1. Introduction

The rapidly urbanizing society and increasing quality of life demand reliable and intelligent infrastructure systems which are capable of catering to the societal needs at different scales – from an individual to the community level. Consequently, the civil and infrastructure industry has undergone profound changes and is constantly evolving. However, the new-age designs and innovations in the civil and infrastructure industry can only be driven by a group of engineering graduates having multidisciplinary training and a sound understanding of emerging technologies. Through this undergraduate program in "Civil & Infrastructure Engineering", IIT Jodhpur is making a stride to re-imagine the course structure that incorporates and integrates the elements of conventional civil engineering with advanced transformative technologies such as artificial intelligence (AI), cyber-physical-systems (CPS), digital twins (DT), and automated management and information systems. Additionally, a major thrust is also planned on the design, implementation, and maintenance of large-scale integrated infrastructure systems across different domains.

2. Objective of the program

To provide an expanded but holistic understanding of different civil and infrastructure systems and an in-depth understanding of the differences, similarities, and relations between different scales and components of it.

To produce graduates with an ability to integrate conventional methods with emerging technologies to design intelligent civil and infrastructure systems from a multidisciplinary perspective.

To provide exposure to techniques such as Internet-of-Things (IoT), machine learning, big data, cyber-physical systems, and digital twin (DT) in the design and maintenance of different civil and infrastructure systems.

3. Expected Graduate Attribute

1. A strong foundation in the analytical, experimental, and computational methods to study various aspects of civil and infrastructure systems.
2. A thorough understanding of green and sustainable materials, practices, and principles to design resilient infrastructure systems.
3. An ability to understand real-world problems related to air and water pollution, solid waste management, ecological and environmental degradation, and their monitoring and remediation.
4. Ability to adopt safe methodologies coupled with advanced technologies in the design and construction of civil and infrastructure systems.
5. Ability to monitor and evaluate health of old structures and renovating to bring sustainability.
6. An understanding of the use of digital twins (DT), cyber-physical-systems (CPS), internet-of-Things (IoT), artificial intelligence (AI) in designing, monitoring, surveillance and security of infrastructures.
7. An innate ability to take multidisciplinary approach to problem solving and willingness to go beyond conventional paths.
8. Ability to engage in ethical and responsible practices while pursuing professional growth.

4. Learning Outcome

1. Strong understanding of structural engineering and its application in reinforced concrete, prestressed concrete, and steel structure design.
2. In-depth knowledge of geotechnical engineering for ground improvement and foundation engineering.
3. Knowledge of pavement design, traffic planning, and highway design for urban transport management.
4. Knowledge of critical experiments and advanced mathematical models for environmental engineering application.
5. Knowledge of GIS and remote sensing for application in agriculture, environment, geo-resource exploitation, and constructing digital twin of built environment.

6. Knowledge of smart and sustainable material, and best practices for construction and infrastructure development.
7. Strong foundation in computational methods and artificial intelligence (AI) for application in various civil and infrastructure problems.
8. Knowledge of cyber-physical-systems, advanced visualization techniques, and digital twins for application in smart infrastructure.
9. Knowledge of town planning, logistics and layout engineering

5. New Skill Sets Targeted

1. The following advanced and new skill sets have been targeted in the UG programme of Civil and Infrastructure Engineering at IIT Jodhpur:
2. Capability to design and develop smart infrastructure systems integrating cutting-edge cyber-physical systems, and visualization techniques.
3. A thorough understanding of geological and geotechnical engineering as applicable in infrastructure development, natural disaster risk reduction and resilience, and geo-energy extraction.
4. Knowledge of best practices, methods, and materials for sustainable Infrastructure planning, construction, and management.
5. Preliminary knowledge of monitoring, evaluation, restoration, and renovation of existing and old infrastructures and maintenance.

6. Topic Clouds and Mapping of Topic Clouds with Proposed Courses (PC: Program Core; PE: Program Elective)

Area	Topics	Courses
Foundation Courses	Probability Spaces; Random Variables; Estimation and Test of Hypothesis; Stochastic Processes	Probability, Statistics, and Stochastic Processes (LS)
	Geometrical Crystallography; Crystal Structure; Imperfections of Solids; Thermodynamics and Kinetics; Forms of Corrosion; Corrosion Protection; Structure-Property of Bulk Polymers; Viscoelasticity	Structure of Materials + Corrosion + Polymers (IE)
	Newtonian and Lagrangian Mechanics; Central Force Problem; Variational Principles and Lagrange's Equations; Rigid body Motion	Introduction to Analytical Mechanics (LS)
	Signal and Systems; Frequency Domain; LTI System; Applications	Signals and Systems (IE)
	Basic Concepts; Energy Transfer; Thermodynamics Properties; Open and Closed System; Second law of Thermodynamics; Entropy; Exergy	Thermodynamics (IE)
Geotechnical Engineering	Soil classification; index and engineering properties of soils; compaction and consolidation of soils; shear strength of soils; shallow and deep foundations; earth retaining structures	Geotechnical Engineering (PC)
		Geotechnical Engineering Lab (PC)
	Rocks and minerals; Erosional and depositional processes of air, water, wind, and ocean; Seismic hazard; Landslide hazard; Volcanic hazard; Site inspection; Engineering geology	Geology for Civil Engineers (PE)

	In-situ densification methods; preloading and dewatering techniques; mechanical and chemical stabilization of soils; grouting and geosynthetics	Ground Improvement Techniques (PE)
	Vibration theory; wave propagation; cyclic behavior of soils; seismic ground motion; dynamic soil properties; geophysical testing; seismic soil liquefaction; seismic microzonation; seismic slope stability; seismic response of retaining walls	Introduction to Soil Dynamics (PE)
	Stresses and strains in soils; stress path for total and effective stress; critical state soil mechanics; load transfer mechanism of shallow and pile foundations; structural health monitoring of geotechnical structures; introduction to computational geomechanics	Advanced Geotechnical Engineering (PE)
Water Resources Engineering	Introduction, Evapotranspiration and infiltration, Runoff, Hydraulic analysis and design, Dams and reservoirs, Role of economics in water resources planning, Irrigation, Groundwater	Water Resources Engineering (PC)
	Fluid statics, Kinematics of fluids, Incompressible Inviscid flow, Internal Incompressible Viscous flow, External Incompressible Viscous flow, Dimensional analysis and similarity, Turbulent flows, Compressible flow, Industrial Applications	Fluid Mechanics (PC)
	Water food industry nexus, transport from precipitation to groundwater, modeling hydrologic cycles; precipitation trends and frequencies; Infiltration and soil Moisture Management; peak runoff and stormwater runoff; Streams; Floods and Hydraulic Control Structures; Detention and Retention ponds; ground water mapping	Environmental Hydrology (PE)
Construction and Infrastructure	Construction materials, Building construction, Building estimates, Introduction to project planning and network analysis	Construction Technology and Practices(PC)
	Concrete materials; strength; durability; batching, mixing and transportation; curing; microstructure of concrete; mix design; admixtures; quality control; special types of concrete.	Concrete Technology (PE)

	Urban and rural infrastructure planning; risks associated; project governance; infrastructure maintenance; innovative infrastructure financing; polycentric governance	Infrastructure Planning and Management Engineering (PE)
Environmental Engineering	Sources of wastewater; primary and secondary treatment methods; sludge characteristics; Air pollutants; Effect of air pollution of human health, vegetation, and materials; Pollution monitoring; Control equipments; Indoor air pollutions; Management of solid waste; Environmental Risk Assessment; Treatment of hazardous waste	Environmental Engineering (PC)
	Sources and classification of air pollutants; Air Quality standards; Aerosol dynamics; Pollutant removal; Meteorology; Dispersion modelling; Effects of Air Pollution	Air pollution and Control (PE)
	Mass balance; Reaction kinetics; Micro and macro transport processes; modelling of aquatic systems; Oxygen model; Temperature model; Gaussian plume model and modifications; Dispersion models; Acid rain modeling, dissolved oxygen modelling and add reactor models	Mathematical Modelling in Environmental System (PE)
	Waste types; Sources of waste; Recycling; Waste to energy; Treatment and disposal of waste; Nuclear, biomedical, and steel waste.	Industrial Waste: Control and Utilization (PE)
	Climate and Climate Change; Convection motion and Atmospheric circulations; Role of Oceans; Radiative Heat Transfer; Climate feedbacks; Climate variability; Climate sensitivity; Global Circulation Model	Climate change and Impact (Specialization stream core)
	Photogrammetry; Multispectral remote Sensing; Thermal infrared Remote Sensing; Microwave Remote Sensing; LIDAR; GPS; GIS; Application of GIS, Use of Drones	Geoinformatics (PC)
	Basics of Microbiology; Kinetics and Reactors; The activated sludge process; Nitrification and denitrification; Phosphorus removal; Drinking water treatment; Anaerobic treatment by methanogenesis; Detoxification of hazardous chemicals; Bioremediation	Environmental Biotechnology and Bioremediation (PE)
Transportation Engineering	Introduction to transportation engineering, Transportation planning, Geometric design, Pavement engineering, Traffic engineering	Transportation Engineering (PC)

	Highway cross section elements and geometric design, Horizontal and vertical alignment, Intersection design, Traffic signs and road markings – guidelines and principles, Pedestrian facilities, cycle track, Bus bays, Design layout for On-street and Off-street parking, Smart city roads	Highway Geometric Design (PE)
	Pavement materials, Analysis and stresses in pavements, Factors affecting pavement design, Design of pavements	Pavement Engineering (PE)
	Urban transportation planning process and concepts, Travel demand estimation, Mode split and route split analysis, Landuse-Transportation models	Urban Transportation Planning (PE)
	Road, user, and vehicle characteristics of traffic system; Traffic control devices; control hierarchy; ANN and Fuzzy logic concepts; Intelligent Transport System (ITS); ITS user services; framework for planning, defining, and integrating ITS	Traffic System and ITS (PE)
Structural Engineering	Stress and strain, Mechanical behaviour, Static analysis, Elastic bending, Elastic torsion Strain energy, Elastic buckling	Mechanics of solids (PC)
	Working stress and limit state method of design of RCC structures; design of beam - singly reinforced, doubly reinforced beam; detailing of reinforcement; serviceability criteria; design of slab - one way and two way slab; design of column - axial loading, uniaxial bending, biaxial bending, slender column; design of foundation - isolated and combined footing.	Reinforced Concrete Design (PC)
	Constitutive relations and compatibility conditions; axial force, shear force and bending moment; moment area method; conjugate beam method; principle of virtual work; strain energy method; Maxwell-Betti law; force method; energy method; three moment equation; influence lines; cables, suspension bridges and arches; settlement and temperature effects.	Structural Analysis (PC)
	Indeterminate structures; force method of analysis; displacement method; stress and strain tensors; plastic analysis; basics of FEM; stability of structure; introduction to structural dynamics.	Advanced Structural Analysis (PC)

Structural steel sections; design concepts - working stress design, limit state design; design of connections; welded connections; design of tension and compression members, concept of stability and buckling; design of flexural members; design against shear.	Steel Structure Design (PE)
Mix design of concrete; P-M, M-phi relationships; strut-and-tie method; design of deep beam and corbel; design of shear walls; compression field theory; design against torsion; stability design of steel structures; torsional buckling; design of beam-columns; fatigue resistant design; fire rating.	Advanced Structural Design (PE)
Mass-spring-damper system; equation of motion; Hamilton's principle; single and multiple degree of freedom system; damped and undamped systems; natural frequencies and modes; damping in structures; basics of earthquake response and vibration control.	Dynamics of Structure (PE)
Governing equation and its solution approximations; calculus of variations; Lagrangian and serendipity elements; analysis of framed structures; axisymmetric problems; 3D stress analysis; analysis of plate and shell; numerical integration and convergence; application of FEM in dynamics.	Finite Element Method (PE)
Types of prestressing; pre- and post-tensioning systems; losses in prestress; anchorage slip; analysis and design of members for axial, flexure, shear and torsion loading; deflection, camber and crack width; transmission of prestress - pre- and post-tensioned members; analysis and tendon profile of cantilever and continuous beams; design of composite sections, slabs, compression members etc.	Prestressed Concrete Structure (PE)
Prefabrication materials; modular coordination and standardization; site erection; quality control; prefabricated components; construction of panel, roof and floor slabs, wall panels, columns, shear walls; design of cross section; joint flexibility and deformation; design of expansion joints; design for extreme loads.	Prefabricated Structures (PE)
Review of structural dynamics; structural health management; vibration-based techniques for SHM; modal assurance criterion (MAC); damage localization and quantification; frequency domain decomposition (FDD); time-domain damage detection methods; autoregressive (AR) and autoregressive with exogenous input (ARX) models; ANN approach	Introduction to Structural Health Monitoring (PE)

	to SHM; predictive health monitoring; Bayesian model updating; piezo-electric materials; electro-mechanical impedance (EMI) technique; data acquisition systems; fibre-optics sensors; sensor optimization, placement and layout design.	
	Source of earthquakes; response spectrum; frequency domain analysis; time domain analysis; nonlinear earthquake analysis: earthquake resistance design; concepts of passive controls; geotechnical aspects.	Earthquake Engineering (PE)
Smart Infrastructure Technology	Algorithm analysis and complexity; Abstract Data Types; Search Trees; Heaps; Sets; Greedy Techniques; Sorting Algorithms; Hashing; Dynamic Programming; Graph Algorithms	Data Structure and Algorithm (PC)
	Regression and Supervised Classifiers; Linear Decision boundaries; Unsupervised Learning; Time Series; Artificial Neural Network	Introduction to Machine Learning (IE)
	Various infrastructure systems; need of smart infrastructure; data acquisition and applications; data analysis using AI and ML techniques and their applications in infrastructure systems; control systems applications in infrastructure; design of smart infrastructure with adaptive capabilities.	Smart Infrastructure Engineering (PC)
	Review of artificial neural networks - supervised and unsupervised learning networks; genetic programming; applications in infrastructure engineering – prediction, structural control, damage assessment, ground settlement, uncertainty quantification, surrogate modelling etc.	AI/ML in Infrastructure Engineering (PE)
	Classification of building services; Hot and cold water supply; Fire prevention and control; Gas and storage; Mechanical services; Heating and cooling; Electricity supply and distribution; Acoustics	Building Services (PE)
	Intelligent architecture and Structure; BAS and BAS communication standards; LAN; Light control and security; Smart and optimal control	Intelligent Buildings (PE)
	Introduction to surveillance, critical infrastructures, building security and control	Surveillance and Security of Infrastructures (PE)

	system, surveillance and security of transport infrastructure	
	Cyber-physical systems applications in civil engineering; instrumentation; wireless communications and networks; energy and power sources; stability and rick monitoring using CPS	Cyber-Physical Systems for Infrastructure (PE)
	Digital twin types; Sensors, computation, and visualization; Standards and frameworks; Application: construction, building, smart city, energy assets, transport, water	Digital Twin and Asset management (PE)
	Design and simulation experiments for smart infrastructures	Smart Infrastructure: Design and Simulation (Lab)
Infrastructure Systems	Power plant infrastructure planning and design; hydroelectric infrastructure; thermal energy infrastructure; pipelines in power infrastructure; nuclear energy infrastructure; smart grid, transmission and distribution.	Introduction to Power Infrastructure Engineering (PE)
	Thermal energy infrastructure; plant configuration; repair and maintenance; cooling; risk assessment; design of chimney; power plant waste – fly ash and its reuse; flue gas desulfurization; nuclear energy infrastructure; project implementation; radioactive waste and management; facilities and basic infrastructure.	Thermal and Nuclear Power Infrastructure Engineering (PE)
	Railway operational system, design elements, and maintenance; High speed rails, elevated and underground rails; Airport system planning; Airfield layout planning; Passenger and cargo terminal planning; Airport-landuse compatibility planning	Infrastructure planning and design for rail and air transport (PE)
	Fundamental elements of planning harbours and ports; Design of port and harbour structures, Operations, management, and maintenance of port infrastructures	Infrastructure planning and design for ports and harbours (PE)
	Functions and components of telecommunication; Design, operation, and maintenance of towers; Telecom network management; Components of IT infrastructures; Network and servers; Network security; Role and applications of big data; Information and communication technology in urban services	IT and Telecom Infrastructure (PE)
		Green Building and Sustainable Materials (PE)

| | Design; Assessment; sustainable site and landscape; energy and carbon footprint; Built environment hydrological cycle; Green materials; Indoor environmental quality; Green building economics | |

7. Course Categories and credit distribution in the proposed B.Tech. Programmes

S. N.	Course Type	Course Category	Regular B. Tech.		Double B. Tech.	
			Credit	Total	Credit	Total
1	Institute Core (I)	Engineering (IE)	34	69	34	59
		Science (IS)	16		16	
		Humanities (IH)	12		9	
2	Programme Linked (L)	Science (LS)	7		0	
3	Programme Core (P)	Programme Compulsory (PC)	50	71	50	71
		Programme Electives (PE)	18		18	
		B.Tech. Project (PP)	3		3	
4	Open (O)	Open Electives (OE)	10	10	0	0
5	Engineering Science (E)	Engineering Science Core (EC)	0	0	22	30
		Engineering Science Elective (EE)	0		8	
Total Graded				150		160
6	Non-Graded (N)	Humanities (NH)	6	15	6	15
		Engineering (NE)	3		3	
		Design/Practical Experience (ND)	6		6	
Total Graded + Non-Graded				**165**		**175**

8. Credit Structure of B. Tech. Programme

| Type | L-T-P | Distribution of contact and beyond contact hours | | | Total credit (TC = TH/3) |
		Contact Hours (CH)	Beyond Contact Hours (BCH)	Total Hours (TH)	
1 Hour of Lecture	1-0-0	1 hr	2 hr	3	1
1 Hour of Tutorial	0-1-0	1 hr	2 hr	3	1
1 Hour of Lab/Project	0-0-1	1 hr	0.5 hr	1.5	0.5

9. List of programme compulsory courses

Sr. No	Course Name	L-T-P	Contact Hours	Credit
1	Mechanics of solids	3-1-0	4	4
2	Transportation Engineering	3-0-0	3	3
3	Fluid Mechanics	3-1-2	6	5
4	Geoinformatics	3-0-2	5	4
5	Structural Analysis	3-0-2	5	4
6	Environmental Engineering	3-0-2	5	4
7	a. Geotechnical Engineering	3-1-0	4	4
	b. Geotechnical Engineering Lab	0-0-2	2	1
8	Water Resources Engineering	3-0-2	5	4
9	Reinforced Concrete Design	3-0-2	5	4
10	Smart Infrastructure Engineering	3-0-0	3	3
11	Advanced Structural Analysis	3-0-2	5	4
12	Construction Technology and Practices	3-0-2	5	4
13	Data Structure and Algorithm	3-0-2	5	4
			Total	**52**

10. Area-wise Programme Elective (PE) Courses

Area	Courses	L-T-P	Credit
Smart Infrastructure Technology	AI/ML in Infrastructure Engineering	3-0-0	3
	Building Services	3-0-0	3
	Intelligent Buildings	3-0-0	3
	Surveillance and Security of Infrastructures	3-0-0	3
	Cyber-Physical Systems for Infrastructure	3-0-0	3
	Digital Twin and Asset management	3-0-0	3
Geotechnical Engineering	Geology for Civil Engineers	3-0-0	3
	Ground Improvement Techniques	3-0-0	3
	Introduction to Soil Dynamics	3-0-0	3
	Advanced Geotechnical Engineering	3-0-0	3
Environmental Engineering	Air pollution and Control	3-0-0	3
	Mathematical Modelling in Environmental	3-0-0	3
	Industrial Waste: Control and Utilization	3-0-0	3
	Environmental Biotechnology and Bioremediation	3-0-2	4
Transportation Engineering	Highway Geometric Design	3-0-0	3
	Pavement Engineering	3-0-0	3
	Traffic System and ITS	3-0-0	3
	Urban Transportation Planning	3-0-0	3
Construction and Infrastructure	Concrete Technology	3-0-0	3
	Infrastructure Planning and Management	3-0-0	3
Structural Engineering	Steel Structure Design	3-1-0	4
	Advanced Structural Design	3-0-0	3
	Dynamics of Structure	3-0-0	3

	Finite Element Method	3-0-0	3
	Prestressed concrete structures	3-0-0	3
	Prefabricated structures	3-0-0	3
	Earthquake Engineering	3-0-0	3
	Introduction to Structural Health monitoring	3-0-0	3
Water Resources Engineering	Environmental Hydrology	3-0-2	4
Infrastructure Systems	Introduction to Power Infrastructure Engineering	3-0-0	3
	Thermal and nuclear power infrastructure Engineering	3-0-0	3
	Infrastructure planning and design for rail and air transport	3-0-0	3
	Infrastructure planning and design of ports and harbours	3-0-0	3
	IT and Telecom Infrastructure	3-0-0	3
	Green Building and Sustainable Materials	3-0-0	3

11. Curriculum of B.Tech. Civil and Infrastructure Engineering (Regular)

Cat	Course	LTP	CH	NC	GC	Cat	Course	LTP	CH	NC	GC
	I Semester						II Semester				
IE	Engineering Mechanics	2-1-0	3	-	3	IE	Introduction to Electrical Engineering	3-0-2	5	-	4
IS	Chemistry	3-0-0	3	-	3	IE	Introduction to Computer Science	3-0-2	5	-	4
IS	Physics	3-0-0	3	-	3	IE	Introduction to Bioengineering	3-0-2	5	-	4
IS	Chemistry Lab	0-0-2	2	-	1						
IS	Physics Lab	0-0-2	2	-	1	0					
IS	Mathematics I	3-1-0	4	-	4	IS	Mathematics II	3-1-0	4	-	4
IE	Engineering Visualization	0-0-2	2	-	1	IE	Engineering Realization	0-0-2	1	-	1
NE	Engineering Design I	0-0-2	2	1	-	NE	Engineering Design II	0-0-2	2	1	-
NH	Communication Skill I	0-0-2	2	1	-	NH	Communication Skill II	0-0-2	2	1	-
NH	Social Connect and responsibilities I	0-0-1	1	0.5	-	NH	Social Connect and responsibilities II	0-0-1	1	0.5	-
NH	Performing Arts I /Sports I	0-0-1	1	0.5	-	NH	Performing ArtsII/Sports II	0-0-1	1	0.5	-
Total		**11-2-12**	**25**	**3**	**16**	**Total**		**12-1-14**	**26**	**3**	**17**
	III Semester						IV Semester				
LS	Probability,Statistics and Stochastic Process	3-1-0	4	-	4	IE	Structure of Materials Corrosion Polymers	3 × 1-0-0	3	-	3
IE	Thermodynamics	3-1-0	4	-	4	PC	Mechanics of solids	3-1-0	6		4
PC	Geoinformatics	3-0-2	6		4	PC	Fluid Mechanics	3-1-2	6		5
IE	Introduction to Machine Learning	3-0-2	5	-	4	IE	Signals and Systems	3-1-0	4	-	4
LS	Introduction to Analytical Mechanics	3-0-0	3	-	3	IH	Humanities I	3-0-0	3	-	3
NE	Intro. To Profession	0-0-2	2	1		PC	Data Structure and Algorithm	3-0-2	3	-	4
Total		15-2-6	24	1	19	Total		18-1-6	25	-	23
	V Semester						VI Semester				

PC	Transportation Engineering	3-0-0	3		3	PC	Water Resources Engineering	3-0-2	5		4
PC	Structural Analysis	3-0-2	5		4	PC	Reinforced Concrete Design	3-0-2	5		4
PC	Environmental Engineering	3-0-2	5		4	PC	Smart Infrastructure Engineering	3-0-0	3		3
PC	Geotechnical Engineering	3-1-0	4		4	PC	Advanced Structural Analysis	3-0-2	5		4
PC	Construction Technology and Practices	3-0-2	5		4	PC	Geotechnical Engineering Lab	0-0-2	2		1
IH	Humanities II	3-0-0	3	-	3	PE	Programme/Open Elective	3-0-0	3		3
NH	Professional Ethics I	0-1-0		1	-	NH	Professional Ethics II	0-1-0		1	-
Total		18-2-6	25	1	22	Total		15-1-8	23	1	19
	VII Semester						VIII Semester				
PP	B. Tech. Project	0-0-6	6	-	3	IH	Humanities IV	3-0-0	3	-	3
PE/OE	Programme/Open Electives	8-0-0	8	-	8	PE/OE	Programme/Open Electives	15-0-0	15	-	15
IH	Humanities III	3-0-0	3	-	3						
IS	Environmental Science	2-0-0	2	-	2						
Total		13-0-6	19	-	16	Total		18-0-0	18	-	18
							Total of Graded Credit			-	150
							Non-Graded Credit			9	-
							Non-Graded Design Credits			6	-
							Grand Total				165

12. B.Tech. with Specialization

The students can obtain a Departmental Specialization after completing additional 20 credits beyond the regular B.Tech. program credit requirement. From the 20 credits, 8 credits must be taken from core areas of that specialization and 12 credits should be taken from the electives within that specialization.

i. B Tech with Specialization in Environmental Engineering

(Total credits: 20; Core credits: 8; Specialization Electives: 12)

S. No.	Core Courses	Course Credits
1.	Fate of Chemicals in the Environment	3-0-0 [3]
2.	Climate Change and Impact	3-0-4 [5]

S. No.	Electives	Course Credits
1.	Remote Sensing and GIS for Environment Management	3-0-2 [4]
2.	Solid Waste Management	3-0-0 [3]
3.	Air Pollution and Control	3-0-0 [3]
4.	Advanced Wastewater Treatment	3-0-2 [4]
5.	Environmental Economics and Management	3-0-0 [3]
6.	Environmental Impact Assessment	3-0-0 [3]
7.	Machine Learning for Environmental Engineering.	3-0-0 [3]
8.	Geomorphology	3-0-0 [3]
9.	GIS and Public Health	3-0-0 [3]
10.	Environmental Biotechnology and Bioremediation	3-0-2 [4]
11	Specialization Project (maximum 6 credits)	0-0-12 [6]

ii. B.Tech. with Specialization in Smart Infrastructure

(Total credits: 20; Core credits: 8; Specialization Electives: 12)

S. No.	Core Courses	Course Credits
1.	Cyber-Physical Systems for Infrastructure	3-0-0 [3]
2.	AI/ML in Infrastructure Engineering	3-0-0 [3]
3.	Smart Infrastructure: Design and Simulation	0-0-4 [2]

S. No.	Electives	Course Credits
1.	Transmission Infrastructure	3-0-0 [3]
2.	Thermal and Nuclear Power Infrastructure Engineering	3-0-0 [3]
3.	Surveillance and Security of Infrastructures	3-0-0 [3]
4.	Digital Twin and Asset management	3-0-0 [3]
5.	Introduction to Power Infrastructure Engineering	3-0-0[3]
6.	Infrastructure planning and design for rail and air transport	3-0-0 [3]
7.	IT and Telecom Infrastructure	3-0-0 [3]
8.	Specialization Project (maximum 6 credits)	0-0-12 [6]

13. Detailed Course Contents

Title	Data Structures and Algorithms	Number	CS2XX0
Department	Computer Science and Engineering	L-T-P [C]	3-0-2 [4]
Offered for	B.Tech of all branches	Type	Program Core (PC)
Prerequisite	Introduction to Computer Programming		

Objectives
The Instructor will:
To introduce and practice the implementation of various data structures used for indexing, searching, and sorting operations.
To introduce basic mathematical techniques for algorithm analysis and design.

Learning Outcomes
The students will have the ability to:
Ability to design and implement appropriate data structures for indexing, searching, and sorting operations for real-world problems.
Designing of new algorithms using standard data structures.
Analyzing the time and space complexities of standard data structures and basic algorithms

Contents
Algorithm analysis and complexity: Big/little -Oh, Omega, Theta notation, Recurrence equations (2 Lectures)
Abstract data types: Linear data structures, Tree, Binary trees, Tree traversal, Applications (7 Lectures)
Search trees: Binary search trees, Balanced search trees, AVL trees, B-Trees (5 Lectures)
Heaps: Binary Heap, Heap order property and min/max heaps (3 Lectures)
Sets: Disjoint set ADT, Basic operations on Sets, Union/Find Algorithm (2 Lectures)
Greedy techniques for algorithm design (1 lecture)
Sorting algorithms: Bubble sort, Selection sort, Bucket sort, Insertion sort, Overview of Divide-and-conquer, Quick sort, Merge sort (6 Lectures)
Hashing: Hash tables and operations, Hash function, Open and closed hashing, External and internal hashing, Collision resolving methods, Rehashing (5 Lectures)
Dynamic programming for problem solving (3 Lectures)
Graph algorithms: Definitions, Branch and bound, Backtracking, Representation, Traversal, Shortest-path algorithms, Minimum Spanning Tree algorithm, Topological sorting (8 Lectures)

Laboratory
Implementation of data structures using C programming language.
Practically verifying and comparing run-time performance and asymptotic behavior of various data structures and related algorithms.
Applications of data structures from real-life scenarios.

Text Books
M. A. WEISS (2002), Data Structures and Algorithm Analysis in C, Addison-Wesley, 2nd Edition.

Reference Books
T. H. CORMEN, C. E. LEISERSON, R.L. RIVEST, C. STEIN (2009), Introduction to Algorithms, MIT Press, 3rd Edition.

Online course Material
Data Structures and Algorithms, NPTEL Course Material, Department Computer Science and Engineering, IIT Delhi: https://nptel.ac.in/courses/106102064/

Title	Structure of Materials	Number	MTL2XX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	1–0–0 [1]
Offered for	B.Tech.	Type	Institute Core – Engineering (IE)
Prerequisite	-		

Objectives
1. Introduce the concept of crystal structure, atomic planes and directions
2. Introduce the concept of atomic packing, coordination, and symmetry elements
3. Introduce imperfections in solids

Learning Outcomes
The students are expected to have the ability to:
1. Understand the atomic arrangement in crystalline materials
2. Describe the periodic arrangement of atoms in terms of unit cell parameters
3. Identify various kinds of defects

Contents
Introduction: [3 lectures] Classification of materials, crystalline and non-crystalline solids, atomic bonding
Geometrical Crystallography: [3 lectures] Symmetry elements: the operation of rotation, Proper and Improper rotation axes, Screw axes, Glide planes
Crystal Structure: [4 lectures] Crystal Lattice, Unit Cell, Planes and directions in a lattice, Planar Atomic Density, packing of atoms and packing fraction, Classification and Coordination of voids, Bragg's Law
Imperfections in Solids: [3 lectures] Types of imperfections, Point defects: vacancies, interstitials, line defects, 2-D and 3-defects, Concept of free volume in amorphous solids.

Textbook
Azaroff, L.V., (2001) Introduction to solids, 1st Edition, McGraw Hill Book Company

Reference Books
Callister Jr, W.D., Rethwisch, D.G., (2018), Materials Science and Engineering: An Introduction, 10th Edition, Hoboken, NJ: Wiley

Online Course Material
1. Prasad, R., Introduction to Materials Science and Engineering, NPTEL Course Material, Department of Materials Science and Engineering, Indian Institute of Technology Delhi, http://nptel.ac.in/courses/113102080/
2. Subramaniam, A., Structure of Materials, NPTEL Course Material, Department of Material Science and Engineering, Indian Institute of Technology Kanpur, https://nptel.ac.in/courses/113104014/

Title	Corrosion	Number	MTL2XX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	1–0–0 [1]
Offered for	B. Tech	Type	Institute Core – Engineering (IE)
Prerequisite	-		

Objectives
The Instructor will:
1. Introduce to different forms of corrosion
2. Elucidate thermodynamics and kinetics of corrosion
3. Teach different protection mechanisms against corrosion

Learning Outcomes
The students are expected to:
1. Understand corrosion under different environments
2. Understand the thermodynamics and kinetics of corrosion
3. Know protection methods against corrosion

Contents
Introduction and Motivation: [2 lecture] Economics, forms of corrosion, design, basics of Electrochemistry
Thermodynamics and Kinetics: [6 lectures] Nernst equation, Pourbaix diagram, Rate expression, Exchange current density, Polarization, Tafel Equation, Mixed Potential Theory-Galvanization, Passivation, corrosion measurement
Forms of Corrosion: [5 lectures] Major forms of corrosion (e.g. uniform, galvanic, crevice corrosion, stress corrosion, Hydrogen embrittlement, sulphate attack, etc.), Oxidation, Pilling Bedworth ratio, corrosion of steel, Al, and concrete, microbial corrosion
Corrosion Protection: [1 lecture] Cathodic and anodic protection, Inhibitors, coatings

Textbook
Fontana, M.G., (2017) Corrosion Engineering, 3 rd Edition, McGraw Hill

Reference Books
1. Ahmad, Z., (2006), Principles of Corrosion Engineering and Corrosion Control, Elsevier
2. Revie, W.R., Uhlig, H.H., (2008) Corrosion and Corrosion Control, 4th edition, Wiley

Online Course Material
1. Natarajan, K.A., Advances in Corrosion Engineering, Department of Materials Engineering, IISc Bangalore, http://nptel.ac.in/courses/113108051/
2. Mondal, K., Corrosion I, Department of Material Science and Engineering, Indian Institute of Technology, Kanpur, https://nptel.ac.in/courses/113/104/113104082/

Title	Polymers	Number	CHL2XX0
Department	Chemical Engineering	L-T-P [C]	1-0-0 [1]
Offered for	B.Tech.	Type	Institute Core - Engineering (IE)
Prerequisite	-		

Objectives
The Instructor will:
Provide basic background to structure and properties of polymeric materials

Learning Outcomes
1. The students are expected to have the ability to:
2. Understand the basic classifications and synthesis of polymers
3. Correlate the structure of polymers with properties

Contents
Background: [3 lectures] Terminologies, classification of polymers, Amorphous & semi-crystalline polymer, biopolymers, Functional group reactivity, classification of polymerization reactions
Structure-Property in Bulk Polymer: [6 lectures] Glass transition, crystal structure, crystallinity and melting in polymer, mechanical properties-stress-strain relationship, Electrical properties: Dielectric properties, conduction in polymers
Introduction to Viscoelasticity: [3 lectures] Mechanical models-Kelvin model, Maxwell model, Voigt model
Applications: [2 lectures] Polymer composites, polymers for electronic packaging

Textbook
Young, R.J., and Lovell, P.A. (2011), Introduction to Polymers, 3rd Edition, CRC Press

Reference Books
BillMeyer, F.W., (2007), Textbook of Polymer Science, 3rd Edition, Wiley

Online Course Material
Adhikari, B., Science and Technology of Polymers, NPTEL Course Material, Department of Metallurgical & Materials Engineering, Indian Institute of Technology Kharagpur, http://nptel.ac.in/courses/113105028/

Title	Introduction to Machine Learning	Number	CS2XX0
Department	Computer Science and Engineering / Electrical Engineering	L-T-P [C]	3-0-2 [4]
Offered for	B.Tech of all branches	Type	Institute Core – Engineering (IE)
Prerequisite	Introduction to Computer Programming		

Objectives
1. To familiarize with the fundamental machine learning algorithms.
2. To study applications of machine learning algorithms in different disciplines.

Learning Outcomes
The students are expected to have the ability to:
1. Ability to formulate a machine learning problem
2. Ability to select an appropriate machine learning algorithm for analysing different types of data.
3. Ability to apply pattern analysis tools to practical applications and detect patterns in the data.

Content
Preliminaries: ML pipeline, training, testing, Learning Paradigms: Supervised, unsupervised, and reinforcement, Representation of samples, Correlation and covariance, probability, distributions, hypothesis evaluation, Data processing and normalization, Bias-Variance (8 lectures)
Regression and Supervised Classifiers (18 lectures):
Logistic and Linear Regression (2),
Decision Tree, Boosting and Bagging, K-NN (5)
Bayesian Decision Theory, MLE Parameter Estimation (5)
EM-Algorithms (2 lectures)
SVM (4 lectures)
Linear Decision boundaries, Discriminant Analysis, and Subspace Representation (PCA) (4 lectures)
Unsupervised Learning: K-means and Graph-based Clustering (3 lectures)
Time series: Introduction to Time Series and Stochastic Processes, HMM (3)
Artificial Neural Networks, Autoencoder, and CNN, Regularization Techniques (6 lectures)

Laboratory Classes
Programming labs on Normalization, Visualization (Visualization Tools: regression plots, scatter plot, tableau), Distribution, Evaluation, Regressions, Decision Tree, Bayes, PCA, LDA, ANN, K-means, Graph-based Clustering, HMM.

Case Studies from different departments
BSB: Identification of protein secondary structure (helices, sheets, and coil), or functional categories representing binding sites, cleavage sites, or residues being posttranslationally modified using Neural networks.
ME: Machine Learning for Predictive Maintenance, where sensed machine data can be used in learning whether routine maintenance of the machine is required or not: Classification problem
Chemical Engg: Application of ML to predict life cycle of Lithium Ion Battery. (Challenge: Even with the same chemistry and same operating conditions, there is considerable variability in the life cycle of the lithium ion battery.
Materials: Finding unprecedentedly low-thermal-conductivity half-Heusler semiconductors via high-throughput materials modelling,
Civil Engg: Applications in Transportation Systems, Environmental Pollution Prediction.

Text Books
Machine Learning, T. M. MITCHELL, McGraw Hill Education, 2017

Reference Books
1. Pattern Recognition and Machine Learning, C. M. BISHOP, Springer-Verlag New York, 2006
2. Pattern Classification, R. O. DUDA, P. E. HART, D. G. STORK, Wiley-Blackwell, 2000

Online course Material

1. Introduction to Machine Learning, NPTEL Course Material, Department Computer Science and Engineering, IIT Madras: http//nptel.ac.in/courses/106106139/
2. Machine Learning, Stanford University: https://see.stanford.edu/Course/CS229

Title	Probability, Statistics & Stochastic Process	Number	MAL2XX0
Department	Mathematics	L-T-P [C]	3-1-0 [4]
Offered for	B.Tech BSBE, CSE, EE, DS&AI, CHE, CIE, ES	Type	Institute Core – Engineering (IE)
Prerequisite			

Objectives

The Instructor will:

1. Demonstrate the basic principles of probability theory and random variables.
2. Demonstrate the use of various families of probability distributions to model various types of data.
3. Introduce the concept of stochastic process and its application

Learning Outcomes

The students will have the ability to:

1. Understand probability theory and develop the mathematical foundation of random variables.
2. Understand random sampling, theory of estimation and testing of hypotheses.
3. Understand the concept of stochastic processes and demonstrate the specific applications to Poisson and Gaussian processes.

Content

Probability Spaces and Random Variables [16 lectures]: Axioms of probability, conditional probability, Independence, Bayes' rule, Random variable, Some common discrete and continuous distributions, Distribution of Functions of Random Variable, Two and higher dimensional distributions, Functions of random variables, Conditional distributions, Laws of large numbers, Central limit theorem.

Estimation and Test of Hypothesis [12 lectures]: Parameter Estimation, Maximum Likelihood Estimator [4 lecture], Confidence Interval [2 lecture], Hypothesis Testing [6 lecture].

Stochastic Processes [14 Lectures]: Definition of Stochastic process, Classification and properties of stochastic processes, Simple Markovian stochastic processes, Gaussian processes, Stationary processes, Discrete and continuous time Markov chains, ergodicity.

Text Books

1. Ross, S. M., (2010), A First Course in Probability, Pearson Prentice Hall
2. Ross, S. M., (2012), Introduction to probability and statistics for engineers and scientists, Elsevier
3. Castaneda, L.B., Arunachalam, V. and Dharmaraja, S., (2012), Introduction to Probability and Stochastic Processes with Applications, John Wiley & Sons.
4. Papoulis, A., (1991), Probability, Random Variables, and Stochastic Processes, McGraw-Hill.

Reference Books

Rohatgi, V. K. & Saleh, A.K.M.E., (2011), An Introduction to Probability and Statistics, Wiley

Casella, G. and Berger, R. (2002). Statistical Inference, Cengage Learning

Ross M.S., (2008), Stochastic Processes, John Wiley and Sons.

Hoel, P.G., Port, S.C. & Stone, C.J. (1986) Introduction to Stochastic Processes, Houghton Mifflin Company

Online course Material

1. G. Srinivasan, IIT Madras, Introduction to probability and Statistics,
   https://nptel.ac.in/courses/111/106/111106112/
2. S. Dharmaraja, IIT Delhi, Introduction to Probability Theory and Stochastic Processes,
   https://nptel.ac.in/courses/111/102/111102111/

Title	Signals and systems	Number	EE2XX0
Department	Electrical Engineering	L-T-P [C]	3-1-0 [4]
Offered for	B.Tech	Type	Institute Core – Engineering (IE)
Prerequisite			

Objectives

The Instructor would:

1. Familiarize students with the fundamentals of continuous-time and discrete-time linear systems, and their response analysis
2. Provide understanding frequency-domain transforms and their real-world applications
3. Discuss the applications from the area of engineering and physics

Learning Outcomes

The students will have the ability to:

1. Compute the response and system functions of LTI systems in various domains
2. Solve basic real-world interdisciplinary problems involving time-domain or frequency analysis of signals

Content

Signals and Systems (Continuous and Discrete Time) [10 lectures]:

Description and Classification of signals, signal operations in time domain, Sampling, Description and Classification of LTI System, Properties of LTI system, Impulse response, Convolution and Correlation.

Frequency Domain Representation of Signals [12 lectures]:

Fourier series representation of periodic signals, convergence of Fourier Series & Gibbs phenomenon, Fourier Transform, Fourier transform of periodic signals, properties of Fourier transform, Laplace Transform, Z-Transform, region of convergence & properties, Rational System functions, Inverse Laplace and Z-Transform of Rational Functions and applications.

LTI systems [12 lectures] :

Difference and differential equation representation, block diagram representation, Transfer function and convolution, poles and zeros, step response, Natural Response of 1st and 2nd Order Systems, Sinusoidal steady-state and Frequency Response.

Applications: [8 lectures]:

Applications from the area of condition monitoring, Predictive Operations and Maintenance, Process Control, ECG Signal Filtering and Denoising, Seismic Signal Processing, and few examples related to 2D,3D, and speech signal processing.

Text Books

Oppenheim, A. & Wilsky, A. S., Signals and Systems, 2nd Edition, Prentice-Hall

Reference Books

1. Lathi, B. P., (2009), Principles of Linear Systems and Signals, 2nd Edition, Oxford University Press
2. Haykin, S. & Veen, B. V., (2008), Signals and Systems, 2nd Edition, Wiley
3. Dutta Roy, S. C., Chandra, S., (2018), Circuits, Systems and Signal Processing: A Tutorials Approach, 1st Edition, Springer

Online course Material

1. Dutta Roy, S. C., Indian Institute of Technology Delhi, Signals and Systems,
   https://www.youtube.com/playlist?list=PLC6210462711083C4
2. Venkatesan, K. S., Indian Institute of Technology Kanpur, Signals and Systems, NPTEL,
   https://nptel.ac.in/courses/117/104/117104074/

Title	Thermodynamics	Number	MEL2XX0
Department	Mechanical Engineering	L-T-P [C]	3-1-0 [4]
Offered for	All B. Tech	Type	Institute Core – Engineering (IE)
Prerequisite			

Objectives
1. To understand thermodynamics laws and various thermodynamic processes
2. To comprehend work producing and work consuming cycles
3. To inculcate the importance of change of state responsible for physical and chemical changes.
4. To introduce broader aspects of thermodynamics across disciplines and applicability of laws of thermodynamics and entropy principle in the areas ranging from design of prime movers to design of algorithms.

Learning Outcomes
1. Ability to effectively apply laws of thermodynamics in the practice of engineering.
2. Capability to assess and quantify thermodynamic efficiencies using the second law of thermodynamics.
3. Ability to conduct comprehensive and rigorous treatment of classical thermodynamics while retaining an engineering perspective Content

Content
Implication of Thermodynamics and its scope in various disciplines [2 Lectures]: Mechanical engineering applications, Computer science applications, Electrical Engineering applications, Biological science applications, Chemical engineering applications.
Basic concepts [2 Lectures]: Thermodynamic system, Properties, State, Process, Thermodynamic equilibrium, Pressure measurement, Zeroth law, Temperature measurement.
Concept of energy and energy transfer [7 Lectures]: Work and Heat, Internal energy, First Law of Thermodynamics, Work transfer and its value for different processes, Heat transfer, state functions, Equation of state for ideal and real gases, Gas mixtures; Differential form of First Law, First Law and various Processes.
Thermodynamic properties of pure substance [4 Lectures]: Phase change process of pure substance and their property diagram, Use of steam table and Mollier diagram.
Energy analysis of closed and open systems [8 Lectures]: First law analysis for closed systems, Steady flow energy equation, Flow processes, Throttling process, Joule-Thomson effect, Energy analysis of open systems, and Analysis of First law for unsteady flow.
Second law of thermodynamics [4 Lectures]: Reversible and Irreversible processes, Kelvin-Planck and Clausius statement, Heat engines, Heat pumps, Carnot cycle.
Entropy [9 Lectures]: Definitions of entropy, statistical definition of pressure, temperature, entropy, Change of entropy for various processes, machine learning and coding application examples, Equilibrium, Spontaneity relations for Entropy, Helmholtz free energy, Gibbs free energy.
Thermodynamic property relations [3 Lectures]: Maxwell relations, Clausius-Clapeyron equation
Exergy [3 Lectures]: Definition of exergy, second law efficiency, Irreversibility, Exergy balance.

Text Books
1. Moran, M. J. & Shapiro, H. N., (2011), Fundamentals of Engineering Thermodynamics, 7th Edition, Wiley.
2. Cengel, Y. A. & Boles, M. A., (2010), Thermodynamics: An Engineering Approach, McGraw Hill Education
3. Sonntag, R. E. & Wylen, V., (1998), Fundamentals of Thermodynamics, Wiley
4. Zemansky M., (2017), Heat and Thermodynamics, McGrawhill

Online course Material
Prof. Keith A. Nelson & Prof. Moungi Bawendi., Thermodynamics and Chemical Kinetics, MIT OpenCourseWare, Link: https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/

Title	Introduction to Analytical Mechanics	Number	PHL2XXX
Department	Physics	L-T-P [C]	3-0-2 [4]
Offered for	B.Tech of all branches	Type	Program Linked Science (LS)
Prerequisite			

Objectives
The Instructor will:
Provide concepts and problem solving approach related to Newtonian and Lagrangian formulation in Mechanics.

Learning Outcomes
The students are expected to have the ability to:
Solve problems in Newtonian, Lagrangian and Hamilton formalism

Content
Introduction to Newtonian and Lagrangian mechanics, constraints, D'Alembert's principle, Problems solving approach in Newtonian and Lagrangian formalism (12 Lectures)
Central force problem: The equation of motion, the equivalent one-dimensional problem, classification of orbits, Virial theorem, Differential equation for the orbit, inverse square law of force, scattering in the central force field. (10 Lectures)
Variational Principles and Lagrange's equations: calculus of variations, Hamilton's principle, derivation of Lagrange's equation from Hamilton's principle, its application, conservation and symmetry property. (8 Lectures)
Rigid body motion: orthogonal transformation, the Eulerian angles, Euler's theorem, infinitesimal rotation, Rodrigues formula, quaternion, the heavy symmetrical top, Gyroscope, Foucault Pendulum (8 Lectures)
Hamilton's equation of motion: Legendre transformations and Hamilton's equation (4 Lectures)

Text Books
1.Simon, Keith. R., Mechanics Second Edition Addison -Wesley publication (1960).
2.Analytical Mechanics, L. N. Hand and J. D. Finch Paperback (1998)

Reference Books
1.Goldstein, H., Classical Mechanics, Pearson India Limited, New Delhi (2011).
2.Landau, L.D. and Lifshitz, E.M., Mechanics, Pergamon Press, (1960)

Online course Material
Prof. Harbola. M. K. , Engineering Mechanics, Indian Institute of Technology -Kanpur,
https://nptel.ac.in/syllabus/115/104/115104094/

Title	Fluid Mechanics	Number	MEL2XX0/ CHL2XX0
Department	Mechanical Engineering/ Chemical Engineering	L-T-P [C]	3–1–0[4]
Offered for	B.Tech (ME, CH)	Type	Program Compulsory (PC)
Prerequisite			

Objectives

The instructor will:

1. To inculcate the fundamental laws governing fluid flow
2. Help the students to understand the importance and application of fluid mechanics.
3. To exemplify concepts of similarity and model testing

Learning Outcomes

The students are expected to have the ability to:

1. Apply fundamental knowledge in modelling and analysis of fluid flow problems in engineering
2. Interpret data from experiments of fluid flows and solve using differential equations and charts

Contents

Introduction [2 Lecture]: Definition and properties, continuum approach, types of fluids, basics of vector calculus and index notations.

Fluid statics [4 Lectures]: Basic equations, Manometry,hydrostatic force on submerged bodies, rigid body motion.

Integral analysis of fluid flow [4 Lectures]: Reynolds transport theorem, conservation equations.

Differential analysis [5 Lectures]: Kinematics of fluids -Deformations in fluid particle, strain rate, vorticity, stream function, potential function, streamlines, pathlines, streaklines, derivation of Navier-Stokes equations.

Incompressible Inviscid flow [6 Lectures]: Euler's equation, Bernoulli's equation, elementary potential flows, superposition of elementary flows. Vorticity and vortex flows

Internal Incompressible Viscous flow [4 Lectures]:Hagen-Poiseuille and Couette flows,skin friction and loss coefficients, venturimeter, orifice meter and Pitot tube.

External Incompressible Viscous flow [5 Lecture]: Boundary layer over flat plate, boundary layer thickness, Prandtl-boundary layer equations, momentum integral equation, adverse pressure gradient & separation, drag coefficients.

Dimensional analysis and similarity [2 Lectures]: Buckingham Pi theorem and examples.

Introduction to Turbulent flows [3 Lectures]: Decomposition of instantaneous velocities, time-averaged continuity and Navier-Stokes equations, Reynolds stresses, turbulent viscosity.

Basics of Compressible flow [3 Lectures]: Acoustic waves, isentropic equations, concept of shock waves

Few Industrial Applications [4 Lectures]: Pipe networks, Flow past immersed objects, Agitation and Mixing.

Text Book

1. Fox, R. W., Pitchard, P. J and McDonald, A. T., (2010), Introduction to Fluid Mechanics, 7thEdition, John Wiley & Sons Inc.
2. Munson, B. R., Rothmayer, A. P., Okiishi, T'H., and Huebsch, W. W. Fundamentals of Fluid Mechanics, 7th Edition, John Wiley and Sons
3. Kundu, P. K, Cohen, I. M and Dowling, D. R, Fluid Mechanics, 6th Edn., Associated Press.
4. McCabe, W.L., Smith, J.C., Harriott, P., (2005), Unit Operations of Chemical Engineering, 7th edition, McGraw-Hill International edition.

Reference Books

1. White, F. M.,(2003), Fluid Mechanics, 5thEdition, McGraw-Hil
2. Cimbala, J.M. and Cengel, Y.A., (2010),Fluid Mechanics: Fundamentals and Applications, McGraw-Hill
3. Bird. R. B., Stewart, W. E. and Lightfoot, E. N., 2006, Transport Phenomena, 2nd edition, John Wiley & Sons.
4. Panton, Ronald L - Incompressible flow, John Wiley & Sons, 2006. Third edition is available from Wiley Student Edition

Self-Learning Material

S. Chakrabarty, Introduction to Fluid Mechanics, NPTEL Course Material, Mechanical Engineering, IIT Kharagpur, https://nptel.ac.in/courses/112/105/112105269/

V.Shankar, Fluid Mechanics,   NPTEL Course Material, Chemical Engineering, IIT Kanpur, https://nptel.ac.in/courses/103/104/103104044/#

Title	Fluid Mechanics Lab	Number	MEP3XX0
Department	Mechanical Engineering	L-T-P [C]	0–0–2[1]
Offered for	B. Tech (ME)	Type	Program Compulsory (PC)
Prerequisite	Fluid Mechanics		

Objectives

The instructor will

1. To introduce various forms of flow measuring devices and techniques
2. To provide hands on experience on in the area of experimental fluid mechanics

Learning Outcomes

The students will have:

1. Ability to design experimental methods for fluid flow problems
2. Ability to interpret data from experiments of fluid flows and usage of charts and hand books

Contents

Determination of head loss in pipes having different diameters, different materials and different roughness

Determination of pressure drop at different types of bends and valves

Reynolds apparatus to measure critical Reynolds number for pipe flows

Measurement of Cp distribution on a cylinder

Make survey experiments in a flow over a cylinder

Impacts of jets on flat and curved plates

Wind tunnel calibration using Pitot static tube

Working principle of different flow meters (orifice plate, venture meter, turbine, Rota meter, electromagnetic flow meter)

Effect of change in cross section and application of the Bernoulli equation

Flow measurement around an object or blockage using PIV technique

Class projects for designing and measurement of simple fluid mechanics experiments

Reference Books

1. Fox, R. W., Pitchard,P. J.,and McDonald, A. T., (2010), Introduction to Fluid Mechanics, 7thEdition, John Wiley & Sons Inc.
2. Cimbala, J.M., Cengel, Y. A. (2010),Fluid Mechanics: Fundamentals and Applications, McGraw-Hill

Title	Mechanics of Solids	Number	ME2XX0
Department	Mechanical Engineering	L-T-P [C]	3–1–0 [4]
Offered for	B.Tech	Type	Programme Compulsory (PC)
Prerequisite			

Objectives
The instructor will:
1. To inculcate fundamental concepts of stress, strain and deformation of solids
2. Fundamental of applying equilibrium, compatibility and forced deformation relationships to structural elements

Learning Outcomes
1. Apply the fundamentals to analyze structural members
2. Physical insight into distribution of stresses and strains in structural members
3. Ability to design structural members using dimensions, force-displacement relationships, boundary conditions, loading and allowable stress

Contents
Stress and strain [10 Lectures]: Concept of stress at a point, Plane stress case: transformation of stresses at a point, principal stresses and Mohr's circle, Displacement field, Concept of strain at a point, Plane strain case: transformation of strain at a point, principal strains and Mohr's circle, Strain Rosette, Polar coordinates in stress and strain analysis. St. Venant's principles and stress concentrations
Mechanical behaviour [8 Lectures]: Concepts of elasticity, plasticity, strain hardening, failure (fracture/yielding), Generalized Hooke's law (without and with thermal strains) for isotropic materials, orthotropic and anisotropic materials, Force displacement relationship and geometric compatibility for axially loaded members and thin walled pressure vessels
Static Analysis[5 Lectures]: Complete equations of elasticity; Force analysis (axial force, shear force, bending moment, and twisting moment diagrams) of slender members
Elastic Bending[5 Lectures]: Moment curvature relationship for pure bending of beams with symmetric cross section, bending stress, shear stress; Cases of combined stresses, Deflection due to bending, Integration of the moment curvature relationship for simple boundary conditions, Stress concentrations
Elastic torsion[5 Lectures]: Torsion of circular shafts and thin walled tubes, Stress concentrations
Strain Energy[5 Lectures]: Concept of strain energy, strain energy for simple structural elements, Castigliano's theorems for deflection analysis and indeterminate problems;
Elastic Buckling [4 Lectures]: Concept of elastic instability, Introduction to column buckling, Euler's formula

Text Books
1. Crandall, S.H., Dahl, N.C., and Lardner, T. J., (1978), An Introduction to the Mechanics of Solids, McGraw Hill, Second Ed. with SI Units.
2. Beer, F.P, Johnston, E.R. and De Wolf, J.T., (2004), Mechanics of Materials, Tata McGrawHill.
3. Popov, E.P., (1990),Engineering Mechanics of Solids, First Ed. Prentice Hall
4. Meriam, J.L. and Kraige, L.G., (1980), Engineering Mechanics, Vol. 1: Statics, 2nd Ed. John Wiley
5. Timoshenko, S.P. and Goodier, J.N. ``Theory of Elasticity``, McGraw-Hill, International Edition, 1970.

Self Learning Materials
1. https://nptel.ac.in/courses/105/106/105106116/
2. https://nptel.ac.in/courses/105/102/105102090/
3. https://nptel.ac.in/courses/105/104/105104160/

Title	Geoinformatics	Number	CI2XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech	Type	Program Core (PC)
Prerequisite			

Objectives

The instructor will:

1. To introduce the basic principles of photogrammetry, remote sensing, GPS and GIS.
2. To teach application of geo-informatics in geoscience, ecology and environment study, agriculture, and disaster management.

Learning Outcomes

A graduate of this course will have a thorough idea of:

1. Stereoscopic vision and principles.
2. Multispectral, thermal infrared, and microwave remote sensing.
3. Different map projections and use of GPS.
4. Component GIS and applications.
5. Different cartographic models, implementation, validation, and visualization..

Content

Module I: Photogrammetry (Lectures: 10)

Aerial Photographs and Photography: Types of photographs; Geometry; Image displacement; Comparison of aerial photographs and map; Planning of photographic flights; Execution of flights; Aerial cameras. Use of Drones

Stereoscopic Vision: Binocular observations; Separation of stereoscopic pair; Types of stereoscope; Measurement of height from photographs; Stereo model; Model deformation.

Radio Line Methods and Map Compilations: Graphical Radial Triangulation; Mechanical Radial Triangulation; Map compilations by graphical methods. Radial line plotter. Accuracy of radial lime methods.

Aerial Mosaics: Planning for Mosaics; Mosaic compilation; Annotation and reproduction; Choice of methods.

Module II: Remote Sensing (Lectures: 12)

Basic Concepts: Interaction of EMR with atmosphere; Interaction of EMR with Earth's surface; Sensors; Platforms.

Remote Sensing in Thermal Infrared Region: Emissivity; Thermal Infrared Sensors; Characteristics of thermal images; Applications.

Remote Sensing in Microwave Region and Lidar: Passive systems; Active systems; SAR image characteristics; SAR image interpretation; Lidar.

Multispectral and Hyperspectral Remote Sensing: Basics of multispectral and hyperspectral imaging

Satellite Remote Sensing: Landsat; IRS and other satellites; Visual interpretation; Applications of satellite imagery.

Module III: Global Positioning System (Lectures: 10)

Map: Map numbering; Rectangular grid system; Classification of map projections; Some useful projections; Georeferencing.

Global Positioning System: Components of GPS; Operational principle; Facts and limitations of GPS; GPS receivers; Differential GPS concepts; Types of differential GPS; Areas of application

Module IV: Geographical Information System (Lectures: 10)

Geographical Information System: GIS concepts; components; Spatial Data Representation; Relationships of spatial objects; GIS functions; Remote sensing and GIS; GIS applications and status in India.

Cartographic Modelling: Cartographic models; Inductive and deductive modelling; Model flowcharting; Conflict resolution; Verification and implementation.

Cartography and Visualization: Cartographic output; Thematic maps and cartograms; Multivariate Display; Web mapping and visualization; Virtual and immersion environments; Mapping the temporal dimension.

Applications:Environment; Agriculture; Public Health; Water Resources Engineering; Transportation Engineering; Disaster Management.

Text Books

1. G. S. Srivastava (2014) An Introduction to Geoinformatics. McGraw Hill Education (India) Private Limited. New Delhi. India. ISBN: 9781259058462.
2. Michael N. DeMers (2008) Fundamentals of Geographic Information Systems (4th Ed). Wiley. ISBN: 978-0-470-12906-7.
3. T. M. Lillesand, R. W. Kiefer, J. W. Chipman (2004) Remote Sensing and Image Interpretation (5th Ed). Wiley. ISBN: 0-471-15227-7

Other Books
1. L. E. Johnson (2009) Geographic Information Systems in Water Resources Engineering. CRC Press. Taylor & Francis Group. ISBN 978-1-4200-6913-6.
2. B. Tomaszewski (2015) Geographic Information Systems (GIS) for Disaster Management. CRC Press. Taylor & Francis Group. ISBN-13: 978-1-4822-1169-6.
3. Myer Kutz (Ed.) (2004) Gary S. Spring. Applications of GIS In Transportation. In book: Handbook of Transportation. McGraw-Hill Handbooks.

Online course Material
1. Prof. Arun K. Saraf (2016) Introduction to Geographic Information System. NPTEL.
   https://nptel.ac.in/courses/105/107/105107155/
2. Prof. Arun K. Saraf (2017) Introduction to Remote Sensing. NPTEL.
   https://nptel.ac.in/courses/121/107/121107009/
3. Prof. Rishikesh Bharti (2019) Remote Sensing and GIS. NPTEL.
   https://nptel.ac.in/courses/105/103/105103193/

Title	Geotechnical Engineering	Number	CI2XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech [CIE]	Type	Program Compulsory (PC)
Prerequisite			

Objectives

The instructor will:
1. Introducing basic principles of soil mechanics and foundation design.
2. Introducing the testing techniques to determine the engineering properties of soil.
3. Introducing design principles of foundations for structures.

Learning Outcomes

Students will have the ability to
1. Interpret various engineering properties of soil and choose appropriate strength properties for design.
2. Evaluate the stresses on soils and foundations and provide subsequent design solutions
3. Design shallow and deep foundations for traditional structures
4. Assess the stability of retaining walls under different loading conditions.
5. Apply the soil exploration techniques to prepare subsoil profiles

Contents

Module 1[Lectures: 10]

Introduction, origin of soils, index properties, soil structure and clay mineralogy,basic geotechnical definitions and relationships, laboratory tests, soil classifications,effective stress, capillarity and permeability: Principle of effective stress; Darcy's Law; permeability; coefficient of permeability; permeability of layered systems

Module 2 [Lectures: 6]

Seepage through soils, vertical stresses, flow nets, quick sand condition; stresses induced by applied loads, Boussinesq's and Westergaard's theories for point loads and areas of different shapes, Newmark's influence chart, compaction, laboratory tests

Module 3 [Lectures: 10]

Consolidation, stress history of soil, spring Analogy –Terzaghi's one dimensional consolidation theory, determination of coefficient of consolidation, shear strength of soils, Mohr – Coulomb failure theories, shear strength determination, critical Void Ratio, liquefaction introduction

Module 4[Lectures: 6]

Slope stability, infinite slopes and translational slides, finite slopes, forms of slip surface, total stress and Effective stress methods of analysis, earth pressure and retaining structures, earth pressure theories

Module 5[Lectures: 10]

Shallow foundations, bearing capacity, factors influencing bearing capacity,analytical methods to determine bearing capacity, Terzaghi's theory –IS Methods,plate load test, types of foundation settlements, deep foundations, load carrying capacity of piles, pile load tests, settlement of pile groups, well foundations,components of well; forces acting on well foundations; construction and sinking of wells; tilt and shift

Text Books
1. Bowles J.E. (1997). Foundation Analysis and Design (5th Ed). Tata McGraw-Hill International Edition. ISBN 0-07-912247-7.
2. Budhu. M (2012). Soil Mechanics and Foundations (3rd Ed). John Wiley and Sons. ISBN: 978-0-470-55684-9.
3. Robert W. day (2010). Foundation Engineering Handbook (2nd Ed). McGraw-Hill Professional. ISBN 978-0-07-174010-4

Additional references

Foundation Engineering (2018) by Prof. Kousik Deb on NPTEL. https://nptel.ac.in/courses/105105176/

Title	Geotechnical Engineering Laboratory	Number	CI2XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	0-0-3 [1.5]
Offered for	B.Tech [CIE]	Type	Program Compulsory (PC)
Prerequisite			

Objectives

The instructor will:

1. Familiarizing students with the physical and engineering properties of soil.
2. Introducing the laboratory testing equipment and their functioning principles
3. Introducing basic field soil testing techniques

Learning Outcomes

Students will have the ability to:

1. Classify the soils roughly based on visual identification
2. Determine the index and engineering properties of soils
3. Use simple and complex field and laboratory testing techniques to determine the shear strength of soils

Contents

Experiments

Visual classification of soils

Specific gravity and moisture content determination

Dry and wet sieve analysis of soils

Sedimentation analysis: Hydrometer analysis

Atterberg limits: liquid limit; plastic limit and shrinkage limit

Permeability of soils through constant head and falling head tests

Field unit weight through sand replacement and core cutter tests

Laboratory compaction: light weight and heavy weight

Consolidation of soil

Direct shear test for sands

Unconfined compression test on cohesive specimens

Triaxial compression test: Unconsolidated undrained; consolidated undrained

Vane shear test

Standard penetration test and other miscellaneous field tests

Text Books

1. Das B.M. (2009). Soil mechanics laboratory manual (7th Ed). OUP USA International Edition. ISBN 10-0195367596.
2. Fratta D. Aguettant J. Smith L.R. (2007). Introduction to Soil Mechanics Laboratory Testing. CRC Press-Taylor & Francis Group (1st Ed). ISBN-10: 1138430242
3. Budhu. M (2012). Soil Mechanics and Foundations (3rd Ed). John Wiley and Sons. ISBN: 978-0-470-55684-9.

Title	Environmental Engineering	Number	CI2XX0
Department	Civil and In Engineering	L-T-P [C]	3-0-2 [4]
Offered for	B. Tech [CIE]	Type	Program Compulsory (PC)
Prerequisite			

Objectives

The instructor will:

1. To gain understanding of the basic concept of air pollution, its sources, and pollutant transport and dispersion.
2. To develop understanding of the concepts and strategies for control of particulate matter and gas-phase pollutants.
3. To develop understanding of water quality, water supply systems and wastewater treatment systems.
4. To develop a basic understanding of the life cycle of waste generation to disposal.

Learning Outcomes

1. The students are expected to achieve proficiency in:
2. Developing a broad overview of various unit operations involved in water treatment and design.
3. Understanding and solving problems related to pollutant dispersion as well as identifying the right control techniques/measures to meet the desired standard levels.
4. Develop understanding of collection, transfer, treatment, management and disposal of solid waste.

Contents

Module I: Wastewater Treatment [Lectures 14].

Sources, nature and characteristics, generation and collection of wastewater, sanitary, storm and combined sewage systems design and flows; primary treatment methods (screening, grit removal, sedimentation and coagulation); secondary treatment methods (attached and suspended growth systems, biomass growth and yield, BOD kinetics); Aerobic and anaerobic processes,; Nitrification-denitrification systems; Sludge characteristics, thickening and disposal

Module II: Air pollution [Lectures 14]

Sources, types and classification of air pollutants, air pollution episodes, effect of air pollutants on human health, vegetation and materials, air quality and emission standards, air pollution legislation, effect of meteorology: Lapse rate, Atmospheric Stability, Plume behavior and dispersion, Stack height; Methods for pollutant monitoring and control, design and selection of control equipments, engineering emission control concepts, pollutant removal and disposal, source control technologies, Indoor air pollution sources and control.

Module III: Solid Waste Management [Lectures 14]

Fundamentals of Solid Waste Management, Management of solid waste, Hazardous Waste Management: Fundamentals, Radioactive Waste Management: Fundamentals, Environmental Risk Assessment, Physicochemical Treatment of Solid and Hazardous Waste, Biological Treatment of Solid and Hazardous Waste, Incineration, Landfill Design. E-Waste Management.

Laboratory

Introduction to laboratory and preliminary examination of water (color, odor and taste)
Determination of pH, alkalinity, turbidity and optimum coagulant dose, and conductivity
Determination of solids (total, dissolved, organic, inorganic and settleable) and hardness
Determination of chloride, sulphates and sulfide in water
Determination of iron and manganese in water
Determination of DO and BOD in wastewater
Determination of phosphorus and fluoride in water
Determination of free and combined residual chlorine in water
Determination of coliforms in water
Demonstration of Analytical Instruments: water–related
Demonstration of Air Sampling Devices and Weather Monitoring Station

Text Books

1. Stull, R. "Practical Meteorology: An algebra-based survey of atmospheric science" – version 1.02b. Univ. of British Columbia. 2017.
2. Aerosol Measurement: Principles, Techniques and Applications, edited by K. Willeke, P. Baron, Van Nostrand Reinhold, 1993.
3. Burton F.L., Tchobanoglous G., Stensel H.D., 2017, WasteWater Engineering Treatment and Reuse, 4thed.,Tata McGraw-Hill.
4. Arceivala S.J. and Asolekar S.R., 2007, Wastewater Treatment for Pollution Control and Reuse, 3rd Ed., Tata McGraw Hill.
5. George Tchobanoglous, Hilary Theisen, Samuel Vigil, Integrated Solid Waste Management: Engineering Principles and Management Issues, McGraw-Hill Series in Water Resources and Environmental Engineering, ISBN-10: 0070632375, ISBN-13: 978-0070632370

Title	Smart Infrastructure Engineering	Number	CI2XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech [CIE]	Type	Program Compulsory (PC)
Prerequisite			

Objectives

The instructor will:

1. Understanding the integration of digital technology in infrastructure systems
2. Designing a smart infrastructure system at various scales

Learning Outcomes

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

1. Realize and integrate various elements of smart infrastructure systems
2. Instrument, monitor and analyze a physical entity for effective decision making
3. Design, develop and manage smart infrastructure systems

Contents

Module 1: Introduction to Infrastructure [Lectures: 6]

Examples of infrastructure systems: Water supply and distribution, Transport systems, Energy management, Building infrastructure, Waste Management. Need for making these infrastructures smart.

Module 2: Data Acquisition [Lectures: 8]

Sensors for different applications – Basic Principles and interpretation of their outputs; Sensors – Inertial Sensors, Fibre Optic Sensing, Optical Sensors including 2D and 3D Camera. Use of satellite images and Drones for sensing. IOT, Networking, Fog and Cloud for data acquisition. Sensor placement. Case studies for selected infrastructures.

Module 3: Analysis of Data [Lectures: 12]

Review of data processing for interpretation and decision-making using machine learning and AI; machine learning and AI applications in transportation problems (e.g. planning public transport, road traffic prediction, traffic incident detection) and environmental (e.g. air pollution management), Application of machine learning in water distribution networks (monitoring, alarm generation, urban water resource management). AI for Building Management; Use of ML for structural health management.

Module 4: Control Applications in Infrastructure [Lectures: 10]

Introduction to basics of control systems including feedback control; feedback control in the field of structural dynamics (tool to protect bridges, buildings against wind, earthquake, etc.), life-cycle management of infrastructure; introduction to pollution control systems.

Module 5: Design for adaptability [Lectures: 6]

Design of smart infrastructure with adaptive capabilities; Design of smart city considering infrastructures of energy, mobility, health and sustainability and their growing interdependencies.

Text Books

1. Raj, P., & Raman, A. C. (2015). Intelligent Cities: Enabling Tools and Technology. CRC Press.
2. Meneguette, R. I., De Grande, R. E., & Loureiro, A. A. (2018). Intelligent transport system in smart cities. Springer: Cham, Switzerland.
3. Deakin, Mark; Al Waer, Husam (Eds.) (2012), From Intelligent to Smart Cities, Routledge, Taylor & Francis, USA and Canada
4. Song, H., Srinivasan, R., Sookoor, T., & Jeschke, S. (2017). Smart cities: foundations, principles, and applications. John Wiley & Sons. ISBN 9781119226390

Additional References

Berglund, E. Z., Monroe, J. G., Ahmed, I., Noghabaei, M., Do, J., Pesantez, J. E., ... & Levis, J. (2020). Smart Infrastructure: A Vision for the Role of the Civil Engineering Profession in Smart Cities. Journal of Infrastructure Systems, 26(2), 03120001.

1. Haarstad, H. (2017). Constructing the sustainable city: Examining the role of sustainability in the 'smart city' discourse. Journal of Environmental Policy & Planning, 19(4), 423-437.

2. ASCE. (2017) Infrastructure Report Card: A comprehensive assessment of America's infrastructure. Reston, VA: ASCE.

Title	Construction Technology and Practices	Number	CI2XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-2 [4]
Offered for	B. Tech [CIE]	Type	Program Compulsory (PC)
Prerequisite			

Objectives
1. To motivate students to learn and appreciate various components of a building, their functions, materials of constructions, and different stages of construction.
2. To impact the basics of calculation of quantities and rates of construction works
3. To introduce planning and scheduling of construction projects

Learning Outcomes
At the end of the course, the student should be able to:
1. Assimilate properties of building materials
2. Understand components of building construction such as foundation, floor, wall and roof.
3. Assimilate quantity and quality of materials for building construction and prepare building estimate
4. Create project schedule, bar charts, and critical path networks

Contents
Module I: Construction materials [Lectures-10]:
Properties and uses of common types of stones, bricks, tiles and hollow building blocks, Pozzolanic Material, Cement, lime and mortar, Properties, types and applications of other building materials like timber, protective coverings [Paints and varnishes], rubber, bitumen, tar and asphalt, glass, plastics and polymers, refractory materials etc, Introduction to concrete mix design

Module II: Building construction[Lectures – 10]:
Building construction: Components of building, shallow and deep foundations; Stone and brick masonry, type of bonds, load bearing walls, cavity wall, partition walls, finishing/coating materials for roofs/floors/walls, construction and expansion joints; Introduction to Green building and LEED classifications.

Module III: Building Estimates [Lectures – 10]:
Types and methods, Detailed specifications for common building materials, Preparation of detailed estimates for RCC single storey building, Calculation of quantities of materials and analysis of rates.

Module IV: Introduction to Project Planning and Network Analysis [Lectures -12]
Introduction to Scheduling, Controlling, Methods of Planning and Programming, Network - Graphical Presentation and guidelines

Construction materials laboratory
Cement:
Consistency and setting time
Soundness test
Blaine's air permeability test
Specific gravity
Compressive strength of hydraulic cement

Aggregate:
Specific gravity and water absorption of coarse aggregate
Bulk density
Specific gravity and water absorption of fine aggregate
Particle size distribution
Aggregate crushing strength test.
Los Angeles Abrasion test.
Aggregate impact test.
Flakiness index and Elongation index test.

Concrete:
Concrete slump test
7 day compressive/split tensile/flexural strength
Air content of concrete by pressure method
Determination of unit weight of concrete

Bitumen:
Penetration test
Ductility test
Viscosity test
Softening point test
Flash and fire point test

Miscellaneous test for pavements
Determination of bitumen content by centrifuge extractor
Determination of Marshall stability value
Determination of rebound deflection of pavement by Benkelman beam

Text Books
1. Gambhir, M. L. and Neha Jamwal, Building Materials, Tata McGraw Hill.
2. Huntington, W. C. Building Construction, John Wiley, New York
3. Dutta, B. N. Estimating and Costing in Civil Engineering, Theory and Practice. UBS Publishers' Distributors Pvt Ltd.
4. Srinath, L. S. An Introduction to Project Management, Tata McGraw Hill

Additional References
1. Rangwala, S. C. Engineering Materials, Charotar Publishing House, Anand
2. Punmia, B., C. Building Construction, Laxmi Publications, New Delhi
3. Shah, N. A. Quantity Surveying and Valuation. Khanna Publishers.
4. Mazda, F. Engineering Management, Adison Wesley, Longman Ltd.

Title	Transportation Engineering	Number	CI2XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech [CIE]	Type	Program Compulsory (PC)
Prerequisite			

Objectives

The course will introduce students to the planning, alignment, construction, and operation of highways and traffic flow analysis.

Learning Outcomes

1. At the end of the course, the student should be able to:
2. Carry out surveys involved in planning and highway alignment
3. Design cross section elements, sight distance, horizontal and vertical alignment
4. Determine the characteristics of pavement materials
5. Implement traffic studies, traffic regulations and controls, and intersection design

Contents

Module I: Introduction to Transportation Engineering [Lectures-3]:
Transportation system; Introduction to Highway Engineering; Road classification, Terrain classification, Factors affecting transportation

Module II: Transportation Planning [Lectures – 10]
Urban Transportation Planning- Comprehensive planning, System Engineering process; Zoning for Transportation surveys/data collection; Four-step transportation planning-Trip generation, Trip distribution, Modal split, Route assignment.

Module III: Geometric design [Lectures – 10]:
Highway classification; Factors affecting geometric design; Highway design process-Highway cross sectional elements, Sight distance, Highway alignment: Horizontal alignment -horizontal curve, Super elevation, extra widening, Transition curve, Setback distance, Visibility, Vertical alignment -gradient, grade compensation, summit curve, valley curve.

Module IV: Pavement Engineering [Lectures -10]
Pavement characteristics, materials, Types of pavement- Flexible and Rigid pavements, Wheel load calculations, Flexible Pavement materials- soil, aggregate, bitumen; Tests on pavement materials; Bituminous mix design, Marshall stability; Rigid pavement- joints, analysis of stresses; IRC method for design of flexible and rigid pavement; Pavement failures.

Module V: Traffic Engineering [Lectures -9]
Transportation system, Factors affecting traffic performance, Micro and macro elements of traffic flow, fundamental diagram of traffic flow, Introduction to traffic signs and signals

Text Books

1. N. J. Garber, L.A. Hoel. Traffic and Highway Engineering, 4th Edition
2. Saxena S. C. Textbook of Highway and Traffic Engineering, CBS Publishers.
3. Wright Dixon, Highway Engineering, Wiley India.

Additional References

1. S. K. Khanna, C. E. G. Justo, and A. Veeraragavan. Highway Engineering, Nem Chand and Bros. Publishers.
2. I.S. specifications on concrete, aggregates and bituminous materials.
3. David Croney, Design and performance of road pavements, McGraw Hill
4. Dr. L. R. Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers.
5. James H. Banks, Introduction to Transportation Engineering, McGraw Hill
6. R. Srinivasa Kumar, Textbook of Highway Engineering, University Press
7. IRC: SP:21-2009. Guidelines on landscaping and tree plantation.
8. R. P. Roess, E.S. Prassas, W.R. McShane. Traffic Engineering, 4th edition, Pearson.

9. Chakroborty, P., Animesh Das. Principles of Transportation Engineering. Second Edition, PHI Learning Private Limited
10. Samuel Morgan. Traffic Engineering and Transport Planning. Williford Pr.

Title	Water Resources Engineering	Number	CI2XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-2 [4]
Offered for	B. Tech [CIE]	Type	Program Compulsory (PC)
Prerequisite	-		

Objectives

In this course the students will:

1. Learn to describe the fundamental concepts of hydrology
2. Understand various methods of hydrologic analysis
3. Apply various hydrologic and hydraulic analysis methods to design stormwater drains, dams, irrigation and diversion structures

Learning Outcomes

At the end of the course, the student should be able to:

1. Conceptualize different hydrologic process based on physical laws
2. Apply the concept of flood and reservoir routing in real data and solve the field issues
3. Find solutions for water resources issues such as urban flooding, water management and groundwater depletion.

Contents

MODULE I: [No. of lectures – 11]

Introduction: Hydraulic cycle, Precipitation: forms, classification, variability, measurement, data analysis. Evapotranspiration: Penman-Monteith and other methods, Infiltration: factors affecting, estimation by NRCS, Green-Ampt methods

MODULE II: [No. of lectures-10]

Runoff: Drainage basin characteristics, hydrographs, concepts, assumptions and limitations of unit hydrograph, derivation of unit hydrograph, flow duration curve, rainfall-runoff modelling Hydraulic analysis and design: Design flood estimation, frequency analysis, flood routing, storm drainage design; Flood management: Flood mitigation, flood damage analysis

MODULE III: [No. of lectures-10]

Dams: types, forces, failure types and causes; design of gravity dams. Reservoirs: safe yield, capacity design, reliability, design of overflow spillway; Hydroelectric power: Low, medium and high head plants, powerhouse components, microhydel

MODULE IV: [No. of lectures-11]

Role of economics in water resources planning: Multipurpose projects, issues in water resources planning and development, system techniques, risk analysis Irrigation: Irrigation water requirement computation, diversion structures, cross drainage structures, regulation structures, filed irrigation methods Groundwater: Occurrence, hydraulics of wells, yield, artificial recharge

Irrigation Engineering Design Laboratory:
Design of Irrigation Canal [lined and unlined]
Design of canal outlets
Design of Alluvial channels carrying clear and sediment laden water
Design the section of hydraulic jump
Design of cross drainage structures with typical plan and section
Design of profile of ogee spillway
Design of Trapezoidal Notch Fall, SARDA fall and Glacis Fall
Design of Cisterns
Analysis and Design of gravity dam
Analysis and Design of earth embankment dam
Problems related to energy dissipators

Text Books

1. Mays, L.W. Water Resources Engineering, John Wiley and sons, Inc., Kundli

2. Todd, D. K. and Mays, L. W. Ground Water Hydrology, John Wiley India Edition

Additional References
1. Chow, V.T., Maidment, D.R., and Mays L.W. Applied Hydrology. McGraw-Hill Inc., New York.
2. James, L.D., and Lee, R.R. Economics of water resources planning. McGraw-Hill Book Inc., New York.
3. Garg, S.K. Irrigation Engineering and Hydraulic Structures. Khanna Publishers, Delhi.
4. Linsley, R.K., Franzini, J.B., Freyberg, D.L., and Tchobanoglous, G. Water Resources Engineering, McGraw Hill Inc., Singapore.
5. Singh, V.P. Elementary Hydrology. Prentice Hall, Englewood Cliffs, New Jersey.

Title	Structural Analysis	Number	CI2XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-2 [4]
Offered for	B.Tech. [CIE]	Type	PC
Prerequisite	-		

Objectives

This course aims at:

1. Introduction to fundamental concepts of structural analysis.
2. Development of analytical skills to compute quantities like displacements, stresses etc. in structures subjected to static forces.
3. Analytical and numerical methods as well as procedures in a way that emphasize physical insight.
4. Problem solving ability for static loads in Civil Engineering design of structures.

Learning Outcomes

Students will have the ability to:

1. Establish equilibrium equations of structural systems.
2. Analyze the responses and stresses generated in structures subjected to different types of static loading.
3. Apply the structural analysis methods to solve real-world problems of the building, bridges etc.

Contents

Module 1

Analysis of statically determinate structures: Determination of internal force on a system; internal forces acting on typical structural members - axial force, shear force and bending moment; discussion on sign convention and notations for internal forces; obtaining internal forces in a system - general procedure; internal force diagrams for various systems; analysis of pin jointed determinate truss. (Lectures: 8)

Module 2

Determination of slope and deflection of beams: Solving differential equation of the elastic curve, slope and deflection of beams by method of successive integration; Macaulay's method; moment area method; conjugate beam method; principle of virtual work; strain energy method; bending deflection due to temperature variation; Maxwell-Betti law of reciprocal deflections. (Lectures: 9)

Module 3

Force method: Introduction and applications of analysis of statically indeterminate beams - the force method; analysis of statically indeterminate structures by energy method; three moment equation for shear force, bending moment diagrams, deflection and support settlement. (Lectures: 10)

Module 4

Moving loads and influence lines: Introduction to variable loading, construction of influence lines using equilibrium method, use of influence lines for reaction, shear force and bending moment in simply supported beams; influence lines for forces in trusses; analysis for different types of moving loads - concentrated loads, uniformly distributed load etc. (Lectures: 7)

Module 5

Cables, suspension bridges and arches: Analysis of forces in cables, suspension bridges with three-hinged and two-hinged stiffening girders; theory of arches; Eddy's theorem; analysis of three-hinged and two-hinged arches; settlement and temperature effects. (Lectures: 8)

Text Books

1. C. K Wang (2010) Intermediate Structural Analysis (1st Ed), Tata McGraw Hill. ISBN 9780070702493.
2. S. Timoshenko, D.H. Young, J.V. Rao, S. Patil (2013) Engineering Mechanics (In SI Units) (5th Ed), Tata McGraw-Hill Education Pvt. Ltd. ISBN 9781259062667.
3. R.C. Hibbeler (2018) Structural Analysis (10th Ed), Pearson Education. ISBN 9780134610672.
4. D. Menon (2018) Structural Analysis (2nd Ed), Narosa Publications. ISBN 9788184875973.

Additional References

Structural Analysis I (2009) by Prof. Siddhartha Ghosh and Prof. R.S. Jangid on NPTEL. https://nptel.ac.in/courses/105/101/105101085/

Laboratory

Verification of moment area theorem for the slope and deflection of beam.
Verification of Clerk-Maxwell's reciprocal theorem.

Experimentally determining the elastic properties of an elastic beam.

Experimental and analytical study of defections in a cantilever beam.

To study the behaviour of struts and columns with various support end conditions.

Determination of the deflection of a pin connected truss through analytical, graphically and experimental calculations.

Determine the horizontal thrust in a three hinged arch for a given system of loads experimentally and verify it with theoretical calculations.

Experimental and analytical study of sway in portal frame.

Title	Reinforced Concrete Design	Number	CI2XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-2 [4]
Offered for	B.Tech. [CIE	Type	Program Core (PC)
Prerequisite	Structural Analysis		

Objectives

This course aims at:

1. Providing an in-depth knowledge on the behaviour of RCC structures.
2. Highlighting the significance of working stress and limit state design methods.
3. Comprehensive development of the design and reinforcement detailing of beams, columns, slabs, staircases, footings.
4. Develop an understanding with respect to the importance of stiffness, strength, ductility and configuration which is useful for earthquake resistant design.
5. Practicing reinforcement detailing procedures of a RCC building considering wind and seismic forces as per Indian Standard codes and developing design skills.

Learning Outcomes

Students will have the ability to:

1. Assess the behaviour of RCC structures and apply the appropriate design methodology and reinforcement detailing for different types of RCC structural elements i.e. beams, columns, slabs, staircases, foundations etc.
2. Design and provide reinforcement detailing of multistoried RCC buildings considering dead, wind and seismic forces as per Indian Standard codes.

Contents

Module 1(Lectures: 10)

Introduction to reinforced concrete structures: Properties of concrete; codes of practices; design philosophy of reinforced concrete structures - working stress and limit state design methods.
Design of RCC beams: Singly and doubly reinforced rectangular/flanged sections; design for shear, torsion, bond and anchorage of reinforcement; design of continuous beams.

Module 2(Lectures: 8)

Design of Slabs: One-way and two-way slabs; design of slabs for serviceability; design of continuous slab systems.
Design of RCC staircase.

Module 3(Lectures: 8)

Design of RCC columns: design of short columns under pure compression, uniaxial and biaxial bending; design of long columns.

Module 4(Lectures: 8)

Design of foundations: Isolated footings; combined and strip footing; raft foundation.
Design of retaining walls.

Module 5(Lectures: 8)

Design of RCC structures considering wind and seismic forces: Concept of earthquake resistant design of RCC structures - design philosophy, stiffness, strength, ductility and configurations; estimation of wind and seismic forces as per IS codes; ductile design and detailing of RCC earthquake resistant structures;
Introduction to prestressed concrete.

Text Books

1. U.S. Pillai, D. Menon (2016) Reinforced Concrete Design (3rd Ed), Tata McGraw-Hill Publishing Co. Ltd. ISBN 9780070141100.
2. S.N. Sinha (2014) Reinforced Concrete Design (3rd Ed) McGraw Hill Education Pvt. Ltd. ISBN 9789351342472.
3. A.K. Jain (2012) Reinforced Concrete - Limit State Design (7th Ed), NemChand Brothers. ISBN 9788185240664

4. P.C. Varghese (2010) Limit State Design of Reinforced Concrete (2nd Ed), Prentice Hall of India. ISBN 8120320395.
5. S.K. Mallick, A.K. Gupta (2002) Reinforced Concrete (2nd Ed), Tata McGraw-Hill Publishing Co. Ltd. ISBN 0070473323.

Additional References
Design of Reinforced Concrete Structures (2009) by Dr. Nirjhar Dhang on NPTEL. https://nptel.ac.in/courses/105/105/105105105/

Laboratory Contents
Introduction of computer applications in the structural design.
Design of beam (under-reinforced, balanced, over-reinforced, doubly reinforced) using computer applications.
Design and detailing of slabs (one-way and two-way), columns, walls, footing etc.
Modelling, analysis and design of a multi-storeyed framed structure.
Determination of the compressive strength of concrete.
Strength and deflection testing of a simply supported RCC beam.
Testing of RCC columns for strength subjected to concentric and eccentric loading conditions.
Non-destructive testing – rebound hammer test for concrete, ultrasonic pulse velocity test for concrete, rebar detector test for reinforcement etc.

Title	Advanced Structural Analysis	Number	CI2XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-2 [4]
Offered for	B.Tech. [CIE]	Type	PC
Prerequisite	Structural Analysis		

Objectives

This course aims at:

1. Introduction to advanced concepts of structural analysis and review the concepts of solid mechanics.
2. Further development of analytical skills to compute quantities like displacements, stresses etc. in different structures subjected to static forces.
3. Analytical and numerical methods as well as procedures in a way that emphasize physical insight.
4. Gaining the basic understanding of structural stability and dynamics response.
5. Problem solving ability for static and dynamic loads in structural engineering.

Learning Outcomes

Students will have the ability to:

1. Analyze statically indeterminate trusses, beams and frames.
2. Understand the fundamentals of the matrix formulation of structural analysis through finite element method.
3. Determine bending moment, shear forces and axial force in the rigid frames subjected to lateral and vertical loads.
4. Determine the dynamic response of simple structure under free vibration.
5. Perform comprehensive methods of structural analysis on real-world problems of practical interest.
6. Model real life structures for solving them in standard software and examine both local and global stability of the structural system.

Contents

Module 1

Force method of analysis of indeterminate structures: Fixed and continuous beams, frames etc. - analysis by consistent deformation method; application of moment area and conjugate beam methods for fixed beams; theorem of three moments for continuous beams. (Lectures: 5)

Displacement method of analysis of indeterminate structures: Analysis of continuous beams, beams with overhang, rigid frames with sloping legs, settlement effects etc.; moment distribution method as successive approximation of slope deflection equations. (Lectures: 5)

Module 2

Stress and strain tensors: Generalized strain displacement relationship; compatibility condition and constitutive relationship; plane stress and plain strain problems; some boundary value problems in elasticity; yield criterion. (Lectures: 7)

Plastic analysis: Introduction to plastic theory; concept of plastic hinge; plastic modulus; shape factor; redistribution of moments; collapse mechanism; plastic analysis of beams and portal frames by equilibrium and mechanism methods. (Lectures: 5)

Module 3

Introduction to FEM: Energy methods and variational principles; generation of stiffness matrix of 1D and 2D elements by FEM approach; use of virtual work method for generating stiffness matrix of structure; matrix formulation of structural analysis. (Lectures: 6)

Stability of structure: Concept of structural stability; classical stability analysis of beams and frames; energy method of the stability analysis of beams, frames and plates. (Lectures: 6)

Module 4

Introduction to structural dynamics: Basic concepts of dynamic loading and response; types of mass-spring-damper system; equation of motion using direct equilibration, Hamilton's principle. (Lectures: 2)

Single-degree of freedom system: Development of equation of motion; statement of problem and solution; damped and undamped systems; free vibration response. (Lectures: 6)

Text Books

1. C. K Wang (2010) Intermediate Structural Analysis (1st Ed), Tata McGraw Hill. ISBN 9780070702493.
2. S. Timoshenko, D.H. Young, J.V. Rao, S. Patil (2013) Engineering Mechanics (In SI Units) (5th Ed), Tata McGraw-Hill Education Pvt. Ltd. ISBN 9781259062667.
3. R.C. Hibbeler (2018) Structural Analysis (10th Ed), Pearson Education. ISBN 9780134610672.

4. D. Menon (2018) Structural Analysis (2nd Ed), Narosa Publications. ISBN 9788184875973.
5. J.B. Wilbur, C.H. Norris, S. Utku (2006) Elementary Structural Analysis, McGraw Hill, New York. ISBN 9781258242909.
6. A.K. Chopra (2017) Dynamics of Structures Theory and Application to Earthquake Engineering (5th Ed), Prentice Hall, NJ. ISBN 978-0-134-55512-6.

Additional References
Advanced Structural Analysis (2012) by Prof. Devdas Menon on NPTEL. https://nptel.ac.in/courses/105/106/105106050/

Laboratory
Introduction of computer applications in structural analysis.
Create and analyze models to determine the shear force, bending moment, deflection diagrams for statically indeterminate beams.
Create and analyze models to determine the shear force, bending moment, deflection diagrams for portal frames.
Create and analyze models to determine the shear force, bending moment, deflection diagrams for multi storeyed buildings.
Determine shear force, bending moment, deflection diagrams for multi-storey frames using approximate methods.
Modelling and analysis of 3D structures.

Title	Steel Structure Design	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-1-0 [4]
Offered for	B.Tech. [CIE]	Type	Program Elective (PE)
Prerequisite	Structural Analysis		

Objectives

This course aims at:

1. Providing an in-depth knowledge on the behaviour of steel structures.
2. Comprehensive development of the design and associated analysis of critical components such as joints, fasteners etc.
3. Practicing limit state design of structural steel members subjected to compressive, tensile and bending loads, including connections as per Indian Standard codes.

Learning Outcomes

Students will have the ability to:

1. Design bolted and welded connections for steel structures.
2. Design tension members, understand the effect of shear lag and understand the design concept of axially loaded columns and column base connections.
3. Understand specific problems related to the design of laterally restrained and unrestrained steel beams.
4. Design structural systems such as roof trusses, gantry girders as per provisions of Indian Standard code for working stress and limit state methods.

Contents

Module 1: Introduction (Lectures: 7)

Mechanical properties and types of structural steel; Indian structural steel products; brief on the steps involved in the design process of steel structural systems and their elements; type of loads; standards and specifications; concept of allowable stress method and limit state design methods for steel structures; relative advantages and limitations; strengths and serviceability.

Module 2: Connections (Lectures: 9)

Type of fasteners – rivets, bolts and welds; types of connections;relative advantages and limitations; modes of failure; concept of shear lag;prying forces and hanger connection; design of slip critical connections; design of joints; eccentrically loaded bolted bracket connections; welds; effective area of welds; fillet and but welded connections; axially loaded connections;eccentrically loaded bracket connections.

Module 3: Tension members (Lectures: 8)

Types of tension members and sections; behaviour of tension members modes of failure; slenderness ratio; net area; net effective sections for plates, angles etc. in tension; design of plate and angle tension members; design of built up tension members; connections in tension members; use of lug angles; design of tension splice.

Module 4: Compression members (Lectures: 8)

Types of compression members and sections;behaviour and types of failures; short and slender columns; effective length;design of single section and compound angles - axially loaded solid section columns subjected to biaxial bending; design of built up laced and battened type columns; design of column bases; plate and gusseted bases for axially loaded columns; splices for columns.

Module 5: (Lectures: 10)

Types of steel beam sections; behaviour of beams in flexure; classification of cross sections; flexural strength and lateral stability of beams; shear strength;web buckling, crippling and deflection of beams; design of laterally supported beams, solid rolled section beams, plated beams with cover plates, purlin in roof trusses, open web and hollow sections etc.

Text Books

1. N. Subramanian (2015) Design of Steel Structures, Oxford University Press. ISBN 9780199460915.
2. M.L. Gambhir (2013) Fundamentals of Structural Steel Design (1st Ed), McGraw Hill Publication. ISBN 9781259006760.

3. S.K. Duggal (2019) Limit State Design of Steel Structures (3rd Ed), McGraw Hill Publication. ISBN 9789353164874.
4. K.S. Sai Ram (2015) Design of Steel Structures (2nd Ed), Pearson Education. ISBN 9789332542105.
5. M.R. Shiyekar (2017) Limit State Design in Structural Steel (3rd Ed), Prentice Hall of India Pvt. Ltd. ISBN 9788120353503.

Additional References
Design of Steel Structures I (2009) by Prof. S.R. Satish Kumar and Prof. A.R. Santha Kumar on NPTEL. https://nptel.ac.in/courses/105/106/105106112/

Title	Advanced Structural Design	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE], M Tech [CIE]	Type	PE
Prerequisite	Reinforced Concrete Design		

Objectives

This course aims at:

1. Providing in-depth advance knowledge on the behaviour of RCC and steel structures.
2. Develop an understanding with respect to design of different structural components such as deep beam, shear wall etc.
3. Practicing detailing procedures and developing design skills of RCC and steel structures using Indian and foreign standard codes.

Learning Outcomes

Students will have the ability to:

1. Assess the behaviour of RCC and steel structures and apply the appropriate design methodology and reinforcement detailing for different types of RCC and steel structural elements.
2. Design and provide detailing of multistoried RCC and steel buildings considering dead, wind and seismic forces as per Indian and international standard codes.

Contents

Module 1

Review of basics concepts: Design philosophy, modelling of loads, material characteristics. (Lectures: 4)

Durability and mix design of concrete. (Lectures: 4)

Module 2

Advanced reinforced concrete design: P-M, M-phi relationships, strut-and-tie method, design of deep beam and corbel; design using Indian, America and European standards. (Lectures: 9)

Module 3

Design of shear walls, compression field theory for shear design, design against torsion. (Lectures: 9)

Module 4

Advanced design of steel structures: Stability design; torsional buckling (pure, flexural and lateral); design using Indian and AISC Standards; Eurocode. (Lectures: 9)

Module 5

Design of beam-columns, fatigue resistant design, fire rating and minimum thickness etc. (Lectures: 7)

Text Books

1. P.C. Varghese (2005) Advanced Reinforced Concrete Design (2nd Ed), Prentice Hall of India
2. C.-K. Wang, C.H. Solomon, J. A. Pincheira (2007) Reinforced Concrete Design (7th Ed), John Wiley and Sons.
3. J.G. MacGregor, J.K. Wight (2008) Reinforced Concrete: Mechanics and Design (5th Ed), Pearson Education.
4. U.S. Pillai, D. Menon (2016) Reinforced Concrete Design (3rd Ed), Tata McGraw-Hill Publishing Co. Ltd. ISBN 9780070141100.
5. N. Subramanian (2015) Design of Steel Structures, Oxford University Press. ISBN 9780199460915.

Additional References

1. Design of Reinforced Concrete Structures (2009) by Dr. Nirjhar Dhang on NPTEL. https://nptel.ac.in/courses/105/105/105105105/
2. Design of Steel Structures I (2009) by Prof. S.R. Satish Kumar and Prof. A.R. Santha Kumar on NPTEL. https://nptel.ac.in/courses/105/106/105106112/

Title	Dynamics of Structure	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE]	Type	PE
Prerequisite	-		

Objectives

This course aims at:

1. Introducing the behaviour of structures (especially framed building) to various dynamic loads, viz. earthquake, machine vibration etc.
2. Fundamental understanding to analyze structures subjected to dynamic excitation and computing quantities like displacements, forces, stresses etc.
3. Analytical and numerical methods as well as procedures in a way that emphasize physical insight.
4. Problem solving ability for dynamic response in Civil Engineering design.

Learning Outcomes

Students will have the ability to:

1. Establish dynamic equilibrium and equation of motion for structural systems.
2. Analyze the dynamic response and stress generation in single and multi degree of freedom systems for different types of loading.
3. Implement the basis for the classical energy formulations in dynamical systems.
4. Model structural damping and solve problems in frequency as well as time domain.
5. Solve the eigenvalue problems and gain knowledge on its useful properties.
6. Device methods to protect new and existing structures against seismic collapse.
7. Apply the structural dynamics theory to real-world problems like seismic analysis and design of structures.

Contents

Module 1

Introduction to dynamics of structure: Review of basic concepts of dynamic loading and response; degrees of freedom; types of mass-spring-damper system; equation of motion using direct equilibration, principle of virtual displacement and Hamilton's principle. (Lectures: 3)

Single-degree of freedom system: Development of equation of motion; statement of problem and solution; damped and undamped systems; free vibration response; logarithmic decrement. (Lectures: 5)

Module 2

Solution of different loading cases: Responses to harmonic, periodic, arbitrary, pulse etc. excitations; numerical evaluation; generalized system. (Lectures: 8)

Module 3

Two-degree of freedom system: Development of equation of motion; statement of problem and solution methods; free vibration response; damping; natural vibration frequencies and modes; computation of vibration properties. (Lectures: 10)

Module 4

Multiple degree of freedom system: Solving problems with more than two degrees of freedom systems; static condensation. (Lectures: 6)

Damping in structures: Estimating modal damping ratios; construction of damping matrix. (Lectures: 3)

Module 5

Introduction to Earthquake response: Response of linear elastic building subjected to seismic excitation; basic concepts of vibration control. (Lectures: 7)

Text Books

1. J.M. Biggs (1964) Introduction to Structural Dynamics, McGraw Hill, NY. ISBN 07-005255-7.
2. R.W. Clough and J. Penzien (1993) Dynamics of Structures (2nd Ed), McGraw Hill Inc Editor. ISBN 0-07-011392-0.
3. A.K. Chopra (2017) Dynamics of Structures Theory and Application to Earthquake Engineering (5th Ed), Prentice Hall, NJ. ISBN 978-0-134-55512-6.
4. A.K. Jain (2017) Dynamics of Structures with MATLAB® Applications, Pearson Education, Chennai, India. ISBN 978-9-332-55855-7
5. M. Paz and Y.H. Kim (2019) Structural Dynamics Theory and Computation (6th Ed), Springer Nature, Switzerland. ISBN 978-3-319-94742-6.

Additional References

Structural Dynamics (2012) by Dr. Pradipta Banerji on NPTEL. https://nptel.ac.in/courses/105/101/105101006/

Title	Finite Element Method	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE], M Tech [CIE]	Type	Program elective (PE)
Prerequisite	-		

Objectives

This course aims at:

1. Introduction to fundamental concepts of finite element analysis.
2. Development of analytical skills to compute quantities like displacements, stresses etc. in structures subjected to static and dynamic forces.
3. Analytical and numerical methods as well as procedures in a way that emphasize physical insight.

Learning Outcomes

Students will have the ability to:

1. Establish equilibrium equations of structural systems.
2. Analyze the responses and stresses generated in structures subjected to different types of static loading.
3. Apply the FEM to solve real-world problems of the building, bridges etc.

Contents

Module 1(Lectures: 6)

Fundamental concepts: Introduction to FEM; stresses and equilibrium; boundary conditions; strain-displacement and stress-strain relations; governing equation and its solution approximations (e.g. Collocation, Least Squares, Galerkin's method, the Ritz method).

Module 2(Lectures: 10)

Introduction to calculus of variations: Functionals; extremization; variational form from differential equation; principle of virtual work and minimum potential energy.
Concept of discretization of structures and shape functions; Lagrangian and serendipity elements; isoparametric formulation.

Module 3(Lectures: 9)

Analysis of framed structures: plane stress and plane strain problems; axisymmetric problems; 3D stress analysis.

Module 4(Lectures: 10)

Analysis of plate and shell.
Numerical integration: Numerical integration formulae; order of integration; error analysis and convergence.

Module 5(Lectures: 7)

Programming applications: Computer implementations of algorithms.
Application of FEM in dynamics: Eigenvalues and orthogonality.

Text Books

1. J.N. Reddy (2003) An Introduction to the Finite Element Method (2nd Ed), Tata McGraw Hill.
2. C.S. Krishnamoorthy (1994) Finite Elements Analysis: Theory and Programming (2nd Ed), Tata McGraw Hill.
3. R.D. Cook, D.S. Malkus, M.E. Plesha (2002) Concepts and Applications of Finite Element Analysis (4th Ed), John Wiley & Sons.
4. O.C. Zienkiewicz, R.L. Taylor, J.Z. Zhu (2005) Finite Element Method Its Basis and Fundamentals (6th Ed), Elsevier
5. S.S. Rao (1999) Finite Element Method in Engineering (3rd Ed), Butterworth Heinemann.
6. K.J. Bathe (2002) Finite Element Procedures, Prentice Hall of India Pvt. Ltd.

Title	Earthquake Engineering	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE], M Tech [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives

This course aims at:

1. Introduction to fundamental concepts of earthquake analysis.
2. Development of analytical skills to compute quantities like displacements, stresses etc. in structures subjected to ground motions.
3. Analytical and numerical methods as well as procedures in a way that emphasize physical insight.
4. Problem solving ability for dynamics loads in seismic design of structures.

Learning Outcomes

Students will have the ability to:

1. Establish equilibrium equation of structural systems subjected to ground motion based excitations.
2. Analyze the responses and stresses generated in structures subjected to seismic loading.
3. Apply the frequency and time analysis methods to solve problems of the building, bridges etc. due to seismic activity.

Contents

Module 1(Lectures: 10)

Basic of earthquake engineering: Cause and source of earthquakes; magnitude and intensity; ground motions; site effects; sensors; equation of motion.

Response spectrum: Construction of response spectrum; response spectrum characteristics; design of response spectrum.

Module 2(Lectures: 9)

Linear earthquake analysis: Idealization of structures; response spectrum analysis; coupled systems; frequency domain analysis; time domain analysis.

Module 3(Lectures: 8)

Nonlinear earthquake analysis: Force-deformation relationships; equation of motion for nonlinear system; controlling parameters.

Module 4(Lectures: 8)

Earthquake resistance design: Philosophy of ductility based design; detailing provisions; concepts of passive controls.

Module 5(Lectures: 7)

Geotechnical aspects: Dynamic properties of soil; dynamic earth pressures; liquefaction and ground improvement techniques; retrofitting and strengthening of buildings and bridges.

Text Books

1. R.W. Clough and J. Penzien (1993) Dynamics of Structures (2nd Ed), McGraw Hill
2. M. Paz (1987) Dynamics of Structures, CBS Publication.
A. K. Chopra (2007) Dynamics of Structures - Theory and Application to Earthquake Engineering (3rd Ed), Pearson Education.
3. T. Paulay and M.S.N. Priestley (1992) Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley and Sons.
4. D. J. Dowrick (1987) Earthquake Resistant Design for Engineers and Architects, John Wiley and Sons.

Additional References

Introduction to Earthquake Engineering (2013) by Prof. R.S. Jangid on NPTEL.
https://nptel.ac.in/courses/105/101/105101004/

Title	Concrete Technology	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-3 [4.5]
Offered for	B.Tech. [CIE]	Type	Program Elective (PE)
Prerequisite	-		

Objectives

This course aims at:

Introduction to fundamental concepts and physical insight of cement concrete.

Development of skills for mix design of concrete with admixtures.

Comprehensive understanding of chemical and physical processes attached to the cement concrete.

Learning Outcomes

Students will have the ability to:

Mix design the concrete based on different material properties to attain desired quality control.

Use admixtures for designing concrete with different applications.

Understand the behaviour of cement concrete and its performance in presence of admixtures and environmental exposures

Contents

Module 1(Lectures: 8)

Introduction to materials: Concrete materials; cement - physical tests; hydration; Bogues equation; aggregates; water - quality for mixing and curing.

Module 2(Lectures: 8)

Admixtures: Introduction to admixtures, types of admixtures; accelerating admixtures; retarding admixtures; air entraining admixtures; plasticizers.

Batching, mixing and transportation; placing of concrete; curing of concrete.

Module 3(Lectures: 10)

Mix Design of concrete: Factors influencing mix proportion; mix design methods; design of high strength concrete; strength of concrete - important factors.

Module 4(Lectures: 9)

Properties of concrete: Interfacial transition zone; microstructure of concrete; shrinkage and temperature effects; creep; permeability; durability; thermal properties; micro-cracking.

Module 5(Lectures: 7)

Advanced topics: Introduction to special concrete; lightweight concrete; fiber reinforced concrete; polymer modified concrete; Ferrocement; ready mix concrete; self compacting concrete.

Quality control: Sampling and testing; acceptance criteria.

Text Books

A. Neville (2011) Properties of Concrete (5th Ed), Pearson Education India. ISBN 9788131791073.

M. L. Gambhir (2017) Concrete Technology (5th Ed), McGraw Hill Education. ISBN 9781259062551.

M.S. Shetty, A.K. Jain (2019) Concrete Technology: Theory and Practice (8th Ed), S. Chand Publishing. ISBN 9789352533800.

A.M. Neville, J.J. Brooks (2010) Concrete Technology (2nd Ed), Pearson Education. ISBN 9780273732198.

P.K. Mehta, P.J.M. Monteiro (2014) Concrete: Microstructure, Properties, and Materials (4th Ed), McGraw Hill. ISBN 9789339204761.

Additional References

Concrete Technology (2014) by Dr. B. Bhattacharjee on NPTEL.

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

Laboratory Contents

Determination of fineness and specific gravity of cement.

Determination of consistency of standard cement paste.

Determination of initial and final setting times of cement.

Determination of compressive strength of cement.
Determination of soundness of cement by Le-Chatelier's apparatus.
Workability tests: slump cone test, compaction factor test, Vee-Bee consistometer and flow test.
Determination of compressive strength of concrete specimens.

Title	Prestressed Concrete Structures	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE], M Tech [CIE]	Type	PE
Prerequisite	-		

Objectives

This course aims at:

Fundamental understanding of the behaviour of prestressed concrete structures.

Developing skills for analysis and design of prestressed sections in beams, columns, bridges etc.

Learning Outcomes

Students will have the ability to:

Assess the effect of losses and forces such as axial, flexure, shear and torsion in prestressing.

Design the beams, columns, bridge decks etc. based on prestressed concrete.

Contents

Module 1

Introduction to prestressing system: Basics of prestressed concrete structures and advantages; types of prestressing; pre- and post-tensioning systems and devices; review of concrete - properties; prestressing steel – forms, types and properties. (Lectures: 8)

Module 2

Losses in prestress: Elastic shortening; friction; anchorage slip; force variation; creep; shrinkage. (Lectures: 3)

Analysis of members: Analysis under axial load - permissible prestress based on transfer, stresses under service loads, ultimate strength of member; Analysis of members under flexure – at transfer and service, calculation of cracking moment, location of kern points and pressure lines, ultimate strength. (Lectures: 5)

Module 3

Design of member sections: For axial tension; flexure – type 1 and type 2; choice of section; limiting zone; Magnel's graphical method; tendon profile and reinforcement detailing. (Lectures: 7)

Analysis and design for shear and torsion: Cracks and modes of failure due to shear and torsion; effect of prestressing force; limit state of collapse for shear and torsion; design of longitudinal and transverse reinforcement. (Lectures: 6)

Module 4

Deflection, camber and crack width: Deflection due to gravity load and prestressing; camber; determination of flexural crack width; limits of deflection and crack width. (Lectures: 3)

Transmission of prestress: Pre- and post-tensioned members. (Lectures: 2)

Analysis and tendon profile of cantilever and continuous beams. (Lectures: 3)

Miscellaneous topics: Design of composite sections, one- and two-way slabs, compression members etc. (Lectures: 5)

Text Books

C.W. Dolan, H.R. Hamilton (2019) Prestressed Concrete Building, Design, and Construction, Springer. ISBN 9783319978819.

N. Krishna Raju (2006) Prestressed Concrete (3rd Ed), Tata McGraw-Hill Publishing Company Ltd. ISBN 0070634440.

E.G. Nawy (2005) Prestressed Concrete – A Fundamental Approach (5th Ed), Pearson. ISBN 9780131497597.

Additional References

Prestressed Concrete Structures (2009) by Prof. Amlan K. Sengupta and Prof. Devdas Menon on NPTEL. https://nptel.ac.in/courses/105/106/105106117/

Title	Prefabricated Structures	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE], M Tech [CIE]	Type	PE
Prerequisite	-		

Objectives

This course aims at:

Imparting knowledge on modular construction, industrialised construction and design of prefabricated elements and construction methods.

Learning Outcomes

Students will have the ability to:

Understand the design, transportation and erection steps required in the prefabricated structures.

Understand the concepts of joint flexibility and deformation for different types of joints and connections.

Contents

Module 1

Introduction to prefabricated structures: Need for prefabrication and its principles; prefabrication materials for precast elements; modular coordination; standardization; systems; production; transportation; site erection; quality control. (Lectures: 8)

Module 2

Prefabricated components: Behaviour of structural components, large panel constructions; construction of roof and floor slabs; wall panels; columns; shear walls. (Lectures: 9)

Module 3

Design principles: Disuniting of structures; design of cross section based on efficiency of material; problems in design because of joint flexibility; allowance for joint deformation. (Lectures: 9)

Module 4

Joint in structural members: Joints for different structural connections; dimensions and detailing; design of expansion joints. (Lectures: 8)

Module 5

Design for extreme loads: Progressive collapse; codal provisions; equivalent design loads for considering effects such as earthquakes, cyclones etc.; importance of avoidance of progressive collapse. (Lectures: 8)

Reference Books/ Reports

H. Bachmann, A. Steinle (2011) Precast Concrete Structures, Wilhelm Ernst & Sohn. ISBN 9783433029602.

Precast Concrete Connection Details - Structural Design Manual (1978), Society for Studies on the use of Precast Concrete, Netherlands.

K.S. Elliott (2002) Precast Concrete Structures, Butterworth-Heinemann. ISBN 0750650842.

Title	Highway Geometric Design	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives

The course will help students to understand the concepts involved in geometric design of intersections, horizontal & vertical alignment of roads & pedestrian facilities.

Learning Outcomes

At the end of the course, the student should be able to:

Describe the urban street hierarchy and functional classification system.

Demonstrate the relationship between mobility and access and formulate a functional design process that accommodates the needs of all users and allows for street designs that are compatible with the surrounding area.

Identify and define the elements of a roadway cross-section.

Design alignment and grade elements including sight distance; horizontal and vertical curves; and terrain and acceptance grades for urban local and collector streets.

Define the functional area of an intersection and identify key design elements for intersections.

Identify pedestrian street crossing issues.

Understand the design concepts of smart city roads

Contents

MODULE I:[Lectures – 9]

Highway Cross Section Elements and Geometric Design: Functional Classification of Highway System; Design Control characteristics, Objectives and elements of Geometric Design, Pavement Surface characteristics, Camber, Objectives of Camber, design standards.

MODULE II: Lectures – 12]

Horizontal and Vertical Alignment: Objectives of horizontal curves, Super elevation, Minimum Radius of Curve, Extra widening on Curves, Transition Curves, Types of Gradients, Vertical Curves – Types and Design, Grade Compensation, Sight Distances, Importance of Sight Distances for Horizontal and Vertical Curves.

MODULE III:[Lectures – 8]

Intersection Design: Types of Intersections; Design Principles for Intersections; Design of At-grade Intersections – Channelization, Objective; Traffic Islands and Design standards; Rotary Intersection – Concept and Design, Advantages and Disadvantages; Grade separated Interchanges – Types, warrants and Design standards

MODULE IV:[Lectures -5]

Traffic signs and road markings: Types of Road Signs; Guidelines for the provision of Road Signs; Cautionary Signs, Regulatory Signs, Information Signs – Design standards; Road markings – Objective of Road Markings; Types of Road Markings; Role of Road markings in Road Safety and Traffic Regulation; Specification for Road Markings. Highway Appurtenances – Delineators, Traffic Impact Attenuators, Safety Barriers.

MODULE V: [Lectures -8]

Miscellaneous Elements: Requirements of Pedestrians; Pedestrian facilities on Urban Roads; Cycle Tracks – Guidelines and Design standards; Bus bays – Types and Guidelines; Design of On-street and Off-street Parking facilities – Guidelines for lay out Design; Design concepts of smart city roads

Text Books

L.R. Kadiyali and N.B. Lal, Principles and Practice of Highway Engineering, Khanna Publications

C.E.G. Justo and S.K. Khanna, Highway Engineering, Nem Chand and Brothers.

Additional References

IRC Codes for Signs, Markings and Mixed Traffic Control in Urban Areas.

Traffic Engineering and Transportation Planning, L.R.Kadiyali, Khanna Publications.
Chai K. Toh, Julio A. Sanguesa, Juan C. Cano and Francisco J. Martinez. Advances in smart roads for future smart cities.
https://royalsocietypublishing.org/doi/10.1098/rspa.2019.0439

Title	Pavement Engineering	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives

The course will help students to understand about the materials, analysis, design, and construction of different types of pavements.

Learning Outcomes

At the end of the course, the student should be able to:

Characterize the response characteristics of soil, aggregate, asphalt, and asphalt mixes

Analyze flexible pavements

Analyze rigid pavements

Design a flexible pavement using IRC and AASHTO methods

Design a rigid pavement using IRC, and AASHTO methods.

Contents

Module 1 :Pavement Materials [Lectures – 10]

Types and component parts of pavements, highway and airport pavements, Materials used in pavements, basic soil properties relevant to pavement applications, resilient modulus, and modulus of subgrade reaction, Physical properties of aggregates and blending, Basic properties of bitumen, polymer and rubber modified bitumen, Dynamic modulus, flow time and flow number of bituminous mixes. Cement: chemical composition, types, physical properties. Distresses in flexible and rigid pavements. Use of geosynthetics in pavements.

Module II: Analysis & Stresses in Pavements [Lectures – 12]

Stresses in flexible pavements: layered system concepts, stress solution for one, two and three-layered systems, fundamental design concepts. Stresses in rigid pavements: Westergaard's theory and assumptions, stresses due to curling, stresses and deflections due to loading, frictional stresses, stresses in dowel bars and tie bars.

Module III: Factors Affecting Pavement Design [Lectures – 12]

Variables considered in pavement design, Classification of axle types, articulated commercial vehicles, legal axle and gross weights on single and multiple units, tyre pressure, contact pressure, ESWL, EWLF and EAL concepts, Traffic analysis: ADT, AADT, growth factor, lane distribution, directional distribution and vehicle damage factors.

Module IV: Design of Pavements [Lectures -8]

IRC method of flexible pavement design, IRC methods of rigid pavement design, AASHTO method of flexible pavement design, AASHTO method of rigid pavement design

Text Books

Yoder and Witezak, Principles of Pavement Design, John Wiley and sons.

Harold N. Atkins, Highway Materials, Soils, and Concrete, Prentice Hall

IRC: 37-2012, Guidelines for the Design of Flexible Pavements, The Indian Roads Congress, New Delhi, India

IRC: 58-2011, Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, The Indian Roads Congress, New Delhi, India

Additional References

Yang, Design of functional pavements, McGraw-Hill.

Robert D. Krebs, Highway Materials, McGraw Hill Text

Asphalt Institute, The Asphalt Handbook

RRL, DSIR, Concrete Roads, HMSO, IRC Publications

Huang, Y.H. Pavement Analysis and Design, Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi

Mallick, R.B. and T. El-Korchi Pavement Engineering – Principles and Practice, CRC Press, Taylor and Francis Group, Florida, USA7.

Papagiannakis, A.T. and E.A. Masad Pavement Design and Materials, John Wiley and Sons, New Jersey, USA, 2008.

Title	Traffic system and ITS	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives
The course will help students to understand the working and control of traffic engineering elements and its integration with advanced technologies such as ITS.

Learning Outcomes
At the end of the course, the student should be able to:
Analyse the road traffic characteristics and can undertake various types of road traffic studies
Suggest and design appropriate control measures for traffic congestion management
Understand the role of ANN and fuzzy logic in traffic control measures
Understand the fundamentals and taxonomy of Intelligent Transport System (ITS) and ITS user services
Understand the integration of ITS to transportation planning
Have knowledge on various public transportation systems.

Contents
MODULE I: [No. of lectures – 10]
Traffic system characteristics: Road, User and Vehicle characteristic Traffic studies: Volume studies, Origin-Destination Studies; Speed studies, Parking studies, Accident studies

MODULE II: [No. of lectures – 12]
Traffic control devices: Definition, necessity, types; Road signs and markings definition, classification. Traffic signals - location, types, signal design by IRC method, Websters methods and HCM method, ANN and Fuzzy logic concepts in traffic control

MODULE III: [No. of lectures – 15]:
Intelligent Transport System [ITS]: Introduction, ITS user services - Travel and traffic management, Public Transport operations, Electronic payment, Commercial vehicle operation, Advanced vehicle control and safety system, Emergency management, Information management, Maintenance and construction management; ITS architecture and planning; Integration of ITS into transportation planning

MODULE IV: [No. of lectures -5]
Public Transportation System: Evolution of public transport system, Need and benefits; Classifications; Rapid Transit systems- BRTS, MRTS, Intermediate Public Transport; Public Transport system in India

Text Books
Nicholas J Garber and Lester A Hoel. Traffic and Highway Engineering. Copyright: Brooks/Cole-Wadsworth Group\Thomson learning
Fred. L. Mannering, Walter P. Kilareski, and Scott S. Washburn. Principles of Highway Engineering and Traffic Analysis. Copyright: John Wiley and Sons, Inc.
M A Chowdhary and A Sadek. Fundamentals of Intelligent Transportation systems planning. Artech House Inc., US, 2003.
Bob Williams. Intelligent transportation systems standards. Artech House, London, 2008
Sussman, J. Perspectives on Intelligent Transportation Systems (ITS). New York, NY: Springer, 2005
Daganzo, C. F. and Quyang, Y. Public Transportation Systems: Principles of system design, operations planning and real-time control. World Scientific Publishers.

Title	Urban Transportation Planning	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives

The course will provide students in-depth understanding on designing, conducting, and administering surveys to provide the data required for transportation planning and will make them understand travel demand modelling procedures.

Learning Outcomes

At the end of the course, the student should be able to:

Design, conduct, and administer surveys to provide the data required for transportation planning

Develop and calibrate trip generation rates for specific types of land use developments.

Estimate the traffic impact of new developments using the four-stage sequential models.

Assess the impact of the transportation project on the land use

Contents

Module I: Urban Transportation Planning Process & Concepts [Lectures-9]:

Role of Transportation and Changing Concerns of Society in Transportation Planning; Transportation Problems and Problem Domain; Objectives and Constraints; Flow Chart for Transportation Planning Process- Inventory, Model Building, Forecasting and Evaluation Stages, Planning in System Engineering Framework; Concept of Travel Demand and its Modelling based on Consumer Behaviour of Travel Choices- Independent Variables, Travel Attributes.

Module II: Travel demand estimation [Lectures – 13]

Assumptions in Demand Estimation- Sequential, Recursive and Simultaneous Process - Introduction to Transportation Planning Practices; Definition of Study Area, Zoning. Trip Generation Analysis: Trip Generation Models- Zonal Models, Category analysis, Household Models, Trip Attractions of Work Centres & Commercial Trips Trip Distribution Analysis: Trip End and Trip Interchange Models; Trip Distribution Models - Growth Factor Models, Gravity Models, Opportunity Models and their calibration; Estimation of Travel Demand based on link volume philosophy.

Module III: Mode Split and Route Split analysis [Lectures -13]

Mode Split Analysis- Mode Choice Behaviour, Competing Modes, Mode Split Curves, Probabilistic Models and Two Stage Mode Split Analysis; Route Split Analysis- Elements of Transportation Networks, Coding, Minimum Path Trees, Diversion Curves, All-or-Nothing Assignment, Capacity Restrained Assignment, Multipath Assignment

Module IV: Landuse-Transportation Models: [Lectures -7]

Location models - Opportunity Models, Lowry based Landuse-Transportation Models – Allocation Function, Constraints, Travel Demand Estimation – Iterative Solutions, Matrix Formulation, Dynamic and Disaggregated extensions.

Text Books

Hutchinson, B.G., Principles of Urban Transportation System Planning, Mc-Graw Hill

Khisty, C J., Transportation Engineering – An Introduction, Prentice-Hall, NJ

Kanafani, A., Transportation Demand Analysis, McGraw-Hill.

Additional references

Wilson, A.G, Urban and Regional Models in Geography and Planning, John Wiley and Sons.

Dickey, J.W., Metropolitan Transportation Planning, Tata Mc-Graw Hill 1980

ITE (1982), 'Transportation and Traffic Engineering Hand Book', Chapters 10,12, and 17, Prentice Hall, New Jersey

Oppenheim, N., Applied Models in Urban and Regional Analysis, Prentice-Hall, NJ.

Dickey J.W., et. al., Metropolitan Transportation Planning, Tata McGraw-Hill.

Gallion A.B and Eisner S., The Urban Pattern, Affiliated East-West Press, New Delhi.

Title	Geology for Civil Engineers	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives

Introducing geological materials, forces, and processes that influence the design and execution of a variety of civil and infrastructure engineering projects and their safety.

Learning Outcomes

After completing this course a student would be able to

Identify different minerals and rocks based on their easily determined properties.

Understand different erosional and depositional activities and landforms associated with streams, glacier movement, ocean activity, and wind activity.

Measure strength and elastic properties of different rocks and classify them as per engineering needs.

Understand the activities related to earthquakes, landslides, and volcanoes that can create hazards to engineering structures.

Undertake basic engineering geological investigation and prepare and comprehensive site investigation report.

Content

Module I: Basics of Geology[Lectures: 7]

Rock types and minerals; Geological time scale;dating methods; Mechanisms of deformation; Folds, faults, and joints; Primary structures of sedimentary rocks; Potential problems from rock structures in engineering construction.

Module II: Geological Processes[Lectures: 13]

Streams: Development stages; Classification of streams; Stream channels; Channel morphology; Drainage basin; Basin morphology; Geologic work of streams; Fluvial landforms.

Glaciers: Glaciers; Glacier movement; Glacial processes; Erosional landforms; Depositional landforms.

Ocean: Features of an ocean; The ocean sediments; Shore processes; Coastal erosion and sediment transport; Depositional features.

Wind: Processes of wind erosion; Sediment transport; Erosional landforms; Depositional landforms.

Module III: Natural Hazards[Lectures: 10]

Earthquakes: Locating an earthquake; measure; World distribution; Important of plate boundaries; Earthquake hazards.

Volcanoes: Volcanic features; Magma types; Geographic distribution of volcanoes; Mode of eruption; Volcanic explosivity Index; Submarine volcano; Volcanic landforms.

Landslides: Causes of landslides; Types of landslides; Kinetic and kinematic methods of investigation; Hazard zonation mapping; Landslide hazard mitigation; Statistical investigation of landslide.

Module IV: Site Geology[Lectures: 12]

Engineering Properties of Rocks: Weathering of rock; Common properties of rocks; Strength and elastic properties of rocks; Rock mass properties; Rock Mass Rating; Geological Strength Index.

Site Investigation and: Stages of site investigation; Aerial photography and remote sensing; Geophysical investigation; Subsoil exploration and sampling of soils; Methods of subsoil exploration; Exploratory drilling; Water pumping tests.

Writing Engineering Geology Report: Objective of a report; Basic aspects; Geologic inputs; Different phases of site investigation; Special investigation; in-field preparation.

Textbooks

S. Gangopadhyay (2013). Engineering Geology. Oxford University Press. ISBN-13: 978-0-19-808635-2.

Sreepat Jain (2014) Fundamentals of Physical geology. Springer. ISBN 978-81-322-1539-4.

Other Reference Material

B. Singh, R. K. Goel.(2011)Engineering Rock Mass Classification. Elsevier. ISBN 978-0-12-385878-8.

R. E. Hunt () Geologic Hazards: A Field Guide for Geotechnical Engineers. CRC Press: Taylor & Francis Group. ISBN-13: 978-1-4200-5250-3.

Online course Material
Prof. Debasis Deb (2009) Engineering Geology. NPTEL. https://nptel.ac.in/courses/105/105/105105106/#

Title	Ground Improvement Techniques	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives
This course aims at :
Introducing the need for ground improvement and available techniques.
Introducing the aspects of soil shear strength modification for effective design of foundations.
Introducing recent soil modification techniques.

Learning Outcomes
Students will have the ability to
Apply the ground modification techniques for efficient design of foundations
Utilize the concepts of preloading and dewatering in soils of cohesive nature
Stabilize the soils using different mechanical and chemical approaches

Contents
Module 1 [Lectures: 10]
Classical examples of soil failure, need of ground improvement, In-situ densification methods, in situ densification of granular and cohesive soils; vibration at ground surface and at depth

Module 2 [Lectures: 10]
Preloading and dewatering, prefabricated vertical drains (PVDs), sand drains, geodrains, filter requirements, spacing effects, stone columns, sumps and interceptor ditches, single and multi-stage well points, vacuum well points, horizontal wells,electro osmosis.

Module 3 [Lectures: 10]
Stabilization of soils, methods of soil stabilization- mechanical, cement, lime,bitumen and polymer stabilization, use of industrial wastes like fly ash and granulated blast furnace slag, Reinforced Earth Technology, concept of soil reinforcement; reinforcing materials; backfill criteria; design of reinforcement for internal stability; applications of reinforced earth structures

Module 4 [Lectures: 10]

Grouting techniques, types of grouts, grouting equipment and machinery, injection methods, grout monitoring, stabilization with cement, lime and chemicals,stabilization of expansive soils, geosynthetics, type of geosynthetics, geotextiles, geomembranes and gabions, miscellaneous methods-soil nailing, thermal methods

Text Books
Hausmann, M.R. (1990). Engineering Principles of Ground Modification, McGraw-Hill International Editions. ISBN: 9780070272798.
Dr. Purushottama Raj (2005). Ground Improvement Techniques. Laxmi Publications. ISBN: 9788170088370.
Budhu. M (2012). Soil Mechanics and Foundations (3rd Ed). John Wiley and Sons. ISBN: 978-0-470-55684-9.

Online references
Ground Improvement Techniques by Prof. G.L. Sivakumar Babu on NTPEL.
https://nptel.ac.in/courses/105/108/105108075/

Title	Introduction to Soil Dynamics	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives

This course aims at :

1. Introducing basic concepts of soil dynamics.
2. Understanding the challenges involved in design of foundations subjected to dynamic loads.

Learning Outcomes

Students will have the ability to

1. Evaluate the stresses in soils due to dynamic loads
2. Analyze the dynamic behavior of soils through laboratory and field tests
3. Apply the principles of earthquake geotechnology in foundation design

Contents

Module 1 [Lectures: 8]

Nature of dynamic loads, vibration theory, single and two-degree freedom systems, free and forced vibrations, wave propagation in elastic rods, shear and compressional velocities

Module 2 [Lectures: 10]

Behavior of cyclically loaded soils, small and large strain dynamic soil properties, laboratory element tests and field tests, design principles for machine foundations, Elastic homogeneous half-space and lumped parameter solutions, codal recommendations

Modules 3 [Lectures: 12]

Earthquake geotechnology, causes and effects of earthquakes, strong ground motion, measurement, characterization and estimation, theory of amplification, ground response analysis, seismic liquefaction and mitigation techniques, seismic hazard assessment, microzonation, earthquake early warning systems

Module 4 [Lectures: 12]

Seismic slope stability, seismic earth pressures on retaining structures, bearing capacity of foundations against seismic loads, introduction to soil-structure and soil-pipe interaction, seismic vibration isolation and damping systems for foundations and structures

Text Books

1. Kramer S.L. (1996). Geotechnical Earthquake Engineering. Prentice Hall, ISBN-10: 8131707180
2. Ishihara, K. (1996). Soil Behavior in Earthquake Geotechnics, Oxford Science Publications, ISBN-10: 0198562241
3. Prakash S. (1981). Soil dynamics. McGraw-Hill, ISBN-10: 0070506582

Online video lecture

Geotechnical Earthquake Engineering by Prof. Deepankar Choudhury on NPTEL. https://nptel.ac.in/courses/105/101/105101134/

Title	Advanced Geotechnical Engineering	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech [CIE], M Tech [CIE]	Type	Program Elective (PE)
Prerequisite	Geotechnical Engineering (PC)		

Objectives

This course aims at:

Introducing basic principles of soil mechanics and foundation design.

Understanding the complex response of soils to isotropic and anisotropic loading conditions.

Learning Outcomes

Students will have the ability to

1. Assess the stress-strain response of soils to practical loading scenario
2. Draw stress paths and utilize them for applications in geotechnical engineering
3. Design shallow and pile foundations based on stress transfer mechanism
4. Assess the stability of retaining walls and slopes under different loading conditions.

Contents

Module 1 [Lectures: 6]

Geotechnical lessons learnt from failures-case studies, brief review of soil behavior under different loading conditions, normal stresses and strains, volumetric stresses shear stresses and strains, elastic state and anisotropy, total and effective stresses

Module 2 [Lectures: 12]

Stress path, stress and strain invariants, mean and deviatoric stress, axisymmetric condition, plain strain condition, Shear strength of soils, drained and undrained shear tests, stress anisotropy, pore water pressure parameters, Critical state soil mechanics, failure surface, normally consolidated and over consolidated soils behavior, critical state boundary, elements of critical state model, failure stresses from critical state

Module 3 [Lectures: 12]

Shallow foundations, allowable loads and settlements, bearing capacity formulations, bearing capacity from field load tests, settlement calculations, Pile foundations, load capacity, pile group capacity, load transfer mechanism, lateral load capacity of pile foundations, Earth-retaining structures, modes of failure of earth retaining structures, stability of rigid and flexible retaining walls, mechanically stabilized earth walls, Slope stability, slope failure types, two-dimensional slope stability analysis

Module 4 [Lectures: 6]

Structural health monitoring of geotechnical structures – shallow and deep foundations, retaining walls, tunnels, underground stations, dams and embankments, interpretation of results, mitigation and requalification strategies

Module 5 [Lectures: 6]

Introduction to numerical and analytical modeling in Geomechanics: development of macros in excel, basic MATLAB programs and demo of geotechnical software-PLAXIS 2D and 3D, FLAC 2D and 3D, OASys, GeoSlope, L-Pile, P-disp/X-disp.

Text Books

1. Budhu. M (2012). Soil Mechanics and Foundations (3rd Ed). John Wiley and Sons. ISBN: 978-0-470-55684-9.
2. Das B.M. (2013). Advanced Soil Mechanics (4th Ed). CRC Press. ISBN-10: 9780415506656
3. Knappett J.A. and Craig R.F. (2012). Craig's Soil Mechanics (8th Ed). CRC Press. ISBN-10: 9780415561266.

Online material

Soil Mechanics course in NPTEL.

https://nptel.ac.in/courses/105/103/105103097/

Title	Air Pollution and Control	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech [CIE], M Tech[CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives

1. To gain understanding of the basic concept of air pollution, its sources and effects on human health and climate.
2. To introduce concepts of aerosol dynamics used in ambient sampling, designing measurement technologies and air quality modelling.
3. To develop understanding of the concepts and strategies for control of particulate matter and gas-phase pollutants.
4. To provide knowledge of the current state of the atmosphere and introduce fundamentals of pollutant transport and dispersion, and modelling.

Learning Outcomes

1. The students are expected to achieve proficiency in:
2. Developing a broad overview of local-to-global scale pollution issues and their specific impact on human health and environment.
3. Solving problems related to dispersion and air quality modelling
4. Understanding the source level air pollution issues and identifying the right control techniques/measures to meet the desired standard levels.
5. Computing the performance of various unit operations and processes used in the air treatment.

Contents

Module I: Introduction to air pollution [Lectures 6]
Historical events [Meuse River Valley 1930, Donora Pennsylvania 1948, London Smog 1952, Bhopal Gas Tragedy 1984, and related Concepts], Scales of air pollution, Sources and classification [CAPs and HAPs] of air pollutants, Air quality and standards, Emission Inventory, The Earth's atmosphere: Structure and Composition, and energy balance.

Module II: Aerosol Physics [Lectures 10]
Fundamentals: Source, Size and Size distribution, Gas and Particle motion: Brownian motion, Diffusion, Inertia, External force field, Aerosol dynamics: coagulation, condensation, nucleation, particle measurements and Sampling techniques

Module III: Emissions Control devices [Lectures 8]
Removal of particles from gas stream: Settling chambers, Cyclone separators, electrostatic precipitation, filtration, wet collectors, collection efficiency; Removal of gases from effluents stream: Absorption by liquids, adsorption on solids, Examples: SO2 and NOx removal.

Module IV: Meteorology [Lectures 6]
Atmospheric meteorology, Wind velocity profile and Wind rose, turbulence, inversion layer and mixing depth and Atmospheric Stability.

Module V: Dispersion of air pollutants and Air Quality modelling [Lecture 6]
Dispersion models, Gaussian dispersion model: assumptions, dispersion parameters and effective stack height, plume rise and plume behavior, Receptor models, Introduction to Dispersion and receptor modelling software.

Module VI: Effects of Air Pollution on Climate and Human health [Lectures 4]
Tropospheric Ozone chemistry, Photochemical Smog, Acid Rain, Visibility, Indoor Air Pollution, Dose Response and Health effects.

Text Books
Atmospheric Chemistry and Physics- From Air Pollution to Climate Change, J. H. Seinfeld and S. N. Pandis, John Wiley and Sons, Inc., Third Edition, 2013.

Aerosol Technology-Properties, Behavior and Measurement of Airborne Particles, W. C. Hinds, John Wiley and Sons, Inc., Second Edition, 1998.

Introduction to Air Pollution Science, R. F. Phalen and R. N. Phalen, Jones & Bartlett Learning, LLC, Burlington, MA, 2013.

Aerosol Measurement: Principles, Techniques and Applications, edited by K. Willeke, P. Baron, Van Nostrand Reinhold, 1993.

Online Course Material
https://nptel.ac.in/courses/105104099/

Title	Industrial Waste: Control and Utilization	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	B Tech [CIE], M.Tech [CIE]	Type	Program Elective (PE)
Prerequisite			

Objective

Classification of waste products and technological management for their environmental sustainability

Learning Outcomes

1. Differentiate among the different kinds of waste.
2. Find optimum method for waste management.

Content

Types of waste: Solid, Liquid and gaseous (4 lectures)

Sources of waste: Industrial: Metallurgical, Pharma & Chemical, Electronic, Biological (8 lectures)

Recycling of waste: Metal Scrap remelting, Extraction of precious and harmful metals from electronic waste, (8 lectures)

Waste to wealth: Waste for energy, Production of commercial nanoparticles from waste (8 lectures)

Treatment Storage and Disposal of waste: Long term storage Land filling, incineration; Short term storage and container materials (8 lectures)

Case Studies: Nuclear industry, Biomedical industry, Steel industry (6 lectures)

Text Books

Pichtel, J.,Waste Management Practices: Municipal, Hazardous, and Industrial, 2nd edition, CRC Press, 2014.

Choudhary, C. K., Waste management and bioremediation, Oxford Book Company, 2012.

Self-Learning materials

Wong, J. W. C, Surampalli, R. Y., Zhang, T. C., Tyagi, R. D., Selvan, A.,Sustainable Solid Waste Management, American Society of Civil Engineers (2016).

Ojovan, M. I., Handbook of Advanced Radioactive Waste Conditioning Technologies, Woodhead Publishing (2011).

Online Course Material

1. Dubey, B. K., Electronic Waste Management - Issues and Challenges, Division of Environmental Engineering and Management at Indian Institute of Technology, Kharagpur, NPTEL, https://onlinecourses.nptel.ac.in/noc18_ce07/preview
2. Dubey, B. K., Integrated Waste Management for a Smart City, Division of Environmental Engineering and Management at Indian Institute of Technology, Kharagpur, NPTEL, https://onlinecourses.nptel.ac.in/noc17_ce20/preview
3. Ramachandra, T. V., Municipal Solid Waste Management, Centre for Ecological Sciences, Indian Institute of Science, NPTEL, http://nptel.ac.in/courses/120108005/2#

Title	Surveillance and Security of Infrastructures	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3–0–0 [3]
Offered for	B. Tech, M.Tech [CIE]	Type	Program Elective (PE)
Prerequisite			

Objective

The course will help students to understand the types and methods of surveillance of building, transport and other critical infrastructures and will introduce several security measures for these infrastructures.

Learning Outcomes

At the end of the course, the student should be able to:

1. Describe the types of surveillance and components of security system for an infrastructure
2. Recognize critical infrastructures and perform risk analysis and vulnerability assessment.
3. Develop surveillance detection plan for a building and can analyse building security
4. Understand the needs and methods of surveillance and security for transportation

Content

MODULE I: [No. of lectures-10]

Introduction to surveillance: Surveillance – definition, needs, and role; types and methods of surveillance, components of security system, security of infrastructure-civil structures, network communications, electricity grid. Attack methodology/Attack cycle/Pre-incident indicators, Surveillance detection

MODULE II: [No. of lectures-12]

Critical infrastructures: Introduction, risk analysis and vulnerability assessment, Representation as a complex system, modelling and simulation, graphical formalisms, monitoring and surveillance technologies.Vulnerability analysis, Potential threats to critical infrastructures and key resources (CI/KR), Red Zone analysis

MODULE III: [No. of lectures – 12]

Building security and control system: Mechanical and electrical installation security, fire protection and escape, monitoring burglary and assault, emergency communication, mobility and access management,communication networks of security systems- Energy Management Systems (EMS), Building Automation Systems (BAS), Building Management Systems (BMS), Hostile operations

MODULE IV: [No. of lectures -8]

Types of Attacks: Surveillance and security of transport infrastructure: In-vehicle, at station, running-way, and facility surveillance; technology, data, and resources; advantages and cautions, risk assessment methods and tools, ITS security areas and multi-modal transportation security. Information and Communication Technologies(ICT)-based system and security in ITS, Security and performance measures, Type of attacks

Text Books

1. Petersen, J. K. Introduction to surveillance studies, CRC Press, Taylor and Francis Group
2. Yan, Q. W. Introduction to intelligent surveillance, Springer, New Zealand
3. Flammini, F, Critical Infrastructure Security: Assessment, Prevention, Detection, Response. WIT Press, Southampton, UK
4. Wang, S. Intelligent buildings and building automaton. Routledge Publication
5. Fries, R. and Chowdhury, M. and Brummond, J. Transportation infrastructure security utilizing intelligent transportation systems. John Wiley and Sons.

Title	Digital Twin and Asset Management	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech [CIE]	Type	Program Elective
Prerequisite	-		

Objectives

This course aims to introduce the cyber-physical system and computational aspect of digital twin models and their application in various infrastructure related issues in civil engineering.

Learning Outcomes

1. Graduate of this course will be familiar with
2. Application of cloud and edge computing, and machine learning of DT.
3. Cyber-physical system and application of IoT in DT
4. Elements of 3D reconstruction and use of AR & VR
5. Standards and frameworks related to DT model building and use.
6. Applications of DT in construction, building management, smart city, transport, and water management

Content

Module I: Introduction (1 lectures)

Relationships among digital twins in systems: hierarchical, associational, and peer-to-peer.

Module II: Building Digital Twin (14 lectures)

Fundamentals – Modeling and Simulation Techniques; 3D modeling techniques; Machine Learning for Modeling of Systems. Simulation using real time data from IOT devices. Cloud based software model.

Sensors: IoT Devices; APIs; Connectivity; Deployment; Security; Interoperability

Representation: (a) Micro - 3D reconstruction: photogrammetry and structure from motion (b) Macro 3D reconstruction: 3D GIS and spatial modelling; Application of AR and VR; Real-time data visualization

Decision making: Information modelling and management; Decision support tools; Rule-based automation; Optimization.

Illustration using example of the Digital Twin of a Smart Building

Module III: Standards (5 lectures)

Digital Twin Standards and Frameworks: Data security; Data collection ethics and principles.

Module IV: Building and Construction (10)

Construction Management: 3D model of Buildings; Automated Progress Monitoring; As-Built Vs As-Designed Models; Monitoring and Tracking of Workers.

Buildings: Data acquisition: Real-time sensors, Asset management System, Building management system, Space management system; Data/Model integration: Building information modelling; Intelligent environment control & energy simulation, Intelligent space & asset management function, Intelligent operation & maintenance managing function.

Smart City: Fixed and moving sensors; Spatial data to 3D/4D models; City Information Model (GIS, BIM, IoT); Underground infrastructure model; Modelling and forecast; Intelligent response; AR Models of infrastructure.

Module V: Other Infrastructure (12)

Energy Asset: 3D models of offshore platforms: wind and hydrocarbon; Sensors for environmental load detection; Digital power plant; Safety and Maintenance planning

Transport: Real-time traffic data; Spatio-temporal demand modelling of fuel stations and EV charging points; Highway and bridge health monitoring; crowd simulation and management.

Water: Hydraulic models; System-level models; hydrological assessment; Smart network; Water quality and supply system monitoring.

Text Books

1. R. Szeliski (2011) Ch. 12 3D reconstruction, In Book: Computer Vision: Algorithms and Applications, Texts in Computer Science, 303 DOI 10.1007/978-1-84882-935-0_7, Springer-Verlag London Limited.
2. R. Szeliski (2011) Ch. 7 Structure from motion, In Book: Computer Vision: Algorithms and Applications, Texts in Computer Science, 303 DOI 10.1007/978-1-84882-935-0_7, Springer-Verlag London Limited.

3. T. Luhmann, S. Robson, S Kyle, J Boehm (2014) Close-Range Photogrammetry and 3D Imaging (2nd ed). De Gruter. ISBN 978-3-11-030269-1.
4. B. Cyganek (2013) Object Detection and Recognition: Theory and Practice. Wiley. ISBN: 978-0-470-97637-1.
5. M. Farsi, A. Daneshkhah, A Hosseinian-Far, H. Jahankhani. (2020) Digital Twin Technologies And Smart Cities. Springer. ISBN 978-3-030-18732-3.

Title	Cyber-Physical Systems for Infrastructure	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech [CIE]	Type	Program Elective (PE)
Prerequisite	-		

Objectives

This course aims at :

1. Introducing the significance of cyber-physical systems (CPS) in civil and infrastructure engineering.
2. Understanding the basic aspects of instrumentation and wireless communications.
3. Applying the cyber-physical system principles to civil engineering applications

Learning Outcomes

At the end of the course, students will be able to

1. Realize the need of CPS, sensors and instrumentation in civil engineering
2. Utilize the concepts of wireless communications in major infrastructure planning
3. Adopt various structural control systems
4. Find innovative CPS based solutions for various civil engineering applications

Contents

Module 1 [Lectures: 8]

Introduction to cyber-physical systems (CPS), significance of CPS in civil engineering, sensors and instrumentation-accelerometers, strain gauges, LVDTs, pressure cells, load cells and other sensors, sensor interfacing with an arduino or raspberry pi based board

Module 2 [Lectures: 10]

Wireless communications and networks, communication principles, fiber optic sensing, time domain reflectometry, microelectromechanical systems, particle image velocimetry, acoustic emission, wireless sensor network, distributed temperature sensing

Module 3 [Lectures: 12]

Structural control systems-passive- hysteretic seismic isolation bearings, energy dissipation dampers and absorbers and others; active-active base isolation, active mass driver and active bracing, semi-active- tuned mass dampers and other dampers; and hybrid-hybrid mass damper, hybrid base isolation and hybrid damper-actuator bracing control

Module 4 [Lectures: 12]

Applications in civil and infrastructure engineering-structural health monitoring of infrastructure systems, subsurface profiling and stability analysis of geotechnical and geophysical systems, hydrological applications, transportation engineering applications, environmental and GIS applications

Text Books

1. Rajeev A. (2015). Principles of Cyber-Physical Systems. The MIT Press. ISBN: 978-0-262-02911-7
2. Lee, E. A., & Seshia, S. A. (2017). Introduction to embedded systems: A cyber-physical systems approach. (2nd Edn). The MIT Press. ISBN-10: 0262533812

Suggested articles

1. Legatiuk, D., Dragos, K., & Smarsly, K. (2017). Modeling and evaluation of cyber-physical systems in civil engineering. PAMM, 17(1), 807-808.
2. Soga, K., & Schooling, J. (2016). Infrastructure sensing. Interface focus, 6(4), 20160023.
3. Saaed, T. E., Nikolakopoulos, G., Jonasson, J. E., & Hedlund, H. (2015). A state-of-the-art review of structural control systems. Journal of Vibration and Control, 21(5), 919-937.

Title	AI/ML in Infrastructure Engineering	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech ,M. Tech [CIE]	Type	Program Elective
Prerequisite	Mathematics I; Mathematics II		

Objectives

This course aims at:
1. Comprehensive understanding of the problem settings and application of machine learning in civil and infrastructure engineering.
2. Development of programming skills to execute machine learning algorithms in civil and infrastructure engineering.

Learning Outcomes

Students will have the ability to:
1. Analyze problems in deterministic and random environments.
2. Solve challenging problems in engineering such as prediction, uncertainty quantification, damage assessment etc. using machine learning methods.

Content

Module 1 Introduction(Lectures: 8)

Review of AI/ML: Fundamentals concepts and working principle of ANN; network training; models; supervised and unsupervised learning networks; feed-forward backpropagation networks; generalized regression networks; radial basis function networks; Gaussian processes.
Support Vector Machine and Support Vector Regression;Spatial and Temporal Data Analysis

Module 2 Deep Learning (Lectures:14)

Overview of Deep Networks; Building Deep Networks for Classification: Stacked Autoencoders, Linear Decoders with Autoencoders, Linear Decoder, Feature extraction using convolution, CNN, Pooling, Classification layer; Training CNN, Restricted Boltzmann Machines, Deep Belief Networks, Introduction to GAN, Introduction to Recurrent Networks and LSTM

Module 3 (Lectures: 10)

Applications in Civil and Infrastructure Engineering: Scope of applications in structural engineering, water resource engineering, geotechnical engineering, transportation engineering, construction engineering, environmental engineering, coastal and marine engineering etc.; examples for application of AI/ML in material modelling, traffic management and safety, foundation settlement.

Module 4 (Lectures: 10)

Other applications: Examples for application of AI/ML in structural control system identification, structural health monitoring, damage assessment, surrogate modelling, uncertainty quantification etc.

Text Books
1. J.-A. Goulet (2020) Probabilistic Machine Learning for Civil Engineers, The MITPress.
2. P.C. Deka (2020) A Primer on Machine Learning Applications in Civil Engineering, CRC Press. ISBN 9781138323391.

C.M. Bishop (2006) Pattern Recognition and Machine Learning, Springer. ISBN 9780387310732.

S. Shalev-Shwartz, S. Ben-David (2014) Understanding Machine Learning From Theory to Algorithms, Cambridge University Press. ISBN 9781107057135.

Deep Learning, Goodfellow et al., MIT Press

Title	Mathematical Modelling in Environmental Systems	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech, M. Tech [CIE]	Type	Program Elective
Prerequisite			

Objectives

To provide comprehensive understanding on scope and application of mathematical modelling to understand environmental processes and solve related problems.

Learning Outcomes

Understanding basic principles of mathematical modelling used in solving complex environmental issues.

Content

Module 1: Environmental process and systems [Lectures 8]

Natural and Engineered Systems, Mass Balance, Reaction Kinetics, Phase equilibrium, Steady State, Response time, Micro and Macro Transport Processes

Module 2: Modelling of reactors [Lectures 10]

Homogeneous and heterogeneous reactors; Mixed batch reactors; sequencing batch reactor, mixed flow reactors, plug flow reactors

Module 3: Surface environment systems and Water Quality Modelling [Lectures 14]

Fundamental of modelling aquatic systems; Lakes, Rivers river and estuaries and lake hydrodynamics; Stratification and eutrophication; Dissolved oxygen model for streams; Temperature models.

Module 4: Air quality modeling[Lectures 10]

Introduction to air quality models; Meteorology; Atmospheric stability and turbulence; Gaussian plume model and modifications, Dispersion models, Receptor models, Acid Rain Modelling, Introduction to Dispersion and receptor modelling software.

Text Books

1. Weber, W.J. Jr., Process Dynamics in Environmental Systems, John Wiley & Sons Inc. (1996).
2. Thomann, R.V., and Muller, J.A., Principles of Surface Water Quality Modelling and Control, Harper International Edition, N.D. (1987).
3. Steven C.Chapra, Surface Water Quality Modelling, The McGraw-Hill Companies,Inc., New York (2009).
4. Deaton and Wine Brake, "Dynamic Modelling of Environmental Systems", Wiley & sons (2002).

Title	Intelligent Buildings	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech, M. Tech [CIE]	Type	Program Elective
Prerequisite			

Objectives

Provide knowledge of advanced intelligent building technologies, system configuration and standards, system operation and control.

To provide basic understanding on the use of system integration, application of technologies and the operation performances.

Learning Outcomes

1. To understand the design and requirements for building automation systems and intelligent building systems
2. Assess the impacts of using different architectures, LAN protocols/standards and Internet technologies in BAS design.
3. Able to integrate and configure building environmental control, lighting control,security and safety control systems.

Content

Module 1: Intelligent Buildings [Lectures 4]

Introduction: Concepts, Definitions, Intelligent architecture and structure, evolution of intelligent buildings, IB assessment criteria

Module 2: Building Automation System (BAS) and BAS communication standards [Lectures 12]

Digital controller, I/P and O/P units, sensors and actuators, architecture and configuration of BAS,BAS outstation and central station, Programming and monitoring platforms and environment, building energy management functions; BAS communication standards(BACnet, LonWorks, Modbus, PROFIBUS, EIB) and their features, compatibility of different protocol standards, integration at management level

Module 3: Local Area Network (LAN) and Applications of Internet technologies in BAS [Lectures 10]

Local Area Network (LAN), protocol standards and OSI model, medium-access schemes, LAN standards, Ethernet, ARCnet, LonTalk, wireless technologies, ZigBee, applications of wireless technologies in BAS; Applications of Internet Technologies: Internet and Internet protocols, TCP/IP, Internet LAN vs WAN, use of Internet technologies at different levels,BACnet/IP, convergence networks and total integration

Module 4: Light Control, and Security and safety control Systems [Lectures 12]

Light Control Systems: Component, analogue and digital control, DXM512-A, digital addressable lighting interface(DALI), systems based on common automation protocols, energy management and lighting control strategies; Security and safety control Systems: CCTV systems, analogue systems and IP-surveillance systems; Access control system, different types of access control, intelligent readers and system topologies; Burglar alarm system, functions of burglar alarm systems; Fire alarm systems, typical fire detectors, conventional fire panels, addressable fire panels.

Module 5: Smart and optimal control[Lectures 6]

Feed forward control, feedback control and adaptive control;process control and optimal control; different optimal control methods (rule-based control,performance-based optimal control and model-based optimal control.

Text Books

1. Wang, S.W. (2010) Intelligent Buildings and Building Automation, Spon Press (Taylor & Francis), London.
2. Atkin, B. (1988) Intelligent Building, John Wiley &Sons.
3. Leszek R. (1987) Introduction to Local Area Networks with Microcomputer Experiments, Prentice-Hall Inc.
4. Levermore, G.J. (1992) Building Energy Management Systems, E&FN Spon.

Title	Building Services	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech, M. Tech [CIE]	Type	Program Elective
Prerequisite	-		

Objectives
To provide knowledge of the operating principles and issues of different building services systems

Learning Outcomes
To develop understanding on selection criteria of suitable building services for specific requirements.
To understand critical issues related with operation and maintenance building services systems in modern complex buildings.

Content
Module 1: Introduction to Building Services[Lectures 4]
Objectives of Building services, Classification bodybuilding services, Selection of services and Application to different types of buildings;Building as a whole, Energy, heat transfer and thermal comfort, Natural and Artificial Lighting; Ventilation and its types; Condensation in Buildings

Module 2: Piped Services[Lectures 14]
Introduction, Hot and Cold water: Direct and Indirect system, protectionist, valves, water storage, Pipe size and resistance, hydraulics and fluid flow,circulation; Sanitary fittings, discharge and waste systems; Fire prevention and control:Fire Fighting equipment, Methods of fighting fire, Combustibility of materials, Structural elements and fire resistance, Fire escape routes, ventilation and control; Gas and storage:Control and safety features, Purging, Flue gas analysis, Gas consumption and pipe sizing,Ventilation requirement; Solid waste disposal: Collection and removal, onsite-processing and disposal methods, Guidelines for Solid waste and Electronic waste management,Disposal practices: landfill, Vermi-compost, Incineration, pyrolysis; Drainage: Surface-water drainage and Below-ground treatment

Module 3: Mechanical services[Lectures 6]
Introduction, Lifts, elevators and escalators, dumbwaiters,conveyors, air conditioning, and their types

Module 4: Space Heating and Cooling[Lectures 6]
Types of heating: Open fires, stoves, boilers, radiators;Flow and Ceiling Heating, Warm air systems and air conditioning, Geothermal and heat pumps, solar energy

Module 5: Electrical Installations and Acoustics[Lectures 12]
Electricity generation, supply and distribution,Circuit design, Cable capacity and voltage drop, Overloads and Safety cut-outs. Testing,Telecommunications installations; Acoustic principles, Sound and Pressure levels, pressure levels in different zones, Sound transmission, Noise rating

Text Books
1. Chadderton D. V. (2007) Building Services Engineering, Fifth Edition, Taylor & Francis, London and New York.
2. Hall, F. ; Greeno, R. (2007) Building Services, Fourth Edition, Butterworth-Heinemann, Elsevier.
3. Harrison, H. W. & Trotman, P. M. (2000) Building Services: Performance, Diagnosis, Maintenance, Repair and Avoidance of defects, London: CRC.

Title	Environmental Biotechnology and Bioremediation	Number	BBL7XX0
Department	Bioscience and Bioengineering	L-T-P [C]	3-0-2 [4]
Offered for	B. Tech, M.Tech, M.Tech.-Ph.D. [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives

Acquaint students with the way wastes/waste waters as well as toxic wastes are treated.
Teach methods pertaining to sustainable waste water recycling

Learning Outcomes

1. Acquaint students with the way wastes/wastewaters as well as toxic wastes are treated.
2. Teach methods pertaining to sustainable wastewater recycling

Content

Introduction: Basics of Microbiology, Stoichiometry and Bacterial energetics [Lectures 5].
Kinetics and Reactors: Microbial Kinetics and Biofilm kinetics, Reactor types, Mass balances [Lectures 7].
The activated sludge process: Characteristics of activated sludge, Process configurations, Design and operating criteria, aeration systems and sludge separation [Lectures 5].
Nitrification and denitrification: Bacterial physiology and basic process including biofilm and hybrid [Lectures 4].
Phosphorus removal: Normal phosphorus uptake into biomass, precipitation and enhanced biological removal [Lectures 4].
Drinking water treatment: Aerobic biofilm processes to remove biological instability, biodegradation and denitrification [Lectures 4].
Anaerobic treatment by methanogenesis: Reactor configurations, Process chemistry and Microbiology, Process kinetics [Lectures 4].
Detoxification of hazardous chemicals: Molecular recalcitrance, Biodegradation of problem environmental contaminants [Lectures 4].
Bioremediation: Scope and characteristics of contaminants, Biodegradability, Treatability studies, Engineering strategies for bioremediation, Biotechnological and genetics engineering approaches-creations of superbugs [Lectures 4].

Laboratory

Determining empirical formula for wastewater based on elemental analysis, Determining COD degradation rate using different electron acceptors, Determining the microbial growth rate in wastewater under oxic/anoxic conditions, Determining the % COD removal using batch & continuous process for simulated wastewater, Determining the effect of initial microbial load on COD removal rate, Determining the effect of C/N ratio on COD removal rate, determine the sludge bulking/good settling sludge, Performing biological nitrification, Biological denitrification, Biofilm process for water treatment, Setting up bio electrochemical system for simultaneous C, N removal, Acclimatizing microbial consortia for treatment of hazardous waste, Setting up an in situ bioremediation system

Text Books

Environmental Biotechnology: Principles and Applications, Rittmann, B.E., McCarty, P.L., Tata McGraw Hill, 2001.

Reference Books

Bioprocess Engineering: Basic Concepts, Shuler, M., Kargi, F., Second Edition Prentice Hall, 2002.
General Microbiology, Stanier, R. Y., W.H. Freeman and Co, 2009.

Online course material

Gargi Singh, Applied Environmental Microbiology, NPTEL Course Material, Department of Civil Engineering, Indian Institute of Technology, Roorkee, http://nptel.ac.in/courses/105107173/

Title	Environmental Hydrology	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-2 [4]
Offered for	B. Tech, M.Tech, M.Tech.-Ph.D. [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives
1. To provide qualitative understanding of hydrologic processes.
2. To inculcate basic steps of quantifying hydrologic parameters.
3. To enable design structures for water and soil management.

Learning Outcomes
The students are expected to achieve proficiency in:
1. Enable to develop and design flood management solutions, wetlands and landscapes.
2. Ability to design hydraulic structures and processes
3. Able to predict and assess the impact of precipitation, and effectively use water for different services such as in agriculture

Content
Hydrological cycle, climate and society: Water food industry nexus, transport from precipitation to groundwater, modelling hydrologic cycles and basic hydrologic data [Lectures 5].
Precipitation: Forms of precipitation, its causes, measurement of precipitation, data of precipitation, precipitation trends and frequencies, depth-duration-frequency of precipitation, Probability of precipitation occurrence [Lectures 7].
Infiltration and soil Moisture Management: Soil properties, soil-water balance, infiltration and its estimation, evaporation and its estimation, evapo-transpiration (ET) and its measurement and estimation, Crop referenced ET [Lectures 7].
Runoff: Why Runoff, Factor affecting Runoff and flow models, watershed, Hydrograph and its components, peak runoff and stormwater runoff, flood and its estimation, catchment character, agricultural and sub-surface drainage [Lectures 5].
Streams : Streams, Temporal and spatial streams, Stream Biota and Order, Measurement of stage and Velocity, stream stability and sediment transport, Meander migration, Flood plains, Stream Classification- Mountain Stream and Rosen stream methods, Channel evolution, Losing and gaining streams Unit hydrograph, flood frequency, Gumbel and Type III distribution studies [Lectures 8].
Floods and Hydraulic Control Structures: open channel flows, Darcy Weisbach and Manning equations, weirs, flumes, conduits, culverts, riffles, pools and runs [Lectures 5].
Hydrology of Wetlands and in Ground Water: Detention and Retention ponds, Agricultural impacts and Brackish systems, Filter Strips, Riparian Buffers and Ditches. Leachate impact, subsurface water, aquifers, wells, recharge, ground water mapping [Lectures 5].
Experimental Outline- Modelling
Use the local historical precipitation data of Jodhpur and find the probability distribution function, which can effectively predict it.
Use the local precipitation data as an input to derive synthetic mass curves. Further, utilize the data to calculate runoff and land use. Use HydroCAD v.9.0.
Model a drainage management scenario of a porous tile of 10 cm diameter running at the boundary between 1ft loamy soil from the atmosphere and 1ft sandy soil below the porous tile. The ponding is 1ft height in an area of 1 acre. Use Ansys Fluent and MicroFEM, and compare the results.
Create a new numerical groundwater flow model with MODFLOW-2005 / MODFLOW-NWT, having a confined aquifer at 80 m depth from soil surface. Import the data (shapefiles, images, spreadsheets) from crop.xls; Use uniform percolation of 1ft per acre as inflow, which can be manual input data to MODFLOW; link packages with their parameters; run a simulation; visualize and export the results.
Use Hydrus 2D to simulate the water potential about the 25 cm larger and 15 cm smaller external diameter of a porous frustum of 0.25 cm thickness leaching out saline solution of 2000 ppm (brackish irrigation water) and train the model using a Python program to handle different concentrations of salinity. Input training data from the field experiments collected after soil analysis at Site C, IIT Jodhpur.
Using the results of water potential from Experiment 5 and estimate net infiltration below the root zone if the crop is Okra. Use Crop ET reference values from Frangmeier et al. 2015. Use INFIL 3.0 for the simulations.

Derive approximate flow effectiveness of a trapezoidal notch of 2.5 m base and 4.5 m surface with a height of 1m using OpenFlow Flow Master and compare the results with Channel Design and Channel Studio.

Use EPANET to evaluate water distribution of a community of 200 households with an average consumption of 300 litres of water per day living at a height of 20 m from ground level. These 200 households are supplied water from a 50 m high tank using a given distribution plan. Refer lecture notes for the approximate length of 200 m. Find the energy expense for distributing the water if the water tank is having 15 m diameter and 10 m height.

Text Books
1. Environmental Hydrology, Andy D. Ward, Stanley W. Trimble, Suzette R. Burckhard, John G. Lyon, CRC Press, Third Edition, ISBN-13: 978-1466589414, ISBN-10: 1466589418, 2016.
2. Engineering Hydrology K Subramanya, Fourth Edition, McGraw Hill Education (India), Pvt, Ltd., New Delhi ISBN 1-25-902997-2, 978-1-25902997-4, 2013.

Title	Introduction to Structural Health Monitoring	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE]	Type	PE
Prerequisite	-		

Objectives

This course aims at:

1. Fundamental understanding of the monitoring systems for estimating structural health.
2. Development of time and frequency domain methods to estimate damage in the structures.

Learning Outcomes

Students will have the ability to:

1. Assess the damage in the existing structures and their components using time and modal based methods.
2. Design the layout of the sensors and hardware for acquiring the experimental data from the structure.

Contents

Module 1

Review of structural dynamics: Development of equation of motion for multi degree of freedom system; solution methods; response in free and forced vibration; types of damping; computation of vibration properties, natural time period and modes. (Lectures: 9)

Module 2

Concept of structural health monitoring (SHM): Introduction to damage; passive and active SHM; non-destructive evaluation (NDE) and SHM; structural health management. (Lectures: 4)

Vibration-based techniques for SHM: Basic concepts; data evaluation and assessment; structural damage assessment – diagnostic levels and methods; modelling of damaged structural elements; modal assurance criterion (MAC); damage localization and quantification. (Lectures: 8)

Module 3

Frequency domain decomposition (FDD); time-domain damage detection methods - Kalman filters, autoregressive (AR) and autoregressive with exogenous input (ARX) models. (Lectures: 9)

Module 4

Miscellaneous topics: ANN and statistical pattern recognition approach to SHM; predictive health monitoring; Bayesian model updating; introduction to piezo-electric materials; electro-mechanical impedance (EMI) technique; fundamentals of restoration and rehabilitation. (Lectures: 8)

SHM system design: Data handling - data acquisition systems and transmission; processing of recorded data; evaluate sources of variability; fibre-optics sensors and smart sensing; sensor optimization, placement and layout design. (Lectures: 4)

Text Books

1. D. Balageas, C.-P. Fritzen, A. Güemes (2006) Structural Health Monitoring, ISTE Ltd. ISBN 9781905209019.
2. C.R. Farrar, K. Worden (2012) Structural Health Monitoring: A Machine Learning Perspective, Wiley. ISBN 9781119994336.
3. H.-P. Chen (2018) Structural Health Monitoring of Large Civil Engineering Structures, Wiley Blackwell. ISBN 9781119166627.
4. C.-K. Soh, Y. Yang, S. Bhalla (2014) Smart Materials in Structural Health Monitoring, Control and Biomechanics, Springer. ISBN 9783642244629.

Additional reference

Structural Health Monitoring (2018) by Prof. Srinivasan Chandrasekaran on NPTEL. https://nptel.ac.in/courses/114/106/114106046/

Title	Infrastructure Planning and Management	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-2 [3]
Offered for	B.Tech [CIE]	Type	Program Elective (PE)
Prerequisite			

Objectives

This course aims at:

1. Introducing basic principles and concepts of infrastructure planning and management.
2. Realizing the real-world risks and challenges in managing infrastructure.
3. Introducing the infrastructure planning process as well as the state of infrastructure across sectors in India.

Learning Outcomes

Students will have the ability to

1. Analyze systematically the various risks that plague infrastructure projects.
2. Develop critical thinking on a variety of novel solutions or fixes which aids in execution infrastructure projects better.
3. Device methods to analyze the infrastructure projects based on various risks.
4. Apply the design methodologies to the real world case studies.
5. Design innovative methods for long lasting infrastructure and understand the successful project delivery strategies.

Contents

Module 1 [Lectures: 6]

Introduction, infrastructure scenario in India, transportation, power and telecom sectors, urban and rural infrastructure in India, road infrastructure development in India, rural roads development in India-opportunities and challenges

Module 2 [Lectures: 8]

Infrastructure economics and finance, project structuring and risk allocation in project finance, Public-Private Partnership (PPP) for infrastructure- case studies, risk management in infrastructure projects, term sheet development, economic and social environmental risk in infrastructure.

Module 3 [Lectures: 8]

Project Governance, public sector governance, strategies for governing against infrastructure project turbulence, the governance model, data–base management, actor mapping and social network analysis, fair process and negotiations, design thinking, life cycle and benefit cost analysis, pavement preservation and road asset management system.

Module 4 [Lectures: 10]

Maintenance of infrastructure, case studies of infrastructure, privatization in infrastructure projects, road information system for maintenance management of road infrastructure projects, flexibilities and options on projects, module flexibilities in projects, tourism infrastructure projects- implementation on PPP Format.

Module 5 [Lectures: 10]

Innovative infrastructure financing, urban infrastructure needs in India and funding options, new and innovative materials for long lasting road infrastructure, green highways –recycling technology, durable road infrastructure –options and recent developments, polycentric governance and incomplete design, successful project delivery strategies.

Text Books

1. Goodman AS, Hastak M (2006). Infrastructure planning handbook: planning, engineering, and economics. New York: ASCE Press.
2. Miller R, Lessard DR (2001). The strategic management of large engineering projects: Shaping institutions, risks, and governance. MIT press.

Additional reference

Infrastructure Planning and Management (2018) by Prof. Ashwin Mahalingam NPTEL. https://nptel.ac.in/courses/105/106/105106188/

Title	Introduction to Power Infrastructure Engineering	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech [CIE]	Type	Program Elective (PE)
Prerequisite	-		

Objectives

This course aims at:

1. An overview of the key renewable energy infrastructure technologies in wind, hydroelectric, tidal and solar.
2. Introduction of fundamentals of piping, transmission and distribution systems in the power infrastructure.

Learning Outcomes

Students will have the ability to:

1. Conceptualize and use the knowledge on different civil engineering components for executing renewable power infrastructure projects.
2. Design and develop smart grid networks for transmission and distribution of the energy in rural and urban sectors.

Contents

Module 1

Introduction to power infrastructure: Types of electrical generation; generation system architecture; power plant planning and design. (Lectures: 3)

Hydroelectric infrastructure: Site selection; classification; hydrographs; storage and pondage; essential elements; selection of turbines. (Lectures: 6)

Module 2

Tidal energy infrastructure: Fundamentals of tide; wave theory, loading and energy; operating principle - oscillating device; turbine characteristics; devices; moorings and anchors; foundations. (Lectures: 6)

Wind energy infrastructure: Offshore and onshore wind; properties of wind; wind resource assessment; wind turbine blades; wind turbines in grid; wind projects. (Lectures: 6)

Module 3

Solar energy infrastructure: Basics of solar PV, fundamentals of the design of solar energy fields; concentrated solar power plant; solar water heating systems. (Lectures: 6)

Introduction to pipelines in power infrastructure: Materials; pressure design of piping; fittings; layout and supports; flexibility and fatigue; vibration. (Lectures: 7)

Module 4

Smart grid, transmission and distribution: Grid resilience; environmental performance; operational efficiencies; network architecture; transmission systems; wide area monitoring, protection and control, transmission and distribution architecture; microgrids; vulnerability; peak load shifting and grid storage. (Lectures: 8)

Reference Books/Reports

1. L.F. Drbal, P.G. Boston, K.L. Westra, R.B. Erickson (1996) Power Plant Engineering, Kluwer Academic Publishers. ISBN 9781461380474.
2. S. Borlase (2013) Smart Grid Infrastructure, Technology, and Solutions, CRC Press. ISBN 9781439829103.
3. G.A. Antaki (2005) Piping and Pipeline Engineering Design, Construction, Maintenance, Integrity, and Repair, Taylor & Francis. ISBN 0824709640.
4. P. Jain (2011) Wind Energy Engineering, McGraw-Hill. ISBN 9780071714778.
5. D. Greaves, G. Iglesias (2018) Wave and Tidal Energy, John Wiley & Sons Ltd. ISBN 9781119014454.
6. S. A. Kalogirou (2009) Solar Energy Engineering Processes and Systems, Elsevier. ISBN 9780123745019.

Title	Thermal and Nuclear Power Infrastructure Engineering	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. [CIE]	Type	PE
Prerequisite	-		

Objectives

This course aims at:

1. An overview of the energy infrastructure technologies in thermal and nuclear systems.
2. Introducing the waste generated from the above systems and its respective utilization in civil and infrastructure engineering.

Learning Outcomes

Students will have the ability to:

1. Conceptualize and use the knowledge on different civil engineering components for executing power infrastructure projects.
2. Design and develop cooling networks and chimneys for power plants.

Contents

Module 1

Overview of power plant planning and design. (Lectures: 2)

Thermal energy infrastructure: Plant configuration; emission reduction; repair; maintenance; cooling; reliability and risk assessment. (Lectures: 11)

Module 2

Chimney: Design of chimney; construction and maintenance. (Lectures: 5)

Waste management and fly ash: Power plant waste – fly ash; chemical composition and classification; disposal and reuse; applications in cement, soil stabilization, pavement construction, geo polymers, bricks etc.; environmental issues and exposure concerns; flue gas desulfurization. (Lectures: 10)

Module 3

Nuclear energy infrastructure: Policy and regulations; economics and financing of nuclear power plants; nuclear technology selection and project implementation; fuel supply, radioactive waste and management; issues; facilities and basic infrastructure. (Lectures: 14)

Reference Books/Reports

1. L.F. Drbal, P.G. Boston, K.L. Westra, R.B. Erickson (1996) Power Plant Engineering, Kluwer Academic Publishers. ISBN 9781461380474.
2. Basic Infrastructure for a Nuclear Power Project (2006) Technical Report, IAEA. ISBN 9201085060.
3. G.F.M. de Souza (2012) Thermal Power Plant Performance Analysis, Springer. ISBN 9781447123088.

Title	Infrastructure planning and design for rail and air transport	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech [CIE]	Type	Program Elective (PE)
Prerequisite	-		

Objectives

In this course the students will learn to plan and design the elements of rail and air transportation system and will understand their operational principles.

Learning Outcomes

At the end of the course, the student should be able to:

Understand various elements of rail and air transportation systems

Forecast travel demand for these transportation systems

Understand the layout, design, and operation of these transportation systems

Conceptually design a transport system compatible with the surrounding land use

Understand the mobility and accessibility of these systems.

Content

MODULE I: [No. of lectures – 12]

Railway operational system, traffic forecast and surveys, components of railway track and rolling stock, railway alignment, geometric design elements, traction, safety measures, track laying, inspection and maintenance, track drainage, bridge maintenance, classification of renewal works, track renewal trains.

MODULE II: No. Of lectures - 8

Signaling and interlocking – objectives and classification, Site selection and facilities for railway stations and yards, High Speed Railways- Modernization of railways, effect of high-speed track, vehicle performance on track, high speed ground transportation system, ballast less track, elevated railways, underground and tube railways.

MODULE III: [No. of lectures-10]

Airport system planning, Airport strategic and master planning, Air Traffic demand forecasting, Airline operations and economics, Airspace and airport capacity and delay, From planning to construction, Airfield layout planning and design

MODULE IV: [No. of lectures- 12]

Passenger terminal planning, Air cargo facilities and logistic planning, Airport ground access, Environmental planning and management, Airport noise management, Airport land use compatibility planning, Planning for unmanned aircraft system and future air mobility.

Text Books

Satish Chandra and M. Agrawal, Railway Engineering, Second Edition, Oxford University Press

Norman J. Ashford, Saleh Mumayiz, Paul H. Wright. Airport Engineering: Planning, Design, and Development of 21st Century Airports. John Wiley and Sons Inc.

Additional reference

C. Venkatramaiah. Transportation Engineering: Volume II: Railways, Airports, Docks and Harbors, Bridges and Tunnels. Universities Press (India) Private Ltd.

Title	Infrastructure planning and design of ports and harbours	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech [CIE]	Type	Program Elective (PE)
Prerequisite	--		

Objectives

In this course the students will learn to plan and design the elements of ports and harbours for water transportation.

Learning Outcomes

At the end of the course, the student should be able to:

1. Understand various elements of ports and harbour infrastructures
2. Forecast travel demand water transportation systems
3. Understand the layout, design, and operation of ports and harbours
4. Conceptually design a port and harbour system compatible with the surrounding land use

Content

MODULE I: [No. of lectures-12]

Fundamentals-Tide and current conditions inside harbor, water circulation, breakwaters, jetties and quay walls; mooring, berthing and ship motion inside the port. Port layout, continuation of port layouts, port planning, harbour layout, Site characteristics, Bathymetric survey, Wave rose diagram

MODULE II: [No. of lectures-15]

Design issues of Sea port layout, Design of Port Infrastructures, Design of breakwaters, berm breakwater, Dredging and methods of disposal, Berthing structures- loads, analysis, and design, mooring berthing and seismic forces, Slipway, drydock,floating dock, shiplift, soil structure interaction, Ground improvement techniques

MODULE III: [No.of lectures-7]

Planning multipurpose port terminals. Operation- Allowable wave conditions for cargo handling and human safety on quays and breakwaters, forecasting / nowcasting of wave and current conditions for port operations

MODULE IV: [No. of lectures-8]

VTMS and management of computerized container terminal, safety & environment. Maintenance of waterways, construction of environmentally engineered banks, Impact of possible climate change scenarios, sustainable development strategies for cities and ports.

Text Books

Gaythwaite, J. Design of Marine Facilities: Engineering for port and harbor structures. 3rd Edition, ASCE Press

Richand L. Silister, Coastal Engineering Volume I & II, Elsevier Publishers

Tsinker, G. P. Handbook of Port and Harbour Engineering: Geotechnical and structural aspects, International Thomson Publishing

Additional reference

C. Venkatramaiah. Transportation Engineering: Volume II: Railways, Airports, Docks and Harbors, Bridges and Tunnels. Universities Press (India) Private Ltd.

Title	IT and Telecom Infrastructure	Number	CI4XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech [CIE]	Type	Program Elective (PE)
Prerequisite	-		

Objectives

The course will help students to understand the fundamentals of IT and telecommunication infrastructure and their integration for sustainable livelihood.

Learning Outcomes

At the end of the course, the student should be able to:
1. Understand the components and functions of telecommunication.
2. Understand the preliminaries of telecom tower construction
3. Understand the fundamental elements of IT infrastructure such as networks and servers, storage, remote access, and network security
4. Understand the integration of information and communication technology for urban services

Content

MODULE I: [No. of lectures – 14]

Telecommunication – definition, use, functions, and components, site surveys- raw land tower site survey and boundary survey, classification of telecommunication towers, Telecommunication signals, Design of towers – configuration, analysis of loads, design of tower members, design of foundation, tower erection, transmission lines construction, operation and maintenance of distribution systems. Overview of - the role of telecommunication in IT industry, telecom network management, and wireless and mobile communication)

MODULE II: [No. of lectures – 13]

IT infrastructure – components of IT infrastructure, Internet and world wide web, design, planning, and implementation of networks and servers, storage management , Backup / Restore Methodology, Remote Access, Control, Administration, Introduction to -Network security, cloud computing, cyber-physical system, Preliminary concepts on Big data

MODULE III: [No. of lectures – 15]

Definition and concepts of Smart city, Intelligent city, Digital city, and Ecity. Information and Communication Technology (ICT) in Urban services : Specific interests - Emergency response, water and electrical utilities, sewage treatment, Health, safety, and security; General interest: Public service and governance, Urban administration, Urban infrastructure planning

Text Books
1. Steve Morris, Up the Tower: The complete Guide to Tower Construction, Champion Radio Products
2. Brian W. Smith, Communication Structures, Thomas Telford publications

Additional reference
1. Graham, S. and Marvin, S. Planning Cybercities? Integrating Telecommunications into Urban Planning, The town planning review, 70(1), Liverpool University Press
2. ICT in Urban services, Compendium of global good practices, National Institute of Urban affairs, http://pearl.niua.org/sites/default/files/books/GP-GL1_ICT.pdf
3. Fundamentals of telecommunication. https://www.net.t-labs.tu-berlin.de/teaching/computer_networking/documents/telecomm_fundamentals.pdf

Title	Green Building and Sustainable Materials	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech, M.Tech, M.Tech.-Ph.D. [CIE]	Type	Program Elective (PE)
Prerequisite	-		

Objectives

Objectives of this course are:

To introduce elements of green building construction and use of sustainable materials.

To familiarize students with different national and international green performance ratings.

To teach students methods of carbon footprint reduction and increase in energy efficiency of a building.

Learning Outcomes

A graduate of this course will have a thorough idea of:

National and international green building assessment system and requirements.

Green building design elements and use of sustainable materials.

Techniques to reduce the carbon footprint of a green building.

Management of hydrological cycle, treatment of waste, and maintenance of indoor air quality.

Green building economics, business plan, and management.

Content

Introduction to green building: Rationale for high-performance green building; green building progress and obstacles; trends in high-performance green building; the green building movement. (Lectures: 3)

Ecological design: design vs ecological design; contemporary ecological design; future ecological design; thermodynamics: limits on recycling and the dissipation of materials (Lectures: 3)

Green building assessment: US green building assessment system; international green building assessment system; performance assessment. (Lectures: 3)

LEED building rating system: history of LEED; structure of the LEED suite of building assessment systems; LEED credentials; the LEED process; LEED categories. (Lectures: 3)

The Green Globes building assessment system: the Green Globes process; Green Globes verification and certification; structure of the ANSI/GBI 01-2010 standard; the Green Globes professional and Green Globes Assessor. (Lectures: 3)

Green building design process: conventional vs green building delivery systems; executing the green building project; the integrated design progress; role of Charrette in the design process; green building documentation requirements. (Lectures: 3)

Sustainable site and landscape: land and landscape approaches for green buildings; sustainable landscapes; enhancing ecosystems; stormwater management; low-impact development; heat island mitigation; light trespass and pollution reduction; sustainable site initiative. (Lectures: 3)

Energy and carbon footprint reduction: building energy issues; high-performance building energy design strategy; passive design strategy; building envelope; internal load reduction; active mechanical system; water-heating system; electrical power systems; innovative energy optimization strategies; renewable energy systems; fuel cells; smart buildings and energy management systems; ozone-depleting chemicals in HVAC&R systems; reducing carbon footprint of the built environment. (Lectures: 4)

Built environment hydrological cycle: global water resource depletion; hydrological cycle terminology; high-performance building hydrological cycle strategy; designing the high-performance building hydrological cycle; water budget rules of thumb; sustainable stormwater management; landscaping water efficiency. (Lectures: 4)

Closing materials loops: distinguishing between green building products and green building materials; LCA of building materials and products; environmental product declaration; materials and product certification systems; emerging construction materials and products; design for deconstruction. (Lectures: 4)

Indoor environmental quality: IEQ issues; design; main components of integrated IEQ design; emission from building materials; economic benefits of good indoor environmental quality. (Lectures: 3)

Construction operations and commissioning: site protection planning; indoor air quality during construction; construction materials management; construction and demolition waste management. (Lectures: 3)

Green building economics: the business case for high-performance green building; the economics of green building; quantifying green building benefits. (Lectures: 3)

Text Books
Charles J. Kibert (2013). Sustainable Construction. John Wiley & Sons. ISBN 978-1-118-33013-5
J. Newman and Ban Sang Choo (2003) Advanced Concrete Technology-Constituent Materials (1st Ed), Elsevier. ISBN 9780080489988.
S. Kubba (2010) LEED Practices, Certification, and Accreditation Handbook (1st Ed) Elsevier. ISBN 9780080958590.

Additional reference
Ministry of Power, Energy Conservation Building Code 2018, Revised Version, Bureau of Energy Efficiency, 2018,
Indian Building Congress, Practical Handbook on Energy Conservation in Buildings, 1 st ed. Nabhi Publication, 2008.
TERI-Griha's Green Design practices (www.teriin.org/bcsd/griha/griha.htm)
Sartori, I., and Hestnes, A. G. "Energy use in the life cycle of conventional and low-energy buildings: A review article", Energy and Buildings., 20, 249-257.2007
Green Building Basics, California Integrated Waste Management Board (www.ciwmb.ca.gov/GREENBUILDING/Basics.htm#What)
Catarina Thormark. "A low energy building in a life cycle—its embodied energy, energy need for operation and recycling potential", Building and Environment., 37, 429-435.2001.

Online course Material
"NOC:Energy Efficiency, Acoustics and Daylighting in Building" by Prof. B. Bhattacharjee on NPTEL. https://nptel.ac.in/courses/105/102/105102175/

Title	Smart Infrastructure: Design and Simulation	Number	CI5XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	0-0-4 [2]
Offered for	B.Tech [CIE]	Type	Program Compulsory (PC) for specialization
Prerequisite	-		

Design/Simulation experiments

Hands-on-experience and response monitoring of instrumentation such as sensors, accelerometers, strain gauges, LVDTs, fiber optics, smart sensors, data acquisition systems etc.

Monitoring instrumentation placement and layout design in the campus pipeline system through optimal sensor placement (OSP) approach

Beam-column damage identification and analysis through digitized sensors and FE simulation (Ansys LS-DYNA)

Health monitoring and fatigue analysis of scaled infrastructure models in the laboratory using Machine Learning, Artificial Intelligence techniques and Ansys Mechanical simulation

Vibration monitoring of campus entities using High-speed visual measuring system

Digital twin development of built environment using Ansys Twin Builder

Safety and security planning of campus entities using Ansys Medini Analyze

Simulation of multimodal transportation system using VISSIM

Development of driver behaviour models in the context of Indian traffic using Ansys VRXPERIENCE

Planning and monitoring of power infrastructure in the campus

Automated water distribution system planning for the campus

Planning of automated-digitized environmental aspects (solid waste management and air pollution control) for the campus

Spatial data analysis and remote sensing application for land use optimization for smart city design through simulations (ArcGIS, etc.)

Smart city and green field city design through data-driven simulation (Programs-Urban Sim, SimCities, Siradel, etc.)

Text Books

Raj, P., & Raman, A. C. (2015). Intelligent Cities: Enabling Tools and Technology. CRC Press.

Meneguette, R. I., De Grande, R. E., & Loureiro, A. A. (2018). Intelligent transport system in smart cities. Springer: Cham, Switzerland.

Deakin, Mark; Al Waer, Husam (Eds.) (2012), From Intelligent to Smart Cities, Routledge, Taylor & Francis, USA and Canada

Articles

Berglund, E. Z., Monroe, J. G., Ahmed, I., Noghabaei, M., Do, J., Pesantez, J. E., ... & Levis, J. (2020). Smart Infrastructure: A Vision for the Role of the Civil Engineering Profession in Smart Cities. Journal of Infrastructure Systems, 26(2), 03120001.

ASCE. (2017) Infrastructure Report Card: A comprehensive assessment of America's infrastructure. Reston, VA: ASCE.

Li, L., Aoyama, T., Takaki, T., Ishii, I., Yang, H., Umemoto, C., ... & Fujiwara, A. (2017). Vibration distribution measurement using a high-speed multi thread active vision. In 2017 IEEE International Conference on Advanced Intelligent Mechatronics (AIM) (pp. 400-405). IEEE.

Manual, A. U. S. (2016). Ansys user's manual. SAS IP inc.

Title	Transmission Infrastructure	Number	EE7XX0
Department	Electrical Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M. Tech, M. Tech-PhD, Ph.D	Type	SSE
Prerequisite			

Objectives

The Instructor will:

1. Provide knowledge related to infrastructure in various modes of power transmission such as underground, marine, and overhead.

2. Provide knowledge related to design, installation, and maintenance of the transmission infrastructure.

Learning Outcomes

The students are expected to have the ability to:

1. Select appropriate transmission infrastructure needed for transmission of electric power based on various factors.

2. Design, install, and maintain power transmission infrastructure.

Contents

Overhead transmission lines: Overhead line routing, aerial survey, ground survey, overhead line foundations, soil investigation, foundation types, foundation design, support structures, steel lattice towers, tower testing, overhead line fittings, suspension clamps, sag adjusters, bi-metal connectors, conductor loads, lightning, surge diverters, insulator arcing horn co-ordination, aerodynamic phenomena, transmission voltage level clearances, wooden poles, distribution voltage clearances, overhead line maintenance, environmental considerations (18 lectures)

Underground cables: Types of cable, insulation and conductor materials, air cable ampacity, underground cable ampacity, short circuit and its effect, thermal & electromechanical stresses, cable termination and joints, pulling the cable, installing cable racks, conduits, cable supports, cable tray and trenches, cable testing, steps for fault location, fault location methods (12 lectures)

Marine cables: Introduction, marine survey, cable routing, cable system design parameters, cable design parameters, cable accessories, cable installation, cable materials & accessories, cable joints and terminations, inspections and testing, maintenance and failure investigation (12 lectures)

Text Books

1. Kiessling,F., Nefzger,P., Nolasco,J.F., Kaintzyk,U., (2003), Overhead Power Lines Planning Design Construction, 4th Edition, Springer
2. Ganguli,S.K., Kohli,V., (2016), Power Cable Technology, CRC Press
3. Worzyk,T., (2009), Submarine Power Cables Design, Installation, Repair, Environmental Aspects, Springer
4. Bayliss,C., Hardy,B., (2012), Transmission and Distribution Electrical Engineering, 4th Edition, Newnes publications

Title	Fate of Chemicals in the Environment	Number	CI7XX0
Department	Civil and Infrastructure Engineering		3-0-0 [3]
Offered for	M.Tech, M.Tech.-Ph.D. [CIE]	Type	Specialization Stream Elective
Prerequisite	Chemistry, Flow Mechanics, Soils		

Objectives

1. To provide a qualitative understanding of what happens to chemicals as it enters an environment.
2. To inculcate the dynamics of chemicals as they interact with different phases during their transport.
3. To inculcate different ways of chemical transport.

Learning Outcomes

1. To enable identification of mass transport and distinguish various chemical transformations.
2. Able to predict mobilizing and spreading of chemicals in a media or material or a volume of air
3. Relate the general fate of contaminants when passing through water, air and soil due to forces such as precipitation.

Contents

Basics of Mass transport: Continuity Thought of Chemicals; Earth's Environmental Compartments, Lavosier species, Mass Balances, history of mass conservation, basic concept of chemical fate [Lectures 6].

Modes of Transport: Ficks law of diffusion, films and finite fluid layers, dispersion, advection of solutes and particles in fluids. Turbulent diffusion, film theory, penetration, surface renewal, and boundary layer thought [Lectures 6].

Transformation and Phases: Phases, Partitioning coefficients, Aspects of Equilibrium with Dissociating chemicals, Partitioning in multi-component systems, Basics of fugacity-Mackay models [Lectures 6].

Soils: Soil and Its Functions, soil nutrients and contamination, Diffusion/advection equation for transport in soil, infiltration and leaching, evaporation and capillary transport, Analytical Solutions for Vertical Transport in Soil [Lectures 6].

Precipitation and Streams: Land use, Hydrological Data, Hydrograph, Analytical Steady-State Surface Water Model, Runoff, Streams, Mass Balances and Plug flow [Lectures 6].

Surface Waters: Wetlands, constructed systems, Mass balances on wetland systems, Nutrient loading criteria, Streeter-Phelps Equation, Waste Load allocation and Dissolved gases in river waters [Lectures 6].

Atmospheric Transport: Area and Point source of pollutants in air, box model for area source plume model for point sources, dry and wet deposition at surfaces or soil, uptake by plant roots, transpiration, metabolism and photo-degradation [Lectures 5].

Text Books

Louis J. Thibodeaux, Environmental Chemodynamics: Movement of Chemicals in Air, Water, and Soil, 2nd Edition,1996, ISBN: 978-0-471-61295-7

Stefan Trapp, and Michael Matthies, Chemodynamics and Environmental Modeling, Springer-Verlag Berlin Heidelberg 1998, ISBN-13: 978-3-642-80431-1 e-ISBN-13: 978-3-642-80429-8

Open Source Models

ICECRM 1.1 (indoor chemical exposure classification/ranking model)
The CoZMoMAN Model- The Multimedia fate and transport models
The Global Distribution Model (Globo-POP Version 1.1)- Global fate of organic chemicals

NPTEL

Dr Bhanu Prakash Vellanki,Environmental Remediation of Contaminated sites, https://nptel.ac.in/courses/105/107/105107181/, IIT Roorkee

Dr Manoj Datta, Geoenvironmental Engineering, (Environmental Geotechnology); Landfills, Slurry Ponds & Contaminated Sites, IIT Delhi https://nptel.ac.in/courses/105/102/105102160/#

Title	Climate Change and Impact	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-4 [5]
Offered for	M.Tech, M.Tech.-Ph.D. [CIE]	Type	Specialization Stream Elective
Prerequisite			

Objectives

To gain understanding of scientific foundation and key concepts of atmospheric science, climate data collection and impacts of GHGs.

To develop the scientific basis of our understanding of the climate system and climate change, and associated uncertainties.

To provide knowledge on the impacts of climate change on the natural world in the current scenario and coming centuries.

Learning Outcomes

The students are expected to achieve proficiency in:

Understanding the present climate system in the context of Earth's history, reconstructing climate evolution and relevant scientific uncertainties.

Developing basics of climate change science with key concepts of climate, weather, energy balance and GHG effect.

Understanding energy flows within the Earth-Atmosphere system.

Explaining the large-scale atmospheric circulations with underlying fluid mechanics principles and role of oceans in climate variability.

Developing scientific understanding of climate forcing, sensitivity and feedback systems.

Understanding the basics of energy balance models and fundamental equations of Global Circulation Models for simulating and estimating past and future climate systems.

Understanding the potential impacts of climate change and future climate change projections.

Contents

Introduction to Climate and Climate Change: Evolution of Earth's climate: history, Instrumental and paleoclimatic record, Climate Change: Definition, Components of climate system, Global energy balance, GHGs and Greenhouse effect [Lectures 5].

Radiative Energy Transfer: Radiation laws, Radiation Processes, Absorption and Scattering by Gases and Particles, Solar Zenith Angle and Aerosol Optical Depth, Radiative Transfer Equation [Lectures 5].

Convection and Atmospheric Circulation: Dry and moist convection, Atmospheric convection and types, Scales of motion, Energy and Momentum Transport [Lectures 7].

Oceanic Circulation: Physical characteristics of ocean, Energy transport mechanism: Wind driven circulation theories, and thermohaline circulation [Lectures 4].

Climate sensitivity and feedback mechanisms: Equilibrium Climate sensitivity, Transient Climate Response, Feedback: Concept, Fast and slow feedback mechanisms/Processes, Climate sensitivity estimates [Lectures 5].

Climate Variability: Buffering atmospheric temperature changes, Atmosphere-ocean coupling: El Nino and Southern Oscillations [Lectures 3].

Climate modeling: One layer energy balance model, 1D EBM, Global Circulation Model, difference between Weather forecast models and GCMs [Lectures 8].

Climate Change Impacts and future projections: Sea level rise, Ecosystem and biodiversity, Shifting water resources, Agricultural impacts, severe weather impacts and Human health; Impact assessment of GHGs on global temperature, rainfall and drought patterns, atmospheric circulation. [Lectures 5].

Laboratory

Time series analysis of century-long historical temperature records to understand climate variability and examine evidence of global warming.

Statistical analysis of sea surface temperature for identification of ENSO (El Nino-Southern Oscillations) events.

Hadley Circulation interpretation using NASA MERRA reanalysis model.

Model scenarios of greenhouse gas (GHG) emissions in the current century and simulate first-order response of the earth system (e.g., ClimateSim simulator).

Download emissions data from satellite observations and compare with existing emission inventories.

Hand-on experience on installation of Regional/ Global Climate model (RCM/GCM) and performing simulations to compare the model output (climate variables and Emissions) under different Representative Concentration Pathways (RCPs) with existing emission inventories.
Group report on " Scientific Evidence for Anthropogenic Climate Change"

Text Books
Atmospheric Chemistry and Physics- From Air Pollution to Climate Change, J. H. Seinfeld and S. N. Pandis, John Wiley and Sons, Inc., Third Edition, 2013.
Fundamentals of Atmospheric modeling, Marck Jacobson, Cambridge University Press, Second Edition, 2005.
Air Pollution and Global Warming: History, Science and Solutions, Mark Jacobson, Cambridge University Press, Second Edition, 2012.
Atmosphere, Ocean, and Climate Dynamics, John Marshall and R. Alan Plumb, Elsevier Academic Press, 2008.

Online course Material
https://courses.edx.org/courses/course-v1:SDGAcademyX+CCSI001+3T2019/course/
https://nptel.ac.in/courses/119106008/

Title	Remote Sensing and GIS for Environment Management	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-2 [4]
Offered for	M.Tech, M.Tech.-Ph.D. [CIE-EE]	Type	Specialization Stream Elective
Prerequisite			

Objectives
To introduce you to the basic principles of observing the Earth's geography and concepts of remote sensing
To explore its applications specific to the environment and natural resource management.

Learning Outcomes
Identify and obtain appropriate satellite imagery for a land surface based resource management, service infrastructure and real world application
Demonstrate proficiency in the common (open source: QGIS/ Google Earth Engine, ERDAS Imagine, ENVI) and advanced (ARCGIS, Ecognition, QT modeler) remote sensing software packages
Conduct basic to intermediate remote sensing analyses (atmospheric and geographic corrections, spectral transformations and enhancements, classification, modelling and change detection)

Contents
In-situ field observation; data collection; Photographic and Remote Sensing data collection, Spectral spatial and temporal aspects, analog and digital processing introduction and sensing economics [4]
Electromagnetics: conduction, convection and radiation; radiation and its models, [6].
Aerial Photography- Camera, photography filtration-films, planning field missions [4]
Photogrammetry : Aerial photography, stereoscopy and its principles, image digitization, aero-triangulation, extracting spot elevation, contours and DEMs using soft copy photography, Ortho-imagery and Area Measurement [6]
Multispectral Imagery: discrete detectors and scanning mirrors, Landsat: multi-spectral scanner, thematic mapper, Enhanced Thematic Mapper plus (Landsat 7), , GOES-,AVHRR Radiometer, Aircraft Multispectral Scanners[8]
Thermal Infrared Remote Sensing: Thermal infrared radiation properties, laws (Stefan-bolzmann, Wein's, Kirchoff's)[2]
Microwave Remote Sensing: RADAR, SAR remote sensing, Radar interferometry, LIDAR Passive Microwave Remote Sensing- Radiometers. [3]
Visual image Interpretation: The aerial/regional perspective, 3D depth perspective [5]
Digital Image Interpretation and Analysis: Preprocessing of Images, Image Enhancement, Contrast and basics of spatial feature manipulation. [5]
Note: Labs will have hands-on use of the latest Google Earth Engine (GEE), QGIS, ERDAS IMAGINE, and ArcGIS software. It will also look into application of remote sensing imagery in soil and water analysis, overlaying data retrieved from different subject areas of engineering, lidar imagery and other GIS data.
List of experiments in Surveying based Laboratory
To assess the distance between two inaccessible points in a specific area using a compass as well as plotting the area using closed traverse (prismatic compass).
To solve two-point, and three-point problems using plane table survey.
To understand differential levelling, vertical/cross sectional plotting and contouring using automatic levellers.
To survey a nearby plot bounded by any polygon using a theodolite and also to perform trigonometric levelling to find the characteristics of a nearby building.
To plot a known area using GPS measurements and assess the accuracy of the measurement
Using total station to combine electromagnetic distance measurement and electronic theodolite to understand the ramp in the institute and their geometrical features with high accuracy.
List of experiments in GIS Laboratory
To create a map of any area using vector data models using available ground data.
To perform geo-referencing when coordinate values are not given.
To study terrain data such as slope, aspect, and hill shade. How to use these for representation of different social/service as well as frequency of different aspects concerning demographic data.
To create a stream network or perform stream order generation or delineate watersheds created by a water body using DEM files.

To perform site suitability analysis for a service building (example hospital) near to an agricultural and inhabited land near an arid village at the edge of an oasis near Jodhpur.
Basic experiments on image sharpening and image resolution using ArcGIS/ ERDAS IMAGINE processing tool.

Text Books
John R. Jenkins, Remote Sensing of the Environment: An Earth Perspective
Lillesand, T.M., Kiefer, R.W. & Chipman, J.W. 2008. Remote Sensing and Image Interpretation, 6th Edition, John Wiley and Sons.

Reference Books
Floyd F. Sabins, Remote Sensing: Principles and Applications (3rd edition), Publisher : Waveland Press, Edition : 3rd, Print ISBN : 9781577665076, 1577665074, eText ISBN : 9781478618171.0
Gopi, S., Sathikumar, R., and Madhu, N., Advanced Surveying: Total Station, GIS and Remote Sensing, Pearson, 2007, Dorling Kindersley (India).ISBN 978-81-3017-0067-9.
Barrett, E.C. & Curtis, L.F. 2007. Introduction to Environmental Remote Sensing, Routledge Publisher.

Title	Solid Waste Management	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M. Tech, M. Tech-Ph.D. [CIE-EE]	Type	Specialization Stream Elective
Prerequisite			

Objectives

To enable understanding of life cycle of waste generation to disposal or sustainable re-use
To inculcate basic steps of solid waste management
To enable selection of best possible location specific solid waste management options

Learning Outcomes

Conceptually design waste conversion/treatment processes
Able to assess the environmental and the economic impact of specific types of solid waste generated and its reuse
Enabled to develop innovative and smarter solutions of solid waste management at rural and urban environs

Contents

Solid waste type and Classification, Quantity, Types of Waste Stream and its life cycle Waste Generation-Industrial, Municipal and Agriculture, 4R strategies and Social costs [Lectures 4].
Collection and Transport: Collection Components, their Reliability, Scavengers, Automated Waste Collection, Design for Larger Transfer Operations, Automated Control, Inventory and Monitoring [Lectures 5].
Separation and Processing Techniques: Separation and Screening Equipment, Automated Sorters, Solid Waste Processing, Recovering, Waste to Energy transformation, E-Waste, Size Reduction, Incineration and pyrolysis [Lectures 6].
Options for Disposal, Selection Criteria, Sanitary Landfill, Properties of Gases from Landfills, Hazards and Air Pollution, , Leachate Control and Management [Lectures 5].
Composting: Benefits of Composting, Biological Processes Involved in Composting Chemical Processes, Physical Processes, Thermodynamics of Compositing, Gasifying, Refuse-derived fuel, Thoughts on Circular Economy [Lectures 8].
Microbiology: Biological decomposition, Microbiology of composting, Municipal solid waste Pathogens, enteric microbes in landfills and leachate, Pure culture, Mixed culture screening tests [Lectures 6].
Reuse and Recycle: Reuse, Increased Product Lifetime, Material Life Cycle Studies, Recycling, New Materials-Self Destructing/Organic, MSW Handling Rules, Public Aptitude, and Legislation [Lectures 6].

Text Books

George Tchobanoglous, Hilary Theisen, Samuel Vigil, Integrated Solid Waste Management: Engineering Principles and Management Issues, McGraw-Hill Series in Water Resources and Environmental Engineering, ISBN-10: 0070632375, ISBN-13: 978-0070632370
Kanti L. Shah, Basics of Solid and Hazardous Waste Management Technology, Prentice Hall, ISBN-10: 0139603786, ISBN-13: 978-0139603785
Ni-Bin Chang, Ana Pires, Sustainable Solid Waste Management: A Systems Engineering Approach, Wiley-IEEE Press; 1 edition (March 16, 2015), ISBN-10: 1118456912, ISBN-13: 978-1118456910

References Books

Edward A. McBean, Frank A. Rovers, Grahame J. Farquhar, Solid Waste Landfill Engineering and Design, Prentice Hall; ISBN-10: 0130791873, ISBN-13: 978-0130791870
Christian Ludwig, Stefanie Hellweg, Municipal Solid Waste Management , Springer 2003, London, ISBN 978-3-642-62898-6.
Roger Tim Haug, Composting Engineering: Principles and Practice, Ann Arbor Science, MI, ISBN-0-250-40347-1

Online Resources

T V Ramachandra Municipal Solid Waste Management, IISc Bangalore
https://nptel.ac.in/courses/120108005/
Solid and Hazardous Waste Management,IITM, https://nptel.ac.in/courses/105106056/

Title	Advanced Wastewater Treatment	Number	CI7XX0
Department	Chemical Engineering, (ii) Civil and Infrastructure Engineering	L-T-P [C]	3-0-2 [4]
Offered for	M.Tech, M.Tech.-Ph.D. [CIE-EE]	Type	(i) Programme Elective for Chemical Engineering, (ii) Specialization Stream Elective for Environmental Engineering
Prerequisite			

Objectives

The instructor will:

Impart comprehensive knowledge of industrial and municipal wastewater.

Discuss mechanism and methodologies for wastewater treatment.

Discuss case studies.

Learning Outcomes

The students are expected to have the:

1. Comprehensive knowledge of wastewater treatment.

2. Knowledge of advanced methodologies such as recycle and reuse.

Contents

Introduction: Waste water engineering: an overview, characterisation of waste water and monitoring of industrial and municipal wastewater, emerging contaminants, environmental impacts of wastewater constituents [Lectures 4].

Conventional Water and WasteWater Treatment: Existing unit operations and processes, basic philosophy of water treatment plants; physio-chemical treatment methods: (i) Screening, (ii) conventional filtration (iii) coagulation, (iv) flocculation, (v) floatation (vi) Clari- flocculation (vii) sedimentation, (viii) sand filtration, etc. [Lectures 10].

Aerobic and Anaerobic Suspended and Attached Growth WasteWater Treatment Processes: Aerated lagoon, activated sludge systems, trickling filter, sequential batch reactor, fluidized bed bioreactors, Up-flow Anaerobic Sludge Blanket (UASB) and hybrid Up-flow Anaerobic Sludge Blanket (UASB) reactors [Lectures 8].

Advanced Treatment Processes: Membrane Filtration, reverse osmosis, ultrafiltration, nanofiltration and electrodialysis; wet air oxidation, adsorption and ion-exchange; Wet- land and root-zone treatment of industrial and municipal wastes; Design of sludge drying beds, thermal and biological processes for sludge and land fillings. Membrane Reactors, New Technologies for Wastewater Disinfection [Lectures 12].

Water Recycling and Reuse: Different unit operations for water recycling depending on end use, energy considerations, recovery of valuables from wastewater, zero liquid discharge (ZLD) [Lectures 8].

Wastewater design lab [28 hours]

Clarifier

Aerator

Sand filtration system

Municipal waste water system

Grey water treatment system

Sewage water treatment system

Industrial waste water systems

Pond water treatment

Text Books

Burton F.L., Tchobanoglous G., Stensel H.D., 2017, WasteWater Engineering Treatment and Reuse, 4thed.,Tata McGraw-Hill.

Arceivala S.J. and Asolekar S.R., 2007, Wastewater Treatment for Pollution Control and Reuse, 3rd Ed., Tata McGraw Hill.

Reference Books

Henze M., van-Loosdrecht M.C.M., Ekama G.A. and Brdjanovic D., 2008, Biological Wastewater Treatment: Principles, Modelling and Design, IWA publishing.
Sincero A.P. and Sincero G.A., 1996, Environmental Engineering – A Design Approach, Prentice-Hall.
Online Course Material
Tiwari M K, Wastewater treatment and recycling, NPTEL course material, Department of Civil Engineering, IIT Kharagpur, https://nptel.ac.in/courses/105105178/

Title	Environmental Economics and Management	Number	CI7XX0
Department	(i) Civil and Infrastructure Engineering (ii) School of Management and Entrepreneurship	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech, M.Tech.-Ph.D. [CIE]	Type	Specialization Stream Elective
Prerequisite			

Objectives

To introduce the methods used by Economists in analyzing environment related issues.

To introduce concepts of positive and normative aspects of Environmental Economics.

To provide knowledge on different approaches such as Regulations and Incentive based Programs used in controlling pollution.

Learning Outcomes

The students are expected to achieve proficiency in:

The students are expected to achieve proficiency in:

Explaining the interactions between the economy and environment.

Understanding the concepts of market failure and their role in determining the level of environmental quality.

Understanding the role of costs and benefits in environmental decision-making processes.

Explaining the conceptual framework and theoretical basis of economic valuation research

Recognizing and implementing the most appropriate techniques while performing economic valuation research.

Employing regulatory tools to deal with pollution control.

Contents

Introduction: The environment and economics, Cost of Environmental Protection, Positive and Normative Analysis [Lectures 4].

Principles of Environmental and Resource Economics: Markets and Market Failure, cost-benefit analysis [Lectures 10].

Economic Valuation: Random utility models in environmental valuation, Hedonic Price Method, Defensive Expenditures and the Travel Cost Method, Contingent Valuation [Lectures 10].

Controlling Pollution: : Regulation, Pigouvian Fees/ Emission Fees & Marketable permits, Property Rights and Marketable Permits, Regulation over Time and Space/ Transboundary Pollution, Regulations under Uncertainty (Regulating Polluters with Unknown Costs) [Lectures 12].

Life Cycle Assessment of Products, Processes and Services; Special topics and case studies on environmental economics; Environmental Justice and Environmental Ethics; Environmental Movement; Environmental Activism [Lectures 6].

Text Books

Environmental Economics, Charles. D. Kolstad, Oxford University Press, Second Edition, 2011.

Environmental Economics in Theory and Practice, N. Hanley, J. F. Shorgen, B. White, Macmillan.

Title	Environmental Impact Assessment	Number	CI7XX0
Department	Chemical Engineering Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech, M.Tech.-Ph.D. [CIE]	Type	(i) Programme Elective for Chemical Engineering, (ii) Specialization Stream Elective for Environmental Engineering
Prerequisite			

Objectives
The instructor will:
Impart the knowledge to the students with the methods of assessment of environmental impacts due to developmental and industrial activities.
Expose the students with the EIA regulations and EMP.

Learning Outcomes
The students are expected to have the:
In-depth knowledge of the methods of assessment of environmental impacts due to developmental and industrial activities.
In-depth knowledge of EIA regulations and EMP.

Contents
Introduction to EIA; definitions and concepts; evolution of EIA; historical development of EIA; forecasting environmental changes; strategic environmental assessment; ISO provisions, environmental clearance procedure [Lectures 11].
EIA documentation and processes; preliminary stages of EIA; project types and screening; impact prediction; evaluation and mitigation; EIA monitoring and auditing. [Lectures 11].
EIA regulations; TOR for EIAs; environmental indices, EIA at regional level, sectoral level, and policy level; sustainable development; Environmental Management Plan (EMP) [Lectures 11].
Future strategies and EIA case studies [Lectures 9].

Text Books
Canter, L., Environmental Impact Assessment, McGraw Hill, New York, 1996.

Reference Books
World Bank, 'Environmental Assessment SourceBook', Environment Dept., Washington D.C., 1991.
Rau, G.J. and Wooten, C.D., Environmental Impact Analysis Handbook, McGraw Hill, New York, 1980.
Preventive environmental management.

Online course Material
https://nptel.ac.in/courses/127105018/

Title	Machine Learning for Environmental Engineering	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech, M.Tech.-Ph.D. [CIE]	Type	Specialization Stream Elective
Prerequisite	Statistics for Environmental Engineering		
Anti-requisite	Machine Learning-I		

Objectives

To introduce students to various multivariate data analysis tools to deal with multi-dimensional data. Appreciate the areas of Environmental Engineering problems and issues where they can be effectively applied.

Learning Outcomes

The students will be able to:

1. Identify appropriate multivariate data analysis techniques.
2. Develop a good understanding of the conceptual framework of how these multivariate techniques work and applied.

Contents

(Fractal 1) CSL7XX1: Machine Learning I: Supervised Learning 1-0-0[1]

Introduction: Motivation, Different types of learning, Linear regression, Logistic regression [Lectures 2].

Gradient Descent: Introduction, Stochastic Gradient Descent, Subgradients, Stochastic Gradient Descent for risk minimization [Lectures 2].

Support Vector Machines: Hard SVM, Soft SVM, Optimality conditions, Duality, Kernel trick, Implementing Soft SVM with Kernels [Lectures 4].

Decision Trees: Decision Tree algorithms, Random forests [Lectures 2].

Neural Networks: Feedforward neural networks, Expressive power of neural networks, SGD and Backpropagation [Lectures 3].

Model selection and validation: Validation for model selection, k-fold cross-validation, Training-Validation-Testing split, Regularized loss minimization [Lecture 1].

(Fractal 2) CSL7XX2: Machine Learning I: Unsupervised Learning and Generative Models 1-0-0[1]

Nearest Neighbour: k-nearest neighbour, Curse of dimensionality [Lecture 1].

Clustering: Linkage-based clustering algorithms, k-means algorithm, Spectral clustering [Lectures 3].

Dimensionality reduction: Principal Component Analysis, Random projections, Compressed sensing [Lectures 2].

Generative Models: Maximum likelihood estimator, Naive Bayes, Linear Discriminant Analysis, Latent variables and Expectation-maximization algorithm, Bayesian learning [Lectures 5].

Feature Selection and Generation: Feature selection, Feature transformations, Feature learning [Lectures 4].

(Fractal 3) Application to Environmental Data 1-0-1 [1]: Assessment of Surface water quality parameters; Assessment of Landfill leachate treatment; Air Quality Assessment and source recognition; Spatial differences in river estuaries and possible sources, Miscellaneous case studies [Lectures 14].

Text Books

1. Applied Multivariate Statistical Analysis, Johnson, R. A. and Wichern, D. W., Pearson Prentice Hall, Sixth Edition, 2007.
2. Multivariate Statistical Methods: A Primer, Manly, B. F. J., Chapman and Hall/CRC, Third Edition, 2005.
3. Applied Multivariate Statistical Analysis, Wolfgang, K. H. and Leopold, S., Springer, Fourth Edition, 2015.
4. Understanding Machine Learning: From Theory to Algorithms, Shalev-Shwartz,S., Ben-David,S., Cambridge University Press, 2014.
5. Applied Statistics for Environmental Science with R, Alkarkhi, A. F. M. and Alqaraghuli, W. A. A., Elsevier, ISBN 978-0-12-818622-0.

Reference Books
Mitchell Tom (1997). Machine Learning, Tata McGraw-Hill

Online course material
https://online.stat.psu.edu/stat505/

Self Learning Material
Department of Computer Science, Stanford University,   https://see.stanford.edu/Course/CS229

Mitchell Tom (1997). Machine Learning, Tata McGraw-Hill

https://online.stat.psu.edu/stat505/

Title	Geomorphology	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech, M.Tech.-Ph.D. [CIE]	Type	Specialization Stream Elective
Prerequisite			

Objectives

The instructor will:

Introduction to different geological processes behind observed geomorphological features.

Complete understanding of depositional and erosional landforms created in different environments.

Knowledge of natural hazards and application of geomorphology in managing them.

Learning Outcomes

The students are expected to have the:

Understanding of physics and chemistry of geological processes and their interrelationship.

Knowledge of spatial and temporal evolution of different landforms.

Knowledge of geological hazard identification, risk assessment, and mitigation.

Contents

Introduction to Geomorphology: Introduction to geomorphology and physical geology; Earth' components: atmosphere, lithosphere, hydrosphere, biosphere; The age of the earth: absolute dating methods; relative dating methods; Geological time scale [Lectures: 4]

Weathering and Mass Wasting: Types of weathering: physical, mechanical, chemical, and biological; Rates of weathering; The stability of minerals; Weathering of common rocks; Mass wasting processes; Factors responsible for mass wasting [Lectures: 4]

Fluvial Geomorphology: Development stages of a stream; Classification of streams; Genetic classification of streams; Stream channels; Channel geomorphology; Drainage basin and system; Basin morphology; Geological work of streams; Fluvial landforms. [Lectures: 5]

Desert Geomorphology: Process of wind erosion; Sediment transport by wind; Erosional landforms; Depositional landforms; Desert and desert types; Surface processes and desert landforms; Aridity. [Lectures: 4]

Glacial Geomorphology: Formation of glaciers; Glacier movement; Glacier types; Glacial processes; Erosional landforms; Depositional landforms. [Lectures: 4]

Coastal Geomorphology: Ocean waves, currents and tides; Oceanic sediments; Shore processes; Coastal erosion and sediment transport; Depositional features formed by waves. [Lectures: 5]

Tectonic Geomorphology: Continental drift and evidence; Plate tectonics; Continental crust and plate tectonics; Causes of plate tectonics; geomorphic markers; Paleoseismology; Deformation and landscape responses. [Lectures: 4]

Earthquakes: Location of an earthquake; Measurement and classification; The cause of origin; Spatial and temporal distribution of earthquakes; Earthquake hazard. [Lectures: 4]

Volcanoes: Magma and lava flows; Global distribution of volcanoes; Classification of volcanoes; Modes of eruption; Volcanic Explosivity Index; Volcanic landforms; Submarine volcanoes. [Lectures: 4]

Applied Geomorphology: Geomorphological hazard; Hazard assessment for risk analysis and risk management; Geomorphic hazards and sustainable development; Geomorphology and disaster prevention. [Lectures: 4]

Text Books

Sreepat Jain (2014) Fundamental of Physical Geology. Springer. ISBN 978-81-322-1539-4.

Richard J. Huggett (2007). Fundamentals of Geomorphology (2nd Ed). Taylor & Francis Group. ISBN 978-0-203-94711-1 ebk.

Additional Reading

Douglas W. Burbank, Robert S. Anderson (2011) Tectonic Geomorphology (2nd Ed). Wiley-Blackwell; ISBN: 978-1-444-33886-7

Ro Charlton (2007) Fundamentals of Fluvial Geomorphology (1st Ed). Taylor & Francis Group. ISBN: 9780203371084

Eric C. F. Bird (2008) Coastal Geomorphology: An Introduction (2nd Ed). Wiley. ISBN: 978-0-470-51729-1

Anthony J. Parsons, A. D. Abrahams (2009) Geomorphology of Desert Environments. Springer. ISBN 978-1-4020-5719-9

I Alcántara-Ayala, A. Goudie (Eds.). (2010). Geomorphological Hazards and Disaster Prevention. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511807527

Title	GIS and Public health	Number	CI7XX0
Department	Civil and Infrastructure Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech, M.Tech.-Ph.D. [CIE]	Type	Specialization Stream Elective
Prerequisite			

Objectives
The instructor will:
Providing exposure to the application of GIS in infectious and vector-borne diseases analysis.
Introducing techniques of GIS in management of health services.

Learning Outcomes
Ability to accurately model temporal and spatial distribution of health events.
Knowledge of surveillance and mapping techniques for infectious and vector-borne diseases.
Ability to identify healthcare "shortage" areas and analysis of access to healthcare services.

Contents
Geographic Information Systems: GIS functions; Trends in GIS applications; Public health application of GIS; GIS and the internet [Lectures 3].
Spatial data: Field and object data; Tessellation and vector data models; Measuring locations; Scale, projection, and symbols of cartographic data sources; Geographic data quality; Role of metadata [Lectures 3].
Spatial Databases for Public Health: Foundation spatial data; population data; Health data; Making population and health data mappable; database integration; Data sharing [Lectures 3].
Mapping Health Information: Mapping process; representing health information; viewing health information; GIS and map publication [Lectures 3].
Analyzing Spatial Clustering of Health Events: Mapping disease rates; spatial clustering methods; space-time clustering; choosing a clustering method; uses of spatial clustering methods [Lectures 4].
Analyzing Environmental Hazards: Source location analysis; modelling of fate, transport, and environment quality; GIS and exposure modelling; GIS and dose; outcome surveillance; environmental risk management; issues in environmental health mapping and analysis [Lectures 5].
Analyzing the Risk and Spread of infectious Diseases: Spatial diffusion; mapping case distributions; mapping the ecology of risk; temporal and geographical trends in disease outbreaks; forecasting spatial diffusion of communicable diseases; planning public health interventions; privacy and confidentiality [Lectures 5].
Exploring the Ecology of Vector-Borne Diseases: Global burden of zoomatic diseases and the challenge of emerging infectious diseases; surveillance and mapping of vector-borne diseases; modelling of vector-borne diseases; environmental impacts of controlling vector-borne diseases; systematic perspective on disease [Lectures 4].
Analyzing Access to Health Services: mapping service locations; mapping health care needs and services; assessing potential access to health services; analysing service utilization [Lectures 4].
Locating Health Services: health care shortage areas; components and dimensions of health service delivery systems; client population distribution; meaning of "centrality" in health service facility location; normative models of facility location and service delivery; incorporating normative models of facility location and service delivery into GIS; spatial decision support systems [Lectures 4].
Health disparities: context and composition; visualizing and measuring area characteristics; defining neighbourhood contexts; modelling neighbourhood effects on health; location processes and link between location and well-being [Lectures 4].

Text Books
GIS and Public Health, Ellen K. Cromley, Sara L. McLafferty, Guilford Publications, Second Edition, 2017, ISBN 978-1-60918-750-7.
GIS in Public Health Practice, Ravi Maheswaram, Massimo Craglia, CRC Press, 2004, ISBN 0-415-30655-8.