. Devdas Menon and S. Pillai, Reinforced Concrete Design, Tata McGraw Hill Pub., 2017, 3rd Edition.
2. R. Park and T. Paulay, Reinforced Cement Concrete Structures, MISL-WILEY Series, Wiley India Pvt. Ltd, 2009.

Online Resources:

1. https://nptel.ac.in/courses/105/105/105105105/

CE1307 **3-0-0 (3)**

Highway Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Plan highway network.
CO-2	Design highway geometrics.
CO-3	Determine the characteristics of traffic flow.
CO-4	Characterize the pavement materials and design a bituminous mix.
CO-5	Analyze, design, and construct the flexible and rigid pavements.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	3	3	-	-	-	-	-	-	-	2	2	3	1
CO-2	3	2	2	3	1	-	-	-	-	-	-	-	2	1	2	-
CO-3	2	2	2	3	2	-	-	-	-	-	-	-	2	-	2	-
CO-4	3	2	2	2	2	-	-	-	-	-	-	-	2	1	2	2
CO-5	3	3	3	2	2	-	-	-	-	-	-	-	2	1	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Highway Network Planning: Introduction, role of highway transportation, classification, network patterns, planning surveys, preparation of plans, master plan, evaluation by saturation system, 20-year road development plans, determination of road lengths.

Highway Alignment and Geometric Design: Principles of highway alignment, controlling factors, engineering surveys, design controls and criteria, cross-section elements, camber, carriageway, Krebs, road margins, formation, right of way, typical cross-sections, sight distance concepts and requirements, design of horizontal alignment, superelevation, transition curves, design of vertical alignment, gradients, and vertical curves.

Traffic Engineering Principles: Traffic characteristics; components of traffic stream: flow speed-density, measurement and analysis, q-k-v relationships, hourly design volume, concept of EPCU, capacity, level of service, parking studies and road safety, types of intersections and design requirements.

Pavement Materials and Mix Design: Types of pavement structures, functions, conventional materials used in pavements, properties relevant to the pavement, blending of aggregates, grading of bitumen, bituminous mix design using Marshall method and introduction to SUPERPAVE mix design.

Design of Pavements: Stresses and layered system concepts, stress solution for one, two, and three-layered systems, fundamental design concepts: axle types, standard and legal axle loads, ESWL, EWLF, VDF, lane distribution factors, directional distribution factor, tire pressure, contact pressure, design life; design of flexible and rigid pavement using IRC codes; stresses in rigid pavements: Westergaard's theory, stress due to curling, frictional stresses and design of rigid pavement using IRC method.

Pavement Construction: Construction of subgrade unbound and bound layers, bituminous works, and concrete pavement construction, MoRTH specifications.

Learning Resources:

Text Books:

1. Khanna, S.K., Justo C.E.G., and Veeraragavan A., Highway Engineering, Nem Chand, and Bros., Roorkee, India, 2017, Tenth Edition
2. Kadiyali, L.R., Traffic Engineering and Transportation Planning, Khanna Publishers, 2018 Ninth Edition.

Reference Books:

1. Bituminous Road Construction in India, Kandhal P.S., PHI Learning Pvt. Ltd., New Delhi.
2. Principles of Pavement Design, Yoder E.J. and M.W. Witczak., Second Edition, John Wiley

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/101/105101087/
2. https://www.youtube.com/watch?v=5zKC_aq4ypM

CE1381 **1-0-0 (0.5)**

Fractal Course - I

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire an in-depth Knowledge of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Civil Engineering.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content
CO-4	Recognize the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	–	–	–	–	–	–	–	–	–	1	2	2	–
CO-2	–	–	–	2	2	3	3	–	–	–	–	–	3	2	3	–
CO-3	–	–	3	2	2	–	–	–	–	–	–	–	3	1	3	–
CO-4	–	–	–	–	–	–	–	–	1	3	–	2	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Civil engineering field and enhancing their readiness for professional careers.

a. Structure: Lectures delivered by an expert from the Civil Engineering Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. Content: Topics covering current practices, case studies, technological advancements, and future trends.

c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

Text Books:

1. Course material and any learning resources suggested by the experts

CE1309 **0-1-2 (2)**

Environmental Engineering Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Determine physical, chemical and biological characteristics of water and wastewater
CO-2	Determine optimum dosage of coagulant
CO-3	Determine break - point chlorination
CO-4	Assess the quality of water and wastewater

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	1	1	2	–	1	–	–	–	–	–	1	2	–	2	–
CO-2	1	1	1	2	–	1	–	–	–	–	–	1	1	–	2	–
CO-3	1	1	1	2	–	1	–	–	–	–	–	1	1	–	2	–
CO-4	2	2	2	2	2	1	–	–	–	–	–	1	2	–	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Determination of pH.
2. Determination of Conductivity.
3. Determination of Acidity of water.
4. Determination of Alkalinity of Water.
5. Determination of Chlorides.
6. Determination of Hardness of water.
7. Determination of Fluorides.
8. Determination of Available Chlorine in bleaching powder.
9. Conducting Break Point Chlorination Test.
10. Determination of Residual Chlorine.
11. Determination of Dissolved Oxygen.
12. Determination of Chemical Oxygen Demand.
13. Determination of Biochemical Oxygen Demand.
14. Conducting Jar test for determining optimum dosage of coagulant.
15. Determination of Total Solids, Total Dissolved Solids & Settleable Solids

Learning Resources:

Text Books:

1. APHA, Standard methods for the examination of water and wastewater. (2012). 21st Edition, Washington:
2. CPCB, Guide Manual: Water and Wastewater Analysis

Reference Books:

1. Sawyer, C. N., McCarty, P. L., and Perkin, G.F., Chemistry for Environmental Engineering and Science, 5th edition McGraw-Hill Inc., 2002
2. Kotaiah, B., and Kumara Swamy, N., Environmental Engineering Laboratory Manual, Charotar Publishing House Pvt. Ltd., 1st Ed., 2007.

Other Suggested Readings:

1. https://www.vlab.co.in/

CE1311 **0-1-2 (2)**

Concrete Laboratory

Pre-Requisites: None

Course Outcomes:

CO1	Identify Quality Control tests on concrete making materials
CO2	Comprehend the behaviour of fresh and hardened concrete
CO3	Design concrete mixes as per IS and ACI codes
CO4	Determine the durability properties of concrete
CO5	Explore special concretes for construction

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	-	-	-	2	-	2	-	-	2	-	-	3	2	-
CO2	-	3	2	-	-	2	-	2	-	-	2	-	-	2	3	-
CO3	-	-	3	2	-	2	-	2	-	-	2	-	-	2	3	-
CO4	-	3	2	3	-	2	-	2	-	-	1	-	-	2	3	2
CO5	-	2	2	2	-	2	-	2	-	-	1	-	-	3	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Determination of Fineness and Specific Gravity of cement.
2. Determination of consistency of Standard Cement Paste.
3. Determination of initial and Final Setting times of Cement.
4. Determination of Compressive Strength of Cement.
5. Determination of Fineness modulus of Coarse and Fine Aggregates.
6. Determination of percentage of voids, Bulk density, Specific Gravity of coarse and Fine Aggregates.
7. Workability Tests: Slump Cone Test, Compaction factor test, Vee-Bee Consistometer Test.
8. Determination of hardened properties of concrete – compressive strength split tensile strength and flexural strength.
9. Study of stress - strain characteristics of concrete and tests for tensile strength of concrete.
10. Experiments to demonstrate the use of non-destructive test equipment.

Learning Resources:

Text Books:

1. A M Nevelli, Properties of Concrete, Prentice Hall Publishers, 2012, 5th Edition.
2. M. S. Shetty and A. K. Jain, Concrete Technology: Theory And Practice, S Chand Co., Publishers, 2018.

Reference Books:

1. J. J. Brooks and A. M. Neville, Concrete Technology, Pearson, 2019, 2nd Edition.
2. A. R. Santhakumar, Concrete Technology, Oxford Higher education, 2018

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/102/105102012/

6th Semester

CE1302 **3-1-0 (4)**

Construction Technology and Project Management

Pre-Requisites: None

Course Outcomes:

CO-1	Describe the factors considered in planning and construction of building
CO-2	Estimate schedule of activities in a construction project
CO-3	Categorize the equipment used in construction
CO-4	Assess the safety practices in construction industry
CO-5	Outline tender and contract document for a construction project

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	–	–	–	–	–	–	–	3	–	3	–	1	–	2	1
CO-2	–	2	–	–	3	–	–	–	–	–	3	–	–	–	2	–
CO-3	–	–	–	–	–	–	–	–	–	–	2	–	–	1	–	–
CO-4	–	–	3	–	–	2	–	–	–	–	2	–	–	–	–	3
CO-5	–	–	–	–	–	–	–	2	–	3	2	–	–	–	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Functional planning of Buildings: Types of Buildings, Aspects and Principles of Building Planning, Building By-laws and Regulations, Site Selection criteria, Orientation of Building and its relation to surrounding environment, Sustainability and Green Buildings, Foundation and its requirements, Masonry construction and Materials used; Construction of Floors and Roofs; Functional requirements and planning of a staircase.

Project Management: Role of Project manager, Stakeholders in construction project, Different types of projects, similarities & dissimilarities in projects., Time, Scope & Money, Knowledge areas & Processes involved in construction projects, WBS of a major work, Planning, monitoring & executing, Planning, sequencing, scheduling, Bar Charts, Networks, CPM, PERT, Cash flow diagram, resource levelling & resource allocation, Crashing of project, Earned Value Analysis, Construction finances- decision making.

Safety in construction: Cost of Accidents - Safety norms - Safety aids, Damping causes, its effects, and Proofing techniques; Fire hazards, protection, and grading rules; Methods of thermal insulation and materials used.

Equipment for construction: Earthwork - Concreting - Pavement – Hoisting etc.

Estimation, Tenders & Contracts: EOI- Prequalification - Types of Contract - Terminology use.

Advanced Construction Techniques: Construction of piles, tunnels, cofferdams, etc. Advanced formwork techniques-Slip form, Maivan, Doka, etc.

Learning Resources:

Text Books:

1. Kumar Neeraj Jha, Construction Project Management, Pearson Publication, 2015, Second edition
2. K. K. Chitkara, Construction Project Management, Tata McGraw Hill Publishing Company Limited, New Delhi, 2019, Fourth Edition

Reference Books:

1. R. L. Peurifoy, Construction Planning, Equipment and Methods, McGraw Hill Education, 2010
2. Punmia and Khandelwal K.K., Project Planning and Control with PERT and CPM, Laxmi Publications Delhi, 2016
3. Choudhary S, Project Management, Tata McGraw Hill Publishing Company Limited, New Delhi, 2017

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/106/105106149/
2. https://nptel.ac.in/courses/105/103/105103093/

CE1304 **3-0-0 (3)**

Airport and Railway Engineering

Pre-Requisites: **CE1307**

Course Outcomes:

CO-1	Determine the factors governing design of railway infrastructure.
CO-2	Study the types and functions of track, Points and crossings, junctions and railway stations
CO-3	Design the railway track system and identify suitable signal system.
CO-4	Study the aircraft characteristics influencing the planning of airport infrastructure
CO-5	Study the geometric and pavement design aspect of airfield pavements

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	-	1	1	-	1	1	-	-	-	-	1	1	2	3	1
CO-2	3	3	1	2	-	1	1	-	-	-	-	1	2	1	3	-
CO-3	3	3	3	2	3	1	1	-	-	-	-	1	2	-	3	2
CO-4	3	3	3	3	2	2	2	-	-	-	-	1	-	1	3	-
CO-5	3	-	1	1	-	1	1	-	-	-	-	1	1	2	3	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Aircraft and Airfield Components: Aircraft components; landing gear configurations; aircraft weight; engine types; atmospheric conditions affecting aircraft performance; air traffic separation rules; navigational aids; airport classification and planning; passenger terminal system and its components; aircraft parking type, apron layout; airport lighting, marking, airfield signage.

Geometric and Structural Design of the Airfield Infrastructure: Runway configurations, runway orientation, wind rose, estimating runway length; exit taxiway geometry, location of exit taxiways, design of taxiway curves and intersections, end-around taxiways; Aprons; pavement design using FAARFIELD.

Railway Track Geometric Design and Rolling Stock: Railway development and terminology; Locomotive types and classification; Train resistance and tractive power: various forces, locomotive tractive effort, hauling power; track gauge; permanent way; Forces acting; coning of wheels; tilting of rails; Rails; Sleepers; Ballast; Formations; Track fittings and fastenings; Gradients; Horizontal curves; Vertical curves.

Points and crossings and Track junctions: Terminologies; components of turnout and switch; Switches: terms, types; tongue rails; crossing: terminologies, movable crossing, number and angle; design of turnouts: Coles method, IRS method, with curved switches. Turnout and flexure types, Junctions; level crossings.

Railway Station, Yards and Signalling: Railway station classification, types; types of yards; equipment at railway stations; railway signalling: railway signs and symbols; Interlocking; automatic warning system.

Learning Resources:

Text Books:

1. Chandra, S., and Agarwal, M.M., Railway Engineering, Oxford University Press, Noida, India, 2013, 2nd Edition.
2. Horonjeff, R., McKelvey, F.X., Sproule, W.J., and Young, S.B., Planning and Design of Airports, McGraw-Hill, New York, USA, 2010, 5th Edition.

Reference Books:

1. Mundrey, J.S., Railway Track Engineering, Tata McGraw-Hill Education Private Limited, New Delhi, India, 2017, 5th Edition.
2. Khanna, S.K., Arora, M.G., and Jain, S.S.; Airport Planning and Design, Nem Chand and Bros, Roorkee, India, 2012, 6th Edition.

Other Suggested Readings:

1. https://rdso.indianrailways.gov.in
2. https://www.faa.gov/

CE1306 **0-1-4 (3)**

Product Development

Pre-Requisites: CE1101

Course Outcomes:

CO-1	Express Product Design Ideas using 2D or 3D sketches
CO-2	Model the components with geometric (engineering) specifications and appropriate materials
CO-3	Develop a prototype of the product
CO-4	Evaluate the entire product and the product based on testing with user
CO-5	Explore the scope for protecting novelty of the product through patent

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	–	2	3	3	3	2	2	3	3	2	3	–	–	–	–
CO-2	–	–	2	3	3	3	2	2	3	3	2	3	–	–	–	–
CO-3	–	–	2	3	3	3	2	2	3	3	2	3	–	–	–	–
CO-4	–	–	2	3	3	3	2	2	3	3	2	3	–	–	–	–
CO-5	–	–	2	3	3	3	2	2	3	3	2	3	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Design Thinking process for Product Development: Review of five step design thinking process of Empathize- Define- Ideate- Prototype- Test.

Project Selection: Identification of the problem through empathy, formulate and ideate to solve the problem.

Product Development:
Sketching: 2D and 3D sketching: Students will sketch the concept on drawing sheets/ digital screens. The drawings will contain the specifications of the geometric form.
3D Modelling*:* Develop the 3D model features including free form surfaces, final product design specifications, Parametric design.
Physical Component Development*:* Development of components: fabrication of actual components of the product using the materials and tools available in the lab, Iterations.

Iterative improvement of the product and Report writing: Development of assemblies/mock-up models/ working models/ prototypes/functional models/products, Testing and design review, Report writing.

IPR: Different forms of innovations emanating from the human mind and their protection using different tools of IPR, Basic introduction to Patents, Trademarks, Copyright, Industrial Designs Registrations, Geographical Indications Trade Secrets. Filing of IPR, implications, Ethics and societal implications of Intellectual Property Rights.

Learning Resources:

Textbooks:

1. The design studio method: creative problem solving with UX sketching, Sullivan, Brian, Focal Press, 2016.
2. Autodesk Fusion 360 Black Book, Verma G., CADACAMCAE Works, 2021, 2nd edition.
3. Class Junghans and Adam Levy, “Intellectual Property Management: A guide for Scientists, Engineers, Financers and Managers”, Willey (2006)

Other Suggested Reading:

1. Self-Paced Tutorials: https://help.autodesk.com/view/fusion360/ENU/courses/
2. Product Documentation https://help.autodesk.com/view/fusion360/ENU/?guid=GUID1C665B4D-7BF7-4FDF-98B0-AA7EE12B5AC2

CE1382 **1-0-0 (0.5)**

Fractal Course - II

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire an in-depth Knowledge of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Civil Engineering.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content
CO-4	Recognize the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	–	–	–	–	–	–	–	–	–	1	2	2	–
CO-2	–	–	–	2	2	3	3	–	–	–	–	–	3	2	3	–
CO-3	–	–	3	2	2	–	–	–	–	–	–	–	3	1	3	–
CO-4	–	–	–	–	–	–	–	–	1	3	-	2	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Linear Algebra: This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Civil engineering field and enhancing their readiness for professional careers.

a. Structure: Lectures delivered by an expert from the Civil Engineering Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. Content: Topics covering current practices, case studies, technological advancements, and future trends.

c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

Text Books:

1. Course material and any learning resources suggested by the experts

CE1308 **0-1-2 (2)**

Civil Engineering Software Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO1	Identify software tools in analysis and design of Civil Engineering Systems
CO2	Apply the available open source software tools used for analyzing specific problems in Civil Engineering
CO3	Develop Civil Engineering drawings using CAD software
CO4	Apply latest software tools for Advanced Modelling and Design of Civil Engineering Systems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	2	2	3	-	-	-	2	3	2	-	-	-	2	3
CO2	-	-	2	-	2	-	-	-	1	2	1	-	-	1	2	2
CO3	1	-	-	-	2	-	-	-	1	-	-	-	-	-	1	-
CO4	-	-	2	2	3	-	-	-	2	1	2	-	-	2	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. MATLAB - Applications
2. Civil Drawing: CAD, AutoDESK,
3. SAP 2000/STAAD pro/ETABS, MSP, Primavera, REVIT
4. Geotechnical software: Plaxis/Geostudio/Rocscience,
5. Transportation software: MxRoad Suite/VISSIM & VISSUM
6. Water and Environmental Software: MIKE-SHE/HEC-HMS/SWMM/SWAT/EPANET/Open FOAM/EIA/LCA

Learning Resources:

1. Software Manuals

CE1310 **0-1-2 (2)**

Transportation Engineering Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Conduct traffic studies to estimate traffic flow characteristics
CO-2	Characterize the pavement materials.
CO-3	Perform quality control tests on flexible pavements and flexible pavement materials.
CO-4	Estimate earth work from longitudinal and cross-section details.
CO-5	Design at-grade intersections.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	3	2	-	-	2	3	2	1	1	-	-	3	2
CO-2	2	2	-	2	-	-	-	2	2	2	-	1	3	3	1	-
CO-3	3	2	2	3	1	-	-	2	2	2	-	1	1	3	1	1
CO-4	2	2	3	2	2	-	1	-	-	-	-	1	3	-	3	1
CO-5	3	3	3	1	2	-	-	-	-	-	-	1	-	-	3	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Tests on Aggregate: Aggregate gradation, combined flakiness and elongation tests, specific gravity test, water absorption test, aggregate impact test, Los Angeles abrasion test, demonstration of soundness test.

Tests on Bitumen: penetration test, flash and fire point tests, ductility test, softening point test, specific gravity test, demonstration of absolute and kinematic viscosity tests, demonstration of rolling thin film oven test.

Tests on Bituminous Mixtures: bituminous mix design using Marshall stability test, stripping value of aggregates, demonstration of retained tensile strength test, demonstration of bitumen extraction.

Tests on Soil: California bearing ratio test.

Field tests: pavement unevenness using MERLIN, and pavement layer density using sand replacement method, demonstration of vehicle mounted road master.

Traffic Studies: traffic volume studies for mid-block section and intersection, spot speed, headway distribution studies, parking usage; drawing of highway longitudinal section, cross sections in embankment and cutting, and earthwork calculations; design and drawing of plain and rotary intersection.

Learning Resources:

Textbooks:

1. Khanna, S.K., Justo, C.E.G. and A. Veeraragavan Highway Materials and Pavement Testing, 5th Edition, Nem Chand, and Bros, Roorkee, India, 2009.
2. Relevant IRC codes; IS Codes; ASTM Codes.

7th Semester

CE1401 **3-0-0 (3)**

Hydraulic Structures

Pre-Requisites: **None**

Course Outcomes:

CO-1	Plan and design diversion head works
CO-2	Design canal regulators, canal falls and cross drainage works
CO-3	Analyze gravity dams
CO-4	Analyze Earth Dams
CO-5	Design spillways and energy dissipation systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	2	3	1	1	–	–	–	–	1	2	–	3	–
CO-2	3	3	3	2	3	1	1	–	–	–	–	1	2	–	3	–
CO-3	3	3	3	1	3	1	1	–	–	–	–	1	1	–	3	3
CO-4	3	3	3	1	3	1	1	–	–	–	–	1	1	–	3	3
CO-5	3	3	3	1	3	1	1	–	–	–	–	1	1	–	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Types of hydraulic structures, Diversion and Storage headworks.

Surface and Subsurface Flow Analysis in Hydraulic Structures: Hydraulic structures on permeable foundation, Seepage theories, Principles of design of hydraulic structures on permeable foundation, Principles of energy dissipation.

Design of diversion head works: Types of hydraulic structures, Layout of a diversion head work, Design of vertical drop weir, Design of sloping glacis weir, Silt control in head works.

Design of Canal Structures: Canal regulators, Types of canal falls, Design of Sarda type fall, Design of straight glacis fall, Types of cross drainage works, Design of canal fluming, Design of aqueduct/ syphon aqueduct.

Gravity Dams: Types of storage head works, Forces acting on gravity dams, Analysis of gravity dams, Profile of a gravity dam.

Earth dams: Types of earth dams, Causes of failure of earth dams, Seepage analysis, Seepage control, Stability analysis.

Spillways and energy dissipation systems: Types of spillways, Design of Ogee spillway, Design of stilling basins.

Learning Resources:

Text Books:

1. Modi P.M., Irrigation Water Resources and Hydropower Engineering, Standard Book Publishing, 2014, Ninth Edition.
2. Arora K.R., Irrigation, Water Power and Hydropower Engineering, Standard Book Publishing, 2018, Fifth Edition.

Reference Books:

1. Asawa G.L., Irrigation and Water Resources Engineering, New Age International Publishers, 2006, Second Edition.
2. Murthy C.S.N., Water Resources Engineering – Principles and Practice, New Age International Publishers, 2020, Second Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/105/105105110/

CE1403 **0-1-2 (1)**

Quantity Surveying & Public works Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO1	Prepare quantity estimates for Civil Engineering works
CO2	Calculate the quantity of materials required for civil works as per specifications
CO3	Evaluate contracts and tenders in construction practices
CO4	Prepare cost estimates

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	3	-	-	-	-	3	1	3	3	3	-	2	-
CO2	-	2	-	-	3	-	-	-	3	1	3	3	-	-	3	-
CO3	-	3	-	-	-	-	-	-	2	2	2	1	-	2	2	2
CO4	-	3	-	-	3	-	-	-	2	2	2	3	-	2	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Estimates: Purpose of estimating, Different types of estimates - their function and preparation.

Building Estimates: Methods, Estimation of different building components, Schedule of rates, Units of measurements, Units of works.

Earthwork: Different methods, Earthwork for roads, rails and canals, Earthwork for hill roads.

Analysis of Rates: Preparation for analysis of rates, Quantity of materials per unit rate of work, Labour estimate.

Specifications: Necessity, Types of specifications, Specifications for different civil engineering materials.

Contracts: Essentials of contracts Types of engineering contracts Advantages and disadvantages.

Tenders: Tender forms, Tender documents & notices time limits, Necessity.

Valuation: Purpose, Difference between value and cost, Qualifications and functions of a valuer, Scrap & salvage value, Sinking fund, Capitalised value.

Learning Resources:

Text Books:

1. M Chakraborti, Estimating Costing Specification & Valuation in Civil Engineering, National Halftone Co. Calcutta, 2006.
2. B. N. Dutta, Estimating and Costing in Civil Engineering, CBS Publishers & Distributors Private Limited, 2020.

Reference Books:

1. G.S. Birdie, A Text Book of Estimating and Costing for Civil Engineering, Dhanpat Rai Publishing Company Private Limited, 2014.
2. D. D. Kohli, R. C. Kohli, A Textbook of Estimating and Costing (Civil), S Chand Publishing, 2013.
3. https://www.udemy.com/course/estimating-and-costing/

CE1405 **0-1-2 (1)**

RS & GIS Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Interpret the remotely sensed data
CO-2	Map the earth surface features
CO-3	Prepare the different geospatial layers
CO-4	Compute geometric measurements and perform spatial analysis
CO-5	Create high-quality maps and associated graphics and Integrate different geospatial layers

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	3	2	-	-	2	3	2	1	1	-	-	3	2
CO-2	2	2	-	2	-	-	-	2	2	2	-	1	3	3	1	-
CO-3	3	2	2	3	1	-	-	2	2	2	-	1	1	3	1	1
CO-4	2	2	3	2	2	-	1	-	-	-	-	1	3	-	3	1
CO-5	2	2	1	2	1	-	-	1	2	1	-	1	1	-	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Remote Sensing:

1. Satellite Data downloading from different sources (Bhuvan, USGS, Earth data etc.,)
2. Spectral signature curves of various Land Use and Land Cover (LU/LC) features
3. Image Processing
4. Spectral Indices
5. Land use and land cover classification.

GIS:

1. Importing maps and layers from various sources
2. Georeferencing and projection
3. Digitization of Points and Lines
4. Editing Map Elements/Attribute Data Entry and Manipulation
5. Cleaning, Building and Transformation
6. Data Analysis – Overlay, Buffer
7. Map Generation with Patterns and Legends
8. Buffer Analysis and Network Analysis
9. Digital Elevation Model (DEM) applications
10. GIS Process and Model application
11. Google Earth Engine Applications
12. Field collection of geospatial features

Learning Resources:

Text Books:

1. Lillie and T.M and Kiefer R.W., Remote Sensing and Image Interpretation, John Wiley and Sons, 2015.
2. ERDAS Software user manuals

CE1489 **0-0-2 (2)**

Seminar and Technical Writing

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify and chose appropriate topic of relevance.
CO-2	Assimilate literature on technical articles of specified topic and develop comprehension.
CO-3	Prepare technical report.
CO-4	Design, develop and deliver presentation on specified technical topic.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	3	-	-	-	-	-	-	3	-	-	-	-
CO-2	2	2	2	2	2	-	-	3	3	-	3	3	-	-	-	-
CO-3	-	-	-	-	-	3	3	-	-	-	-	3	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	3	-	3	-	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search
- The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report
- The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation
- The project must cover at least any one area suggested below:
  - Design, analysis and/or methodological framework,
  - Experimentation,
  - Product design and development,
  - Design and development of laboratory equipment's/testing's,
  - Industry needs based basic survey or Testing or Analysis etc.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	Weightage for each criterion will be determined by the panel and will be informed to the students.
II	List of lectures attended	
III	Report	
IV	Presentation	
V	Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II	X			
III		X		
IV			X	X
V			X	X

Learning Resources:

Reference Books:

1. A guide to Technical writing by – T.A. Rickard
2. Technical Writing by- Serena Henning

CE1491 **0-0-0 (2)**

SHORT TERM INDUSTRIAL / EPICS / RESEARCH EXPERIENCE

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply engineering principles to real-world problems, gaining practical experience
CO-2	Plan, manage and execute the work with ethical consideration
CO-3	Review the social and environmental impact of the work
CO-4	Communicate the learnings through report and presentation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	3	-	-	-	-	-	-	3	-	-	-	-
CO-2	2	2	2	2	2	-	-	3	3	-	3	3	-	-	-	-
CO-3	-	-	-	-	-	3	3	-	-	-	-	3	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	3	-	3	-	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Every student has to undergo either a Summer Internship / EPICS / Research project. The summer internship may be undergone in an Industry/Research organization or any premier academic Institution, including NIT Warangal for 6-8 weeks. The EPICS/research project shall be registered under the guidance of any faculty member in the institute. The student is required to submit a report and present the work before an evaluation committee, nominated by the Head of the Department.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Relevance of the area of work	Weightage for each criterion will be determined by the panel and will be informed to the students.
II	Performance of the Task	
III	Crucial learnings from the work	
IV	Report Preparation	
V	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X
V				X

CE1495 **0-0-0 (2)**

Minor Project

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify an open-ended problem in area of Civil engineering and gap findings
CO-2	Explore the methods and materials required for the project work
CO-3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting
CO-4	Analyze the results to come out with tangible solutions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	2	-	2	2	1	-	-	-	2	2	2	2	3
CO-2	1	2	2	3	-	2	2	2	-	-	-	2	2	2	2	2
CO-3	2	-	2	-	-	3	3	-	2	3	-	3	-	-	-	-
CO-4	1	2	2	3	2	1	-	1	-	-	-	2	-	2	2	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Student can choose any topic, of his choice, pertaining to Civil Engineering. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the selected area of Civil Engineering for choosing their seminar topics. Student should review minimum of 10 research papers relevant to the topic chosen, in addition to standard textbooks, handbooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	The Weightages will be given by the evaluation panel.
II	List of lectures attended	
III	Report	
IV	Presentation	
V	Response to questions	

Learning Resources:

1. Civil Engineering Research Journals
2. Research Articles / Reports available on Internet
3. Civil Engineering Textbooks and Handbooks

8th Semester

CE1498 **0-0-0 (6)**

MAJOR PROJECT

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify a domain specific and contemporary topic
CO-2	Review literature to identify gaps and define objectives & scope of the work.
CO-3	Develop a prototype/model, experimental set-up or software systems to meet the objectives
CO-4	Analyze the results to draw valid conclusions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	-	-	2	1	-	1	3	1	1	2	-	-	-	-
CO-2	2	2	-	-	1	2	1	1	2	2	-	3	-	-	-	-
CO-3	2	2	3	3	3	2	2	2	2	1	3	2	-	-	-	-
CO-4	2	2	-	3	3	-	-	-	2	2	-	3	-	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project

The method of evaluation should be as per the guidelines stipulated for the B.Tech. Project evaluation. The template for preparation of the project report may be downloaded from (**https://www.nitw.ac.in/path/?dept=/nitwForms**) under UG Forms. The students are required to submit a report showing that plagiarism is within 30%. The B.Tech. Project work will be evaluated for 100 marks, with the following weightages:

Component	**Weightage**
Periodic evaluation by Guide	40 marks
Mid-term review	20 marks
End Semester viva-voce examination	40 marks
Total	100 marks

If the performance of a student is not satisfactory even after the extended time period, he/ she will have to repeat the project work in the next academic year.

Refer to B.Tech-Regulations for any further information regarding mid-term review, end-semester evaluation, template for report preparation and plagiarism.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Selection of Topic	Weightage for each criterion will be determined by the panel and will be informed to the students.
II	Literature Survey	
III	Objectives and Solution Methodology	
IV	Performance of the Task and clarity on the work	
V	Report Preparation	
VI	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III		X		
IV			X	
V				X
VI				X

Professional Elective-1

CE1321 **3-0-0 (3)**

Concrete Technology

Pre-Requisites: None

Course Outcomes:

CO1	Identify Quality Control tests on concrete making materials
CO2	Comprehend the behaviour of fresh and hardened concrete
CO3	Design concrete mixes as per IS and ACI codes
CO4	Determine the durability properties of concrete
CO5	Explore special concretes for construction

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	-	-	-	2	-	2	-	-	2	-	-	3	2	-
CO2	-	3	2	-	-	2	-	2	-	-	2	-	-	2	3	-
CO3	-	-	3	2	-	2	-	2	-	-	2	-	-	2	3	-
CO4	-	3	2	3	-	2	-	2	-	-	1	-	-	2	3	2
CO5	-	2	2	2	-	2	-	2	-	-	1	-	-	3	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Concrete Making Materials: Cement, Fine Aggregate, Coarse aggregate, Water, Chemical & Mineral admixtures.
Hydration of Cement: Bogue's compounds, Hydration, Gel formation, Types of cement,pore & capillary water.
Quality tests on cement: Different test on cement as per Indian standards
Aggregates: Tests on aggregates as per Indian standards, Bulking of sand, Sieve analysis – Grading.
Fresh concrete: Properties of fresh concrete- Workability – different tests of workability-Factors influencing workability compaction, finishing, curing.
Hardened concrete: Tests on hardened concrete as per IS codes, Relationship between different strengths, factors influencing strength, NDE Techniques.
Durability: Factors influencing durability – Chemical effects on concrete- Carbonation,Sulphate attack, Chloride attack.
Concrete Mix design: Different methods of mix design – factors affecting mix design –exercises.
Special concrete: Heavy density concrete, underwater concrete, self-compacting concrete,light weight concrete,UHPC, etc.

Learning Resources:

Text Books:

1. AM Nevelli, Properties of Concrete, Prentice Hall Publishers, 2012, 5th Edition.
2. M. S. Shetty and A. K. Jain, Concrete Technology: Theory And Practice,S Chand Co., Publishers, 2018.

Reference Books:

1. J. J. Brooks and A. M. Neville, Concrete Technology, Pearson, 2019, 2nd Edition.
2. A. R. Santhakumar, Concrete Technology, Oxford Higher education, 2018

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/102/105102012/

CE1323 **3-0-0 (3)**

Ground Water Development

Pre-Requisites: None

Course Outcomes:

CO-1	Evaluate groundwater resources using geophysical methods
CO-2	Estimate aquifer parameters
CO-3	Model regional groundwater flow
CO-4	Design water wells
CO-5	Identify sites for artificial recharge of groundwater

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	1	3	2	1	1	–	–	–	–	1	3	–	1	1
CO-2	3	2	1	3	2	1	1	–	–	–	–	1	3	–	1	1
CO-3	3	3	3	3	2	1	1	–	–	–	–	1	1	–	3	2
CO-4	3	2	3	2	2	1	1	–	–	–	–	1	1	–	3	
CO-5	3	2	2	3	2	1	2	–	–	–	–	1	1	–	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Groundwater resources of India, Regional Groundwater balance, Distribution of subsurface water, Occurrence of groundwater in hydrogeological formations.

Rock properties affecting groundwater: Aquifers, Geologic formations of Aquifers, Types of aquifers, estimation of aquifer parameters by different methods, Porosity and representative volume, specific surface, storage coefficient.

Geophysical exploration studies: electrical resistivity method, seismic refraction method, Gravity and Magnetic methods, Test Drilling, Determination of Aquifer thickness.

Groundwater movement: Darcy's law, Permeability, Conductivity and Transmissivity, Determination of in-situ hydraulic conductivity, Anisotropic Aquifers, Groundwater flow rates and directions, General flow equations, Unsaturated flow.

Steady State well hydraulics: Steady unidirectional flow, Steady radial flow to a well, Yield from a well under steady state conditions.

Unsteady flow in confined and unconfined aquifers: well losses and specific capacity, Pumping tests.

Water well design: Well construction and maintenance procedures, Testing wells for yield, Characteristics of well losses.

Artificial recharge: Concept, Artificial recharge methods.

Learning Resources:

Text Books:

1. Todd D.K., and Mays L.W., Groundwater hydrology, John Wiley & sons, 2011 3rd Edition
2. Rastogi A.K., Numerical Groundwater Hydrology, Penram International Publishing Pvt. Ltd., 2012

Reference Books:

1. Karamouz M., Ahmedi A., Akhbari M., Groundwater Hydrology: engineering, planning, and management, CRC Press, 2011 2nd edition
2. Raghunath H.M., Groundwater, New Age International Publications, 2002.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/103/105103026

CE1325 **3-0-0 (3)**

Industrial Wastewater Treatment

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify the characteristics of industrial wastewaters
CO-2	Describe pollution effects of disposal of industrial effluent
CO-3	Identify and design treatment options for industrial wastewater
CO-4	Design system or process for various industries to meet desired standards

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	–	–	3	–	–	–	–	1	–	–	–	–
CO-2	3	3	3	–	1	1	3	–	–	1	–	1	–	–	–	1
CO-3	3	3	3	3	–	–	3	2	1	–	2	1	–	1	3	–
CO-4	3	3	3	–	–	–	3	2	1	–	2	1	–	1	3	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Composition of an industrial effluent: Difference between Domestic and Industrial Wastewater, Measurement of Polluting parameters and their effects on water bodies, Current legislation.General standards for discharge of environmental pollutants, industry-based wastewater generation standards.

Pre and Primary treatment for industrial wastewater: Treatment – Equalization, Proportioning, Neutralization, Oil Separation by Floatation – Waste Reduction – Volume Reduction - Strength Reduction

Control and removal of specific pollutants in industrial wastewaters: Unit processes and operations to remove oil and grease, cyanide, fluoride, toxic organics, heavy metals, radioactivity substances, some advanced technologies for removal of toxic contaminants from industrial wastewater.

Treatment of specific Industrial wastewater: Dairy, Pulp and Paper, Tanneries, Textiles, and Pharmaceuticals.

Learning Resources:

Text Books:

1. Metcalf & Eddy, Wastewater Engineering Treatment and Reuse, McGraw Hill Education, 2017, 4th Edition
2. W' Wesley Eckenfelder, Industrial Waste Water Pollution Control by – McGraw-Hill

Reference Books:

1. Rao, M.N., and Dutta, A.K., Wastewater Treatment, IBH Publ., 1995
2. WEF Manual of practice No. FD-3, Industrial Wastewater Management, Treatment and Disposal, 3rd Ed., WEF Press and McGraw Hill, 2008

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/106/105106119/
2. http://nptelvideos.com/video.php?id=1118

CE1327 **3-0-0 (3)**

Remote Sensing

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the energy interaction with atmosphere and earth surface features
CO-2	Identify the earth surface features and prepare the thematic maps
CO-3	Select the type of remote sensing technique / data for required application
CO-4	Apply the remote sensing principles in civil engineering practice

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	–	–	2	–	–	–	2	–	–	2	–	–	–	–
CO-2	2	1	1	3	2	2	2	1	1	3	2	2	–	–	–	–
CO-3	–	1	1	2	2	–	2	2	2	2	2	2	–	–	–	–
CO-4	–	2	3	3	2	3	3	3	2	3	3	2	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Physics of Remote Sensing: Sources of Energy, Active and Passive Radiation, Stages of Remote Sensing, Advantages of Remote Sensing over conventional surveying methods.

Electromagnetic Spectrum: Wavelength regions important to remote sensing, Reflectance, Transmission, Absorption, Thermal Emissions, Interaction with Atmosphere, Atmospheric windows, Spectral reflectance of Earth's surface features, Multi concept of Remote Sensing.

Platforms and Sensors: Types of platforms, orbit types, Sun-synchronous and Geosynchronous, Passive and Active sensors, resolution concept.

Earth resources and meteorological satellites: Characteristics - LANDSAT, SPOT, IRS, IKONOS, QUICK BIRD, CARTOSAT, INSAT and other Satellites.

Image interpretation: Data Products and Their Characteristics, Basic Elements of Visual Interpretation (Image and Terrain), Equipment for Visual Interpretation, Ground Truth, Ground Truth Equipment. **Image Processing**: Digital Image Processing – Pre-processing – image enhancement techniques – multispectral image classification – Supervised and unsupervised.

Applications: Geosciences, Water Resources, Land use – Land cover, Transportation Engineering.

Learning Resources:

Text Books:

1. James B. Campbell & Randolph H. Wynne., Introduction to Remote Sensing, The Guilford Press, 2011.
2. Charles Elach & Jakob van Zyl., Introduction to the physics and techniques of Remote Sensing, John Wiley & Sons publications, 2006.

Reference Books:

1. Lille's and T.M & Kiefer R.W., Remote Sensing and Image Interpretation, John Wiely and Sons, 2015

CE1329 **3-0-0 (3)**

Construction Geotechniques

Pre-Requisites: **CE1208**

Course Outcomes:

CO-1	Comprehend the advanced construction methods in geotechnical engineering.
CO-2	Apply the current piling methods / techniques for specific works
CO-3	Apply different construction techniques in deep excavation for Engineering works
CO-4	Comprehend the application of diaphragm walls for Engineering works
CO-5	Comprehend and apply suitable tunnel driving /excavation method for specific ground conditions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	2	-	2	2	1	-	2	2	3	2	3	-	3
CO-2	1	2	2	3	-	2	2	2	-	2	2	3	2	-	2	2
CO-3	1	2	2	2	2	2	-	1	-	2	2	2	-	-	2	-
CO-4	1	2	2	3	2	1	-	1	-	2	2	2	-	-	1	-
CO-5	1	2	-	2	2	2	-	1	2	2	3	2	2	1	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Deep Excavation Techniques: Need for deep excavations, susceptibilities of deep excavations-oozing of water, caving of sides; supporting techniques- bracing and sheet pile walls, piling, secant piling, nailing, coffer dams.

Special Piling Techniques: Special piling applications, construction techniques for Special cased concrete piles and uncased concrete piles, screw piles, micro-piles.

Drilled Piers: Applications of drilled piers, Construction techniques of drilled piers: Chicago method, Gow method, dry method, casing method and slurry method, potential construction problems.

Diaphragm walls: Applications of diaphragm walls, Construction of deep diaphragm walls of rigid and flexible type, secant pile walls.

Shafts and Tunnels: Applications of shafts and tunnels, types, excavation techniques in soils- cut and cover method, bored tunnel method, clay kicking method, shaft method, pipe jacking method, box jacking method; Under water tunnels; excavation methods in rock- full face method, top heading and benching method, pilot tunnel method, spiral drilling and blasting method and TBM.

Learning Resources:

Text Books:

1. Nainan P. Kurian, Introduction to Modern Techniques in Geotechnical Engineering, 2019, Alpha Science, 1st Edition.
2. R.M. Koerner, Construction and Geotechnical Methods in Foundation Engineering, , 1984, 1st Edition.

Reference Books:

1. Gopal Ranjan and A.S.R. Rao, Basic and Applied Soil Mechanics, New Age Int. Publishers, 2019, 3rd Edition.
2. V.N.S. Murthy, Geotechnical Engineering, CBS Publishers, 2018, 1st Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/103/105103206/

Professional Elective-2

CE1322 **3-0-0 (3)**

Prestressed Concrete

Pre-Requisites: **None**

Course Outcomes:

CO1	Apply the concepts of pre-stressing in concrete structures & identify the prestress-able material
CO2	Analyse pre-stressed concrete sections
CO3	Estimate losses of pre-stressing
CO4	Design pre-tensioned and post tensioned girders for flexure and shear
CO5	Design continuous pre-tensioned and post tensioned beams

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	-	-	-	1	-	1	-	-	1	-	-	2	1	-
CO2	-	3	1	-	-	1	-	1	-	-	1	-	-	-	3	1
CO3	1	2	3	-	-	1	-	1	-	-	1	-	-	-	2	-
CO4	-	1	3	2	-	1	-	1	-	-	1	-	-	-	3	-
CO5	-	-	2	3	-	1	-	1	-	-	1	-	-	-	3	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Fundamentals of prestressing - Classification and types of prestressing- Concrete Strength and strain characteristics - Steel mechanical properties - Auxiliary Materials like duct formers.
Prestressing Systems: Principles of pre-tensioning and post tensioning - study of common systems of prestressing for wires strands and bars.
Losses of Prestress: Losses of prestress in pre tensioned and post tensioned members -I.S. code provisions.
Analysis of Sections: In flexure, simple sections in flexure, kern distance - cable profile - limiting zones - composite sections cracking moment of rectangular sections.
Design of Simply Supported Beams: Allowable stress as per I.S. 1343 - elastic design of rectangular and I-sections.
Shear and Bond: Shear and bond is prestressed concrete beams - conventional design of shear reinforcement - Ultimate shear strength of a section - Prestress transfer in pretensioned beams-Principles of end block design.

Learning Resources:

Text Books:

1. Krishna Raju. N, Prestressed Concrete, Tata Mc Graw Hill, 2018, 6th Edition.
2. Lin.T.Y and Ned H. Burns, Design of Prestressed concrete, Mc Graw Hill Pub. Co., 2010

Reference Books:

1. Edward G. Nawy P.E., Prestressed Concrete: A Fundamental Approach, 1999
2. P. Dayaratnam, P Sarah, Prestressed Concrete Structures, 2017, 6th Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/106/105106117/

CE1324 **3-0-0 (3)**

Geosynthetic Applications

Pre-Requisites: **None**

Course Outcomes:

CO-1	Select suitable geosynthetic material for the intended purpose
CO-2	Evaluate the properties of geosynthetics
CO-3	Design the Geosynthetics for Engineering works
CO-4	Design and apply Geocomposite systems to solve contemporary Geotechnical problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	2	-	2	2	1	-	2	2	3	2	3	-	3
CO-2	1	2	2	3	-	2	2	2	-	2	2	3	2	-	2	2
CO-3	1	2	2	2	2	2	-	1	-	2	2	2	-	-	2	-
CO-4	1	2	2	3	2	1	-	1	-	2	2	2	-	-	1	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: An overview on the development, functions and applications of various geosynthetics - the geotextiles, geogrids, geonets, geomembranes, geocomposites and other products.

Designing with geotextiles: Manufacture of geotextiles, Geotextile properties and test methods – functions - Designing geotextiles for separation, reinforcement, stabilization, filtration and drainage works.

Designing with geogrids: Manufacture of geogrids, Types of geogrids, Geogrid properties and test methods – physical properties, mechanical properties, endurance properties and environmental properties – Designing geogrid for reinforcement in pavements, retaining walls and bearing capacity. New generation polymeric strap reinforcing materials.

Designing with geonets: Manufacture of geonets, Geonet properties and test methods – Physical properties, mechanical properties, hydraulic properties, endurance properties and environmental properties -Designing geonet for drainage applications.

Designing with geomembranes: Geomembrane properties and test methods – physical properties, mechanical properties, chemical properties and biological hazard - Applications of geomembranes and design.

Designing with geocomposites: Geocomposites in seperation, reinforcement – reinforced geotextile composites – reinforced geomembrane composites – reinforced soil composites using discontinuous fibres and meshes, continuous fibres and three –dimensional cells -Designing for bearing capacity, geocomposites in drainage and filtration.

Learning Resources:

Text Books:

1. Sanjay Kumar Shukla and Jian-Hua Yin., Fundamentals of Geosynthetics Engineering, CRC Press, 2017, 1st edition.
2. Koerner, R.M., Designing with geosynthetics, Pearson Education Inc., 2012, 6th edition

Reference Books:

1. Mandal, J.N., Geosynthetics Engineering: in Theory and Practice, Research Publishing, Singapore, 2018, 1st edition.
2. Swami Saran, I.K. Reinforced Soil and its Engineering Applications, International Publishing House Pvt. Ltd., 2019, 1st edition.
3. Rao, G.V. and Goutam K. Pothal " Geosynthetics Testing – A laboratory Manual" Sai Master Geoenvironmental Services Pvt. Ltd. Hyderabad, 2008.
4. Rao, G.V. – "Geosynthetics – an Introduction", Sai Master Geoenvironmental Services Pvt. Ltd. Hyderabad, 2011.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/101/105101143/
2. https://freevideolectures.com › course › 3352 › geosynthetics

CE1326 **3-0-0 (3)**

Travel Demand Analysis

Pre-Requisites: None

Course Outcomes:

CO-1	Develop a basic knowledge of urban transportation planning and urban transportation issues.
CO-2	Assess the data required for travel demand estimation.
CO-3	Analyse and estimate urban travel demand.
CO-4	Develop transportation network and apply traffic assignment.
CO-5	Analyse and estimate regional travel demand.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	1	-	-	-	-	-	-	-	-	1	1	-	1	-
CO-2	3	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO-3	3	3	2	2	1	-	1	-	-	-	-	1	-	-	2	1
CO-4	3	3	3	1	-	-	-	-	-	-	-	1	-	-	1	1
CO-5	3	1	1	-	-	-	-	-	-	-	-	1	1	-	1	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Urban Transportation Planning and Issues: Urbanization, urban class groups, transportation problems and identification, impacts of transportation, urban transport system planning process; transportation problems and issues in urban areas; travel characteristics; issues related to regional transportation planning, methods of delineation regions; policies for urban and regional transportation; types of transit systems, public, private, para-transit transport, mass and rapid transit systems, BRTS and Metro rails, capacity, merits and comparison of systems; social equity; coordination, types of coordination

Travel Demand and Data Collection: Basic Concepts in Transportation Planning; accessibility and mobility; scale and context; demand function; travel attributes; assumptions in demand estimation; sequential, and simultaneous approaches; aggregate and disaggregate techniques; Collection of data – organization of surveys and analysis; study area, zoning, screen lines; types and sources of data - road side interviews; home interview surveys; stated and revealed data-collection; commercial vehicle surveys, sampling techniques, expansion factors; accuracy checks, use of secondary sources; economic data: income, population, employment, vehicle owner ship; trends in passenger travel and goods in urban area.

Trip Generation Analysis: Zonal models, category analysis, household models, trip attraction models, commercial trip rates.

Trip Distribution: Growth factor methods, gravity models, opportunity models, time function iteration models.

Mode Choice Analysis: Logit model derivation and application; random utility modeling; maximum likelihood estimation; selecting models and model fit; Mode choice behaviour, competing modes, mode split curves, models and probabilistic approaches.

Traffic Assignment: Basic elements of transport networks, coding, route properties, path building criteria, skimming tree, network representation and analysis: minimum path finding and equilibrium assignment. All-or-Nothing assignment, capacity restraint techniques, reallocation of assigned volumes, Equilibrium Assignment.

Regional Travel Demand Estimation: Factors affecting goods and passenger flows, use of aggregate direct demand model to estimate freight and passenger demand, IVF models.

Learning Resources:

Text Books:

1. Traffic Engineering And Transport Planning, Kadiyali, L.R., Khanna Publishers, 2018, Ninth Edition.
2. Transportation Engineering, Khisty, C.J., and Lall, B.K., Pearson, 2017, Third Edition.

Reference Books:

1. Transportation Planning: Principles, Practices and Policies, Sarkar, P.K., Maitri, V., Joshi, G.J., PHI Learning, 2017, Second Edition.
2. Urban Transport: Planning and Management, Jain A.K., APH Publishing Corporation, 2008.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/107/105107067/
2. https://dspace.mit.edu/bitstream/handle/1721.1/107706/11-540j-fall-2006/contents/lecture-notes/index.htm

CE1328 **3-0-0 (3)**

Systems Analysis in Civil Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Formulate and solve deterministic optimization models
CO-2	Apply deterministic optimization techniques for resource allocation, scheduling, inventory control, capacity expansion and transportation problems
CO-3	Apply decision theory and stochastic optimization techniques for decision making under uncertainty
CO-4	Formulate and solve optimization models for planning and design of civil engineering systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	3	1	–	1	–	–	–	1	1	1	–	2	–
CO-2	3	3	3	3	2	–	1	–	–	–	1	1	1	–	3	–
CO-3	3	3	3	3	2	–	1	–	–	–	1	1	1	–	3	2
CO-4	3	3	3	3	3	–	1	–	–	–	1	1	1	–	3	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Modeling Techniques: Concepts of Systems Engineering, Types of mathematical models, Formulation of a prescriptive model, Overview of optimization techniques.

Linear Programming: Graphical method, Simplex method, Sensitivity analysis, Dual LP, Transportation problem, Assignment problem, Integer Linear Programming.

Dynamic Programming: Concepts of dynamic programming, Formulation of recursive equation, Resource allocation using DP, Capacity expansion, Inventory control.

Nonlinear Optimization: Classical optimization techniques, Lagrange methods, Kuhn-Tucker conditions, steepest gradient technique and other gradient based search techniques, Overview of genetic algorithm.

Decision Theory: Decision analysis, Decision making under risk and uncertainty, Markovian decision process, stochastic inventory control.

Simulation: Types of simulation models, Monte-Carlo simulation, Applications of simulation. Overview of Multi Objective Optimization Techniques.

Learning Resources:

Text Books:

1. Revelle C.S., Whitlatch E.E. and Wright J.R., Civil and Environmental Systems Engineering, Pearson Education Inc., New Jersey, 2004
2. Dahe P. D., Operations Research – A Systems Engineering Approach, CENGAGE India, 2019.

Reference Books:

1. Hillier F.S. and Lieberman G.J., Introduction to Operations Research, McGraw Hill Education, 2017
2. Taha H.A., Operations Research – An Introduction, Pearson Education, 2019
3. https://nptel.ac.in/courses/105/108/105108081/

CE1330 **3-0-0 (3)**

GIS for Civil Engineering Applications

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze geospatial data for solving problems of natural and anthropogenic systems
CO-2	Preparation of geospatial features in computing environment
CO-3	Create GIS and cartographic outputs for presentation
CO-4	Apply the geospatial skills in implementing a GIS Project

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	–	–	2	2	2	–	1	1	–	1	3	–	2	1
CO-2	3	2	2	1	3	2	2	–	1	1	1	1	3	–	2	2
CO-3	2	1	3	2	3	2	2	–	2	3	2	2	2	–	2	2
CO-4	3	2	3	2	3	3	3	3	3	3	3	3	2	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: GIS definition, development, application areas.

Map Concept: Map-Definition, Elements of Maps, Types of maps, Advantages and disadvantages of analog/digital maps, Coordinate Systems- Geometric models of earth, Global/Local coordinate system, Projection Systems- Classification, Cylindrical projection, Conical projection, Selection of a particular projection.

Fundamental concepts of GIS: Modeling Real World Features- Raster data model, vector data model, Data Formats- Spatial and Non-Spatial data.

Database preparation and editing: Data collection and Input, Data conversion, Hardware & software Requirements, Topology – Editing and Error Rectification, Types of topology, Topological Relationships.

Spatial Analysis: Buffer Analysis-Variations in Buffering, Applications of buffering, Overlay Analysis-Feature type and overlay, Vector Overlay methods, Network Analysis-Impedance, Shortest path analysis, closest facility, Concepts of Proximity analysis, Neighborhood operations, DEM and TIN.

GIS Project Planning: Steps in GIS project, Problem Identification and Implementation of a GIS project.

GIS Applications: Transportation, Water Resources, Environment, Geology, Emergency Management, Agriculture, Urban planning, climate change, Business.

Advances in GIS: Concepts and application of open source Mobile and Web GIS.

Learning Resources:

Text Books:

1. C.P. Lo, Albert K. W. Yeung, Concepts and Techniques of Geographic Information Systems, Prentice Hall India Pvt. Ltd, New Delhi, 2016.
2. Kang-Tsung Chang, Introduction to Geographic Information Systems, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2015.
3. Peter A. Burrough and Rachael A. McDonnell, Principles of Geographical Information Systems, Oxford University Press, 2016.

Professional Elective-3

CE1332 **3-0-0 (3)**

Foundation Analysis and Design

Pre-Requisites: None

Course Outcomes:

CO-1	Identify the behaviour of problematic soils
CO-2	Design various types of foundations
CO-3	Estimate the compressive, uplift and lateral capacities of piles
CO-4	Analyze the lateral stability of well foundations
CO-5	Evaluate design parameters for dynamic loading

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	2	-	2	2	1	-	2	2	3	2	3	-	3
CO-2	1	2	2	3	-	2	2	2	-	2	2	3	2	-	2	2
CO-3	1	2	2	2	2	2	-	1	-	2	2	2	-	-	2	-
CO-4	1	2	2	3	2	1	-	1	-	2	2	2	-	-	1	-
CO-5	1	2	-	2	2	2	-	1	2	2	3	2	2	1	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Problematic soils: Different types of problematic soils – Soft Clays, Loose Sands, Expansive soils, Erodible soils and Collapsible soils, Identification, categorization and problems associated with these soils, Geotechnical remedies for rectification of damage potential of these soils.

Expansive soils: Identification and characteristics of Expansive soils, Free swell index and swell potential, Swell pressure – Factors –Test, Effect of swelling on building foundations, Fundamental design in expansive soil – CNS layer, Under reamed pile and other concepts, Problems.

Shallow foundations: Individual footings, Combined Footings and Mat/Raft foundations - Computation of loads – Design steps – Proportioning of footings, Bearing capacity and settlements of foundations, Types of rafts – Conventional methods of design (Rigid beam analysis), Beams on Elastic foundations, Problems.

Pile foundations: Pile behavior under axial loads (piles under compression) – Review uplift capacity / resistance of piles (piles under tension), Lateral load capacity/ Resistance of piles, Winkler's hypothesis – Differential equations, Brom's solution for laterally loaded vertical piles in sand and clay, IS Code method, Problems.

Well foundations: Introduction – types and shapes of Caissons – Grip length, Estimation of bearing capacity and settlement of well foundation, Design of various elements/components of well foundation, Forces acting on well foundation, Lateral stability of well foundations by IRC method, Problems.

Soil Dynamics and Machine foundations: Introduction, Fundamentals of vibration and soil dynamics, Types of Machines and Foundations, General requirements, Foundations of Reciprocating and Impact Machines, Vibration isolation and screening - Introduction, force isolation, motion isolation, screening of vibrations by use of open trenches, passive screening by use of pile barriers, problems.

Learning Resources:

Text Books:

1. Murthy V.N.S, Soil Mechanics and Foundation Engineering - CBS publications, 2018.
2. Gopal Ranjan, Rao ASR, Basic and applied soil mechanics – New age publication, Delhi, 2000.

Reference Books:

1. Das, BM, Geotechnical engineering – Cengage learning, New Delhi, 2009.
2. Srinivasulu, P. And Vaidyanathan, C. V, Handbook of Machine Foundations, Tata McGraw-Hill, New Delhi, 2017
3. Prakash Shamsher and Puri Vijay K, “Foundations for Machines, Analysis and Design” John Wiley and Sons, USA, 1988.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/104/105104162/

CE1334 **3-0-0 (3)**

Highway Construction

Pre-Requisites: CE1307

Course Outcomes:

CO-1	Select appropriate pavement construction equipment depending on the requirement.
CO-2	Develop construction procedures for subgrade, unbound, and bound granular layers.
CO-3	Formulate strategies to produce optimal bituminous mixes
CO-4	Prepare quality assurance and quality control plans to construct better-performing pavements.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	1	2	1	2	-	-	-	-	-	-	-	2	2	1	1
CO-2	2	2	2	2	2	-	-	-	-	-	-	-	1	1	2	-
CO-3	1	2	2	2	1	-	-	-	-	-	-	-	2	-	2	-
CO-4	2	1	1	1	3	-	-	-	-	-	-	-	2	2	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Highway Construction and Management: pre-construction activities; field inspection, different pavement construction equipment, applications and safety aspects of earth-moving equipment, compaction equipment, road-making equipment, concreting equipment, and paving equipment.

Construction of Subgrade: earthwork grading; compaction and construction of embankments and subgrade; types of subgrade material and strength gain; subgrade stabilization construction operation; construction involving geosynthetic application in subgrade and embankment; quality control checks for embankment and subgrade construction.

Construction of Unbound and Bound Granular Layers: gradation and material quality requirement for granular subbase and base layers, blending and proportioning, compaction requirements; field quality control; stabilized subbase and base layers: mix design, placing, laying and compaction requirements; crack relief and SAMI layer; construction of subsurface drainage for highways and airfield pavements.

Paving and Construction of Asphalt Layers: general guidelines requirements, new construction/overlay, prime coat, tack coats: recommended applications, distribution, verifying the application rates; asphalt pavers and compaction; joints; compaction mechanics; cold weather paving; roller types; sequence of rolling: breakdown, intermediate and finishing; quality assurance: quality control tests.

Construction of Concrete Pavements: Concrete production; preparation of subgrade and base; reinforcement presetting for JPCP and CRCP; PCC slab constructions: slip form paving, fixed form paving; curing process; quantification of curing effectiveness; quality control tests.

Learning Resources:

Text Books:

1. Kandhal, P.S., Bituminous Road Construction in India, PHI Learning Pvt. Ltd, 2016, First Edition.
2. Specifications for Road and Bridge Works, Ministry of Road Transport and Highways, Indian Roads Congress, New Delhi, India, 2013, Fifth Edition.

Reference Books:

1. Norbert, J.D., Concrete Pavement Design, Construction and Performance, CRC Press, 2014, Second Edition.
2. Construction of Quality Asphalt Pavements, MS-22, Asphalt Institute, 2020, Third Edition.

Other Suggested Readings:

1. https://pavementinteractive.org/reference-desk/construction/site-preparation/subgrade-preparation-for-new-pavements/
2. https://www.virginiadot.org/vtrc/main/online_reports/pdf/15-r6.pdf

CE1336 **3-0-0 (3)**

Municipal solid waste management

Pre-Requisites: **None**

Course Outcomes:

CO-1	Appreciating the fundamentals of solid waste
CO-2	Analyze solid waste generation and collection
CO-3	Explore Waste recovery and treatment technologies
CO-4	Apply principles of recycling and circular economy
CO-5	Demonstrate critical thinking through case studies

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	3	2	3	3	3	2	2	2	3	–	–	3	1
CO-2	3	3	2	3	2	3	3	3	2	2	2	3	–	1	3	1
CO-3	3	3	3	3	3	3	3	3	3	2	2	3	–	1	3	1
CO-4	3	3	3	3	3	3	3	3	3	2	2	3	–	1	3	1
CO-5	2	3	2	3	2	3	3	3	2	2	2	3	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Evolution, Sources, Composition, and Properties of Solid Waste: Introduction to solid waste; Functional elements; Sources, types, and composition of MSW; Physical, chemical and biological properties of MSW.

Waste Generation, Handling, Collection and Transport: Solid waste generation and collection rates; Waste handling and separation, storage and processing at the source; Collection of solid waste; Transfer and Transport.

Waste Processing, Recovery and Disposal: Materials-recovery Facilities; Material separation and processing techniques; Thermal conversion technologies; Biological and chemical conversion technologies; Disposal of solid waste and residual matter.

Recycling, Minimization and Circular Economy: Principles and benefits of recycling; Circular economy principles in waste management; Emerging trends in SWM technologies.

Case studies: Landfill, Composting, Anaerobic digestion etc

Learning Resources:

Text Books:

1. Tchobanoglous G, Theisen H and Vigil SA, Integrated Solid Waste Management, Engineering Principles and Management Issues, McGraw Hill Education, 2014, Indian Edition.
2. John Pichtel,Waste Management Practices: Municipal, Hazardous and Industrial, CRC Press, 2014, 2nd Edition

Reference Books:

1. Vesilind PA, Worrell W and Reinhart D,Solid Waste Engineering, Brooks/Cole Thomson Learning Inc., 2010, 2nd Edition
2. Peavy, H.S., Rowe, D.R., and Tchobanoglous G.,Environmental Engineering, McGraw Hill Education, 2017 First Indian Edition

Other Suggested Readings:

1. NPTEL: Municipal Solid Waste Management, IIT Guwahati

2.http://cpheeo.gov.in/cms/manual-on-municipal-solid-waste-management-2016.php

CE1338 **3-0-0 (3)**

Watershed Management

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify the causes of soil erosion
CO-2	Plan and design soil conservation measures in a watershed
CO-3	Plan and design water harvesting and groundwater recharging structures.
CO-4	Plan measures for reclamation of saline soils

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	1	1	1	1	–	–	–	–	1	2	–	3	-
CO-2	3	2	3	1	1	1	1	–	–	–	–	1	2	–	3	-
CO-3	3	2	3	1	1	1	2	–	–	–	–	1	2	–	3	2
CO-4	3	2	3	1	1	1	2	–	–	–	–	1	1	–	3	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Concept of watershed, need for watershed management, concept of sustainable development, Hydrology of small watersheds.

Principles of soil erosion: causes of soil erosion, types of soil erosion, estimation of soil erosion from small watersheds, Control of soil erosion, methods of soil conservation – structural and non-structural measures.

Principles of water harvesting: methods of rainwater harvesting, design of rainwater harvesting structures.

Artificial recharge of groundwater in small watersheds: methods of artificial recharge.

Reclamation of saline soils: Micro farming, biomass management on the farm.

Learning Resources:

Text Books:

1. Murthy J.V.S., Watershed Management, New Age International Publishers, 2017 2nd Edition
2. Murthy V.V.N., and Jha M.K., Land and Water Management, Kalyani Publishers, 2013, 6th Edition

Reference Books:

1. Suresh R., Soil and Water Conservation Engineering, Standard Publishers, 1998
2. Chatterjee S.N., Water Resources Conservation and Management, Atlantic Publishers, 2008

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/101/105101010/
2. http://ecoursesonline.iasri.res.in/course/view.php?id=542

CE1340 **3-0-0 (3)**

Applied Stress Analysis

Pre-Requisites: CE1205

Course Outcomes:

CO-1	Comprehend the basic concepts of elastic theory to determine stresses and strains
CO-2	Model and analyse homogenous and isotropic plane elastic problems
CO-3	Formulate the stress analysis problems using elasticity theory
CO-4	Apply experimental techniques to solve field problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	-	-	2	-	-	-	1	-	2	-	1	-	2	1	-
CO-2	2	-	-	2	-	-	-	1	-	2	-	2	-	2	1	-
CO-3	2	2	-	2	-	-	-	1	1	1	-	1	-	2	1	1
CO-4	2	3	-	1	-	-	-	1	2	2	-	2	-	1	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Continuum Mechanics: Assumptions made in elasticity theory, Necessary and sufficient conditions for analyzing a structure, Specification of stress at a point, Specification of stress at a point- Determination of normal thrust and shear stress

Concept of Orthogonal Transformation of axes: Determination of Stress invariants, Determination of principal stresses and planes, Determination of maximum shear stresses and their corresponding planes, Tresca's criteria.
Derivation of Equilibrium conditions in three dimensions: Concept of Strain at a point, Determination of Normal and Shear Strain, Generalized Hooke's Law, Interrelationship between stresses and Strains in three dimensions, Formulation of a plane stress problem.

Derivation of Airy's Stress function: Boundary conditions, equilibrium equations, compatibility conditions, solution to stress analysis problems based on direct, inverse and semi-inverse methods

Introduction to Experimental stress analysis: Strain measurement- Types of strain gauges, Characteristics of ideal strain gauges, gauge factor, Strain gauge Rosettes, Introduction to two dimensional photo elasticity, Stress-Optic law.

Learning Resources:

Text Books:

1. S. Timoshenko and J N Goodier, Theory of Elasticity, McGraw Hill Education; 2017, 3rd Edition.
2. T.G.Sitharam, L.Govinda Raju, Theory of Elasticity, Springer, 2021.

Reference Books:

1. A.E.H.Love, A Treatise on the Mathematic Theory of Elasticity, Cambridge University Press, 2013.
2. Applied Elasticity, Matrix and Tensor Analysis of Elastic Continuum, Horwood Publishing Limited, 2005.
3. N.Krishna Raju, Advanced Mechanics of Solids and Structures, Mc Graw Hill Education(India) Pvt Ltd, 2018.
4. https://onlinecourses.nptel.ac.in/noc21_ce45/

Professional Elective-4

CE1421 **3-0-0 (3)**

Advanced Reinforced Concrete Design

Pre-requisites: CE1305

Course Outcomes:

CO1	Design cantilever and counterfort retaining walls
CO2	Design underground and elevated water tanks
CO3	Design bunkers and silos
CO4	Design reinforced concrete chimneys

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	-	2	-	-	1	1	-	-	1	-	-	-	2	-
CO2	2	2	-	2	-	-	1	1	-	-	1	-	-	-	2	-
CO3	1	2	1	2	-	-	-	1	-	-	1	-	-	-	2	-
CO4	-	2	1	-	-	-	1	1	-	-	1	-	-	-	2	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Principles of Cantilever and Counterfort type retaining walls,
2. Detailed design of cantilever type of retaining walls,
3. Detailed Design of Grid Floors, Analysis and Design of Flat Slabs,
4. Design principles of underground and elevated water tanks,
5. Detailed design of rectangular and circular elevated water tanks as per IS 3370
6. Detailed Design of Intz Tanks,
7. R.C. Bunkers and Chimneys.

Learning Resources:

Text Books:

1. Advanced Reinforced Concrete Design, N. Krishna Raju, CBS Publishers,2016, 3rd Edition.
2. RCC Designs (Reinforced Concrete Design), Punmia B.C. Ashok Kumar Jain and Arun K. Jain, Lakshmi Publishers, 2006, 10th Edition.

Reference Books:

1. Advanced Reinforced Concrete Design, Varghese, PHI pub., 2005, 2nd Edition.
2. Advanced R.C.C Design (R C C Vol. 2), S.S. Bhavikatti, New Age International Pub., 2016, 3rd Edition.

Online Resources:

1. https://www.youtube.com/watch?v=BNZp9121cms

CE1423 **3-0-0 (3)**

Geological Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Classify weathering processes and mass movement
CO-2	Identify geological formations and structures for rock mass quality assessment
CO-3	Identify subsurface information and groundwater potential sites through geophysical investigations
CO-4	Apply geological principles for mitigation of natural hazards and select sites for dams and tunnels

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2
CO-2	1	2	-	2	-	-	2	-	2	2	2	2	3	3	2	2
CO-3	2	2	3	3	3	2	2	2	2	2	3	3	2	2	3	3
CO-4	2	2	2	2	3	2	2	1	3	2	3	2	2	2	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Ground Geology: Branches and scope of geology, Importance of geology in Civil engineering. Earth-surface features and internal structure, weathering of rocks.

Minerology: Minerals, physical properties, identification of important rock forming and economic minerals.

Petrology: Formation and classification of rocks – Igneous, Sedimentary and metamorphic rocks, their textures and structures. Drilling Techniques, Core Recovery, RQD, Engineering Properties of Rocks

Structural Geology: Geological Map, outcrop, attitude of beds, types and classifications of folds, faults, joints, unconformities.

Ground Water: Subsurface distribution of ground water, water table, aquifers, occurrence of ground water in different geological formations, springs, ground water exploration.

Earthquakes and Landslides: Causes and effects of earthquakes and landslides, Remedial measures to prevent damage for engineering structures.

Subsurface Investigations: Soil Profile, Geophysical methods – Electrical Resistivity and Seismic refraction methods.

Dams: Types of dams, Requirements of dam sites, preliminary and detailed geological investigations for a dam site. Factors affecting the seepage and leakage of reservoir and the remedial measures.

Tunnels: Purpose of tunneling, geological considerations for tunneling, geothermal step, over break, stand up time, and logging of tunnels.

Learning Resources:

Text Books:

1. N. Chenna Kesavulu, Text Book of Engineering Geology, Mac Millan Ltd., New Delhi. 2018
2. D Venkat Reddy, Engineering Geology, Vikas Publishing House Pvt. Ltd., 2017

Reference Books:

1. Parbin singh, Engineering and General Geology –Katson Publishers. 2013

2. K.V.G.K. Gokhale, Principles of Engineering Geology –BS Publications, Hyderabad, 2006.
3. D.P. Krynine, W.R. Judd, Principles of Engineering Geology and Geotechnics –2018

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/105/105105106/

CE1425 **3-0-0 (3)**

Traffic Engineering Design

Pre-Requisites: **CE1307**

Course Outcomes:

CO-1	Conduct traffic flow studies and determine basic characteristics of traffic stream
CO-2	Collect and analyze the traffic flow data and estimate capacity and LOS
CO-3	Design geometric elements of traffic flow facility
CO-4	Analyze and design un-signalized and signalized intersections

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	-	-	2	-	1	-	-	-	-	1	-	-	1	1
CO-2	3	3	-	2	2	1	1	-	-	-	-	1	1	-	3	1
CO-3	3	3	3	2	3	1	1	-	-	-	-	1	-	-	3	-
CO-4	3	3	3	3	2	2	2	-	-	-	-	1	1	-	3	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Traffic System Characteristics: Human-vehicle-environment system, Fundamental parameters of traffic and relationships; Microscopic and macroscopic characteristics; Single and Multi-regime models.

Traffic Data Collection: Types of data; Volume studies; Speed studies; Travel time and delay studies; Intersection studies, Pedestrian studies; Parking studies, Vehicle detection methods; Advanced methods: GPS, Instrumented Vehicles, Image Processing, Bluetooth, Infrared methods, Drone based traffic data collection.

Design of Unsignalized Intersections: At grade intersection types and their suitability, factors affecting design, data requirement, parameters selection, intersection controls, estimation of conflict points, uncontrolled intercession analysis, sight distance requirements, roundabouts and design methodologies, capacity of roundabouts, mini-roundabouts.

Design of Signalized Intersections: Warrants for signalization, saturation flow rate and capacity, estimation of amber time, design of all aspects of signal timings, estimation of queue length and control delay, signal coordination, types of interchanges, practice examples.

Capacity Analysis: Capacity and level of service concepts; Factors affecting capacity and LOS; Freeway and multi-lane analysis; Capacity of Urban arterials; Signalised intersections; Un-signalised intersections; US Highway Capacity Manual (HCM) and IRC standards, Indo-HCM standards

Design of Parking Facilities: Parking and influencing factors, type of parking system, parking angles and aisle width, on-street parking design, design parameters, parking surveys and demand estimation, various parking layouts and vehicle circulation, design of off-street parking facilities, types and layouts, design examples.

Learning Resources:

Text Books:

1. Traffic Engineering and Transport Planning, Kadiyali, L.R., Khanna Publishers, 2018, Ninth Edition.
2. Traffic Engineering, Roger P. Roess, Elena S. Prassas and William R. McShane, Prentice Hall, 4th Edition, 2010.

Reference Books:

1. Nicholas J. Garber, Lester A. Hoel, Principles of Traffic and Highway Engineering, Cengage Learning India, 2nd Edition, 2010.
2. Indian Highway Capacity Manual (INDO-HCM), Chandra, Satish, Gangopadhyay, S, Velmurugan, S, Ravinder, Kayitha, CSIR-CRRI, 2017.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/101/105101008/
2. https://nptel.ac.in/courses/105/104/105104098

CE1427 **3-0-0 (3)**

Water Quality Modeling and Management

Pre-Requisites: **None**

Course Outcomes:

CO-1	Assess water quality parameters and their importance
CO-2	Identify water quality monitoring strategies
CO-3	Formulate mathematical models to assess water quality
CO-4	Assess water quality indices
CO-5	Formulate water quality management/ plans for restoration

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	2	3	2	3	2	–	–	–	–	–	2	–	–	2
CO-2	2	3	2	3	2	3	2	–	–	–	–	–	2	–	–	2
CO-3	3	3	3	3	3	3	2	–	–	–	–	–	2	–	–	2
CO-4	2	3	3	3	3	3	2	–	–	–	–	–	2	–	–	2
CO-5	2	3	2	3	2	3	2	–	–	–	2	–	2	–	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Water Quality, Objectives and Standards, Water quality characteristics, sampling and analysis, Analytical methods, Automated analysis and remote monitoring.

Water quality monitoring: Water Pollution, Sources of Pollution, Nature of pollutants, Existing Approaches for Control/Abatement of Water Quality Degradation, Water Quality Monitoring in River Basins and lakes.

Water quality modeling: Modelling and Monitoring, Evolution of Water Quality Models, Types of Water Quality Models, Streeter Phelps Model, Non-Point Source Pollution, Modelling Approaches For Modeling Non-point Sources, River Water Quality Models and Lake Quality Models, Water quality indices

Water Quality Management: Overview of Water Quality Management, Water Quality degradation, Flow Augmentation, environmental flows in rivers, water quality restoration, , Regulatory Provisions Pertaining to Water Quality Management, Water quality indices and Legal Aspects of Water quality management, Public and Private Sector Involvement

Management Practices for pollution control - Technology based approach - Water quality based approach - Control of point sources - Control of nonpoint sources- BMPs to control NPS Pollution, Optimization in Water Quality Management, Management plan case studies, Rivers, Lakes, reservoirs and Groundwater.

Learning Resources:

Text Books:

1. Chapra, S.C.Surface Water Quality Modelling, ISBN-13: 978-1577666059; ISBN-10: 1577666054, Waveland Press, 2008
2. Marcello Benedini, George Tsakiris, Water Quality Modelling for Rivers and Streams, Springer Science & Business Media, 2013.

Reference Books:

1. Eckenfelder, Principles of Water Quality Management, ISBN 978-94-011-7117-5, Elsevier, 1980.
2. Thomann, R.V., Mueller, J.A., Principles of Surface Water Quality Modelling and Control, (1987), Harper and Row Publishers.

Other Suggested Readings:

1. https://www.epa.gov/waterdata/surface-water-quality-modeling
2. https://www.youtube.com/watch?v=sItfGlg4sz0

CE1429 **3-0-0 (3)**

Air Pollution

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify sampling and analysis techniques for air quality assessment
CO-2	Describe the plume behaviour for atmospheric stability conditions
CO-3	Apply plume dispersion modelling and assess the concentrations
CO-4	Design air pollution controlling devices

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	2	3	2	3	2	–	–	–	–	–	2	–	–	2
CO-2	2	3	2	3	2	3	2	–	–	–	–	–	2	–	–	2
CO-3	3	3	3	3	3	3	2	–	–	–	–	–	2	–	–	2
CO-4	2	3	3	3	3	3	2	–	–	–	–	–	2	–	–	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Water Quality, Objectives and Standards, Water quality characteristics, sampling and analysis, Analytical methods, Automated analysis and remote monitoring.

Air Pollution: Definition - Sources & Classification of Air Pollutants - Effects of air pollution on humans, plants and materials- Global effects - Air Quality and NAAQS - National Clean air Programme- Sampling of Pollutants in ambient air - Stack sampling

Meteorology and Air Pollution: Factors influencing air pollution, Wind rose, Mixing Depths, Lapse rates and dispersion - Atmospheric stability, Plume rise and dispersion, Prediction of air quality, Box model - Gaussian model - Dispersion coefficient - Application of tall chimney for Pollutant dispersion.

Control of Particulate Pollutants: Properties of particulate pollution - Particle size distribution - Control mechanism - Dust removal equipment - Design and operation of settling chambers, cyclones, wet dust scrubbers, fabric filters & ESP.

Control of Gaseous Pollutants: Process and equipment for the removal by chemical methods - Design and operation of absorption and adsorption equipment - Combustion and condensation equipment.

Learning Resources:

Text Books:

1. Khare M, Sharma P, Kota, S.H, Sumanth C, Air Pollution Science Engineering and Management Fundamentals, ISBN 9780367750527, CRC Press, 2024.
2. Noel, D. N., Air Pollution Control Engineering, ISBN 978-0070393677, Tata McGraw Hill Publishers, 1999.

Reference Books:

1. Colls, J., Abhishek T, Air Pollution: Measurement, Modeling and Mitigation, ISBN13: 978-0- 415-47932-5 CRC Press, 2009.
2. Boubel, R.W., Fox, D.L., Turner, D.B. and Stern, A.C., Fundamentals of air pollution, Third Edition, ISBN 978-0-08-050707-1, Academic Press, New York, 1994.
3. https://nptel.ac.in/courses/105102089
4. https://indair-neeri.res.in/

Professional Elective-5

CE1431 **3-0-0 (3)**

Earthquake Resistant Design

Pre-Requisites: **CE1202**

Course Outcomes:

CO-1	Apply seismic coefficient and response spectrum methods for analysis of multi storied buildings
CO-2	Apply concepts of ductility in the design of multi-storeyed structures
CO-3	Analyze multi-storeyed building frames based on latest earthquake code
CO-4	Apply the concepts of base isolation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	-	2	3	-	-	1	-	1	-	-	1	-	-	-	2	3
CO-2	-	-	3	2	-	1	-	1	-	-	1	-	-	-	3	1
CO-3	-	2	3	1	-	1	-	1	-	-	1	-	-	-	3	1
CO-4	-	-	2	3	-	1	-	1	-	-	1	-	-	-	2	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Elements of Earthquake Engineering: Earthquake magnitude and intensity, Focus and Epicentre, Causes and Effects of Earthquakes, Characteristics of Earthquake, Seismic zone mapping.

Structural Systems for Seismic Resistance: Structural systems – building configuration, frames, walls, dual systems – response in elevation – plan – influence of structural classification- Concepts of seismic design.

Analysis for Earthquake Loads: IS: 1893-2016- Seismic Coefficient method- modal analysis- Applications to multi-storied building frames.

Ductile Detailing: Ductility of R.C structures- Confinement- detailing as per IS-13920-2016- moment redistribution – principles of design of beams, columns – beam column joints – soft story concept

Base Isolation: Isolation systems – Effectiveness of base isolation and applications.

Learning Resources:

Text Books:

1. A.K. Chopra, Dynamics of structures, Prentice Hall, 2020.
2. I.S. 1893 - 2002, Criteria for Earthquake Resistance design of Structures.

Reference Books:

1. Clough R.W, Dynamics of Structures, 2015, 2nd Edition.
2. Mario Paz and Young Hoon Kim Structural Dynamics: Theory and Computation, Springer Publisher, 2018, 6th Edition
3. https://nptel.ac.in/courses/105/107/105107204/

CE1433 **3-0-0 (3)**

Ground Improvement Techniques

Pre-Requisites: CE1208

Course Outcomes:

CO-1	Identify ground conditions and suggest methods of improvement
CO-2	Design and assess the level of improvement
CO-3	Apply principles of soil reinforcement and confinement in engineering constructions
CO-4	Design reinforced soil structures

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	2	2	1	1	–	–	1	1	–	1	3	1	1	2
CO-2	3	2	3	1	–	1	1	–	–	–	–	–	–	1	3	1
CO-3	2	2	–	–	2	–	1	–	–	–	–	–	–	3	–	–
CO-4	3	2	3	1	–	1	1	–	–	–	1	–	–	2	3	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Ground Improvement: Overview of ground improvement techniques, Importance of ground improvement in construction projects, Factors influencing the need for ground improvement, Historical development and evolution of ground improvement methods

Shallow Stabilization Techniques: Introduction to shallow stabilization techniques, Types of shallow stabilization methods: compaction, preloading, vibro compaction, soil reinforcement, and chemical stabilization, Principles and mechanisms of each technique, Influence on bearing capacity and settlements in cohesive and cohesionless soils, Design considerations and factors affecting the selection of shallow stabilization methods, Case studies and real-world applications of shallow stabilization techniques

Deep Stabilization Techniques: Introduction to deep stabilization techniques, Types of deep stabilization methods: deep compaction (dynamic compaction, vibro compaction), deep mixing (deep soil mixing, jet grouting), stone columns, and grouted ground, Principles and mechanisms of each technique, Influence on bearing capacity and settlements in cohesive and cohesionless soils Design considerations and factors affecting the selection of deep stabilization methods, Case studies and real-world applications of deep stabilization techniques

Combined Methods and Hybrid Techniques: Overview of combined methods and hybrid techniques in ground improvement, Integration of shallow and deep stabilization techniques for complex ground conditions, Case studies demonstrating the effectiveness of combined methods, Challenges and considerations in implementing combined and hybrid techniques, Future trends and innovations in combined ground improvement methods

Quality Control and Monitoring in Ground Improvement: Importance of quality control and monitoring in ground improvement projects, Key parameters to monitor during ground improvement activities, Instrumentation and techniques for monitoring ground improvement processes, Precautions to avoid different type of errors, Data interpretation and analysis for assessing the effectiveness of ground improvement measures, Case studies highlighting the role of quality control and monitoring in successful ground improvement projects

Learning Resources:

Text Books:

1. Manfred R. Hausmann, Engineering Principles of Ground Modification, McGraw-Hill College, 2013, First Edition
2. Bujang B.K. Huat, Arun Prasad, Sina Kazemian, Vivi Anggraini, Ground Improvement Techniques, 2021, First Edition

Reference Books:

1. Klaus Kirsch and Fabian Kirsch, Ground Improvement by Deep Vibratory Methods, CRC Press, 2017, Second Edition
2. Buddhima Indraratna, Jian Chu and Cholachat Rujikiatkamjorn, Ground Improvement Case Histories, Elsevier, 2015, First Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/105108075

CE1435 **3-0-0 (3)**

Pavement Forensics and Rehabilitation

Pre-Requisites: **CE1307**

Course Outcomes:

CO-1	Explain and identify the various types of pavement distress and failure mechanisms
CO-2	Conduct pavement forensic investigations using non-destructive testing
CO-3	Assess the performance of pavement and decide on different rehabilitation strategies.
CO-4	Design effective pavement rehabilitation solutions.
CO-5	Conduct economic & environmental implications of pavement rehabilitation techniques

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	3	2	-	-	-	-	-	-	-	2	2	2	1
CO-2	2	2	2	2	2	-	-	-	-	-	-	-	3	1	2	-
CO-3	3	3	2	2	1	-	-	-	-	-	-	-	2	-	2	-
CO-4	3	2	3	3	3	-	-	-	-	-	-	-	1	2	2	1
CO-5	2	1	3	2	2	-	-	-	-	-	-	-	2	1	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Pavement Forensics: Pavement Infrastructure, Liabilities arising due to premature pavement failures, Introduction to Pavement Forensics, Preliminary Investigation-Assessment of whether forensic evaluation is justified; Overview of forensic investigation plan –team formulation, Pre-investigation site visits, Preliminary investigation, initial forensic testing plan, Final testing plan.

Distress identification in pavement structures: Distress identification in the flexible pavement – Cracking, Surface deformation, Patching, and potholes, Surface Defects; Distress identification in concrete pavements – Cracking, Joint Deficiencies, Surface defect; miscellaneous defects in flexible and concrete pavements, Distresses in inverted pavements, Quantification of distresses in flexible and concrete pavements.

Non-Destructive, Destructive and laboratory evaluation procedures: Introduction to Non-Destructive testing – Ground penetrating radar, Profilometer, Falling weight deflectometer, Density gauge, Field permeameter, Magnetic tomography technology; Destructive evaluation – Field coring, Test pits and trenches; Laboratory investigations – separation/detection of individual materials, physical and chemical properties, relevant strength assessment; Traffic studies – quantifying overloading.

Forensics evaluation case studies: Failure investigation of rutting without shoving, with shoving, wheel path cracking, non-wheel path cracking, moisture damage in bituminous mixes, delamination failure, Cracking in concrete pavements, Durability failures in concrete pavements

Rehabilitation techniques: Rectification of distresses in flexible pavements, Recycling (hot and cold) techniques, Full depth reclamation, Rectification of distresses in concrete pavements, Reinstating load transfer efficiency across cracks, sublimation, strengthening of flexible pavements.

Learning Resources:

Text Books:

1. Kandhal, P.S., Bituminous Road Construction in India, PHI Learning Pvt. Ltd, 2016, First Edition.
2. Specifications for Road and Bridge Works, Ministry of Road Transport and Highways, Indian Roads Congress, New Delhi, India, 2013, Fifth Edition.

Reference Books:

1. IRC SP 82 Code of practice for the maintenance of flexible pavements
2. IRC SP 83 Guidelines for maintenance, repair and rehabilitation of cement concrete pavements

Other Suggested Readings:

1. https://pavementinteractive.org/reference-desk/construction/site-preparation/subgrade-preparation-for-new-pavements/
2. https://www.virginiadot.org/vtrc/main/online_reports/pdf/15-r6.pdf

CE1437 **3-0-0 (3)**

Conservation of Heritage Structures

Pre-Requisites: None

Course Outcomes:

CO-1	Explore the importance of conserving the heritage structures
CO-2	Identify different aspects of conservation of structures
CO-3	Analyse the restoration and reconstruction procedures
CO-4	Identify the structural materials in heritage constructions
CO-5	Exposure to structural health monitoring of the heritage structures

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	1	1	1	2	3	3	1	2	1	2	3	–	–	–	–
CO-2	2	2	2	3	2	3	2	2	-	2	2	3	–	–	–	–
CO-3	1	2	3	3	3	2	3	1	-	2	2	2	–	–	–	–
CO-4	1	2	1	1	3	2	3	1	-	2	3	2	–	–	–	–
CO-5	1	2	-	3	2	2	3	1	1	3	1	3	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Historical Perspective of conservation, Classification of heritage based on different criteria, Policies and agencies of conservation across world, Conservation principles and practices, Conservation scenario – Global and Indian versions.

Geotechnical and structural aspects of conservation Processes: Conservation approach, Diagnostic investigations, Masonry characterisation, Deterioration in heritage structures – causes of decay, Maintenance, preservation, Repairs, restoration and reconstruction, Structural strengthening and retrofitting module.

Structural materials and systems in heritages constructions: Rock-cut architecture, Structural behaviour of heritage structures, Material behaviour – stones, clay bricks, mud & masonry mortars, Concrete & modern heritage buildings, new buildings in heritage settings.

Structural health monitoring: Investigations and conservation of historic structures – case studies, Heritage conservation – challenges and opportunities; Heritage tourism, sustainability aspects.

Learning Resources:

Text Books:

1. Francesca Gherardi and Pagona Noni maravelaki, Conserving stone heritage: Traditional and Innovative materials and techniques, Springer, 2011
2. GG Amorodo and V. Fassina, Stone Decay and conservation: atmospheric pollution, cleaning, consolidation and protection, Elsevier, 1983

Reference Books:

1. National policy for conservation of the ancient monuments, Archaeological sites and remains, ASI, New Delhi.

Professional Elective-6

CE1422 **3-0-0 (3)**

Rock Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Comprehend the significance of rock mechanics in engineering practice.
CO-2	Determine rock properties and classify the rock mass.
CO-3	Assess the stability of rock slopes and suggest slope protection methods.
CO-4	Evaluate the rock bearing capacity and calculate the load capacity for deep foundations in rock.
CO-5	Identify the suitable tunnel driving and support/stabilization methods.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	2	1	–	–	–	–	–	2	1	3	1	3	3	–
CO-2	3	1	2	3	–	–	–	–	1	2	–	1	1	3	1	–
CO-3	–	2	3	2	2	2	–	2	–	2	–	1	1	–	3	3
CO-4	–	–	3	1	–	–	–	–	–	2	–	2	–	–	3	–
CO-5	–	1	3	–	–	–	1	–	2	2	–	1	–	–	3	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Development of Rock Mechanics and its Engineering Importance.

Laboratory and in-Situ Testing: Rock sampling, Determination of density, Porosity and Water absorption, Uniaxial Compressive strength, Determination of elastic parameters, Tensile strength, Shear Strength, Flexural strength, Swelling and slake durability, permeability, point load strength, Factors affecting strength of rocks.

Engineering classification of Intact rock and rock mass: Classification by Rock Quality Designation (RQD), Rock structure Rating (RSR), Rock Mass Rating (RMR), Geomechanics and Norwegian Geotechnical Classification (Q-system). Strength and modulus from classifications, Classification based on strength & modulus and strength.

Stability of Rock Slopes and Foundations on Rocks: Types, mode of slope failure, causes of slope failure, stability analysis, Hoek's stability charts, prevention and control of rock slope failures, stabilization methods, prevention methods and warning methods.

Rock Foundations: Types of Foundations, Shallow foundation- failure mechanisms, different situations with shallow foundations, sliding instability, foundations over sinkholes, foundations on faults, foundations on swelling rocks, deep foundations.

Tunneling in rocks: Applications of tunnels, investigation and planning, tunnel drilling methods, tunnel support systems and stabilization methods, construction control and tunnel maintenance

Learning Resources:

Text Books:

1. Ramamurthy T. Engineering in Rocks for slopes, foundations and tunnels, Prentice Hall of India. Learning Pvt. Ltd., (2015).
2. John A. Franklin and Maurice B. Dusseault, Rock Engineering Applications, McGraw Hill, 1991.

Reference Books:

1. Nagaratnam Sivakugan, Sanjay Kumar Shukla, Braja M. Das, Rock Mechanics an Introduction, CRC Press, 2019.
2. B.P. Verma, Rock Mechanics for Engineers, Khanna Publishers, 2015.

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc21_ce34/preview

CE1424 **3-0-0 (3)**

Land and Water Management

Pre-Requisites: **None**

Course Outcomes:

CO-1	Plan irrigation systems and command area development programs
CO-2	Evaluate performance of an irrigation system
CO-3	Plan measures for reclamation of waterlogged lands
CO-4	Develop strategies for conflict management in irrigation projects

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	2	3	1	2	–	–	–	1	1	1	–	3	2
CO-2	2	3	3	3	2	2	1	–	–	–	1	1	1	–	3	-
CO-3	2	3	3	2	2	1	1	–	–	–	1	1	1	–	3	-
CO-4	2	3	3	2	2	2	2	–	–	–	1	1	1	–	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Need for proper management of land and water resources.

Planning of irrigation projects: Inadequacies in present approaches in canal irrigation management – command area development programs.

Classification of irrigable soils: soils-plant-water relationships – soil management Irrigation management – Irrigation Management Matrix – Society and irrigation – perceptions of various stake holders on irrigation system performance

Macro and precision irrigation: Diagnostic analysis of irrigation systems – performance indicators for performance evaluation of irrigation projects

Water logging and salinity: Water quality for irrigation

Participatory irrigation management: Farmer's management of irrigation system acts - conflict resolution

Legal aspects in water sharing and management: PC-CP - case studies

Learning Resources:

Text Books:

1. Majumdar D.K., Irrigation Water Management, Prentice Hall of India, New Delhi, 2013, 2nd Ed.
2. Michael A.M., Irrigation: Theory and Practice, Vikas Publishing House Pvt. Ltd. New Delhi, 2009

Reference Books:

1. Murthy V.V.N., Land and Water Management Engineering, Kalyani Publishers, Ludhiana, 2011
2. Scwabe G.O., Fangmeir D.D., and Elliot W.J., Soil and Water Management Systems, John Wiley and Sons, N York, 1996

Other Suggested Readings:

1. https://www.iima.ac.in/c/document_library/4ParticipatoryIrrigation8f9a.pdf?uuid=a5eced82-3f75-4068-9aa1-57aef9de0876&groupId=62390

2. https://www.iwapublishing.com/news/integrated-water-resources-management-basic-concepts
3. https://www.indiawaterportal.org/articles/introduction-integrated-water-resourcemanagement-iwrm-open-courseware-united-nations

CE1426 **3-0-0 (3)**

Highway Safety

Pre-Requisites: **CE1307**

Course Outcomes:

CO-1	Analyze the effect of driver characteristics, roadway characteristics, and climatic factors on highway safety
CO-2	Interpret and analyse the road crash data using various methods
CO-3	Identify the hazardous location and predict the possibility of road crashes
CO-4	Analyse the intersection traffic safety using empirical and non-empirical methods
CO-5	Apply traffic management techniques to solve safety issues

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	1	–	2	1	–	2	–	1	4	–	–	–	–	–	–
CO-2	2	2	–	2	2	–	–	–	–	1	–	–	–	–	–	–
CO-3	–	4	–	4	2	–	–	1	–	–	–	–	–	–	–	–
CO-4	–	4	–	–	2	–	–	–	–	–	–	–	–	–	–	–
CO-5	–	–	–	4	2	1	–	–	–	–	1	1	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction of highway safety: Scenario and statistics, accident characteristics, crash types, causes, severity, factors affecting highway/road safety, safety aspects related to geometric design, road safety improvement strategies, elements of a road safety plan, examples for practice.

Analysis of accident data: accident/crash data and record, accident data analysis, crash rate and its estimation, accident exposure, cash frequency, relative safety, identification of hazardous location, black spot, statistical analysis using crash data, collision diagram, condition diagrams, crash reconstruction, understanding basic physics, calculation of speed for various skid, friction, worked examples.

Accident prediction: method for prediction of crash, variables influencing accidents, potential index for safety improvements, determination of expected crashes, safety performance functions, before-after methods in crash analysis, with control sites, crash modification factor, empirical bays models, crash reduction factors, working examples and case study.

Intersection safety analysis: Background, intersection features affecting safety, geometric design, traffic control and traffic characteristics, safe sight distance requirements, uncontrolled intersection safety, roundabout crash analysis, intersection level, approach level safety analysis, conflict categories, level of injury crash, worked examples and case study.

Traffic management and road safety audit: Traffic improvements strategies for safety, Intelligent transportation system, crash avoidance system, incident management, road safety audit procedure, aims and objectives, roles and responsibility, design standards, tasks, various stages of safety audits; common identifiable problems, structuring of report, identifying common problems, case study.

Learning Resources:

Text Books:

1. L.R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publisher, 2017, 9th Edition
2. Nicholas J. Graber and Lester A. Hoel, Traffic and Highway Engineering, Cengage Learning India Privet Limited, 2017, 5th IS Edition

Reference Books:

1. R Srinivasa Kumar, Introduction to Traffic Engineering, University Press (India), 2018, 1st Edition
2. C. Jotin Khisty and B. Kent Lal, Introduction to Transportation Engineering, Pearson Press, 2018, 3rd Edition

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc22_ce41/preview
2. https://ocw.mit.edu/courses/16-63j-system-safety-spring-2016/

CE1428 **3-0-0 (3)**

Design of Bridges

Pre-Requisites: **None**

Course Outcomes:

CO1	Apply the codal provisions for loading and design standards of bridges.
CO2	Design the substructure including pier and pier cap and well elements.
CO3	Design the superstructure of bridge using different methods.
CO4	Design girder bridges and cable stayed bridges.
CO5	Design and select materials suitable for bearings.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	-	2	2	1	-	1	-	-	1	-	-	2	1	-
CO2	2	3	1	3	3	1	-	1	-	-	1	-	-	-	3	1
CO3	3	2	3	2	2	1	-	1	-	-	1	-	-	-	2	-
CO4	2	1	3	2	2	1	-	1	-	-	1	-	-	-	3	-
CO5	2	-	2	3	3	1	-	1	-	-	1	-	-	-	3	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Bridge components - Classification – Investigation for bridges – Loads and Loading standards – IRC and Railway loads – Impact.

Bridge substructure: Determination of maximum flood discharge - Determination of linear water way - Determination of maximum depth of scour - Loads acting on substructure - Design of abutment, pier and pier cap - Design of well elements - Sinking of wells.

Bridge Superstructure: Effective dispersion width method and Pigeaud's curves method for design of slab - Analysis of beams– Courbon's Method – Hendry Jaeger Method – Guyon and Massonet Method - Box Girder Bridges - Grillage analogy.

Cable Bridges: Advantages - Arrangement of stay cables - types of towers - Linear analysis of cables and towers

Bridge Bearings and expansion joints: Functions, types and selection of bearings - Bearing materials - Design of elastomeric bearings and spherical pot bearings for different conditions - Expansion joints – types of expansion joints.

Learning Resources:

Text Books:

1. Analysis and Design of Substructures: Limit State Design, Swami Saran, Oxford & IBH Publishing Co., 2018, 2nd Edition.
2. Bearings in Structural Engineering, J.E. Long, Wiley, 2016.

Reference Books:

1. Concrete Bridge Design, R.E. Rowe, Elsevier Science and Technology, 1962, 1st Edition.
2. The Analysis of Grid Frameworks and Related Structures, L.G. Hendry and A.W. Jaeger, Chatto & Windus, 1958.

Other Suggested Readings:

1. https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-ce23/

CE1430 **3-0-0 (3)**

Low Carbon Materials and Green Buildings

Pre-Requisites: **None**

Course Outcomes:

CO-1	Exposure to clean and renewable energy systems & Technologies
CO-2	Identify the sustainable materials and their usage in the constructions
CO-3	Analyse optimizations for design of energy efficient buildings
CO-4	Estimate the renewable energy of buildings.
CO-5	Hands on experience for the design of a sustainable building

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	2	3	2	–	–	–	–	–	–	1	–	–	–	3	2
CO-2	2	2	2	3	–	–	–	–	–	–	1	–	–	–	3	-
CO-3	1	2	2	2	–	–	–	–	–	–	1	–	–	–	3	-
CO-4	2	2	3	2	–	–	–	–	–	–	1	–	–	–	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Embodied energy, Operational energy in Building and Life cycle energy. Ecological foot print, Bio-capacity and calculation of planet equivalent.

Role of Materials used in constructions: Carbon from Cement, alternative cements and cementitious material, Alternative fuel for cements for reduction in carbon emission, Sustainability issues for concrete; Role of quality, minimization of natural resource utilization, High volume fly ash concrete, geo-polymer concrete etc. concrete with alternative material for sustainability.

Energy use in Buildings: Reduction in water consumption in concrete, Recycled aggregate, Energy for grinding crushing of cement aggregate etc. and reduction. Operational energy in building role of materials and thermal conductivity; Comparative energy performance emission performance and financial performance, Indoor air quality, volatile organic content (VOC) emission issues and indoor air quality for sustainability and health hazard.

Green Buildings: Operational energy reduction and net zero building, Optimization for design of building for energy efficiency and example of optimization through use of Evolutionary genetic algorithm; Radiation budget, urban heat island; Surface water balance, Effects of trees and microclimatic modification through greening.

Renewable Energy: Use of Building Integrated Photo Voltaic (BIPV) and other renewable energy in buildings, basic concepts and efficiency; Energy codes ECBC requirement, Concepts of OTTV etc; Green Performance rating, requirements of LEED, GRIHA etc.

Sustainable building: A small project on designing a sustainable building

Learning Resources:

Text Books:

1. Newman, J. and Choo, Ban Sang, Advanced Concrete Technology-Processes, Elsevier, 2003, 1st Edition.
2. Newman, J. and Choo, Ban Sang, Advanced Concrete Technology-Constituent Materials, Elsevier, 2003, 1st Edition.

Reference Books:

1. Kubba, S, LEED Practices, Certification, and Accreditation Hand book, 1st ed. Elsevier, 2010.
2. Minsitry of Power, Energy Conservation Building Code 2018, Revised Version, Bureau of Energy Efficiency, 2018

Other Suggested Readings:

1. TERI-Griha's Green Design practices (www.teriin.org/bcsd/griha/griha.htm)
2. Leadership in Energy and Environmental Design (www.usgbc.org/LEED)

Professional Elective-7

CE1432 **3-0-0 (3)**

Seismic Hazard Analysis

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the mechanism involved in earthquakes
CO-2	Evaluate the effect of earthquake motion on soil properties
CO-3	Determine the Probabilistic and Deterministic Seismic Hazard Analysis
CO-4	Design of structures and foundations under seismic loading

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	1	–	–	1	2	1	–	–	–	–	–	–	–	–	3
CO-2	2	1	–	–	1	2	1	–	–	–	–	–	–	–	–	3
CO-3	1	3	–	–	–	1	–	–	–	–	–	–	–	–	–	3
CO-4	1	3	2	1	–	–	–	–	–	–	–	–	–	–	–	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Seismic microzonation; Basic steps; Site characterization and quantification; Seismic zonation map of India; factors affecting seismic microzonation, seismic microzonation of mega cities.

Seismotectonic Sources and Seismicity Data: Geological and seismological criteria used for source identification and source geometry; Characteristics and Delineation of Seismic Sources for Seismic Hazard Analysis; Modeling of fault segments in hazard analysis; Completeness in size and time; Estimation of maximum probable magnitude.

Earthquake Occurrence Models and Ground Motion Prediction Equations: Gutenberg Richter frequency magnitude distribution, return period; log normal distribution, Strong motion attenuation relationships, PGA and spectral accelerations.

Deterministic and Probabilistic Seismic Hazard Analysis: Deterministic and probabilistic seismic hazard methods; Types of earthquake sources-point, line and areal sources, Epistemic and aleatory uncertainty estimation, deaggregation, logic tree, hazard estimation at the bedrock level, design specifications for structures and foundations under seismic loading.

Seismic Microzonation Deliverables: Amplification maps, fundamental frequency map, probability of exceedance of strong ground motion; Liquefaction potential maps; Landslide hazard zonation maps.

Learning Resources:

Text Books:

1. Kramer, S. L., “Geotechnical Earthquake Engineering”, Pearson Education, 2004.
2. Reiter, L.“Earthquake Hazard Analysis, Issues and Insights”, Columbia University Press, 2001.

Reference Books:

1. Antoni Roca and Carlos Oliveria, “Earthquake Microzoning”, Birkhauser Verlag, Berlin, 2002.
2. Day Robert W., “Geotechnical Earthquake Engineering Handbook”, McGraw-Hill, New York, 2001.
3. https://nptel.ac.in/courses/105/108/105108074/#

CE1434 **3-0-0 (3)**

Advanced Structural Analysis

Pre-Requisites: None

Course Outcomes:

CO-1	Develop shape functions and stiffness matrices different finite elements
CO-2	Develop global stiffness matrices and global load vectors
CO-3	Apply natural and arial coordinate systems to constant strain triangle and linear strain triangle elements
CO-4	Analyze planar structural systems using finite element modeling

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	-	1	3	-	-	-	-	1	-	-	-	-	-	-	2	-
CO-2	-	-	2	3	-	-	-	1	-	-	-	-	-	-	2	-
CO-3	-	-	2	3	-	-	-	1	-	-	-	-	-	-	2	-
CO-4	-	-	3	2	-	-	-	1	-	-	-	-	-	-	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Kani's method: Application to continuous beams and portal frames (Single bay two storey).

Approximate methods of analysis: Portal method - Cantilever method – Substitute frame method.

Indeterminate Structural Analysis using Energy Methods: Axial, bending, shear, torsion, warping.

Finite Element Method: Introduction to Finite Element Method: Background and general description of the method – summary of the analysis procedure. Theory of Finite Element method: Discretization concept-Concept of element – various elements shapes – displacement models – Convergence- shape functions – condensation of internal degrees of freedom-Summary of analysis procedure.

Finite Element Analysis: Development of shape functions for different elements-Spring- Truss Beam-Plane elements- Plane stress and plane strain-Assemblage of elements construction of stiffness matrix and loads – boundary conditions –patch test-solution of overall problem.

Structural Dynamics: Single degree of freedom system without and with damping.

Learning Resources:

Text Books:

1. C Krishnamoorthy, Finite Element Analysis: Theory and Programming, McGraw Hill Pub., 2017, 2nd Edition.
2. Tirupathi chandra Patla and Belugundu, Introduction to Finite elements in Engineering, Pearson, 2015, 4th Edition

Reference Books:

1. David Hutton, Fundamentals of finite element analysis, McGraw Hill Pub., 2017.
2. Bathe K J, Numerical Methods in Finite Element Analysis, Prentice-Hall civil engineering and engineering mechanics series, 2016
3. https://nptel.ac.in/courses/105/105/105105041/

CE1436 **3-0-0 (3)**

Pedestrian and Bicycle Facility Design

Pre-Requisites: **None**

Course Outcomes:

CO-1	Introduce current issues as well as future trends in pedestrian and bicycle planning
CO-2	Quantify the benefits of creating walkable and bikeable environments.
CO-3	Analyse the characteristics of pedestrians and bicyclists.
CO-4	Design and Implementation of pedestrian and bicycle facilities.
CO-5	Assess bicycle and pedestrian safety and existing facilities.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	-	1	1	-	1	1	-	-	-	-	1	1	2	3	1
CO-2	3	3	1	2	-	1	1	-	-	-	-	1	2	1	3	-
CO-3	3	3	3	2	3	1	1	-	-	-	-	1	2	-	3	2
CO-4	3	3	3	3	2	2	2	-	-	-	-	1	-	1	3	-
CO-5	3	-	1	1	-	1	1	-	-	-	-	1	1	2	3	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Pedestrian and Bicycle Transportation: Benefits of pedestrian and bicycle transportation & advocacy movements; barriers for walking and bicycling; travel behavior: shifting automobile travel to walking and bicycling; health, social equity, environment, and economic development issues; pedestrian and bicycle suitability assessment methods; first and last mile connectivity with pedestrian and bicycle facilities.

Pedestrian and Bicycle Facilities: Need for pedestrian and bicycle facilities; human behavior and sustainable transport modes; pedestrians with disabilities; measuring current non-motorized travel; predicting potential non-motorized travel; neo-traditional neighborhood design for NMT; evaluating existing conditions and prioritize improvements.

Pedestrian and Bicycle Data Analysis: Characteristics of pedestrian and bicycle; surveys; crash data; barrier effect; cycling condition evaluation techniques; pedestrian condition evaluation techniques; prioritizing improvements and selecting preferred options; demand estimation and analysis.

Planning and Design of Pedestrian Facility: Pedestrian facilities and planning; pedestrian standards and improvements; design of pedestrian facilities sidewalks, crosswalk, Foot over bridges; level of service.

Planning and Design of Bicycle Facility: Bicycle network planning; Integrating cycling into roadway planning; accommodating cyclists on rural roads; design of bicycle boulevards/bike paths; bicycle parking/storage facilities; roadway maintenance for cyclists.

Pedestrian and Bicycle Operation, Safety: Trends in walking and bicycle safety; safety at school zones; pedestrian safety action plans; pedestrian signs and markings; bicycle-specific traffic signs; first and last mile connectivity with public bikesharing.

Learning Resources:

Text Books:

1. Transportation Engineering, Khisty, C.J., and Lall, B.K., Pearson, 2017, Third Edition.
2. Sustainable Transport: Planning for walking and cycling in urban environments, Tolley, R., CRC Press; 2003, First Edition.

Reference Books:

1. Design and Safety of Pedestrian Facilities: A Recommended Practice of the Institute of Transportation Engineers, Zegeer, C.C.V., TENC-5A-5 Engineering Council Committee Traffic, The Institute of Transportation Engineers, 2016.
2. Pedestrian- and Transit-Oriented Design, Ewing, R., and Bartholomew, K., Urban Land Institute Publishing House, 2013.

Other Suggested Readings:

1. CREATING WALKABLE + BIKEABLE COMMUNITIES: A user guide to developing pedestrian and bicycle master plans (OTREC)
2. http://www.pdx.edu/ibpi/sites/www.pdx.edu.ibpi/files/IBPI%20Master%20Plan%20Handbook%20FINAL%20(7.27.12).pdf

CE1438 **3-0-0 (3)**

Hydro Power Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Estimate hydropower potential
CO-2	Identify types of hydropower plants
CO-3	Design penstocks and surge shaft
CO-4	Plan the layout of a hydropower plant

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	2	3	1	2	–	–	–	–	1	1	–	3	2
CO-2	3	3	3	2	3	1	1	–	–	–	–	1	2	–	3	
CO-3	3	3	3	2	3	1	1	–	–	–	–	1	1	–	3	2
CO-4	3	3	3	1	3	1	1	–	–	–	–	1	1	–	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Stream flow analysis: Hydrograph, Mass curve, Runoff estimation methods, estimation of hydropower potential, flow duration curves, power duration curves, pondage and storage.

Electrical load on hydro turbines: load curves, load duration curves, Performance factors.

Types of hydropower plants: Storage power plant, Runoff River plant, Pumped storage plant, two units and three unit arrangements, Reversible pump turbines, types of turbines, hydraulics of turbines, cavitation in turbine, efficiency of pumped storage plants.

Intakes: Losses in intakes, air entrainment at intake, inlet aeration, Water conveyance systems, fore bay, canals, Tunnels and Penstocks, classification of penstocks, design criteria of penstock, economical diameter of penstock, Anchor blocks, Conduit valves, types of valves, bends and manifolds.

Water hammer: Resonance in penstocks, channel surges, Gates, Surge tanks, Power house layout, lighting and ventilation, variations in design of power house, underground power house, structural design of power house.

Learning Resources:

Text Books:

1. Modi P.M., Irrigation Water Resources and Hydropower Engineering, Standard Publishing Company, New Delhi, 2000.
2. Dandekar M.M., and Sharma K.N., Water Power Engineering, Vikas Publishing Company, New Delhi, 2003

Reference Books:

1. Jog M.G., Hydroelectric and Pumped Storage Plants, Wiley Eatern Ltd., New York, 1989.
2. Varshney R.S., Hydro Power Structures, Nem Chand & Bros. 2001.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/105/105105110/
2. https://nptel.ac.in/courses/105/104/105104103/

CE1440 **3-0-0: 3**

Photogrammetry and UAV

Pre-requisites: **None**

Course Outcomes:

CO1	Classify the photogrammetry methods and their applications
CO2	Determine the scale, ground coordinates and the aerial extent of aerial photographs
CO3	Explain various methods of photogrammetric techniques
CO4	Apply the photogrammetric skills to extract the earth surface features

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	1	3	2	2	-	1	1	1	1	3	-	1	1
CO2	3	3	-	-	2	2	2	-	1	1	-	1	3	-	1	-
CO3	2	1	3	2	3	2	2	-	2	3	2	2	2	-	2	1
CO4	3	2	3	2	3	3	3	3	3	3	3	3	2	2	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to photogrammetry: Photogrammetric terms, applications, advantages,limitations and a brief history, types of camera: metric vs. non-metric, types of photogrammetry

Aerial photogrammetry: Geometry of vertical/near-vertical aerial photographs: Orthographic vs. perspective projection, Map vs. photograph, scale of photograph, estimate the scale, reliefdisplacement and its determination, parallax in photographs and measurement, stereoscopy.

UAV: History of unmanned air vehicle (UAV) development. Classifications and components ofUAVs – Design standards and Regulatory aspects – Environment, Budget & Time, Airframe Design & Payload, Flight planning, Mosaicing, Ground control, Feature detection and mapping,Point cloud, 3D Models, DEM generation, Orthophoto generation, UAV Applications.

Laser Scanning: Principles, methods of scanning, scanning of terrestrial structures, monuments, LiDAR characteristics and types of systems

Integrated systems (UAV, Car, Aircraft etc.): Applications and some case studies: Mining, exploration, SLAM.

Learning Resources:

Text Books:

1. Wolf P. R., Elements of Photogrammetry with Application in GIS, McGraw Hill International Book Company, Fourth Edition, 2014.
2. Paul Gerin Fahlstrom & Thomas James Gleason., Introduction to UAV Systems, Wiley Publications, 2012

Reference Books:

1. Toth, C., K., Shan, J.Topographic laser ranging and scanning Principles and Processing, CRC Press
2. Thomas Luhmann, Stuart Robson, Stephen Kyle & Jan Boehm., Close Range Photogrammetry

and 3D Imaging., Walter de Gruyter GmhH, 2014, 2nd Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/104/105104100/

Professional Elective-8

CE1442 **3-0-0 (3)**

River Hydraulics

Pre-Requisites: CE1204

Course Outcomes:

CO-1	Determine the characteristics of Rivers and Sediments
CO-2	Comprehend the concept of incipient motion and bed load
CO-3	Compute sediment load
CO-4	Design river training works

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	1	1	3	1	1	1	-	-	-	-	1	2	-	1	
CO-2	2	2	1	2	1	1	1	-	-	-	-	1	3	-	1	1
CO-3	3	2	2	3	1	1	1	-	-	-	-	1	1	-	3	2
CO-4	3	3	2	2	2	1	1	-	-	-	-	1	1	-	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Behaviour of Rivers: Introduction, River Channel patterns, Straight river channels, causes, characteristics and shapes of meanders and control, Braided Rivers, Bed forms, Instability of rivers.

Incipient Motion: Properties of sediment, Incipient motion and quantitative approach to incipient motion.

Bed forms and resistance to flow: Sediment transport and budgets, Bed forms and resistance to flow. Channel degradation and armouring.

Modes of sediment transportation: Various approaches for bed load transport, suspended load profile and suspended load equations, total load transport including total load transport equations. Comparison and evaluation of sediment transport equations. Sediment sampling.

Bed level variation: Bed level variations, local scour, degradation, aggradation and reservoir sedimentation.

Design of stable channel: Stable channel design with and without suspended sediment and sediment control. River Training and Protection Works: Introduction, Classification of River Training, Types of training works, Protection for Bridges with reduced waterway, Design of Guide Band, embankment and spurs/dampeners and other river/ flood protection works

Learning Resources:

Text Books:

1. Garde R. J. and Ranga Raju K. G., Mechanics of Sediment Transportation and Alluvial Stream Problems, New Age Publishers.
2. Jansen P. P. H., Principals of River Engineering, VSSD Publications.

Reference Books:

1. Dey S., Fluvial Hydraulics, Springer, 2014.
2. Pierre Y. Julien, River Mechanics, Cambridge University Press, 2002.
3. https://www.routledge.com/IAHR-Design-Manual/book-series/TFIAHRHSDM

CE1444 **3-0-0 (3)**

Pavement Management System

Pre-Requisites: **CE1307**

Course Outcomes:

CO-1	Identify and select suitable database strategies for a given pavement.
CO-2	Determine the pavement condition using functional and structural methods.
CO-3	Decide the type and timing of maintenance required for given pavement.
CO-4	Estimate the life cycle cost of pavements and implementation strategies.
CO-5	Develop the PMS software and treatment selection criteria

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	3	-	-	-	-	-	-	-	-	-	-	-
CO-2	3	3	1	2	2	-	-	-	-	-	-	-	-	-	-	-
CO-3	3	3	3	3	1	-	-	-	-	-	-	-	-	-	-	-
CO-4	3	3	2	1	2	-	-	-	-	-	-	-	-	-	-	-
CO-5	2	2	1	2	2	-	-	-	-	-	-	-	-	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Pavement Management System (PMS): Importance of managing pavement network effectively, Basic framework of PMS, Benefits of using pavement management, Role of PMS in asset management.

Pavement Inventory and condition assessment: types of inventory information needed to support PMS, referencing systems, Data integration approaches, Role of GIS in PMS type of Pavement condition data to be collected, Data collection techniques, Pavement distress identification and quantification, sampling intervals, developing condition indices.

Pavement Performance Modelling: data requirements in Pavement performance modelling, Performance modelling approaches – Deterministic and Probabilistic models, Family modeling

Pavement Preservation strategies: identifying the treatment needs, treatment trigger rules, optimal timing of maintenance, techniques for project and treatment selection -Ranking, Multiyear prioritization techniques, Illustrating the impact of different funding scenarios.

Implementation of PMS: PMS software selection, Implementation steps and Institutional Issues

Learning Resources:

Text books:

1. Pavement Management for Airports, Roads and Parking Lots, Shahin, M.Y., Chapman & Hall, New York, 1994.
2. Modern Pavement Management, Haas, R., W. R., Hudson, and J. P. Zaniewski. Modern Pavement Management. Krieger Publishing Company. Malabar, Florida, 1994.

Reference Books:

1. Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation, and Renovation. Hudson, W. R., R. Haas, and W. Uddin., McGraw Hill. New York, 1997.
2. Southeast Michigan Council of Governments. Pavement Management System, SEMCOG, 1997.

Other Suggested Readings:

1. https://www.youtube.com/watch?v=lDv67Eppaos
2. https://ocw.mit.edu/courses/civil-and-environmental-engineering/

CE1446 **3-0-0 (3)**

Repair & Rehabilitation of Structures

Pre-Requisites: None

Course Outcomes:

CO1	Identify the reasons for distress and deterioration of structures.
CO2	Apply NDE for condition assessment of structures in distress
CO3	Select a suitable repair material for various field applications
CO4	Select suitable repair and rehabilitation methods for Civil Infrastructure

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	1	-	1	-	2	2	-	1	-	2	-	-
CO2	2	2	1	3	3	-	-	-	2	-	-	2	-	-	2	-
CO3	2	1	1	-	-	-	2	1	1	-	1	1	-	3	2	-
CO4	3	1	2	1	1	-	-	1	1	1	1	2	-	1	2	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Causes of distress in concrete structures- Permeability of concrete, aggressive chemical agents, durability aspects, Holistic models for deterioration of concrete

Condition Survey: Preliminary inspection, planning stage, visual inspection, field laboratory testing stage, consideration for repair strategy

Non-Destructive Evaluation tests: Estimation of Strength, Chemical and other durability tests, estimation of corrosion potential

Selection of repair materials for concrete: Ideal characteristics for selection of repair materials, premixed cement concrete and mortars, polymer modified mortars and concrete, epoxy and epoxy systems

Repair /Rehabilitation methods: Shortcreting and Guniting. Repair and strengthening of columns and beams using ferrocement jacketing, fiber wrap technique, Foundation Rehabilitation methods

Learning Resources:

Text Books:

1. B.Bhattacharjee, Concrete Structures-Repair, Rehabilitation and Retrofitting, CRS Publishers and Distributors, 2017.
2. R.Dodge Woodson, Concrete Structures-Protection, Repair and Rehabilitation, Elsevier, 2009.

Reference Books:

1. Santha kumar A.R, Concrete Technology, Oxford University Press, New Delhi, 2007
2. CPWD Handbook on Repair and Rehabilitation of RCC buildings, Govt of India Press, New Delhi, 2014.
3. ACI 546R-14, Guide to Concrete Repair, American Concrete Institute, 2014

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/106/105106202/
2. https://www.concrete.org/store/productdetail.aspx?ItemID=W1506&Format=ONLINE_LEARNING&Language=English&Units=US_Units

Open Electives

CE1473 **2-0-0 (2)**

Building Technology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply basic principles to develop building plans
CO-2	Identify general and special requirements for planning and design
CO-3	Identify different prefabricated building components
CO-4	Comprehend application of different construction equipment and technologies

Syllabus:

Building planning: Types of Buildings – components, definitions, economy and design, Principles and aspects of building planning, Definitions and importance of Grouping and circulation; Lighting and ventilation; Sustainability and Green Buildings.

General requirements: Requirements for safety against fire, termite, damping, earthquakes, Vertical transportation in building – planning of vertical transportation, Stairs, different forms of stairs, Other modes of vertical transportation.

Special Requirements: Air conditioning – process and classification of air conditioning, Dehumidification. Systems of air-conditioning, ventilation, functional requirements of ventilation. Thermal insulation. Acoustics, effect of noise, properties of noise and its measurements, Principles of acoustics of building. Sound insulation.

Prefabrication systems: Prefabricated walls, openings, cupboards, shelves etc., planning and modules and sizes of components in prefabrication. Plumbing services – water supply system, maintenance of building pipe line, Sanitary fittings, Design of building drainage.

Construction Equipment: Introduction and Planning for construction Equipment, Earthmoving and Excavating equipment, Pile driving equipment, Lifting and Concreting Equipment.

Learning Resources:

Text Books:

1. Punmia B. C., Jain A.J., and Jain A.J., Laxmi, Building Construction, Publication, 2016, Eleventh Edition.
2. Arora S. P., and Bindra S. P., The Text book for Building Construction, Dhanpat Rai Pubications, 2010.

Reference Books:

1. Varghese P.C., Building Construction, PHI Learning Pvt. Ltd., 2017, 2nd Edition.
2. Robert P., Clifford J. S., and Aviad S., Construction Planning, Equipment and Methods, McGrawHill Education, 2010

Other suggested Readings:

1. https://nptel.ac.in/courses/105/103/105103206/
2. https://nptel.ac.in/courses/105/102/105102175/

CE1475 **2-0-0 (2)**

ENVIRONMENTAL MANAGEMENT

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the need for Environmental Management
CO-2	Identify the attributes of Environment Management system and standards
CO-3	Apply different methodologies for impact assessment
CO-4	Identify the techniques and control measures for Environment management

Syllabus:

Introduction to Environmental Management: Scope and nature of Environment Management. Its need and brief discussion on the ethical, legal and financial reasons for Environment Management, the framework and approach to develop Environment management system. Policies and legal aspect in India.

Environment management system (EMS) standard: Guideline to implement effective Environment management system, core element of EMS, EMS standard: ISO 14000, its evolution, principle and specification, benefit of EMS. Planning and its implementation, Comparison of other standards with ISO 14000.

Environmental Impact Assessment: EIA definition, its need and principle, scoping, screening and the baseline condition, different methodologies, Impact identification and decision making. EIA case studies in India.

Environment management plan: Planning and identification of baseline condition and impact, monitoring and evaluation of risk, mitigation plan, legislation and environmental audit, disaster management plan, Life cycle assessment and risk analysis.

Environmental management techniques and control measure: Environmental monitoring, modelling and risk assessment. Implementation of sustainable design, control measure for different environment pollution such as air pollution, water pollution, soil and noise pollution.

Learning Resources:

Text Books:

1. Iyyanki V. Muralikrishna and Valli Manickam, Environmental management: Science and Engineering for Industry, Butterworth-Heinemann, 2017.
2. Environmental Management Systems: An Implementation Guide for Small and Medium-Sized Organizations, Second Edition, NSF International, Ann Arbor, Michigan, January 2001

Reference Books:

1. Harry W. Canter, Environmental Impact Assessment, McGraw Hill, 1996, 2nd edition.
2. Rau, J.G. and Wooten, D.C., Environmental Impact Assessment, McGraw Hill Pub. Co., New York, 1996.
3. Anjaneyulu.Y., and Manickam. V., B.S. Environmental Impact Assessment Methodologies, Publications, Hyderabad, 2007.
4. Wathern.P., Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004.
5. ISO 19011: 2002, “Guidelines for quality and/or Environmental Management System auditing, Bureau of Indian Standards, New Delhi, 2002 Paul L Bishop ‘Pollution Prevention: Fundamentals and Practice’, McGraw- Hill international, Boston, 2000.

Other suggested Readings:

1. MEVE-001: Environmental Impact Assessment for Environmental Health - Course (swayam2.ac.in)
2. 120108004.pdf (nptel.ac.in)
3. environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/ommodel2.html
4. environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/ommodel3.html
5. https://nptel.ac.in/courses/120/108/120108004/

SYLLABI

Minor: Civil Engineering

CEM101 **3-0-0 (3)**

Building Construction Practices

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the different components of building
CO-2	Map the geospatial features and Identify different navigation systems and constellations
CO-3	Study the construction practices and techniques for the different components of buildings
CO-4	Comprehend the use of Formwork in construction
CO-5	Plan the sequence of construction of Buildings

Syllabus:

Introduction: Types of Buildings, Components of buildings, Foundation and its functional requirements, Characteristics of soil, types of foundations, construction of foundation

Geomatics and Remote sensing: Definition, disciplines and techniques constituting Geomatics, Elements of Cartography- Earth shape, Reference systems and Coordinate systems, Scale, Map Classification and Map reading. Land Surveying, Principles, Distance measuring instruments and methods, Angle measuring instruments and methods, Leveling and Contouring, Applications, Types of maps, Remote Sensing, Electromagnetic spectrum, Global Navigation Satellite System and Geographical Information System

Masonry: Definitions of terms used in masonry, Materials used, Stone masonry, Brick masonry, Different bonds used for brick masonry.

Floors, Roofs and Staircases: Components of a floor, materials used for floor construction, Different types of flooring, Types of roofs, Basic roofing elements and Roof coverings, Functional requirements of a good stair, type of steps, type of stairs, planning a staircase.

Formwork in Construction: Requirements of Formwork, Types of formwork, Timber, Steel, Modular shuttering, Slip forms, Scaffolding.

Planning for Construction: Selection of site for building construction, Sequence of Construction

Learning Resources:

Text Books:

1. P C Varghese, Building construction, PHI Learning Pvt. Ltd., 2016.
2. B C Punmia, A J Jain and A J Jain, Building construction, Laxmi Publications, 2016.

Reference Books:

1. S P Arora and S P Bindra, The text book of building construction, Dhanpat Rai Publications, 2010
2. Handbook on Building Construction Practices (Excluding Electrical Work), SP62 (1997), Bureau of Indian Standards.
3. B.C. Punmia, A K Jain & A K Jain, Surveying Vol I & II, Laxmi publications (P) Ltd, 2005
4. S.K. Duggal, Surveying Vol. II, Tata McGraw Hill Ltd, 2015
5. Introduction to GIS, Kang-Tsung Chang, Tata McGraw-Hill Publishing Co. Ltd, 8e, 2016
6. M Lillesand and W Kiefer, Remote Sensing and Image Interpretation, John Wiley and Sons, Inc., 2015

Other Suggested Readings:

1. https://www.youtube.com/watch?v=5kt0t5AQBZw
2. https://www.youtube.com/watch?v=XaHpTvUfnfQ
3. https://nptel.ac.in/courses/105/108/105108077/
4. https://nptel.ac.in/courses/105/102/105102015/

CEM102 **3-0-0 (3)**

Elements of Structural Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Visualize, conceptualize and synthesize structural elements
CO-2	Analyse structural elements for bending, shear and torsion
CO-3	Apply design concepts to structural steel elements
CO-4	Apply design concepts to RCC elements

Syllabus:

Introduction to Structural Engineering Concepts: Types of structures, Geometrical and structural classification, Material laws, Laws of structural mechanics, Action and displacement in structures- examples simply supported / hinged beam, Cantilever beam, Use of principle of superposition, Visualize, Conceptualize and Synthesize structural elements.

Concepts of Bending and shear stresses: Assumptions - Theory of Simple Bending - Bending stresses in beams – Flexural shear stress distribution in various shapes of cross section of beams.

Analysis of structural elements: Combined action of bending and shear, shear and torsion, concept of principal stress and strain, structural analysis using tables and charts. Examples on continuous beams.

Methods of Structural steel design and its principles: Introduction-Types of loads- Design Philosophies- working stress method, Limit State Method, Safety factors for Materials and Loads-Indian Standards, Standard sections, General concept in the design of structural elements- tension, compression, beam, column and floor elements.

Concepts of RCC Design: Introduction- Design Philosophies- working stress method, Limit State Method, Safety factors for Materials and Loads-Indian Standards, General concept in the design of structural elements- tension, compression, beam, column and floor elements.

Learning Resources:

Text Books:

1. S Timoshenko, D H Young, J V Rao and S Pati, Engineering Mechanics (In SI Units), McGraw Hill Publishers, 2017.
2. S B Junarkar and H J Shah, Charotar Mechanics of Structures Vol 1 (Strength of Material), Publishing House Pvt. Ltd., 2012.

Reference Books:

1. L S Negi, Design of Steel Structures, Tata Mc Graw Hill Publishers, 2017.
2. Design Of Reinforced Concrete Structures, IS:456-2000, N.Krishnaraju, CBS Publications, 2019.

Other Suggested Readings:

1. https://nptel.ac.in/courses/122/104/122104015/
2. https://nptel.ac.in/courses/112/106/112106180

CEM103 **3-0-0 (3)**

Hydrology and Environmental Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the components of hydrologic cycle
CO-2	Explain the various hydrological processes
CO-3	Estimate yield from surface and subsurface resources
CO-4	Assess water demand and identify the components of water treatment systems
CO-5	Estimate the wastewater quantity and comprehend the components of wastewater treatment systems

Syllabus:

Introduction: Description of Hydrologic Cycle, Components of hydrologic cycle, Forms and types of precipitation, Abstractions from Precipitation, Evaporation, Evapotranspiration, Infiltration process, and effective rainfall.

Stream Flow: flow duration curve and flow mass curve, Hydrograph, Basics of unit hydrograph theory, Concepts of flood routing and flood frequency analysis, Occurrence of groundwater, types of aquifers, aquifer properties.

Estimation of Water Demand: water consumption rate, fluctuations in rate of demand, design period, population forecasting methods, working principles and design of water treatment units, screening, plain sedimentation, sedimentation aided with coagulation, filtration, disinfection, water softening, miscellaneous treatments, water distribution.

Wastewater Collection and Transfer: Preliminary & primary treatment of wastewater, secondary treatment of wastewater, disposal.

Learning Resources:

Text Books:

1. K Subramanya, Engineering Hydrology, Tata McGraw Hill Publications, 2020.
2. H S Peavy, D R Rowe and G. Tchobanoglous, Environmental Engineering, McGraw Hill Education, 2017.

Reference Books:

1. P N Modi, Environmental Engineering (Vol. I): Water supply Engineering, Standard Book House, 2018.
2. S K Garg, Environmental Engineering (Vol.II): Sewage Disposal and Air Pollution Engineering, Khanna Publishers, 1999

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/105/105105201/
2. https://nptel.ac.in/courses/105/106/105106119/

CEM104 **3-0-0 (3)**

Soil and Foundation Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the soil as a natural supporting and construction material
CO-2	Calculate 3-phase soil parameters and classify the soils
CO-3	Apply effective stress principle to engineering works
CO-4	Apply the principles of soil compressibility and settlements
CO-5	Comprehend the significance of shear strength and different types of foundations

Syllabus:

Introduction: Soil formation- Development of soil engineering - Importance of soil engineering- Major soil deposits of India and their engineering concerns.

Phase Soil System: 3-phase diagram, basic definitions and formulations, Index properties and soil classification.

Soil-Water: Types of soil- water, permeability of soils, effective stress principle, Estimation of effective stress for different field conditions.

Compressibility and shear strength of Soils: a) Stresses in soil under applied loads.

b) Compaction of soils – Purpose, IS light and Heavy compaction, compaction quality control.

c) Consolidation of soils- Definitions, total settlement and rate of settlement.

d) Shear strength- Definition and significance of shear strength - Source of shear strength, Mohr's stress circle.

Types of foundations and Bearing Capacity: Importance of bearing capacity, Shallow foundations and Deep foundations, their suitability and selection.

Learning Resources:

Text Books:

1. G Ranjan, A S R Rao, Basic and Applied Soil Mechanics, New Age International Pvt. Ltd, 2016.
2. V N S Murthy, Textbook of Soil Mechanics and Foundation Engineering, CBS, 2018.

Reference Books:

1. B M Das and and N. Sivakugan, Introduction to Geotechnical Engineering, Cengage Learning India Private Limited, 2015.
2. J E Bowles, Foundation Analysis and Design, Mc.Graw Hill Company limited, 1988.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/105/105105168
2. https://onlinecourses.nptel.ac.in/noc21_ce39/preview

CEM105 **3-0-0 (3)**

Transportation Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Differentiate different systems of transportation
CO-2	Estimate travel demand
CO-3	Analyze the traffic flow data and propose road safety measures
CO-4	Design highway geometrics and flexible pavement
CO-5	Appraise different intelligent transportation systems to ensure effective traffic

Syllabus:

Transportation Systems: Role of transport in national development, the transportation system, modes of transportation and their characteristics, urban and regional transportation problems, travel characteristics, transport development plans, highway classification, and network patterns.

Travel Demand: Issues related to regional and urban transportation planning, long-term and short-term plans, travel attributes, data Collection, four stage travel demand forecasting, Trip Generation Model, Trip Distribution Model, Mode Split Model and Traffic Assignment Technique.

Traffic Engineering and Safety: Traffic characteristics, flow-speed-Density, q-k-v relationships, road traffic studies and analysis, hourly design volume, types of intersections and design considerations, Traffic Signs and Signals, road accidents and measures, Road Safety Analysis and Audit.

Highway Design: Highway alignment, engineering surveys, design control and criteria, cross sectional elements, sight distances, design of horizontal and vertical curves. Types of pavement structures, functions of pavement component layer, basic properties of soil, aggregates, and bitumen, overview of bituminous mix design, Design of flexible pavement

Smart Mobility: Intelligent transportation Systems, advanced vehicle control and safety systems, electronic toll collection, Traveler Information System, Autonomous vehicles, electric trucks, hyperloop and drones.

Learning Resources:

Text Books:

1. S K Khanna and C E G Justo and A Veeraragavan, Highway Engineering, Nem Chand and Bros., 2017.
2. L R Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers, 2018.

Reference Books:

1. D J Findley, B J. Schroeder, C H Cunningham, T H Brown, Jr. Maximize., Highway Engineering, 2015.
2. J Sussman, Introduction to Transportation Systems, 2000.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/101/105101087/
2. https://ocw.mit.edu/courses/civil-and-environmental-engineering/

SYLLABI

Honors-1: Construction Technology and Management

CE16001 **3-0-0 (3)**

Construction Techniques

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify various construction techniques and their limitations.
CO-2	Analyze productivity and economics in construction techniques.
CO-3	Comprehend modular construction practices.
CO-4	Implement advanced construction techniques for Civil Engineering projects.

Syllabus:

Prefabricated Structures: Introduction to Prefabricated structures, Planning for pre-casting, Selection of equipment for fabrication, Transport and erection of prefabricated components, Quality measures, Design considerations of precast elements, Safety measure during erection.

Modular Construction Practices: Introduction to Modular Construction, Modular coordination, Modular Standardization, Modular System Building, Limitation and Advantages of Modular Construction

Formwork: Requirements of Formwork, Loads carried by Formwork, Types of Formwork: Timber, Steel, Modular shuttering, Slip forms, Scaffolding, Deep Excavation Methods.

High Rise Buildings: New Design Trends in Geometrical Forms, Construction Techniques of High Rise Buildings, High Rise Construction Techniques, Brick work, Selected High-Tech High-Rise Buildings.

Bridge construction techniques: Introduction, Embankments and Foundations, Conventional Bridge Construction Techniques, Accelerated Bridge Construction, Prefabricated Bridge Construction.

Learning Resources:

Text Books:

1. Robert L.Peurifoy, Clifford, J. Schexnayder, Robert Schmitt and AviadShapira, Construction Planning, Equipment, and Methods, McGraw-Hill Education, 2018, Ninth Edition.
2. S. C. Sharma, Construction Equipment and Management, Khanna Publishing, 2019, First Edition.

Reference Books:

1. Cameron Andres, Ronald Smith and W. Woods, Principles and Practices of Commercial Construction, Pearson, 2018, Tenth Edition.
2. D. S. Vijayan, S. Arvindan and A. Paulmakesh, Construction Materials and Techniques, Notion Press, 2021, First Edition.
   Edward Allen and Joseph Iano, Fundamentals of Building Construction: Materials and Methods, Wiley, 2019, Seventh Edition.

Other Suggested Readings:

1. http://www.sasurieengg.com/e-course-material/CIVIL/III-Year%20Sem%205/CE%206506%20Construction%20Techniques,%20Equipment%20and%20Practice.pdf
2. https://www.nbmcw.com/product-technology/precast/prefabrication-building-construction-an-indian-perspective.html
3. https://www.sciencedirect.com/topics/engineering/prestressed-concrete

CE16003 **3-0-0 (3)**

Lean Construction

Pre-Requisites: **None**

Course Outcomes:

CO-1	Comprehend the principles and concepts in Lean Construction
CO-2	Apply lean techniques in construction projects
CO-3	Demonstrate lean integration aspects
CO-4	Comprehend the application of lean through Information Technology

Syllabus:

Lean Thinking: Introduction to lean concepts and core concepts in lean thinking, Productivity measurements.

Lean Tools in Construction: Work Sampling, process charts, foreman delay survey, Last Planner System, Value stream mapping, 5S, case studies.

Lean Integration: Lean Construction and safety, Lean Construction and sustainable development, Lean and Green, Issues in lean implementation in the construction industry, case studies.

Enabling Lean through Information Technology: Building Information Modelling, Integrated project delivery, case studies.

Value Engineering Techniques in Construction Management: General and Specific Techniques.

Learning Resources:

Text Books:

1. Forbes L., Ahmed, S, Modern Construction-Lean project delivery and integrated practices, CRC Press, New York, 2011.
2. Patricia Tzortzopoulos, Mike Kagioglou and Lauri Koskela, Lean Construction: Core concepts and New Frontiers, Routlege, Taylor and Francis Group, 2020

Reference Books:

1. Shang Gao and Sui Pheng Low, Lean Construction Management: The Toyota Way, Springer, 2014
2. Lincoln H. Forbes and Syed M. Ahmed, Lean Project Delivery and Integrated Practices in Modern Construction, Routlege, Taylor and Francis Group, 2020

Other Suggested Readings:

1. http://www.leanconstruction.org/readings.htm
2. International Labour Organization (work sampling and Process charts

MS16061 **3-0-0 (3)**

Construction Economics and Finance

Pre-Requisites: **None**

Course Outcomes:

CO-1	Prepare income, profit and loss statements and implement construction accounting.
CO-2	Evaluate construction project economics, cost-benefit analysis and Breakeven Analysis.
CO-3	Analyze and evaluate construction risks and uncertainties.
CO-4	Manage working capital and employ budgeting and control.

Syllabus:

Construction Accounting: Income statement and Balance sheet, Depreciation and amortization.

Engineering economics: Time Value of Money, Break even analysis, Benefit-cost analysis.

Capital Budgeting & Methods: Discounted Cash flow, Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Annual Rate of Return (ARR), Risks and uncertainties and management.

Taxation and inflation: Cost Elements, bidding and award revision due to unforeseen causes, escalation. Financial planning, multiple sources of finance, Working capital Management. Budgeting and budgetary control, Project Appraisal and Project yield, Performance – appraisal and project yield.

Learning Resources:

Text Books:

1. Danny Myers, Construction Economics: A New Approach, Taylor and Francis Publisher, 2022.
2. Vazirani and chandola, Construction Accounting and Finance, Dhanpat Rai Publications, 8th edition.

Reference Books:

1. Ofori, G, The Construction Industry Aspects of its Economics and Management, Singapore University Press, 1990.
2. Coombs W.E and W.J Palmer, Construction and Finance Management, Mc-Graw-Hill New York,1994.
3. Halpin, D.W, Financial and Cost concepts for construction Management, John Wiley & sons, New York,1985.

Other Suggested Readings:

1. https://www.financialexpress.com
2. https://economictimes.indiatimes.com
3. https://www.coursera.org › learn › construction-finance

CE16002 **3-0-0 (3)**

Contract Management and Arbitration

Pre-Requisites: **None**

Course Outcomes:

CO-1	Prepare contract schedules, notice inviting tender and contract documents.
CO-2	Identify and implement contract formats
CO-3	Implement dispute resolution.
CO-4	Prepare contract management plan as per standards.

Syllabus:

Contract Formats: FIDIC, CPWD, Special Conditions of Contract (SCC)

Construction contracts: Types of Contracts, Contract specification, types of contract documents used for construction, Contract Procedure, RED Flag Clauses.

Claims and Disputes during Execution Construction Contracts: Claims, Claim Management, Disputes, arbitration and litigation procedure-preparation, settlement, evidence.

Contract Execution: Roles & Responsibilities, Contractor's Liabilities

Contracts – Change Management: Change Management Process & Procedures, Contract Communication & Documentation

Professional Ethics in Construction Industry: Significance of Ethical Practice in an Organization, Professionals and Professional Ethics in Construction Industry, Social Values in Construction, Impact of Professional Ethics on Construction Quality, Code of Ethics, Causes of Unethical Conduct and Ways to Minimize Unethical Conduct.

Learning Resources:

Text Books:

1. B.S. Ramaswamy, Contracts and Their Management, Lexis Nexis, 2016, First Edition.
2. Rashid Hussain, Contracts Management A Life Cycle, 3C Corporate Consulting Contracting, 2020, First Edition.

Reference Books:

1. Arvind Gavade, SunitDhere, Content of Construction Contracts, 2018, First Edition.
2. John Mullen and Peter Davison, Evaluating Contract Claims, Wiley-Blackwell, 2019, Third Edition.
3. J. Roger Knowles, 200 Contractual Problems and their Solutions, Wiley-Blackwell, 2012, Third Edition.
4. Andy Hewitt, Construction Claims and Responses: Effective Writing and Presentation, Wiley-Blackwell, 2016, Second Edition.
5. Brian Greenhalgh, Introduction to Construction Contract Management, Routledge, 2016, First Edition.
6. Geoff Powell, Palgrave Macmillan, Construction Contracts Preparation and Management: From concept to completion, 2016, First Edition.

Other Suggested Readings:

1. Acts and Contract Documents: The Indian Contract Act, 1872. https://legislative.gov.in/sites/default/files/A1872-09.pdf
2. The Arbitration and Conciliation Act, 1996 as amended on Dec 2015. https://lawmin.gov.in/sites/default/files/ArbitrationandConciliation.pdf

3. General Conditions of Contract for Central P.W.D. Works, 2014. http://cewacor.nic.in/Docs/TendersArchieve/ArchieveTender2018/CWVASHITENDER_241218.pdf
4. FIDIC Conditions of contract – Red Book – 1999. https://lauwtjunnji.weebly.com/uploads/1/0/1/7/10171621/fidic_-_conditions_of_contract_for_construction_for_building_and_engineering_works_designed_by_the_employer_(1999).pdf

CE16004 **3-0-0 (3)**

Construction Equipment Management

Pre-Requisites: **None**

Course Outcomes:

CO-1	Select construction equipment appropriate to tasks.
CO-2	Determine equipment ownership and operating costs.
CO-3	Evaluate useful life of equipment and conclude replacement policy
CO-4	Measure the output of equipment based on its performance out of fleet

Syllabus:

Equipment Economics: Equipment Records, Cost of Capital, Elements of Ownership Cost, Operating Cost, Replacement Decisions, Rent and Lease Considerations.

Planning for Earthwork Construction: Planning, Graphical Presentation of Earthwork, Earthwork Quantities, Mass Diagram, Pricing Earthwork Operations.

Compaction and Stabilization Equipment: Compaction of Soil and Rock, Types of Compacting Equipment, Dynamic Compaction, Stabilizing soils with Lime, Cement Soil Stabilization.

Mobile Equipment Power Requirements: Required Power, Available Power, Usable Power, Performance Charts.

Dozers, Scrapers, Excavators: Introduction, Performance Characteristics of Dozers, Pushing Material, Land Clearing, Scraper Types, Operation, Performance Charts, Production Cycle, Hydraulic Excavators, Shovels, Hoes.

Trucks and Hauling Equipment, Finishing Equipment: Trucks, Productivity, Performance Calculations, Graders, Trimmers.

Lifting Equipment and Concreting Equipment: Types of Cranes, Batching equipments, Concrete Mixtures, Vibrators.

Learning Resources:

Text Books:

1. Gransberg, D. D., & Rueda- Benavides, J. A., Construction equipment management for engineers, estimators, and owners, CRC Press, 2020, 2nd Edition.
2. Peurifoy, R. L., Schexnayder, C. J., Schmitt, R. L., Construction planning, equipment, and methods, McGraw-Hill Education, 2018, 9th Edition.

Reference Books:

1. Sharma S.C. Construction Equipment and Management, Khanna Publishers New Delhi, 2019, 1st Edition.
Schaufelberger, J.E. and Migliaccio, Construction equipment management,Routledge, 2019, 1st Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/103/105103206/

SYLLABI

Honors-2: Engineering Structures

CE26001 **3-0-0 (3)**

Theory of Elasticity

Pre-Requisites: **None**

Course Outcomes:

CO1	Comprehend the basic concepts of Continuum Mechanics of Solids including stresses and strains
CO2	Model and analyze homogenous and isotropic plane elastic problems
CO3	Apply analytical techniques to predict Deformation and Internal forces
CO4	Solve engineering problems such as thick cylinders, rotating discs, shafts under complex loading.

Syllabus:

Introduction: Assumptions, Necessary and sufficient conditions, Stress at a point - Normal thrust and Shear stress, Orthogonal Transformation of axes.

Stress invariants: Principal Stresses and Planes. Cauchy's Concoid, Lames Expression Maximum Shear Stresses - Tresca's criteria, Octahedral stresses and planes, deviatoric stresses, Von-Mises criteria, Strain at a point.

Normal and Shear Strain: Generalized Hooke's Law, stress and Strain in three dimensions, Equilibrium conditions in three dimensions, Compatibility conditions in three dimensions, stress tensor, strain tensor, principal stress and strain, maximum shear stress and strain tensor for Plane Stress and Plane Strain cases.

Equations of equilibrium and Compatibility of strain in two dimensions: Boundary Conditions, Governing Differential equation in Cartesian coordinates, Stress analysis in three dimensions and plane cases.

Airy's Stress function: boundary conditions, equilibrium equations, compatibility conditions, Solution to stress analysis problem using method of polynomials, In-direct method, Semi-Inverse method.

Two dimensional problems in rectangular and polar Coordinates: Stress distribution in radially symmetric problems-Thick cylinder, Rotating Discs, Rotating Shafts.

Learning Resources:

Text Books:

1. S. Timoshenko and J N Goodier, Theory of Elasticity, McGraw Hill Education; 2017, 3rdEdition.
2. G.Sitharam, L.Govinda Raju, Theory of Elasticity, Springer, 2021.

Reference Books:

1. L.S. Srinadh, Advanced Mechanics of Solids, McGraw Hill, Delhi 2009, 3rdEdition.
2. A. E. H. Love, A Treatise on the Mathematical Theory of Elasticity, Cambridge University Press, 2013.
3. Applied Elasticity, Matrix and Tensor Analysis of Elastic Continuum, John D Renton, Horwood Publishing Limited, 2ndEdition 2005.
4. N.Krishna Raju, Advanced Mechanics of Solids and Structures, McGraw Hill Education(India) Pvt. Ltd, 2018.
5. https://www.classcentral.com/course/swayam-theory-of-elasticity-20013

CE26003 **3-0-0 (3)**

Behavior of Concrete Structures

Pre-Requisites: **None**

Course Outcomes:

CO1	Apply principles of structural concrete and behaviour of beams in flexure.
CO2	Analyze the behavior of beams in shear and torsion.
CO3	Design columns under combined loading.
CO4	Analyze RC slabs using yield line theory

Syllabus:

Introduction: A brief review of Limit State Design Philosophy-Stress block parameters - Application to beams.

Behaviour of RC Members in Shear and Torsion: Kani's theory for shear - Skew bending theory for torsion - Different modes of failure in torsion and bending - Design of beams in combined Shear, Bending, and Torque as per I.S. code.

Behaviour of slender Columns: Rectangular and circular columns - Interaction diagrams - Biaxial bending - Interaction surfaces - Design for bi-axial bending.

Design of Statically Indeterminate RC Structures: Development of moment curvature diagrams - moment redistribution - Baker's method of design - Ductile Detailing of RC Structures – Earthquake and fire - Confined concrete - Cambridge method of design - Generation of load-deflection diagrams.
Yield line theory of Slabs: Methods of Analysis- Analysis of two way of slabs- square and rectangular slabs.
Serviceability design of RC Structures: Serviceability - Deflection- Short term-Long term deflection due to Shrinkage, Creep- Cracking-Crack width calculation.

Learning Resources:

Text Books:

1. R. Park and T. Paulay, Reinforced Cement Concrete Structures, MISL-WILEY Series, Wiley India Pvt. Ltd, 2009.
2. E.G. Nawy, Reinforced Concrete: A fundamental Approach, CRC Press, 2002,5thEdition

Reference Books:

1. N Krishna Raju, Design of Reinforced Concrete Structures: IS:456-2000, CBS Publishers &Distributors; 2019, 4thEdition.
2. C K Wang, C G Salmon, "Reinforced Concrete Design", 6thEdition John Wiley & Sons 1998.
3. Devdas Menon and S. Pillai,_Reinforced Concrete Design, , McGraw Hill, 2017, 3rdEdition.

Online Resources:

https://nptel.ac.in/courses/105/105/105105104/
https://nptel.ac.in/courses/105/105/105105105/
https://nptel.ac.in/courses/105/106/105106117/

CE26005 **3-0-0 (3)**

Structural Dynamics

Pre-Requisites: **None**

Course Outcomes:

CO1	Model and Formulate dynamic equilibrium equations for SDOF and MDOF systems.
CO2	Analyze SDOF systems for harmonic & arbitrary excitations
CO3	Perform modal analysis and Compute response of Structural systems using mode superposition
CO4	Analyze the effects modal parameters on dynamic response

Syllabus:

Single Degree of Freedom Systems:

- Equation of motion (EOM), Natural Frequency, D'Alemberts Principle of dynamic equilibrium
- **Free Vibration** :
  Equation of motion (EOM), solution methods for undamped and damped structural system.
- **Forced Vibration**:
  Response of SDOF system subjected to Harmonic/ periodic excitation for undamped and damped structural system.

Forced harmonic vibration with viscous damping,

- Effect of Damping factor on steady state response and Phase angle.

Base Excitation,

- Vibration isolation and transmissibility

Response of SDOF system subjected to arbitrary excitation,

- Duhamels Integral, Concept of Response Spectrum.

Multi-degree of freedom System

- Equation of motion (EOM) and undamped free vibration, solution methods for undamped and damped structural system. Free vibration response subjected to initial conditions.

Modal Analysis & general property matrices of vibration systems,

- Eigen value problem in Vibration analysis.
- Analysis of dynamic response by Mode superposition approach for MDOF system

Vibrations of Continuous Systems:

- Vibration Analysis of simple structural systems,
- Introduction to Approximate methods.

Learning Resources:

Text Books:

1. Clough and Penzien, Dynamics of Structures, McGraw Hill Book Co., 2015, 5th Edition.
2. A.K. Chopra, Dynamics of Structures (SI Units), Pearson, 2019, 5th Edition.
3. J. Humar, Dynamics of Structures, CBS Press, 2012, 3rd Edition.

Reference Books:

1. R Venkatachalam, Mechanical Vibrations, PHI learning, 2014, 1st Edition.
2. J N Biggs, Introduction to Structural Dynamics, McGraw Hill Book Co., 1964.
3. Patrick Paultre, Dynamics of Structures, Wiley Publishers,2011.
4. John T. Katsikadelis, Dynamic Analysis of Structures, Elsevier Academic Press, 2020

Online Resources:

1. https://nptel.ac.in/courses/105/106/105106151/
2. https://nptel.ac.in/courses/105/104/105104189/

CE26002 **0-0-3 (3)**

Structural Stability

Pre-Requisites: **None**

Course Outcomes:

CO1	Determine critical loads in straight columns under different loading and end conditions.
CO2	Determine the critical loads for discrete and continuous systems.
CO3	Assess the buckling of thin walled bars and lateral buckling of beams.
CO4	Assess the buckling of rectangular plates and cylindrical shells.

Syllabus:

Buckling of Columns: Critical loads with different end conditions and loading - Inelastic buckling - Energy methods - Prismatic and non-prismatic columns under discrete and distributed loadings - General Principles of elastic stability of framed structures.

Mathematical modelling: Critical loads & Eigenvalue problem for discrete systems - Critical loads & Eigenvalue problem for continuous systems - Orthogonality relation - converting continuous problem to a discrete problem.

Buckling of Thin Walled Members of Open Cross Section: Torsion of thin-walled bars - Warping - Non-uniform torsion - Tensional buckling under axial loading - Combined bending and torsion buckling.

Lateral Buckling of Beams: Beams under pure bending - I Beams under transverse loading - Energy methods.

Buckling of Plates and Shells:Buckling of Rectangular Plates with various boundary conditions, Introduction to buckling of axially compressed cylindrical shells.

Learning Resources:

Text Books:

1. S. Timoshenko and J Gere, Theory of Elastic Stability, McGraw Hill Education;2017, 2nd Edition.
2. Alexander Chajes, Principles of Structural Stability Theory, Prentice Hall Inc., 1974.
3. N. G. RIyengar, Structural Stability of Columns and Plates, Ellis Horwood Ltd, 1988.

Reference Books:

1. George J. Simitses and Dewey H. Hodges, Fundamentals of Structural Stability, Butterworth-Heinemann, 2006.
2. Theodore V. Galambos Andrea E. Surovek, Structural Stability Of Steel: Concepts And Applications For Structural Engineers, John Wiley & Sons, Inc., 2008
3. A.H. Chilver, Thin Walled Structures, Chatto and Windus Ltd., 1967.
4. Coxhl, H.L., The Buckling of Plates and Shells, Pergaman press, 1963.
5. Stephen H. Crandall, Engineering Analysis - A Survey of Numerical Procedures, Krieger Publishing Co.,1986.
6. Bleich, Buckling of Metal Structures, McGraw Hill Book Co., New York, 1952.
7. https://nptel.ac.in/courses/105/108/105108141/

CE26004 **0-0-3 (3)**

Finite Element Analysis of Structures

Pre-Requisites: **None**

Course Outcomes:

CO1	Discretize structural systems.
CO2	Develop the shape functions for different elements.
CO3	Apply constitutive relations to solve structural engineering problems.
CO4	Apply Finite Element concepts to solve trusses, beams and frames.

Syllabus:

Introduction: Background and general description of the method – Applications.

Methods of Structural Analysis: Review of various classical methods of Structural analysis- Matrix methods- Stiffness and Flexibility methods.

Theory of Finite Element method: Variational method-Discretisation concept- Concept of element – various elements shapes – displacement models – Convergence- shape functions.

Finite Element Analysis: Development of shape functions for different elements-Spring-Truss-Beam-Plane elements- Plane stress and plane strain-Assemblage of elements construction of stiffness matrix and loads – boundary conditions –patch test-solution of overall problem.

Isoparametric Formulation: Concept of Isoparametric element – One and Two dimensional elements-Natural coordinates- Development of Higher order elements- Lagrange –Serendipity –Interpolation-formulation of element stiffness and loads.

Application to Solid Mechanics problems: Analysis of Trusses – Beams – Frames – Plates– Axisymmetric elements.

Learning Resources:

Text Books:

1. C Krishnamoorthy, Finite Element Analysis: Theory and Programming, McGrawHillPub., 2017, 2nd Edition.
2. Tirupathichandra Patlaand Belugundu, Introduction to Finite elements in Engineering, Pearson, 2015, 4th Edition.
3. S.S.Rao, The Finite element Method in Engineering, Elsevier Publication,2020, 6thEdition.

Reference Books:

1. O.C. Zeinkiewicz, Finite Element Method: Its Basic and Fundamentals, Butterworth Heinemann, 2007, 6th Edition.
2. Connie McGuire, Finite Element Method: Concepts and Applications, Clanrye International, 2019.
3. R D Cook, Concepts and Applications of Finite Element Analysis, Willey Publication, 2007, 4th Edition.
4. P. Seshu, Textbook of Finite Element Analysis, PHI Pub., 2003
5. J. N. Reddy, Introduction To Finite Element Method, McGrawHillPub., 2020, 4th Edition,
6. David Hutton, Fundamentals of finite element analysis, McGrawHillPub., 2017.
7. Bathe K J, Numerical Methods in Finite Element Analysis, Prentice-Hall civil engineering and engineering mechanics series, 2016.
8. https://nptel.ac.in/courses/105/105/105105041/

SYLLABI

Honors 3: Environmental Engineering

CE 36001 **3-0-0 (3)**

Environmental Chemistry and Microbiology

Pre-Requisites: **None**

Course Outcomes:

CO1	Apply fundamental chemical principles to environmental engineering problems
CO2	Analyze thermodynamic and kinetic processes in environmental systems
CO3	Evaluate and implement water and wastewater treatment techniques
CO4	Appreciate and apply microbiological concepts in environmental engineering
CO5	Integrate concepts of organic chemistry and environmental chemistry in pollution control

Syllabus:

General Chemistry: Basic principles – chemical equations – formulation, balancing, and types of chemical reactions, calculations from chemical equations, Gas laws; Equilibrium and Le Chatelier's Principle – factors affecting chemical equilibrium, activity and activity coefficient, ionic strength and its effects on reactions.

Physical Chemistry: Thermodynamics – concepts of heat and work, enthalpy, entropy, free energy, temperature dependence of equilibrium constant; Membrane processes; Principles of solvent extraction; Electrochemistry; Chemical kinetics; Adsorption.

Equilibrium Chemistry: Equilibrium relationships -variation and ways of shifting chemical equilibrium; Solutions to equilibrium problems - acid base equilibrium, solubility equilibrium, oxidation reduction equilibrium.

Organic Chemistry and Biochemistry: Organic compounds of interest – general properties and environmental relevance of functional groups; Enzymes – classification, enzyme-catalyzed reactions, energy considerations; Biochemical reactions - breakdown and synthesis of carbohydrates, fats, proteins under aerobic and anaerobic reactions, CNP cycles under aerobic and anaerobic reactions; Concepts of BOD, COD, TOC.

Environmental Chemistry: Surface and colloidal chemistry – fundamentals and environmental applications; Chemistry involved in water treatment; Atmospheric chemistry; Soil chemistry; Emerging pollutants.

Environmental Microbiology: Introduction of microbiology - classification and characterization of microorganisms, including viruses; Bacterial Morphology and structure - nutrient requirement and growth of bacteria; Microbiology of water and sewage; Plankton analysis; Analysis of specific microorganisms; Microbial metabolism; Microbiology of water, wastewater, soil and air.

Learning Resources:

Text Books:

1. Sawyer, C. N., McCarty, P. L., and Perkin, G.F.,Chemistry for Environmental Engineering and Science, McGraw Hill Education, 2017, 5th Edition
2. Pelczar, M.J.Michael, Chan, E.C.S., and Krieg, N.R, Microbiology, The McGraw-Hill Education, 2021, Indian edition

Reference Books:

1. Benefield D. L., Judkins F. J., Weand L. B., Process Chemistry for Water and Wastewater Treatment, Prentice Hall, 1982, 1st Edition
2. Tortora GJ, Funke BR, and Case CL, Microbiology: An Introduction, Pearson Education, 2019, 4th Edition
3. NPTEL: Environmental Chemistry and Microbiology, IIT Kharagpur
4. NPTEL: Environmental Chemistry and Analysis, IIT Madras

CE 36003 **3-0-0 (3)**

Water Supply Systems

Pre-Requisites: **None**

Course Outcomes:

CO1	Plan water supply systems for a community
CO2	Analyze water quality and propose water treatment train
CO3	Design various components of a water treatment plant
CO4	Design advanced treatment systems for the removal of specific contaminants
CO5	Analyze and design water distribution systems
CO6	Plan an appropriate water reuse system

Syllabus:

Need for Transport of water- Water quality- Planning of water supply systems

Intake structures, Selection of pipe materials, Water transmission main design- Gravity and pumping main; Selection of Pumps- Characteristics-Economics; Jointing, Laying and Maintenance, Water hammer analysis; Water distribution pipe networks- Design, analysis and optimization –Appurtenances –Corrosion prevention – Minimization of water losses – Leak detection- SCADA systems- Storage reservoirs-

Water treatment: Screening – Mixing- Equalization – Sedimentation – Coagulation, Flocculation- Filtration– Back washing –Membrane separation- Reverse Osmosis- Nano filtration, Ultra filtration-Electro dialysis- -Specific contaminant removal systems- Disinfection- Distribution

Water reuse/recycle- Sludge thickening-Sludge dewatering systems-Sludge drying beds- Recent Advances.

Use of computer software in water transmission and water distribution systems.

Learning Resources:

Text books:

1. Mackenzie L. Davis,Water and Wastewater Engineering: Design Principles and Practice, McGraw Hill, 2010.
2. Howard S. Peavy, Donald R. Rowe and George Tchobanoglous, Environmental Engineering, McGraw Hill., 2017

Reference Books:

1. Viessman Jr, Hammer J. M, Perez, E.M, and Chadik, P. A,Water Supply and Pollution Control, PHI Learning, New Delhi, 2009
2. WATER QUALITY& TREATMENT AWWA Hand book, McGraw Hill, 2011.
3. Larry W. Mays, Urban Water Supply Handbook, McGraw Hill, 2002.
4. Computer modelling of water distribution system, AWWA manual of water supply practice, 2005.

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc20_ce23/preview
2. https://ocw.mit.edu/courses/urban-studies-and-planning/11-479j-water-and-sanitation-infrastructure-in-developing-countries-spring-2007/readings/hwts_paper.pdf
3. http://www.who.int/water_sanitation_health/dwq/WSH02.07.pdf

CE 36005 **3-0-0 (3)**

Solid Waste Management

Pre-requisites: **NONE**

Course Outcomes:

CO1	Identify various types of solid wastes and their sources
CO2	Examine the physical and chemical composition of wastes
CO3	Analyze the activities associated with the management of solid waste
CO4	Evaluate the techniques and methods used in recovery of materials and energy from solid wastes
CO5	Design a sanitary landfill for disposal of solid waste
CO6	Categorize and manage the hazardous waste

Syllabus:

Solid Waste: Definitions, Characteristics, and Perspectives: Types of solid wastes, sources of solid wastes, properties of solid wastes, solid waste management: an overview

Engineering Systems for Solid Waste Management: Solid waste generation; on-site handling, storage and processing; collection of solid wastes; transfer and transport; processing techniques; ultimate disposal; Integrated SW Management concepts

Engineering Systems for Resource and Energy Recovery: Processing techniques; RRR approach, materials-recovery systems; recovery of biological conversion products; recovery of thermal conversion products; recovery of energy from conversion products; materials and energy recovery systems.

Engineering Disposal of SW: Dumping of solid waste; sanitary landfills – site selection, design and operation of sanitary landfills – Leachate collection & treatment. Identify methods of solid waste disposal during a site visit and follow safety precautions.

Hazardous Waste Management: Introduction; Concern about Hazardous Waste Management; Characteristics of Hazardous Waste; Transportation and Disposal of Hazardous Waste; Industrial/biomedical waste, E- waste management.

Learning Resources:

Text Books:

1. Tchobanoglous G, Theisen H and Vigil SA, Integrated Solid Waste Management, Engineering Principles and Management Issues, McGraw Hill Education, 2014, Indian Edition
2. John Pichtel, Waste Management Practices: Municipal, Hazardous and Industrial, CRC Press, 2014, 2nd Edition

Reference Books:

1. Vesilind PA, Worrell W and Reinhart D, Solid Waste Engineering, Brooks/Cole Thomson Learning Inc., 2010, 2nd Edition
2. Peavy, H.S, Rowe, D.R., and G. Tchobanoglous Environmental Engineering, , McGraw Hill Education, 2017, 1st Indian Edition
3. Tchobanoglous G and Kreith F, Handbook of Solid Waste Management, , McGraw-Hill Education, 2002, 2nd Edition
4. Qian X, Koerner R M and Gray D H, Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, 2002, 1st Edition
5. LaGrega M.D., Buckingham P.L. and Evans J.C. Hazardous Waste Management, Waveland Pr Inc., 2010, Reissue Edition

6. Richard J. Watts, Hazardous Wastes - Sources, Pathways, Receptors, John Wiley and Sons, 1998, 1st Edition.

Other Suggested Readings:

1. http://cpheeo.gov.in/cms/manual-on-municipal-solid-waste-management-2016.php
2. https://nptel.ac.in/courses/105/103/105103205/
3. https://nptel.ac.in/courses/120/108/120108005/
4. https://nptel.ac.in/courses/105/106/105106056/
5. https://nptel.ac.in/courses/105/105/105105160/
6. https://nptel.ac.in/courses/103/107/103107125/

CE 36012 **3-0-0 (3)**

Air Pollution and Control

Pre-Requisites: **None**

Course Outcomes:

CO1	Identify sampling and analysis techniques for air quality assessment
CO2	Describe the plume behaviour for atmospheric stability conditions
CO3	Apply plume dispersion modelling and assess the concentrations
CO4	Design air pollution controlling devices

Syllabus:

Air Pollution: Definition - Sources & Classification of Air Pollutants - Effects of air pollution on humans, plants and materials- Global effects - Air Quality and NAAQS - National Clean air Programme- Sampling of Pollutants in ambient air - Stack sampling

Meteorology and Air Pollution: Factors influencing air pollution, Wind rose, Mixing Depths, Lapse rates and dispersion - Atmospheric stability, Plume rise and dispersion, Prediction of air quality, Box model - Gaussian model - Dispersion coefficient - Application of tall chimney for Pollutant dispersion.

Control of Particulate Pollutants: Properties of particulate pollution - Particle size distribution - Control mechanism - Dust removal equipment - Design and operation of settling chambers, cyclones, wet dust scrubbers, fabric filters & ESP.

Control of Gaseous Pollutants: Process and equipment for the removal by chemical methods - Design and operation of absorption and adsorption equipment - Combustion and condensation equipment.

Learning Resources:

Text Books:

1. Khare M, Sharma P, Kota, S.H, Sumanth C, Air Pollution Science Engineering and Management Fundamentals, ISBN 9780367750527, CRC Press, 2024.
2. Noel, D. N., Air Pollution Control Engineering, ISBN 978-0070393677, Tata McGraw Hill Publishers, 1999.

Reference Books:

1 Colls, J., Abhishek T, Air Pollution: Measurement, Modeling and Mitigation, ISBN13: 978-0- 415-47932-5 CRC Press, 2009
2 Boubel, R.W., Fox, D.L., Turner, D.B. and Stern, A.C. Fundamentals of air pollution, 1994. 3rd Edition, Academic Press, New York

Other Suggested Readings:

1. https://nptel.ac.in/courses/105102089
2. https://indair-neeri.res.in/

CE 36004 **3-0-0 (3)**

Wastewater Treatment Systems

Pre-requisites: NONE

Course Outcomes:

CO1	Identify and assess the characteristics of wastewater and their impacts
CO2	Plan and design the components of wastewater treatment systems
CO3	Comprehend the underlying principles of processes involved in secondary wastewater treatment systems.
CO4	Design sludge treatment and disposal methods.

Syllabus:

Introduction: Wastewater Sources and flow rates, Characteristics, Standards of Disposal, Treatment Objective and Strategies, Sanitary sewer design, Head works and Preliminary design, Layouts of Primary, Secondary and Advanced Treatment Units. Quantity estimation

Design Of Preliminary and Primary Treatment Operations: Screens, Grit Chambers, Skimming Tank, Primary and Secondary Sedimentation Tanks.

Biological Treatment Processes: Types, Kinetics of Plug Flow and Completely Mixed Systems for aerobic and anaerobic systems.

Attached Growth Processes: Trickling Filters (Standard Rate, High Rate), Biofilters, Practices, Features and Design, Operational Difficulties and Remedial Measures, Rotating Biological Contactors.

Suspended Growth Processes: Activated Sludge Process, Modifications and Design Equations, Process Design Criteria, Oxygen and Nutrient Requirements – Classification and Design of Oxidation Ponds, Lagoons, Root Zone Treatment Systems, Membrane bio reactors, fluidized bed reactors, Hybrid Systems.

Sludge Treatment and Disposal: Sludge Thickening, Aerobic and Anaerobic Sludge Digestion Processes, Design of Digester Tank, Sludge Dewatering, Ultimate Disposal, Other Methods of Sludge Treatment.

Learning Resources:

Text books:

1. Metcalf and Eddy, Wastewater Engineering – Collection, Treatment, Disposal and Reuse, 5th Ed., McGraw Hill Pub. Co., 2014
2. Mackenzie L. Davis, Water and Wastewater Engineering: Design Principles and Practice McGraw Hill, 2010.

Reference Books:

1. Benefield L.D. and Randall C.D, Biological Process Designs for Wastewater Treatment, Prentice Hall Pub. Co., 1980
2. Udo Wiesmann, In Su Choi and Eva-Maria Dombrowski, Fundamentals of Biological Wastewater Treatment, 1st Ed., Wiley, 2007
3. Tchobanoglous, G. et al, 5th Edition, Metcalf & Eddy, Inc. Wastewater Engineering: Treatment, Disposal, and Reuse, McGraw-Hill Publishers, New York, 2013.
4. Crittenden, J.C., et al. Water Treatment Principles and Design, 2nd Ed., Montgomery, Inc., John Wiley and Sons, New York, 2005.
5. Reynolds, T.D., Richards, P.A, Unit Operations and Processes in Environmental Engineering, PWS Publishing Company, Boston, 1996

Other Suggested Readings:

1. www.indair-neeri.res.inhttps://nptel.ac.in/courses/105/105/105105178/
2. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-85-water-and-wastewater-treatment-engineering-spring-2006/lecture-notes/
3. https://onlinecourses.nptel.ac.in/noc21_ce25/preview

SYLLABI

Honors-4: Geoinformatics

CE46001 **3-0-0 (3)**

Principles of Remote Sensing

Pre-Requisites: **None**

Course Outcomes:

CO-1	Select the type of remote sensing data for mapping earth surface features
CO-2	Analyze the energy interactions with the atmosphere and earth surface features
CO-3	Identify the earth surface features from satellite images
CO-4	Apply remote sensing techniques for natural resources evaluation

Syllabus:

Chapter-1 Physics of Remote Sensing: Sources of Energy, Active and Passive Radiation, Electromagnetic Radiation - Reflectance, Transmission, Absorption, Thermal Emissions, Interaction with Atmosphere, Atmospheric windows, Spectral reflectance of Earth's surface features, and Multi concept of Remote Sensing

Chapter-2 Platforms and Sensors: Various types of platforms, different types of aircraft, manned and unmanned spacecrafts used for data acquisition - characteristics of different types of platforms - airborne and spaceborne, IRS Satellite Sensors, LANDSAT, SPOT, IKONOS, Quickbird, Geoeye, Kompsat, Worldview II & III, Microwave, ALOS, Planet Data, Sentinel, SMAP, MODIS etc.

Chapter-3 Data Acquisition Systems and Applications: Optical, Thermal and Microwave; Resolutions - spatial, spectral, radiometric and temporal, signal to noise ratio, LiDAR data acquisition and processing. Applications of Remote sensing in various Engineering and Science domains such as Agriculture, Forest, Soil, Geology, LU/LC, Water Resources, Urban, Disaster Management, etc.

Chapter-4 Data Products and Image Preprocessing: Data Products and Their Characteristics, Digital image formation, digital image display mechanism, image histograms, look up table data, Pre-processing – Atmospheric, Radiometric, Geometric Corrections - Basic Principles of Visual Interpretation, Ground Truth, Orthorectification, Applications. Supervised and Unsupervised Image Classification.

Learning Resources:

Text Books:

1. James B. Campbell & Randolph H. Wynne., Introduction to Remote Sensing, The Guilford Press, 2022, Sixth Edition
2. Lillesand T.M & Kiefer R.W., Remote Sensing and Image Interpretation, 2015, John Wiley and

Reference Books:

1. Chritian Matzler., Thermal microwave radiation: Applications for remote sensing, 2006, The institution of Engineering and Technology, London
2. Schowengerdt, R. A., Remote Sensing: Models and Methods for Image Processing, 2007, Academic Press
3. Cracknell, A.P., Introduction to Remote Sensing, 2007, Tylor & Francis, Second Edition, London
4. Freek D. van der Meer, Remote Sensing and Digital Image Processing, 2004
5. Introduction to the physics and techniques of Remote Sensing, Charles Elach & Jakob van Zyl., John Wiley & Sons publications, 2006

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/108/105108077/
2. https://nptel.ac.in/courses/105/101/105101206/
3. https://nptel.ac.in/courses/105/107/105107201/

CE46003 **3-0-0 (3)**

Geographical Information Systems

Pre-Requisites: **None**

Course Outcomes:

CO-1	Analyze the basic components of GIS
CO-2	Classify the maps, coordinate systems and projections
CO-3	Process spatial and attribute data and prepare thematic maps
CO-4	Identify and rectify mapping inaccuracies
CO-5	Conceptualize a GIS project

Syllabus:

Chapter- 1 Map: Mapping concepts, analysis with paper-based maps, limitations, Computer Automated Cartography – History and Developments, GIS- Definition, components, advantages of digital maps, projections and coordinate systems.

Chapter- 2 Fundamentals of GIS: Information Systems, Modelling Real World Features Data, Data Models – Spatial and Non-spatial, Components, Data Collection and Input, Data Conversion, Metadata. Vector and raster data models, TIN data model

Chapter- 3 Database Management: Database Structures, Files; Standard Data Formats, Compression Techniques, Hardware and Software. Introduction to popular GIS software like ArcGIS, QGIS.

Chapter- 4 Topology: Types of Errors, Editing and Error Rectification, Types of Topology, Modelling topological Relationships, Tolerances.

Chapter- 5 Spatial Analysis: Proximity Analysis, Overlay Analysis, Buffer Analysis, Network Analysis – Route alignment, Canal alignment; Digital Elevation Models. Map composition, Preparation of qualitative and quantitative maps, levels of maps, map elements and map scales, 3D Analyst, Interpolation Methods.

Chapter- 6 GIS Project Planning and Implementation: Understanding the Requirements, Phases of Planning, Specifications, and Procedure for analysis projects and design projects.

Learning Resources:

Text Books:

1. Kang Tsung Chang., Introduction to Geographic Information Systems, 9th Edition Tata Mc Graw Hill Publishing Company Ltd, New Delhi, 2018.
2. C.P.Lo & Albert K. W.Yeung, Concepts and Techniques of Geographic Information Systems, second Edition, Prentice Hall India Pvt.Ltd, 2016

Reference Books:

1. Burrough, P.A., Principles of GIS for Land Resource Assessment, Oxford Publications, 2005.
2. John E. Harmon & Steven J. Anderson., The design and implementation of Geographic Information Systems, John Wiley & Sons, 2003.
3. Paul Bolstad, GIS Fundamentals: A First Text on Geographic Information Systems, XanEdu Publishing Inc, 6th Edition, 2019.
4. Paul Longley., Geographic Information systems and Science, John Wiley & Sons, 4th Edition,2015.
5. Michael J De Smith (Author), Michael F Goodchild (Author), Paul a Longley, Geospatial Analysis: A Comprehensive Guide, Winchelsea Press, 6th Edition, 2018.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/102/105102015/
2. https://nptel.ac.in/courses/105/107/105107155/
3. https://nptel.ac.in/courses/107/105/107105088/

CE46005 **3-0-0 (3)**

Programming Methods for Geospatial Systems

Pre-Requisites: **None**

Course Outcomes:

CO-1	Prepare the algorithms and programming syntax
CO-2	Develop programs in C++ and Java
CO-3	Apply the concepts of object-oriented programming
CO-4	Design and develop programs for geospatial systems

Syllabus:

Chapter- 1 Oops Concepts: Classes, Objects, Polymorphism, Inheritance, Encapsulation, Overloading.

Chapter- 2 Basics of C++: Elements of C++, input and output statements, decision making, functions, iterations and loops. Objects and Classes.

Chapter- 3 Programming Methods in C++: Operator Overloading. Inheritance. Pointers. Virtual Functions and Other Subtleties; Streams and Files; Multi-file Programs, Templates and Exceptions, Object-Oriented Software Development.

Chapter- 4 Java Scripting Concepts: Data types, variables and arrays, operators, control statements, objects, functions, document object model, event handling, controlling windows and frames and documents, form handling and validations.

Learning Resources:

Text Books:

1. Object Oriented Programming with C++ - TMH, E. Balagurusamy., 7th Edition, 2017.
2. Thomas Powell, Fritz Schneider "JavaScript The Complete Reference" 3rd Edition, TATA McGraw Hill, 2013 ISBN-13: 9781259064685

Reference Books:

1. Object Oriented Programming in C++, Robert Lafore, 4th Edition, Pearson Pub., 2008
   C++ The complete Reference, Herbert Schildt , 4th Edition, 2017.
2. JavaScript: The Good Parts: The Good Parts 1st Edition, Kindle Edition by Douglas Crockford
3. Eloquent JavaScript, 3rd Edition: A Modern Introduction to Programming by Marijn Haverbeke

Other Suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105151/
2. https://onlinecourses.nptel.ac.in/noc21_cs03/preview
3. https://onlinecourses.nptel.ac.in/noc19_cs84/preview
4. https://www.w3schools.com/cpp/default.asp
5. https://www.w3schools.com/java/default.asp
6. https://www.geeksforgeeks.org/c-plus-plus/
7. https://www.geeksforgeeks.org/java/

CE46002 **3-0-0 (3)**

Global Navigation Satellite System

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify GNSS components and their functions
CO-2	Interpret navigation messages and GNSS satellite signals
CO-3	Identify error sources and apply corrections in GNSS observations
CO-4	Process GNSS data for accurate positioning

Syllabus:

Chapter-1 Introduction to GNSS: History of GNSS; GPS system - Services and Segments, GLONASS system- Services and Segments, Galileo System- Services and Segments, Regional Navigation Satellite Systems (RNSS), Augmentation Systems, GAGAN, IRNSS systems.

Chapter-2 Satellite Orbits and Signals: Orbit - Description, Determination and Dissemination. Structure of Signal, Navigation messages.

Chapter-3 Satellite Observables: Pseudo range measurements, Atmospheric effects, Antenna phase center offset and variation, Multipath, system accuracy characteristics, Data formats, Error budget.

Chapter-4 Surveying with GNSS: Planning a GNSS Survey, Positioning methods – point positioning, relative positioning, Static, Differential, RTK, and Field data collection.

Chapter-5 Data Processing: Ambiguity resolution, Post-processing, real-time processing, Accuracy measures, software modules, GIS and GNSS data integration, Applications of GNSS

Learning Resources:

Text Books:

1. Hofmann-Wellenhof, Lichtennegger, and Wasle., GNSS: Global Navigation Satellite Systems, Springer-Verlag Wein, New York, 2008.

2. Gunter Seeber., Satellite Geodesy: Foundations, Methods and Applications, 2003.

3. Shuanggen Jin, Estel Cardellach, and Feiqin Xie., GNSS Remote Sensing: Theory, Methods and Applications, Springer, London, 2017.

Reference Books:

1. Peter J.G. Teunissen, Oliver Montenbruck., Springer Handbook of Global Navigation Satellite Systems, Springer International Publishing, 2017.
2. B. Bhatta., GNSS: Insights into GPS, GLONASS, Galileo, Compass and Others, CRC Press, 2011.
3. Tan, S., GNSS Systems and Engineering: The Chinese Beidou Navigation and Position Location Satellite, John Wiley & Sons, Singapore, 2018.
4. Awange, J. L., Environmental Monitoring using GNSS: Global Navigation Satellite Systems, Springer, London, 2012.

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc21_ce77/preview
2. https://nptel.ac.in/courses/105/107/105107194/
3. https://onlinecourses.swayam2.ac.in/aic23_ge20/preview

CE46004 **3-0-0 (3)**

Geospatial Data Processing & Modeling

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply advanced GIS tools
CO-2	Prepare GIS data for various elevation models
CO-3	Solve geospatial problems using programming tools
CO-4	Analyze GIS data using complex geospatial models

Syllabus:

Chapter- 1 Interpolation Methods: Local and Global methods of Interpolation, Kriging methods, Geo-statistical Methods.

Chapter- 2 DTM Applications: Slope and aspect, viewshed and watershed analysis;

Chapter- 3 GIS Models: Modelling Process; Classification, Types of process models, creating conceptual models,, Model Building Tools GIS software, Cellular Automata Model

Chapter- 4 Programming Tools: Python, R and JavaScript programming concepts for geo-processing application development

Learning Resources:

Text Books:

1. Principles of GIS for Land Resource Assessment, Burrough, P.A., Oxford Publications, 2005.
2. Concepts and Techniques of Geographic Information Systems, C.P.Lo & Albert K. W.Yeung, second Edition, Prentice Hall India Pvt.Ltd, 2016.
3. Maguire, D., M. Batty, and M. Goodchild. 2005. GIS, spatial analysis, and modeling. ESRI Press, 2005

Reference Books:

1. Andrew Crooks, Nick Malleson, Ed Manley, Alison Heppenstall, Agent-Based Modelling and Geographical Information Systems: A Practical Primer (Spatial Analytics and GIS), 2018, 1st Edition, SAGE Publications Ltd
2. Python for Geospatial Data Analysis: Theory, Tools, and Practice for Location Intelligence, 2022 by Bonny P. McClain
3. Learning Geospatial Analysis with Python - Third Edition 2019 by Joel Lawhead

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/102/105102015/
2. https://nptel.ac.in/courses/105/107/105107155/
3. https://nptel.ac.in/courses/107/105/107105088/

SYLLABI

Honors-5: Geotechnical Engineering

CE 56001 **3-1-0 (4)**

Advanced Soil Mechanics

Pre-Requisites: None

Course Outcomes:

CO-1	Characterization of soils and stress distribution in soils
CO-2	Analyse effective stresses in soils for different field conditions
CO-3	Apply three-dimensional consolidation theory for different geotechnical applications
CO-4	Find state of stresses at different stages of loading through stress paths
CO-5	Estimate pore pressure and Hvorslev shear strength parameters
CO-6	Analyse of critical state conditions of soils

Syllabus:

Introduction: Introduction to soils, Deposition and Origin of natural soil, Complexity of soil nature, Soil Structure, Mineralogy and soil Water: Soil mineralogy and structure of clay minerals; classification of soils, Inter-particle forces in soils; Modes of occurrence of water in soils – Absorbed, Adsorbed, Double layer and Capillary water.

Stress distribution: Types of stresses, Estimation of stresses in soils, Isobar and Pressure bulb, Variation of vertical stress under point load along the vertical and horizontal pleas, Newmark's Influence Chart

Effective Stress: The principle and nature of effective stress, Inter-granular pressure, Pore pressure, effective stress under different conditions, Hydrostatics, Vertical & lateral effective stress, Effective stress for partially saturated soils, Quick sand phenomenon

Permeability: Flow through Soils: Darcy's law, Hydraulic conductivity of soils, Steady and Transient flows, seepage analysis, Flownets, Critical hydraulic gradient.

Consolidation: Principle of consolidation-compressibility, Difference between compaction and consolidation, pressure-void ratio relationships, Settlement and Time rate fo consolidation, Terzaghi's one dimensional consolidation parameters, pre-consolidation pressure, Estimation of total Settlement. Two- and three-dimensional consolidation, Secondary compression, methods for accelerating the consolidation settlements, Sand and Wick drains.

Shear Strength: Basic concepts, Mohr-Coulomb theory; measurement of shear strength, drainage conditions, stress paths, pore pressure parameters; Shear strength of cohesionless soils – Friction between solid surfaces, Factors affecting strength and deformation, Shear strength of saturated cohesive soils – Effective stress water content relationship, Hvorslev Shear strength parameters; Shear strength of Partially Saturated soils.

Critical State Soil Mechanics: Critical state concept and its importance, Parameters relevant to critical state, Analysis of critical state, Critical state for NC and OC soils, Yielding and boundary surfaces.

Learning Resources:

Text Books:

1. Das, BM, Advanced Soil Mechanics, CRC Press, London & NewYork, 2020, 5thEdition.
2. Murthy V.N.S, Soil Mechanics and Foundation Engineering, CBS publications, New Delhi, 2018.
3. Karl Terzaghi, Ralph B Peck, and Gholamreza Mesri, Soil Mechanics in Engineering Practice, , Wiley, 2009, 3rd Edition.

Reference Books:

1. Gopal Ranjan and Rao ASR Basic and applied soil mechanics, , New age Publications, Delhi, 2016, 3rd Edition.
2. Richard L Handy, Foundation Engineering – Geotechnical Principles & Practical applications, Mc Graw Hill, New York, 2020.
3. Malcom Bolton, A guide to Soil Mechanics, University Press, 1991
4. IS 2720 (Part 1 to 41): Methods of tests for Soils.
5. IS 8009: Code of Practice for calculation of Settlement of Foundations, 1976.
6. William Lamb and Robert V Whitman, Soil Mechanics, Wiley, 2012.
7. Shashi K Gulhati and Majoj Dutta, Geotechnical Engineering, Mc Graw Hill, New Delhi, 2017.
8. D.M. Wood, Soil Behaviour and Critical State Soil Mechanics, Cambridge University Press, 1994.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/104/105104162/
2. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-361-advanced-soilmechanics-fall-2004

CE 56003 **3-1-0 (4)**

Ground Improvement Methods

Pre-Requisites: None

Course Outcomes:

CO-1	Identify solutions for difficult ground conditions in engineering practice
CO-2	Comprehend different ground improvement techniques
CO-3	Propose site specific method of improvement and its design
CO-4	Promote wider use of techno–economical construction techniques such as soil nailing and confinement methods.
CO-5	Effective alternate techniques for soft soil problems

Syllabus:

Introduction to Ground Modification: Need and objectives of Ground Improvement, Classification of Ground Modification Techniques – suitability and feasibility, Emerging Trends in ground improvement.

Mechanical Modification: Methods of compaction, Shallow compaction, Deep compaction techniques – Vibro-floatation, Blasting, Dynamic consolidation, pre-compression and compaction piles, Field compaction control and geomaterial replacement concept.

Hydraulic Modification: Methods of dewatering – open sumps and ditches, Well-point system, Electro-osmosis, Vacuum dewatering wells; pre-loading without and with sand drains, strip drains and rope drains, vertical drains.

Admixture Stabilization: Stabilisation with admixtures like cement, lime, calcium chloride, fly ash and bitumen; Grouting: Categories of grouting, Art of grouting, Grout materials, Grouting techniques and control.

Reinforced Earth Technology: Concept of soil reinforcement, reinforcing materials, backfill criteria, art of reinforced earth technology, design and construction of reinforced earth structures, soil nailing.

Ground Anchors: Types of ground anchors and their suitability, Uplift capacity of anchors.

Geo-materials Confinement Systems: Concept of confinement, Gabion walls, Crib walls, Geo-bags, Sand bags, Fabric form work.

Alternate Techniques: Expansive Soil problems and Foundation Techniques, Construction and application of stone columns in soft clays

Learning Resources:

Text Books:

1. Manfred R. Haussmann, Engineering principles of ground modification, Pearson Education Inc. New Delhi. 2008.
2. Bell, F.G. E & FN Spon, Engineering Treatment of Soils, New York, 2006.
3. Purushothama Raj P, Ground Improvement Techniques, Laxmi Publications (P) Limited, 2006.

Reference Books:

1. Jie Han, Principles and Practice of Ground Improvement, John Wiley & Sons, Inc.,2007.
2. Anjan Patel, Geotechnical Investigations and Improvement of Ground Conditions, Woodhead Publishing Series in Civil and Structural Engineering, 2006, 1st Edition.
3. Ground Improvement, Klaus Kirsch and Alan Bell, 2004, 3rd Edition.
4. https://nptel.ac.in/courses/105/108/105108075/

CE 56005 **3-0-0 (3)**

Geotechnical Exploration and Instrumentation

Pre-Requisites: None

Course Outcomes:

CO-1	Implement various exploration methods in soil and rock
CO-2	Prepare bore log for sub-soil strata
CO-3	Apply relevant instrumentation for Geotechnical Engineering works
CO-4	Interpret field and laboratory data and prepare soil investigation report

Syllabus:

Introduction: Soil Formation, types of soils, physical and chemical weathering, soil transport, deposition and stratification phenomena and Soil Classification.

Methods of Soil Exploration: Methods of Boring, Auguring and Drilling. Machinery used for drilling, types of augers and their usage for various projects.

Soil Sampling: sampling methods, types of samples, storage of samples and their transport. Sample preparation, sample sizes, types of sampler's specifications for testing.

Borehole Logging: Logging of Boreholes - logging methods - Groundwater observations – Water table fluctuations and effects - Preparation of soil profiles and exploration report.

Field testing of soils: methods and specifications – visual identification tests, standard penetration test (SPT), plate load test (PLT), pressuremeter test (PMT) Dilatometer test (DMT) vane shear test (VST), Cone penetration test (CPT), Becker penetration test (BPT), analysis of test results. Geophysical methods of soil exploration- seismic refraction, electrical resistivity, cross hole test.

Report writing: Soil exploration Reports- identification, calculations and preparation.

Field Instrumentation: Strain gauges, Piezometer, Pressure cells, Inclinometers, proving ring, load cells, displacement gauges.

Learning Resources:

Text Books:

1. Site Investigation, Clayton C. R., Matthews M. C and Simons N. E., Blackwell Science. 2005
2. Geotechnical Instrumentation for Monitoring Field Performance, John Dunn cliff, Wiley-Interscience, 2008
3. Basic and Applied Soil Mechanics- A.S. Rao and Gopal Ranjan, New Age International.

Reference Books:

1. Soil mechanics and Foundation Engineering, Muni Budha, John Wiely and sons, 2010, 3rd Edition.
2. Ground Property Characterization from In-Situ Testing, M. D. Desai, IGS-Surat Chapter, 2005.
3. IS:1892-Code of Practice for subsurface investigation for foundation, 1979.
4. IS:4453-Subsurface Exploration by Pits, Trenches, Drifts and Shafts - Code of Practice, 2009.
5. IS:1888-Method of Load Test on Soils, 1982.
6. IS:2131-Method for Standard Penetration Test for Soils, 1981.
7. IS:10108-Code of practice for sampling of soils by thin wall sampler with stationary piston, 1982.
8. IS:4434-Code of practice for in-situ vane shear test for soils, 1978.

9. IS: SP36 Part 1-Compendium of India Standards on Soil Engineering-Laboratory Testing of Soils for Civil Engineering Purposes, 1987.
10. IS: SP36 Part 2-Compendium of India Standards on Soil Engineering-Field Testing of Soils for Civil Engineering Purposes, 1988.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/105/105105039/#

CE56002 **3-1-0 (4)**

Advanced Foundation Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Select different types of foundations based on site conditions.
CO-2	Analyze bearing capacity and settlement of foundations.
CO-3	Design shallow and deep foundations.
CO-4	Analyze and suggest remedial measures against foundation failures.
CO-5	Select special foundations for the problematic soils

Syllabus:

Art of Foundation engineering: Bearing Capacity - Theories of Terzaghi, Meyerhof, Brinch Hansen, Vesic and Skempton, Penetration tests, Plate load tests, Factors; Settlement Analysis - Stresses in soil, Calculation of settlement and bearing capacity for different ground conditions, control of excessive settlements

Foundations: Foundation classification; Choice of foundations; Shallow Foundations - Isolated (individual and combined foundations), Raft foundations - Necessity; Types of rafts; Bearing capacity and settlement of rafts – Beams on elastic foundations

Pile Foundations: Classification and Uses, carrying capacity of Single pile, Pile load tests, cyclic pile load test, pull out resistance, laterally loaded Piles; Pile groups - Group efficiency, Settlement of single pile and pile groups, Negative skin friction, sharing of loads

Well Foundations: Caissons – Types, advantages and disadvantages, Shapes and component parts, Grip length, Bearing capacity and settlement, Forces acting, Sinking of wells, Rectification of Tilts and Shifts, Lateral stability - Terzaghi's method and IRC method

Design of Shallow and Deep Foundations: Soil pressure for structural design; Bending moment and shear force calculations, Conventional structural design of continuous footings, individual footings – Eccentrically loaded footings; combined footings; Pile foundations - Structural design of pile foundations including pile caps; Design of pile groups.

Foundation Failures – Construction aspects of foundations, Types and causes of failures, Remedial measures, Shoring and Underpinning, Ground water lowering and drainage, Legal aspects of foundation engineering, Field tests in foundation engineering including instrumentation for monitoring of foundations; Case Histories related to settlement of Structures, lateral movement, backfill settlements, causes due to soil types such as collapsible soil, expansive soil, soluble soils, slope Failures and landslides, debris flow, trench collapses, failures in soil reinforcement and geosynthetics.

Special Foundations: Foundations for offshore structures, buried structures, Earthquake prone structures; Foundations on problematic soils like expansive soils, Polluted soils etc.

Learning Resources:

Text Books:

1. Principles of Foundation Engineering, Braja M Das, Cengage Learning, Inc, 9th Edition.
2. Foundation Analysis & Design, Bowles J. E., Mc.Graw Hill Book Co.,2017.
3. Foundation Design: Principles and Practices, Donald P Coduto, Pearson Education India, 2014.
4. The engineering of Foundations – R. Salgado, Mc Graw Hill, 2006
5. Teng W. C., "Foundation Design", Prentice Hall of India Ltd., 1962

6. Tomlinson, "Foundation Design and Construction", Pearson Publications, 2001
7. Satyendra Mittal, “Pile foundation design and construction”, 2nd Edition, CBS Publishers & Distributors Pvt. Ltd., 2017
8. Winterkorn H. F., & Fang H., "Foundation Engineering Hand Book", Van Nostrand Reinhold Co, New York, 1975

Reference Books:

1. Foundation Engineering Analysis and Design, An-Bin Huang and Hai-Sui Yu., 1st Edition, Department of Civil Engineering Geotechnical Engineering Division Scheme and Syllabi w.e.f. 2021-22 CRC Press, Taylor and Francis group,2018.
2. Basic and applied soil mechanics, Gopal Ranjan and Rao ASR, New Age Publications, Delhi, 3rd Edition, 2016.
3. IS 6403-1981 (Reaffirmed 2002): Code of Practice for determination of Bearing Capacity of Shallow Foundations
4. IS 1080-1985 (Reaffirmed 2002): Code of Practice of Shallow Foundations in Soils

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/104/105104162/
2. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-364-advancedgeotechnical-engineering-fall-2003

CE 56004 **3-0-0 (3)**

Soil Dynamics and Machine Foundations

Pre-Requisites: None

Course Outcomes:

CO-1	Apply theory of vibrations to solve dynamic problems
CO-2	Determine the dynamic properties of soils using laboratory and field tests
CO-3	Design the reciprocating and rotating machine foundations
CO-4	Design various vibration isolation systems

Syllabus:

Theory of Vibrations: Basics of dynamic system; Types of dynamic loads and solutions; Simple harmonic motion; Free vibration of single degree of freedom systems; Logarithmic decrement; Forced vibration of single degree of freedom under frequency dependent and frequency independent loading; Transmissibility; Bandwidth method; Vibration measuring instruments; Forced vibration of two-degree freedom system.

Dynamic Soil Properties: Elastic constants of soil; Damping of soil; General factors affecting shear modulus and damping; Field tests- cyclic plate load test, block vibration test, standard penetration test, seismic bore hole surveys, Wave propagation tests; Laboratory tests- resonant column test, cyclic simple shear test, cyclic torsional shear test, cyclic triaxial test.

Machine Foundations: General principles of machine foundation design, Types of machines and foundations, General design requirements of machine foundation with codal provisions, Modes of vibration; Design of block foundations under reciprocating and rotating machines- elastic half-space method, linear elastic weightless spring method.

Vibration Isolation: Introduction, Active and passive isolation, Methods and design of vibration isolation systems

Learning Resources:

Text Books:

1. S Prakash and V K Puri, Foundations for Machines: Analysis and Design, Wiley, 1988
2. S Saran, Soil Dynamics and Machine Foundations, Galgotia Publications Pvt Ltd, 1999

Reference Books:

1. B M Das and G V Ramana, Principles of Soil Dynamics, Cengage Engineering, 2014
2. B B Prasad, Fundamentals of Soil Dynamics and Earthquake Engineering, PHI, 2013

Other Suggested Readings:

https://nptel.ac.in/courses/105/101/105101005

SYLLABI

Honors-6: Transportation Engineering

CE66001 **3-1-0 (4)**

Urban Transportation Planning

Pre-Requisites: **NIL**

Course Outcomes:

CO-1	Differentiate different urban forms and structures
CO-2	Identify urban transportation problems.
CO-3	Develop a database for the calibration of travel demand models.
CO-4	Estimate urban travel demand.
CO-5	Plan urban transport networks.
CO-6	Identify urban transport corridors and prepare urban transportation plans.

Syllabus:

Urban Forms and Structures: Urbanization and Migration, Findings of Commission on Urbanization, Urban forms: Garden City, Linear City, Radburn, Urban Neighborhood, Precinct, MARS, Le Corbusier, Collin Buchanan. Urban structures: Centripetal type, Grid type, linear type, and directional grid type; Evolution of spatial structure.

Urban Transportation Problems and Policy: Urban Transportation Issues, Travel Characteristics, Evolution of Planning Process, Supply and Demand – Systems approach; NUTP, Recommendations of 12th FYP and NTDP; Smart Cities, Service Level Benchmarks.

Travel Demand Approaches: Trends, Overall Planning Process, Long-term vs. Short-term Planning, Types of Plans, Master Plans, Demand Function, Independent Variables, Travel Attributes, Assumptions in Demand Estimation, Sequential and Simultaneous Approaches, Aggregate and Disaggregate Techniques, UTPS Approach.

Data Collection and Inventories: Collection of data – Organisation of surveys and Analysis, Study Area, Zoning, Types, and Sources of Data, Roadside Interviews, Home Interview Surveys, Commercial Vehicle Surveys, Sampling Techniques, Expansion Factors, Accuracy Checks, Use of Secondary Sources, Economic data: Income, Population, Employment, Vehicle Owner Ship.

Trip Generation: Trip Generation Analysis: Zonal Models, Category Analysis, Household Models, Trip Attraction Models, Commercial Trip Rates.

Trip Distribution: Trip Distribution: Growth Factor Methods, Gravity Models, Opportunity Models, Time Function Iteration Models.

Mode Split: Mode Choice Behavior, Competing Modes, Mode Split Curves, Models, and Probabilistic Approaches.

Traffic Assignment: Basic Elements of Transport Networks, Coding, Route Properties, Path Building Criteria, Skimming Tree, All-or-Nothing Assignment, Capacity Restraint Techniques, Reallocation of Assigned Volumes, Equilibrium Assignment, and Diversion Curves.

Corridor Identification - Plan Preparation and Evaluation: Selection of Corridor, Corridor Identification, Corridor deficiency Analysis; Multimodal Transportation Planning, TOD; Travel Forecasts to Evaluate Alternative Improvements, Impacts of New Development on Transportation Facilities; Pivot Point Analysis, Environmental and Energy Analysis.

Learning Resources:

Textbooks:

1. C. Jotin Khisty, B. Kent Lall; Transportation Engineering: An Introduction, Pearson Education India, 2016, Third Edition.
2. C.S. Papacostas, P.D. Prevedouros; Transportation Engineering and Planning; Pearson, 2015, Third Edition.

Reference Books:

1. B.G. Hutchinson; Principles of Urban Transportation System Planning, Hutchinson, Allen, Taylor & Francis, 1986.
2. David Johnson Victor, S. Ponnuswamy; Urban Transportation: Planning, Operation and Management, Tata McGraw-Hill Education Pvt. Ltd., 2012, First Edition.
3. ITE, Michael D. Meyer; Transportation Planning Handbook, Institute of Transportation Engineers, John Wiley & Sons, 2016, Fourth Edition.
4. Luis G. Willumsen, Juan de Dios Ortuzar; Modelling Transport, John Wiley & Sons, 2024, Fifth Edition.
5. Michael D. Mayer, Eric J. Miller; Urban Transportation Planning: A Decision-oriented Approach, McGraw Hill, 2001, Second Edition.
6. Michael J. Bruton; Introduction to Transportation Planning, Routledge Library Editions: Global Transport Planning, 2023.
7. S Raghava Chari, Urban Transportation Planning Lecture Notes, REC Warangal, 1990.

Other Suggested Readings:

1. http://www.nptelvideos.in/2012/11/urban-transportation-planning.html
2. https://nptel.ac.in/courses/105107067/
3. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-252j-urban-transportation-planning-fall-2016/
4. https://olc.worldbank.org/content/integrated-urban-transport-planning-self-paced

CE66003 3-0-0 (3)

Traffic Analysis and Design

Pre-Requisites: NIL

Course Outcomes:

CO-1	Estimate essential characteristics of the traffic stream.
CO-2	Explore various methods of traffic data collection.
CO-3	Model traffic stream behaviour at the micro and macro levels.
CO-4	Determine the capacity of highways.

Syllabus:

Components of Traffic System: Introduction to Traffic Engineering, Human-Vehicle-Road User-Environment system, Characteristics of road users, characteristics of vehicles, Characteristics of Pedestrians.

Traffic Data Collection Studies: traffic study components and types of data; volume studies; speed studies; travel time and delay studies; intersection studies; pedestrian studies; parking studies; vehicle detection methods; advanced methods: GPS, Instrumented Vehicles, Image Processing, Bluetooth, Infrared methods, Drone video analysis, Sample selection, and region traffic counts.

Characteristics of Traffic: Fundamental parameters of traffic and relationships; Time headways, temporal, spatial, and flow patterns; Growth factors; Interrupted and un-interrupted traffic; Microscopic and macroscopic speed characteristics; Vehicular speed trajectories; Speed characteristics-mathematical distributions; Speed and travel time variations.

Macroscopic Traffic Stream Models: Stream flow fundamentals; family of models; Hydrodynamic and Kinetic Analysis of Traffic; continuity equation; waves in traffic; Traffic fluid state considerations; Platoon diffusion.

Microscopic Traffic Stream Models: Car-following models; Stimulus-response models; distance-based models; psychophysical models; neuro-fuzzy models; gap acceptance models; mixed traffic flow behaviour: non-lane-based movement and challenges of modelling Indian mixed traffic; Heterogeneity in traffic.

Highway Capacity Analysis: Capacity and level of service concepts; Factors affecting capacity and LOS; Two-lane, Freeway, and multi-lane capacity analysis; Capacity of Urban arterials; Design and Capacity analysis of Signalized Intersections; US Highway Capacity Manual (HCM) and IRC standards, Indo-HCM standards.

Design of Signalized Intersections: Warrants for signalisation, design control variables, lost time estimation, saturation flow rate and capacity, dilemma zone analysis, signal timing design methods, pedestrian considerations, queue length and control delay, signal coordination for urban streets, adaptive traffic signals, design examples.

Learning Resources:

Textbooks:

1. Adolf Darlington May, Traffic Flow Fundamentals, Prentice Hall, 1990 (Digitized in 2011).
2. L.R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publishers, 2024, Ninth Edition.
3. Partha Chakraborty, Animesh Das, Principles of Transportation Engineering, PHI Learning, 2017, Second Edition.

Reference Books:

1. C. Jotin Khisty, B. Kent Lall; Transportation Engineering: An Introduction, Pearson Education India, 2016, Third Edition.
2. Fred L. Mannering, Scott S. Washburn; Principles of Highway Engineering and Traffic Analysis, Jhon Wiley & Sons, 2019, 7th Edition.
3. IRC:93-1985, Guidelines on Design and Installation of Road Traffic Signals, Indian Roads Congress, New Delhi, 1985.
4. Louis J. Pignataro, Traffic Engineering: Theory and Practice; Prentice Hall, Inc., 1973 (Digitized in 2011).
5. Mike Slinn, Paul Matthews, Peter Guest; Traffic Engineering Design: Principles and Practice, CRC Press, 2005, Second Edition.
6. NASEM, TRB, Highway Capacity Manual: A Guide for Multimodal Mobility Analysis, The National Academies Press, Washington, DC, 2022, Seventh Edition.
7. Nicholas J. Garber, Lester A. Hoel; Traffic and Highway Engineering, Cengage Learning India, 2024, Fifth Edition.
8. Roger P Roess, William R McShane, Elena S Prassas; Traffic Engineering, Pearson Education, 2020, Fifth Edition.
9. Satish Chandra, S. Gangopadhyay, S. Velmurugan, Kayitha Ravinder; Indian Highway Capacity Manual (Indo-HCM), CSIR-CRRI, India, 2017.

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/101/105101008
2. https://nptel.ac.in/courses/105/104/105104098
3. https://www.classcentral.com/course/edx-intro-to-traffic-flow-modeling-and-intelligent-transport-systems-12728
4. https://www.crridom.gov.in/sites/default/files/Indo-HCM%20Snippets.pdf
5. https://www.monash.edu/engineering/its/publications/tem2017

CE66005 **3-1-0 (4)**

Pavement Analysis and Design

Pre-Requisites: **NIL**

Course Outcomes:

CO-1	Analyse stresses and strains in a flexible pavement using multi-layered elastic theory and KENLAYER.
CO-2	Compute stresses and strains in a rigid pavement using Westergaard's theory and KENSLABS.
CO-3	Design a flexible pavement using various methods.
CO-4	Design a rigid pavement using various methods.

Syllabus:

Pavement Types and Materials: Types and component parts of pavements; highway and airfield pavements; basic characteristics of materials used in pavements.

Stresses in Flexible Pavements: Layered system concepts; stress solution for one, two, and three-layered systems; fundamental design concepts; stress analysis in flexible pavements using KENLAYER.

Stresses in Rigid Pavements: Westergaard's theory and assumptions; joints in rigid pavements; stresses due to curling, stresses, and deflections due to loading, frictional stresses; stresses in dowel bars and tie bars, dowel group action; stress analysis in rigid pavements using KENSLABS.

Factors Affecting Pavement Design: Variables considered in pavement design; classification of axle types, standard and legal axle loads, tyre pressure, contact pressure, ESWL, EWLF, and EAL concepts; traffic analysis: ADT, AADT, truck factor, growth factor, lane distribution factor, directional distribution factor, and vehicle damage factor.

Design of Flexible Pavements: IRC method of flexible pavement design; Asphalt Institute's design methods with HMA and other base combinations; AASHTO method of flexible pavement design; design of flexible pavement shoulders; introduction to mechanistic-empirical pavement design guide.

Design of Rigid Pavements: IRC method of plain jointed, jointed reinforced, continuously reinforced rigid pavement design; design of conventional and thin white topping; AASHTO method of rigid pavement design; design of rigid pavement shoulders.

Learning Resources:

Textbooks:

1. E.J. Yoder, M.W. Witczak; Principles of Pavement Design, Wiley India Pvt. Ltd., New Delhi, India, 2011, Second Edition.
2. Huang, Y.H., Pavement Analysis and Design, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008, Second Edition.

Reference Books:

1. AI MSI-1: Thickness Design – Asphalt Pavements for Highways and Streets, Manual Series No. 1, Asphalt Institute, Kentucky, USA, 1999, Ninth Edition.
2. IRC:37-2018, Guidelines for the Design of Flexible Pavements, Indian Roads Congress, New Delhi, India, 2018, Fourth Revision.
3. IRC:58-2015, Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, Indian Roads Congress, New Delhi, India, 2015, Fourth Revision.
4. IRC:118-2015, Guidelines for Design and Construction of Continuously Reinforced Concrete Pavement, Indian Roads Congress, New Delhi, India, 2015.
5. IRC: SP76-2015, Guidelines for Conventional and Thin White topping, Indian Roads Congress, New Delhi, India, 2015, First Revision.

Other Suggested Readings:

1. http://onlinepubs.trb.org/onlinepubs/archive/mepdg/guide.htm
2. http://www.trb.org/Pavements/TRBPublications.aspx
3. https://link.springer.com/article/10.1007/BF03325749
4. https://pavementinteractive.org/

CE66002 **3-1-0 (4)**

Advanced Travel Demand Modelling

Pre-Requisites: **CE66001**

Course Outcomes:

CO-1	Assess Qualitative Variables.
CO-2	Develop discrete choice models.
CO-3	Assess travel demand using Stated Preference data.
CO-4	Estimate Travel Demand using activity-based analysis.
CO-5	Test model aggregation and transferability.

Syllabus:

Discrete Choice Analysis: Utility Concept; Mode choice; Logit Models; Dogit Model; Nested Logit Model; Probit Model; Route Choice Modelling; Combined Travel Demand Modelling; Model Parameter Estimation – Maximum Likelihood and Maximum Entropy Estimates.

Stated Preference Methods: Stated preference vs. Revealed Preferences; Design Issues; Survey Methods, Conjoint Analysis; Functional Measurement; Trade-off Analysis, Transfer Price Method

Activity-Based Travel Demand Models: Activity patterns; Activity scheduling; Activity Time Allocation studies; Activity Episode Analysis; Travel Duration Analysis

Qualitative Variables: Role of Soft variables in Travel Demand Forecasting; Attitudes; Psychometric scaling Techniques – One-dimensional Scaling – Multidimensional Scaling; Basic Rating Scales: Comparative Rating Scales, Non – Comparative Rating scale, Itemized rating scale, graphic rating scale; Specific Attitude scales; Successive Categories; Principal Components Factor Analysis; Attitudinal Models.

Model Aggregation and Model Transferability: Aggregation bias and forecasting; Aggregation Methods; Temporal Stability and geographical stability of Models; transfer model updating procedures—transferring with Aggregate and Disaggregate sample data; Transferability Measures.

Simplified Transport Demand Models: Sketch planning Methods; Incremental Demand Models; Model estimation from traffic Counts; IVF Models, Marginal and Corridor Models; Gaming Simulation, Quick Response Techniques.

Introduction to Advanced Modeling Techniques: GO Models; Entropy Models; Equilibrium Assignment Techniques, Multipath Assignment – Dial's Algorithm, Knowledge-Based Expert System; Neuro-Fuzzy Application; ANN Techniques; Genetic Algorithms; Object-Oriented Programming; Decision Support Systems; Goal Programming.

Learning Resources:

Textbooks:

1. Luis G. Willumsen, Juan de Dios Ortuzar; Modelling Transport, Wiley, 2024, Fifth Edition.
2. Norbert Oppenheim, Urban Travel Demand Modelling: From Individual Choices to General Equilibrium, John Wiley and Sons, Inc., 1995 (Digitized 29 June 2011).

Reference Books:

1. Alan Geoffrey Wilson, Optimization in Location and Transport Analysis, John Wiley & Sons, 1981 (Digitized: 31 March 2011).
2. Harry Timmermans (Ed), Progress in Activity-Based Analysis, Elsevier Science, 2005.
3. Joe Castiglione, Mark Bradley, John Gliebe; Activity-Based Travel Demand Models: A Primer, TRB, Washington, DC, 2015
4. Laurie A. Garrow, Discrete Choice Modelling and Air Travel Demand: Theory and Applications, Routledge, 2010
5. Moshe Ben-Akiva, Steven R. Lerman, Discrete Choice Analysis: Theory and Application to Travel Demand, MIT Press, 2018
6. Transportation 26, Special Issue, Time use Analysis, Kluwer Academic Publishers, 1999.

Other Suggested Readings:

1. http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_C46.pdf
2. https://www.nap.edu/download/13678

CE66004 **3-1-0 (4)**

Geometric Design of Transportation Facilities

Pre-Requisites: **CE66003**

Course Outcomes:

CO-1	Examine geometric characteristics and design elements of highways and streets
CO-2	Analyse and design uncontrolled and signalised intersections.
CO-3	Plan and Design parking facilities.
CO-4	Design a street lighting system for roads.

Syllabus:

Geometric Design of Highway Facility: Elements of geometric design, design considerations, factors affecting design, performance-based geometric design, alignment and topography, design of horizontal alignment, reverse and compound curves, design of vertical curves, tangent grade, controls and criteria for expressway, landscaping, freeway and multilane highways and expressways criteria, weaving segments configurations and ramp roadways, auxiliary lanes, and design practices.

Geometric Design of Intersections: Design considerations, factors affecting the design of elements, intersections geometric suitability, alignment, and profile, functional and physical area, data requirement, types of turning roadway, curb radii and turning path, pedestrian considerations in design, design of channelisation, median opening and islands, rotary and modern roundabout design, auxiliary lanes at intersection, ramp roadways and weaving segment design examples.

Design of Street Lighting: Definitions and background, pavement luminance and measurement, illumination level, Veiling Luminance, longitudinal uniformity, utilisation factor, depreciation factor, maintenance factor, traffic criteria, warranting conditions, and design practices.

Pedestrian Facilities, Parking Facilities: Elements of pedestrian facility design, sign of pedestrian facility at junctions, street and corner, pedestrian signals, design examples, Parking influencing factors, types, parking angles and aisle width, on-street parking design, various parking layouts and vehicle circulation, design of off-street parking facilities.

Traffic Interchanges and Terminals: Classification and types, layouts of interchange, warrants, design elements, Interchange evaluation based on delay, Cross-section design of logistic terminals, elements, Location considerations terminal concourse, cross-section design elements, terminal concourse, multiple interchange and vertical separation, traffic circulation, multiple interchange and vertical separation, traffic circulation, design examples.

Learning Resources:

Textbooks:

1. L.R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publishers, 2024, Ninth Edition.
2. Partha Chakraborty, Animesh Das; Principles of Transportation Engineering, PHI Learning, 2017, Second Edition.

Reference Books:

1. C. Jotin Khisty, B Kent Lall; Transportation Engineering: An Introduction, Pearson Education India, 2016, Third Edition.
2. Fred L. Mannering, Scott S. Washburn; Principles of Highway Engineering and Traffic Analysis, Jhon Wiley & Sons, 2019, 7th Edition.
3. NASEM, TRB, Highway Capacity Manual: A Guide for Multimodal Mobility Analysis, The National Academies Press, Washington, DC, 2022, Seventh Edition.
4. Nicholas J. Garber, Lester A. Hoel; Traffic and Highway Engineering, Cengage Learning India, 2024, Fifth Edition.

Online Resources

1. https://nptel.ac.in/courses/105/101/105101008
2. https://nptel.ac.in/courses/105/104/105104098
3. https://www.classcentral.com/course/edx-intro-to-traffic-flow-modeling-and-intelligent-transport-systems-12728
4. https://www.crridom.gov.in/sites/default/files/Indo-HCM%20Snippets.pdf
5. https://www.monash.edu/engineering/its/publications/tem2017

SYLLABI

Honors-7: Water Resources Engineering

CE76001 **3-0-0 (3)**

Applied Hydrology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Analyse components of hydrologic cycle
CO-2	Predict hydrologic extreme events for hydraulic and hydrologic design
CO-3	Develop forecasting models for operation of hydrologic systems
CO-4	Assess surface water resources

Syllabus:

Introduction: Description of Hydrologic Cycle, Overview of application of hydrology in engineering, Historical aspects of development of hydrology, Eco-hydrology

Precipitation: Formation and process, Global Weather Systems, Characteristics of precipitation in India, Analysis of rainfall data, intensity-duration-frequency analysis and depth-area-duration analysis, development of design storms for typical regions in data scarce environment

Evaporation: Process, Measurement, Estimation – Energy Balance method, Aerodynamic method, Combination method, Empirical methods, Factors affecting evaporation rate.

Evapotranspiration: Process, Measurement, Penman-Monteith method, crop water requirement, estimation of effective rainfall.

Infiltration: Process, measurement of infiltration, infiltration models – Richard's equation, Horton's model and Green-Ampt model, factors affecting infiltration rate.

Runoff: runoff generation process, catchment characteristics, factors affecting runoff, advanced streamflow measurement techniques, yield from a catchment, Runoff Estimation methods, flow duration curve, flow mass curve analysis.

Hydrograph Theory: Components of hydrograph, base flow separation, direct runoff hydrograph, Unit hydrograph theory, derivation of unit hydrograph, S-hydrograph and instantaneous unit hydrograph, Derivation of unit hydrograph for ungauged catchments, conceptual models - synthetic unit hydrograph and its derivation

Flood Estimation: Peak discharge estimation procedures, deterministic and probabilistic approaches, enveloping curve, rational method, SCS and unit hydrograph methods

Flood Routing: Concepts of flow routing, hydraulic and hydrologic routing, St. Venant's equations, Reservoir routing, Channel routing, Muskingum and Muskingum-Cunge methods of channel routing and flood forecasting

Learning Resources:

Text Books:

1. Chow, V.T., Maidment, D.R., and Mays, L.W., Applied Hydrology, Tata McGraw Hill Edition, 2017, 2nd Edition
2. Subramanya, K., Engineering Hydrology, Tata McGraw Hill Publications, 2017, 4th Edition

Reference Books:

1. McCuen, R.H., Hydrologic Analysis and Design, Pearson Publications, 2017, 4th Edition
2. Mays, L.W., Water Resources Engineering, Wiley Publications, 2019, 3rd Edition
3. Viessman, W., and Lewis, G.L., Introduction to Hydrology, Prentice Hall of India, 2008, 5th Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/104/105104029/

CE76003 **3-1-0 (4)**

Stochastic Hydrology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Analyse hydrologic data
CO-2	Perform frequency analysis of hydrologic extremes
CO-3	Apply multivariate analysis in hydrologic systems
CO-4	Analyse hydrologic time series
CO-5	Develop models for synthesis of hydrologic variables

Syllabus:

Introduction: Deterministic and Stochastic Hydrology, review of concepts of probability, probability axioms, Random variables and their properties, probability distribution and probability density function.

Probability Distributions: Discrete and continuous probability distributions used in hydrology, moments and expectations of distributions, Parameter estimation, method of moments, maximum likelihood method and method of probability weighted moments.

Hypothesis testing: Goodness test of fit tests, Chi Square test and KS test.

Frequency Analysis: Frequency analysis of hydro-climatic extremes, extreme value distributions, analysis of floods, droughts and other natural hazards, Regional flood frequency analysis, Risk and reliability in hydrologic design, Analysis and measures of hydrologic uncertainty.

Correlation Analysis: Correlation analysis and correlation coefficient, Simple linear regression, Multivariate regression analysis, Correlation coefficient and its significance in regional analysis, analysis of variance, applications – rainfall-runoff analysis, rating curves, water quality modelling, Multivariate analysis, principal component analysis, cluster analysis.

Time Series Analysis: Hydrologic Time Series Analysis, Hydrologic time series, stationary and non-stationary time series, Ensemble and realisation, trend analysis, trend removal, analysis of periodicity, Fourier transformation and harmonic analysis, autocorrelation function, spectral density function, Wavelet analysis.

Time Series Modelling: Modelling of Hydrologic Time Series, Time series models, autoregressive and moving average models, periodic models, Calibration and validation of hydrologic time series models, data generation techniques, simulation of hydrologic time series, streamflow forecasting, First order Markov process, Markov chain, Multi-site time series model, cross- correlation, spatial and temporal disaggregation models.

Copulas: Theory of copula and its use in hydrology, commonly used copula functions, selection of best fit copula, uses of copula.

Learning Resources:

Text Books:

1. Haan T. C., Statistical Methods in Hydrology, East West Publishers, 2002
2. Kotteguda, N.T., and Resso, R., Statistics, Probability and Reliability for Civil and Environmental Engineers, Blackwell Publishing, UK, 2008

Reference Books:

1. Kotteguda, N.T., Stochastic Water Resources Technology, The Macmillan Press, New York, 1982
2. Maity, R., Statistical Methods in Hydrology and Hydro-climatology, Springer Nature Singapore Pte Ltd., 2018

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/108/105108079/

CE76005 **3-1-0 (4)**

Advances in Fluid Mechanics & Hydraulic Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Formulate momentum, energy and mass transport models
CO-2	Analyze Potential Flows
CO-3	Develop approximate solutions for small and large Reynolds number flows
CO-4	Apply turbulent flow models
CO-5	Formulate and solve the problem of propagation of flood wave and surges in channels
CO-6	Perform Hydraulic routing and dam break analysis

Syllabus:

Introduction: Review of physical meaning of mathematics necessary for understanding of fluid mechanics.

Description of fluid flow: With reference to translation, rotation and deformation concept of continuum, control mass & control volume approach, Reynolds transport theorem.

Velocity field: One & two-dimensional flow analysis, circulation and vorticity, stream function and velocity potential function, potential flow, standard flow patterns, combination of flow patterns, flow net.

Dimensional Analysis: Dimensional analysis as a tool in design of experiments, identification of non-dimensional numbers and their significance, dimensional analysis methods.

Equations of Motion: Equations of motion for laminar flow of a Newtonian fluid - Viscous flow – Navier-Stoke's equations, simple exact solutions.

Boundary Layer Theory: Formation, growth and separation of boundary layer-Integral momentum principles to compute drag and lift forces-Mathematical models for boundary layer flows.

Turbulence: Origin of turbulence, universal velocity distribution laws of turbulence, smooth rough and transitional turbulent flow in pipes, pipe resistance equation for pipes design of pipe networks, Diffusion and dispersion of pollutants in natural streams.

Free surface Flow: Gradually varied flow, Specific energy, Critical flow, Channel transitions, Uniform flow formulae, Type of GVF profiles, Computation of GVF profiles, Steady and Unsteady Rapidly Varied Flow, Hydraulic jump in a horizontal rectangular channel, Positive and Negative surges, St. Venant's equation, Method of Characteristics, Hydraulic routing.

Learning Resources:

Text Books:

1. Fox, R.W., Pitchard, P.J., and Mcdonald, A.T., Fluid Mechanics, Wiley India Pvt. Ltd., 2009, 10th Edition
2. Chow, V.T., Open Channel Hydraulics, McGraw Hill Inc. N York, 1979

Reference Books:

1. Schlichting, H., and Gresten, K., Boundary Layer Theory, Springer Publications, 2004.
2. White, F.M., Viscous Fluid Flow, McGraw Hill Pub. Co, New York, 2011.
3. Yalin, M.S., Theory of Hydraulic Models, McMillan Co., 1971
4. French, R.H., Open Channel Hydraulics, McGraw Hill Pub Co., N York, 1986
5. Subramanya, K., Flow in Open Channels, Tata McGraw Hill Pub., 2008
6. Chung Fang, An Introduction to Fluid Mechanics, Springer International Publishing, 2018.

Other Suggested Readings:

1. https://nptel.ac.in/courses/112/105/112105218/
2. https://nptel.ac.in/courses/112/105/112105287/
3. https://nptel.ac.in/courses/105/106/105106114/

CE76002 **3-1-0 (4)**

Water Resources Systems Planning and Management

Pre-Requisites: CE77001, CE77002

Course Outcomes:

CO-1	Apply concepts of systems analysis for planning of water resources systems
CO-2	Perform basic economic analysis to evaluate the economic feasibility of water resources and environmental engineering projects
CO-3	Formulate and solve deterministic optimization models for design and operation of water resources systems
CO-4	Formulate and solve stochastic and fuzzy optimization problems for decision making under uncertainty

Syllabus:

Introduction: Overview of the course, concepts of systems analysis, water resources planning, Modeling techniques, objectives and constraints, overview of optimization techniques.

Linear programming: Linear programming, Graphical method, simplex method, sensitivity analysis, duality. Dynamic programming, concepts, formulation of recursive equation.

Classical Optimization Techniques: Lagrange methods, Kuhn-Tucker conditions, Search techniques,

Stochastic Optimization Techniques: Chance constrained LP, stochastic dynamic programming, decision making under uncertainty, fuzzy optimization.

Multi Objective Optimization: Overview of multi objective optimization, multi criteria decision making, Simulation- optimizations.

Genetic Algorithm: Overview of Genetic Algorithm and other evolutionary algorithms

Economic analysis: Discounting techniques, benefit cost evaluation.

River basin modelling: Storage-yield relation, reservoir design and operation.

Applications of Optimization: Overview of applications of optimization and simulation techniques in hydrologic and water resources systems – irrigation management, water quality management, groundwater management, water conveyance and distribution systems.

Learning Resources:

Text Books:

1. Loucks, D.P., and Eelco van Beek, Water Resources Systems Planning and Management – An introduction to methods, models and applications, UNESCO and Springer, 2017
2. Vedula, S., and Mujumdar, P.P., Water Resources Systems Modeling Techniques and Analysis, Tata McGraw Hill Pub. Co., 2005

Reference Books:

1. Loucks, D.P., Stedinger, J.R., and Haith, D.A., Water Resources Systems Planning and Analysis, Prentice Hall Inc., 1982

2. Charles, S.R., Whitlatch, E.E., and Wright, J.R., Civil and Environmental Systems Engineering, Pearson Education Inc., 2004

Other Suggested Readings:

1. https://nptel.ac.in/courses/105/108/105108130/

CE76004 **3-0-0 (3)**

Groundwater Hydrology

Pre-Requisites: **CE77001**

Course Outcomes:

CO-1	Assess groundwater flow and model regional groundwater flow
CO-2	Identify of groundwater source by groundwater prospecting
CO-3	Design water wells
CO-4	Manage groundwater resources
CO-5	Plan and design artificial recharge systems

Syllabus:

Introduction to Groundwater: Ground water availability, Groundwater in the hydrologic system, Hydrologic budget, Vertical distribution of subsurface strata, Types of aquifers, Aquifer characteristics.

Groundwater Movement: Darcy's law, Hydraulic conductivity and intrinsic permeability, Transmissivity, Homogeneity and isotropy, Stream function, Flownet

Groundwater Flow Hydraulics: Well hydraulics, partial differential equations governing groundwater flow in aquifers, estimation of aquifer parameters by different methods, steady groundwater flow analysis for multi-well systems, Well flow near different boundary conditions, Method of images

Groundwater Modelling: Groundwater modelling, formulation of anisotropic and non- homogenous flow of groundwater, finite difference methods for solving groundwater flow problems, regional groundwater flow modelling

Groundwater Prospecting: Geologic method, Remote sensing, Geophysical exploration, Electric resistivity method, Seismic method, Gravity and magnetic methods

Well Logging and Construction: Type of wells, Selection of well site, Well logging, Well construction techniques, Well completion

Groundwater Management: Concept of basin management, Conjunctive use of surface water and groundwater, Groundwater management techniques

Managed Groundwater Recharge: Objective and purpose of MGR, Methods of MGR

Climate Change Impacts on Groundwater: Hydrological components affecting the groundwater, Direct impacts of climate change on groundwater, Indirect impacts of climate change on groundwater, Climate change impacts on water availability in an aquifer

Learning Resources:

Text Books:

1. Karamouz, M., Ahmadi, A., and Akhbari, M., Groundwater Hydrology: Engineering, Planning and ManagementCRC Press, Taylor et Francis Group, 2020
2. Todd, D.K., and Mays, L.W., Groundwater Hydrology, John Wiley & Sons, Singapore, 2018

Reference Books:

1. Rastogi, A.K., Numerical Groundwater Hydrology, Penram International Publishing Pvt. Ltd., 2012
2. Davis, S. N., and De Weist, R. J. M., Hydrogeology, John Wiley & Sons, New York, 2013
3. Chahar, B. R., Groundwater Hydrology, McGraw Hill Education (India) Private Limited, New Delhi, 2015

Other Suggested Readings:

1. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2002WR001516
2. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/groundwater-management
3. https://www.usgs.gov/mission-areas/water-resources/science/artificial-groundwater-recharge