MANIPUR UNIVERSITY
CURRICULUM & SYLLABUS

FOR

BACHELOR OF ENGINEERING
(Effective from the Academic Session 2021-2022)

IN

CIVIL ENGINEERING
(SECOND YEAR TO FOURTH YEAR)

C O N T E N T S

MISSION AND VISION

The Vision of the Manipur Institute of Technology is:

Excellence in Engineering education and technology with good leadership in Human Resource Development

The Mission of the Manipur Institute of Technology is:

Engineering and technology for all round development and to produce good engineers

The Vision of Civil Engineering Department is:

To be a good leader in Civil engineering education

The Mission of Civil Engineering Department is:

- To empower students and faculty with broad knowledge in Civil Engineering and applications
- To produce Civil engineers, capable of handling technical and social challenges
- To produce entrepreneurs capable of solving present problems of the society
- To provide technological services which are sustainable and environment friendly

PROGRAMME OUTCOMES (PO)

PO1 Engineering knowledge: Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to get the solution of the engineering problems.

PO2 Problem analysis: Ability to Identify, formulates, review research literature, and analyze complex engineering problems.

PO3 Design/development of solutions: Ability to design solutions for complex engineering problems by considering social, economical and environmental aspects.

PO4 Conduct investigations of complex problems: Use research-based knowledge to design, conduct analyse experiments to get valid conclusion.

PO5 Modern tool usage: ability to create, select, and apply appropriate techniques, and to model complex engineering activities with an understanding of the limitations.

PO6 The engineer and society: Ability to apply knowledge by considering social health, safety, legal and cultural issues.

PO7 Environment and sustainability: Understanding of the impact of the adopted engineering solutions in social and environmental contexts.

PO8 Ethics: Understanding of the ethical issues of the civil engineering and applying ethical principles in engineering practices.

PO9 Individual and teamwork: Ability to work effectively as an individual or in team, as a member or as a leader.

PO10 Communication: An ability to communicate clearly and effectively through different modes of communication.

PO11 Project management and finance: Ability to handle project and to manage finance related issue

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning

CURRICULUMS

SECOND YEAR
THIRD SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	MA 231	Engineering Mathematics –III	3	1	0	70	30	-	100	4
2.	CE 231	Disaster Preparedness & Planning	1	1	0	35	15	-	50	2
3.	ME 231	Engineering Mechanics	3	1	0	70	30	-	100	4
4.	CE 232	Engineering Geology	2	1	0	70	30	-	100	3
5.	ME 232	Basic Mechanical Engineering	3	0	0	70	30	-	100	3
6.	EC 231	Basic Electronics	1	1	0	35	15	-	50	2
		SUB-TOTAL	***13***	***5***	***0***				***600***	***18***
		PRACTICAL/DESIGN								
7.	CE 232P	Engineering Geology Lab	0	0	2	-	15	35	50	1
8.	CE 233P	Computer-aided Civil Engineering Drawing	1	0	2	-	30	70	100	2
9.	CE 234P	Internship in industry or at appropriate work place (Not less than 2-weeks)	-	-	-	-	100	-	100	1
		SUB-TOTAL	***1***	***0***	***4***				***250***	***4***
		TOTAL	**14**	**5**	**4**				**850**	**22**

Total credit = 22
Working hour/week = 23

SECOND YEAR
FOURTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	HU 241	Universal Human Values-II	2	1	0	70	30	-	100	3
2.	CE 242	Fluid Mechanics	3	1	0	70	30	-	100	4
3.	CE 243	Solid Mechanics	3	1	0	70	30	-	100	4
4.	CE 244	Surveying & Geomatics	3	0	0	70	30	-	100	3
5.	CE 245	Materials, Testing & Evaluation	2	1	0	70	30	-	100	3
		SUB-TOTAL	***13***	***4***	***0***				***500***	***17***
		PRACTICAL/DESIGN								
6.	CE 242P	Fluid Mechanics Lab.	0	0	3	-	30	70	100	1.5
7.	CE 244P	Surveying & Geomatics Lab.	0	0	3	-	30	70	100	1.5
8.	CE 245P	Materials, Testing & Evaluation Lab.	0	0	3		30	70	100	1.5
		SUB-TOTAL	***0***	***0***	***9***				***300***	***4.5***
		MANDATORY COURSE								
9.	*NC 241*	Management -1 (Organizational Behavior)	*3*	*0*	*0*		50*			**0**
		TOTAL	**16**	**4**	**9**	-	-	-	**800**	**21.5**

Total credit = 21.5
Working hour/week = 29

THIRD YEAR
FIFTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	CE 351	Mechanics of Materials	3	0	0	70	30	-	100	3
2.	CE 352	Hydraulic Engineering	3	0	0	70	30	-	100	3
3.	CE 353	Structural Engineering	3	1	0	70	30	-	100	4
4.	CE 354	Geotechnical Engineering-I	2	1	0	70	30	-	100	3
5.	CE 355	Hydrology & Water Resources Engineering	2	1	0	70	30	-	100	3
6.	CE356	Transportation Engineering-I	2	1	0	70	30		100	*3*
		SUB-TOTAL	***15***	***4***	***0***				***600***	***19***
		PRACTICAL/DESIGN								
7.	CE 352P	Hydraulic Engineering Lab	0	0	3	-	30	70	100	1.5
8.	CE 354P	Geotechnical Engineering Lab	0	0	3	-	30	70	100	1.5
9.	CE357P	Internship in industry or at appropriate work place (Not less than 2-weeks)	-	-	-	-	100	-	100	1
		SUB-TOTAL	***0***	***0***	***6***				***300***	***4***
		TOTAL	**15**	**4**	**6**				**900**	**23**

Total credit = 23
Working hour/week = 25

THIRD YEAR
SIXTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	CE 361	Construction Engineering & Management	2	1	0	70	30	-	100	3
2.	CE 362	Design of Concrete Structures	3	1	0	70	30	-	100	4
3.	CE 363	Design of Steel Structures	3	0	0	70	30	-	100	3
4.	CE 364	Environmental Engineering	2	1	0	70	30	-	100	3
5.	CE 365	Software Applications in Civil Engineering	3	0	0	70	30	-	100	3
6.	CE 366	Elective-I	3	0	0	70	30	-	100	*3*
		SUB-TOTAL	***16***	***3***	***0***				***600***	***19***
		PRACTICAL/DESIGN								
7.	CE 364P	Environmental Engineering Lab	0	0	3	-	30	70	100	1.5
8.	CE 367P	Transportation Engineering Lab	0	0	3	-	30	70	100	1.5
		SUB-TOTAL	***0***	***0***	***6***				***200***	***3***
		MANDATORY COURSE								
9.	NC 361	Constitution of India	3	0	0		50*			`
		TOTAL	**19**	**3**	**6**				**800**	**22**

Total credit = 22.0
Working hour/week = 28

FOURTH YEAR
SEVENTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	CE 471	Geotechnical Engineering-II	3	0	0	70	30	-	100	3
2.	CE 472	Transportation Engineering-II	3	0	0	70	30	-	100	3
3.	CE 473	Engineering Economics, Estimation & Costing	2	1	0	70	30	-	100	3
4.	CE 474	Open Elective-I	3	0	0	70	30	-	100	3
		SUB-TOTAL	***11***	***1***	***0***				***400***	***12***
		PRACTICAL/DESIGN								
5.	CE 473P	Estimation & Costing Practice	0	0	4	-	30	70	100	2
6.	CE 475P	Project-1 (Project work and seminar)	0	0	12	-	100	200	300	3
7.	CE 276P	Internship in industry or at appropriate work place (Not less than 2-weeks)	-	-	-	-	100	-	100	1
8.		*SUB-TOTAL*	***0***	***0***	***16***				***500***	***6***
		SUB-TOTAL								
		TOTAL	**11**	**1**	**16**				**900**	**18**

Total credit = 18
Working hour/week = 28

FOURTH YEAR
EIGHT SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	CE 481	Elective-II	3	0	0	70	30	-	100	3
2.	CE 482	Elective-III	3	0	0	70	30	-	100	3
3.	CE 483	Elective-IV	3	0	0	70	30	-	100	3
4.	CE 484	Open Elective-II	3	0	0	70	30	-	100	3
		SUB-TOTAL	***12***	***0***	***0***				***400***	***12***
		PRACTICAL/DESIGN								
5.	CE 485P	Project-2 (Continued from VII Semester, Project work, seminar and internship in industry or at appropriate work place)	0	0	12		100	200	300	6
		SUB-TOTAL	***0***	***0***	***12***				***300***	***6***
		TOTAL	**12**	**0**	**12**				**700**	**18**

Total credit = 18
Working hour/week = 24

Semester	I	II	III	IV	V	VI	VII	VIII	Total
Credits	17.5	21.0	22	21.5	23.0	22.0	18.0	18.0	163.0
Marks	500	650	850	800	900	800	900	700	6100
Hours/week	22	26	23	29	25	28	28	24	205

SECOND YEAR
THIRD SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	MA 231	Engineering Mathematics –III	3	1	0	70	30	-	100	4
2.	CE 231	Disaster Preparedness & Planning	1	1	0	35	15	-	50	2
3.	ME 231	Engineering Mechanics	3	1	0	70	30	-	100	4
4.	CE 232	Engineering Geology	2	1	0	70	30	-	100	3
5.	ME 232	Basic Mechanical Engineering	3	0	0	70	30	-	100	3
6.	EC 231	Basic Electronics	1	1	0	35	15	-	50	2
		SUB-TOTAL	***13***	***5***	***0***				***600***	***18***
		PRACTICAL/DESIGN								
7.	CE 232P	Engineering Geology Lab	0	0	2	-	15	35	50	1
8.	CE 233P	Computer-aided Civil Engineering Drawing	1	0	2	-	30	70	100	2
9.	CE 234P	Internship in industry or at appropriate work place (Not less than 2-weeks)	-	-	-	-	100	-	100	1
		SUB-TOTAL	***1***	***0***	***4***				***250***	***4***
		TOTAL	**14**	**5**	**4**				**850**	**22**

MA 231	Engineering Mathematics-III	3L:1T:0P	4 credits

Module 1: Fourier Series (6 lectures)
Derichlet's condition-General Fourier series- odd and even functions, Half range-sine and cosine series-complex form of Fourier series, Practical Harmonic analysis.

Module 2: Boundary Value Problems (6 lectures)
Classification of second order quasi linear partial differential equations- solution of one dimensional wave equation, one dimensional heat equation- steady state solution of two dimensional heat equation(insulated edges exclude)-Solution by separation of variables.

Module 3: Complex Analysis (10 lectures)
Analytic function-properties, Cauchy-Riemann equations, construction of analytic function, determination of conjugate harmonic functions, application to two dimensional potential problems. Conformal transformations, Bilinear Transformation. Cauchy's Integral theorem and Cauchy's integral formula (statement only), Taylor's and Laurent's expansions, isolated singularities, residues-Cauchy's residues theorem (statement only), contour integration-over unit circle and semi- circle(excluding poles on real axis).

Module 4: Basic Probability (10 lectures)
Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality.

Module 5: Basic Statistics (8 lectures)
Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation.

Suggested Text & Reference Books:

1. B. S. Grewal, Higher Engineering Mathematics, Khanna Publication, 41 Edition, New Delhi.
2. Erwin Kreyszig, Advance Engineering Mathematics, 9th Edition, John Wiley &Sons, 2006.
3. Ramana B. V., Higher Engineering Mathematics, Tata McGraw Hill, New Delhi, 11th Reprint, 2010.
4. N. O. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
5. P. G. Hoel, S. C. Port and C. J. Stone, "Introduction to Probability Theory", Universal Book Stall, 2003.
6. S. Ross, "A First Course in Probability", Pearson Education India, 2002.
7. W. Feller, "An Introduction to Probability Theory and its Applications", Wiley, 1968.

Course Outcomes:

The objective of this course is to familiarize with basics of Fourier series, Boundary value problems, calculus of complex variable, basics of probability and statistics.

The students will learn:

- The methods to expand a function in Fourier series.
- The methods to solve partial differential equations that are arising in engineering problems.
- The tools of differentiation and integration of functions of a complex variable that are used in various techniques dealing engineering problems.
- The basics of probability and statistics that are essential in most branches of engineering.

CE231	Disaster Preparedness & Planning	1L:1T:0P	2 credits

The overall aim of this course is to provide broad understanding about the basic concepts of Disaster Management with preparedness as a Civil Engineer. Further, the course introduces the various natural hazards that can pose risk to property, lives, and livestock, etc. and understanding of the social responsibility as an engineer towards preparedness as well as mitigating the damages.

The objectives of the course are

i) To Understand basic concepts in Disaster Management
ii) To Understand Definitions and Terminologies used in Disaster Management
iii) To Understand Types and Categories of Disasters
iv) To Understand the Challenges posed by Disasters
v) To understand Impacts of Disasters Key Skills

Module 1: Introduction- Concepts and definitions: disaster, hazard, vulnerability, risks-severity, frequency and details, capacity, impact, prevention, mitigation).

Module 2: Disasters- Disasters classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills, transportation accidents, terrorist strikes, etc.); hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility.

Module 3: Disaster Impacts- Disaster impacts (environmental, physical, social, ecological, economic, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate change and urban disasters.

Module 4: Disaster Risk Reduction (DRR)- Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems, Post-disaster environmental response (water, sanitation, food safety, waste management, disease control, security, communications); Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.

Module 5: Disasters, Environment and Development- Factors affecting vulnerability such as impact of developmental projects and environmental modifications (including of dams, land-use changes, urbanization etc.), sustainable and environmental friendly recovery; reconstruction and development methods.

Text/Reference Books:

1. http://ndma.gov.in/ (Home page of National Disaster Management Authority)
2. http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs).
3. Pradeep Sahni, 2004, Disaster Risk Reduction in South Asia, Prentice Hall.
4. Singh B.K., 2008, Handbook of Disaster Management: Techniques & Guidelines, Rajat Publication.
5. Ghosh G.K., 2006, Disaster Management, APH Publishing Corporation
6. Disaster Medical Systems Guidelines. Emergency Medical Services Authority, State of California, EMSA no.214, June2003
7. Inter Agency Standing Committee (IASC) (Feb. 2007). IASC Guidelines on Mental Health and Psychosocial Support in Emergency Settings. Geneva: IASC

Course Outcomes:

The student will develop competencies in

- the application of Disaster Concepts to Management
- analyzing Relationship between Development and Disasters.
- ability to understand Categories of Disasters and realization of the responsibilities to society

ME 231	Engineering Mechanics	3L:1T:0P	4 credits

Course objectives:

1. To enable students to apply fundamental laws and basic concepts of rigid body mechanics to solve problems of bodies under rest or in motion.
2. To learn the working knowledge of statics with emphasis on force equilibrium and free body diagrams.
3. To tackle equilibrium equations, moments and inertia problems
4. To gain a firm foundation in Engineering Mechanics for furthering the career in Engineering
5. To compute the properties of areas and bodies.

Contents:

Module 1: System of Forces (10 Hrs)

Introduction to mechanics, laws of mechanics, concept of force, system of forces, Principle of Transmissibility of force,Parallelogram law, Triangle law, and Polygon law of forces, resultant and equilibrium of system of coplanar concurrent forces,resultant and equilibrium of system of coplanar non- concurrent forces.

Module 2: Friction (7 Hrs)

Frictional force, types of friction, laws of friction, coefficient of friction, angle of friction, angle of repose, cone friction, impending motion of connected bodies, wedge, screw jack and rope friction.

Module 3: Centroid & Area Moment of Inertia (6 Hrs)

Centroid, Centre of gravity, Centroid of simple figures and composite sections. Area moment of inertia, polar moment of inertia, radius of gyration, theorems of moment of inertia, moment of inertia of standard figures and moment of inertia of composite sections.

Module 4: Centre of Gravity & Mass Moment of Inertia (6 Hrs)

Centre of gravity from first principles, centre of gravity of composite bodies and theorem of Pappus- Guldinus. Definitions, Mass moment of inertia from first principles, transfer formula and mass moment of inertia of composite bodies.

Module 5: Kinematics (6 Hrs)

Introduction to Dynamics, Linear motion- motion with uniform velocity and uniform acceleration, Acceleration due to gravity, motion with varying acceleration. Curvilinear motion- motion of body associated with horizontal projection and inclined projection.

Module 6: Kinetics (6 Hrs)

Introduction, laws of motion, rectilinear motion of a particle, D'Alembert's Principle, Work- Energy Principle- work energy equation for translation, motion of connected bodies.

Module 7: Principle of virtual work (5 Hrs)

Virtual work – Principle of virtual work – System of connected rigid bodies – Degrees of freedom – Conservative forces – Potential energy – Potential energy criteria for equilibrium.

Text Books/ References:

1. Meriam, James Lathrop, L. Glenn Kraige, and William J. Palm. *Engineering mechanics. Vol. 1, Statics*. Wiley, 1987.
2. Meriam, James L., and L. Glenn Kraige. *Engineering mechanics: dynamics*. Vol. 2. John Wiley & Sons, 2012.
3. Beer, Ferdinand P., et al. *Vector mechanics for engineers*. Vol. 1. Tata McGraw-Hill Education, 1977.
4. Engineering Mechanics by Ferdin and L. Singer, 3rd Edition.
5. Engineering Mechanics by S.S. Bhavikatti and K.G. Rajashekarappa, New Age International (P) Limited, Publishers

Course outcomes:

Upon successful completion of the course, student should be able to:

1. Compute the resultant of system of forces in plane and space acting on bodies.
2. Use scalar and vector analytical techniques for analysing forces in statically determinate structures
3. Analyse equilibrium problems with friction.
4. Apply transfer theorems to determine properties of various sections.
5. Apply basic knowledge of maths and physics to solve real-world problems
6. Understand basic kinematics concepts – displacement, velocity and acceleration (and their angular counterparts)
7. Understand basic dynamics concepts – force, momentum, work and energy;
8. Analyse equilibrium of connected bodies virtual work method.
9. Predict motion parameters of bodies under rectilinear, curvilinear and general plane motion

CE 232; CE 232P	**Engineering Geology**	**2L:1T:2P**	**4 credits**

The objective of this Course is to focus on the core activities of engineering geologists – site characterization and geologic hazard identification and mitigation. Through lectures, labs, and case study examination student will learn to couple geologic expertise with the engineering properties of rock and unconsolidated materials in the characterization of geologic sites for civil work projects and the quantification of processes such as rock slides, soil-slope stability, settlement, and liquefaction.

Engineering geology is an applied geology discipline that involves the collection, analysis, and interpretation of geological data and information required for the safe development of civil works. Engineering geology also includes the assessment and mitigation of geologic hazards such earthquakes, landslides, and groundwater remediation and resource evaluation. Engineering geologists are applied geoscientists with an awareness of engineering principles and practice—they are not engineers.

Contents:

Module 1: Introduction-Branches of geology useful to civil engineering, scope of Engineering geology. Department dealing with this subject in India and GSI. Physical properties of minerals, susceptibility of minerals to alteration, basic of optical mineralogy, Studies of rock forming mineral.

Module 2: Petrology-Introduction. Crystallisation of igneous rocks, Ternary diagram. Igneous petrology- .Classification of igneous rock and their characteristics. Texture and its types. Study of Acidic Igneous rocks like Granite, Rhyolite or Tuff, Felsite, Pegmatite, Hornfels. Engineering aspect to granite. Basic Igneous rocks Like Gabbro, Dolerite, Basalt.

Formation of sedimentary rocks and mineralogical Composition of different sedimentary rocks, texture and its types, Structures, Gradation of Clastic rocks. Classification of sedimentary rocks and their characteristics. Study of Conglomerate, Breccia, Sandstone, Mudstone and Shale, Limestone.

Metamorphic petrology- Agents and types of metamorphism, metamorphic grades, Mineralogical composition, structures & textures in metamorphic rocks. Important Distinguishing features of rocks as Rock cleavage, Schistosity, Foliation. Classification. Study of Gneiss, Schist, Slate with engineering consideration.

Module 3: Physical Geology- Weathering, Erosion and Denudation. Factors affecting weathering and product of weathering. Engineering consideration. Waterfall and Gorges, River meandering, Alluvium, Glacial deposits, Laterite (engineering aspects), Desert Landform, Loess. Concept of Hot spring and Geysers.

Module 4: Structural geology. Strength Behavior of Rocks- Stress and Strain in rocks. Concept of Rock Deformation & Tectonics. Dip and Strike. Outcrop and width of outcrop. Inliers and Outliers. Fold- Types and nomenclature, Criteria for their recognition in field. Faults: Classification, recognition in field, effects on outcrops. Joints & Unconformity.

Module 5: Geological Hazards-Rock Instability and Slope movement: Concept of sliding blocks. Different controlling factors. Instability in vertical rock structures and measures to prevent collapse. Types of landslide. Prevention by surface drainage, slope reinforcement by Rock bolting and Rock anchoring, retaining wall, Slope treatment. Case study on black clay. Lowering of water table and Subsidence.

Module 6: Rock masses as construction material: Definition of Rock masses. Main features constituting rock mass. Main features that affects the quality of rock engineering and design. Core logging.

Module 7: Geology of dam and reservoir site- Required geological consideration for selecting dam and reservoir site. Failure of Reservoir. Favorable & unfavorable conditions in different types of rocks in presence of various structural features, precautions to be taken to counteract unsuitable conditions, significance of discontinuities on the dam site and treatment giving to such structures.

Module 8: Rock Mechanics- Sub surface Investigations in rocks. Failure theories and sheer strength of rocks, Bearing capacity of rocks.

CE 232P	Engineering Geology Lab.	2P	1 credits

Practicals:

1. Study of physical properties of minerals.
2. Identification of minerals: Silica group: Quartz, Amethyst, Opal; Feldspar group: Orthoclase, Plagioclase; Cryptocrystalline group: Jasper; Carbonate group: Calcite; Element group: Graphite; Pyroxene group: Talc; Mica group: Muscovite; Amphibole group: Asbestos, Olivine, Hornblende, Magnetite, Hematite, Corundum, Kyanite, Garnet, Galena, Gypsum.
3. Identification of rocks (Igneous Petrology): Acidic Igneous rock: Granite and its varieties, Syenite, Rhyolite, Pumice, Obsidian, Scoria, Pegmatite. Basic rock: Gabbro, Dolerite, Basalt and its varieties, Trachyte.
4. Identification of rocks (Sedimentary Petrology): Conglomerate, Breccia, Sandstone and its varieties, Laterite, Limestone and its varieties, Shales and its varieties.
5. Identification of rocks (Metamorphic Petrolody): Marble, slate, Gneiss and its varieties, Schist and its varieties. Quartzite, Phyllite.
6. Study of topographical features from Geological maps. Identification of symbols in maps.
7. Geological Field Study Tour.

Text/Reference Books:

1. Engineering and General Geology, Parbin Singh, 8th Edition (2010), S K Kataria & Sons.
2. Text Book of Engineering Geology, N. Chenna Kesavulu, 2nd Edition (2009), Macmillan Publishers India.
3. Geology for Geotechnical Engineers, J.C. Harvey, Cambridge University Press(1982).
4. A Textbook of Geology, P.K. Mukerjee, World Press

What will I learn?

Students will be able to:

- Use suitable software to examine geology, soil, geologic hazard, and NEHRP data to characterize a geologic site.
- Calculate the bulk properties of rocks and unconsolidated sediments such as density, void ratio, water contents, and unit weights.
- Evaluate rock-mass quality and perform a kinematic analysis.
- Apply the factor of safety equation to solve planar rock slide and toppling problems.
- Perform a grain-size analysis, determine plastic and liquid limits, and classify soils using the Unified Soil Classification System.
- Calculate soil consolidation magnitudes and rates under induced stress conditions.
- Determine soil strength parameters from in-situ tests.
- Apply the method of slices and factor of safety equation to solve rotational slide problems.

Course Outcomes:

Students will understand:

- Site characterization and how to collect, analyze, and report geologic data using standards in engineering practice
- The fundamentals of the engineering properties of Earth materials and fluids.
- Rock mass characterization and the mechanics of planar rock slides and topples.
- Soil characterization and the Unified Soil Classification System.
- The mechanics of soils and fluids and their influence on settlement, liquefaction, and soil slope stability.

ME 232	Basic Mechanical Engineering	3L:0T:0P	3 credits

Course objectives:

1. To familiarize the concepts of Energy in general and Heat and Work in particular
2. To cover the basic principles of Thermodynamics
3. To demonstrate application of the laws of thermodynamics to wide range of systems.
4. To write steady flow energy equation for various flow and non-flow thermodynamic systems
5. To compute efficiencies of heat engines, power cycles etc.
6. To study the fundamentals of quantification and grade of energy
7. To demonstrate the interrelations between thermodynamic functions to solve practical problems.

Contents:

Module 1: Concepts of Thermodynamics (7Hrs)

Macroscopic and Microscopic concepts; System and its classification; Thermodynamic state, properties, point and path functions, process and cycles; Thermodynamic equilibrium, Energy interactions (Work transfer and its different modes, Heat transfer); Zeroth law of thermodynamics.

Module 2: First law of Thermodynamics (7Hrs)
First law of thermodynamics and its application to non-flow as well as flow processes; Perpetual motion Machine of First kind; Different forms of energies, concepts of internal energy, enthalpy, specific heats, Limitations of first law.

Module 3: Ideal and Real gases (7Hrs)
Definition of Ideal gas, equation of state, universal and specific gas constants, perfect and semi-perfect gases. For various quasi-static processes: Evaluate heat, work, and change in internal energy, enthalpy. Definition of Real gas, Vander Waal's Equation and its constants in terms of critical properties, law of corresponding states, compressibility factor and chart.

Module 4: Second Law of Thermodynamics (8Hrs)
Definition of direct and reversed heat engine (Refrigerator and heat pump), definition of thermal efficiency and COP; Second law of thermodynamics, equivalence of Kelvin-Planck and Clausius statements; Perpetual Motion Machine of Second Kind; Reversibility and Irreversibility, causes for Irreversibility; Carnot cycle; Absolute Thermodynamic Temperature scale.

Module 5: Entropy (7Hrs)
Clausius theorem and inequality, Definition of entropy, entropy as a property, Two reversible adiabatic paths cannot intersect each other, Entropy change in reversible and Irreversible process, Principle of increase of entropy, Illustration of process on T-s diagram, Entropy generation in a closed system and open system, First and Second Laws combined relations.

Module 6: Availability and Energy (6Hrs)
Available and unavailable energy, concept of availability, availability of heat source at constant and variable Temperatures, Dead state, Energy balance equation and Energy analysis for non-flow and steady flow systems, Helmholtz and Gibbs function, second law efficiency.

Text Books/ References:

1. Yunus A. Cengel, Thermodynamics: An Engineering Approach, 8th Edition, McGraw - Hill Education, 2017.
2. Moran, Shappiro, Boettner and Bailey: Principles of Engineering Thermodynamics, 8e: Wiley
3. P. K. Nag, Engineering Thermodynamics, 6th Edition, McGraw - Hill Education, 2017.
4. Boegnakke and Sonntag: Fundamentals of Thermodynamics: 7e: Wiley
5. Rogers and Mayhew: Engineering Thermodynamics, 4e: Pearson Education
6. Basic Mechanical Engineering by Basant Agrawal & C. M. Agrwal, Wiley India Pvt. Ltd.
7. Elements of heat Engines (Vol I, II, III), R.C. Patel and C.J. Karamchandani, Acharya Publications, 2010

Course Outcomes:
On successful completion of this course, a student would be able to:
1. Develop the basic concepts of thermodynamic systems, point and path functions, equilibrium and fundamental laws of engineering thermodynamics.

2. Apply the energy balance to thermodynamic systems involving heat and work interactions to determine thermodynamic properties.
3. Evaluate the performance of energy conversion devices undergoing a thermodynamic process or cycle and entropy of system.
4. Analyze a thermodynamic system for Availability & Irreversibility
5. Calculate thermodynamics properties based on thermodynamics relations.

EC 231	Basic Electronics	1L:1T:0P	2 credits

The objective of this Course is to provide the students with an introductory and broad treatment of the field of *Electronics Engineering to facilitate better understanding of the devices, instruments and sensors used in Civil Engineering applications.* Lab should be taken concurrently. This course emphasizes more on the laboratory/practical use of the knowledge gained from the course lectures.

What Will I Learn?

a) Know broadly the concepts and functionalities of the electronic devices, tools and instruments
b) Understand use, general specifications and deployabilities of the electronic devices, and assemblies
c) Confidence in handling and usage of electronic devices, tools and instruments in engineering applications

(All modules to provide only broad overview)

Module1: *Diodes and Applications* covering, Semiconductor Diode - Ideal versus Practical, Resistance Levels, Diode Equivalent Circuits, Load Line Analysis; Diode as a Switch, Diode as a Rectifier, Half Wave and Full Wave Rectifiers with and without Filters; Breakdown Mechanisms, Zener Diode – Operation and Applications; Opto-Electronic Devices – LEDs, Photo Diode and Applications; Silicon Controlled Rectifier (SCR) – Operation, Construction, Characteristics, Ratings, Applications;

Module 2*: Transistor Characteristics* covering, Bipolar Junction Transistor (BJT) – Construction, Operation, Amplifying Action, Common Base, Common Emitter and Common Collector Configurations, Operating Point, Voltage Divider Bias Configuration; Field Effect Transistor (FET)
– Construction, Characteristics of Junction FET, Depletion and Enhancement type Metal Oxide Semiconductor (MOS) FETs, Introduction to CMOS circuits;

Module 3*: Transistor Amplifiers and Oscillators* covering, Classification, Small Signal Amplifiers – Basic Features, Common Emitter Amplifier, Coupling and Bypass Capacitors, Distortion, AC Equivalent Circuit; Feedback Amplifiers – Principle, Advantages of Negative Feedback, Topologies, Current Series and Voltage Series Feedback Amplifiers; Oscillators – Classification, RC Phase Shift, Wien Bridge, High Frequency LC and Non-Sinusoidal type Oscillators;

Module 4*: Operational Amplifiers and Applications* covering, Introduction to Op-Amp, Differential Amplifier Configurations, CMRR, PSRR, Slew Rate; Block Diagram, Pin Configuration of 741 Op- Amp, Characteristics of Ideal OpAmp, Concept of Virtual Ground;

Text/Reference Books:

1. David. A. Bell (2003), *Laboratory Manual for Electronic Devices and Circuits*, Prentice Hall, India
2. Santiram Kal (2002), Basic Electronics- Devices, Circuits and IT Fundamentals, Prentice Hall, India
3. Thomas L. Floyd and R. P. Jain (2009), *Digital Fundamentals* by Pearson Education,
4. Paul B. Zbar, A.P. Malvino and M.A. Miller (2009), *Basic Electronics–A Text-Lab. Manual*, TMH
5. R.T. Paynter (2009), *Introductory Electronic Devices & Circuits, Conventional Flow Version*, Pearson

CE 233P	Computer-aided Civil Engineering Drawing	1L:0T:2P	2 credits

The students will be able to

a) Develop Parametric design and the conventions of formal engineering drawing
b) Produce and interpret 2D & 3Ddrawings
c) Communicate a design idea/concept graphically/visually
d) Examine a design critically and with understanding of CAD - The student learn to interpret drawings, and to produce designs using a combination of 2D and 3D software.
e) Get a Detailed study of an engineering artifact.

Module 1: INTRODUCTION

Introduction to concept of drawings, Interpretation of typical drawings, Planning drawings to show information concisely and comprehensively; optimal layout of drawings and Scales; Introduction to computer aided drawing, co-ordinate systems, reference planes. Commands: Initial settings, Drawing aids, Drawing basic entities, Modify commands, Layers, Text and Dimensioning, Blocks. Drawing presentation norms and standards.

Module 2: SYMBOLS AND SIGN CONVENTIONS:

Materials, Architectural, Structural, Electrical and Plumbing symbols. Rebar drawings and structural steel fabrication and connections drawing symbols, welding symbols; dimensioning standards

Module 3: MASONRY BONDS*:*

English Bond and Flemish Bond – Corner wall and Cross walls - One brick wall and one and half brick wall

Module 4: BUILDING DRAWING:

Terms, Elements of planning building drawing, Methods of making line drawing and detailed drawing. Site plan, floor plan, elevation and section drawing of small residential buildings. Foundation plan. Roof drainage plans. Depicting joinery, standard fittings & fixtures, finishes. Use of Notes to improve clarity

Module 5: PICTORIAL VIEW:

Principles of isometrics and perspective drawing. Perspective view of building. Fundamentals of Building Information Modelling (BIM)

It may be advisable to conduct Theory sessions along with Lab demonstrations.

List of Drawing Experiments:

1. Buildings with load bearing walls including details of doors and windows.
2. Taking standard drawings of a typical two storeyed building including all MEP, joinery, rebars, finishing and other details and writing out a description of the Facility in about 500-700words.
3. RCC framed structures
4. Reinforcement drawings for typical slabs, beams, columns and spread footings.
5. Industrial buildings - North light roof structures-Trusses
6. Perspective view of one and two storey buildings

Text/Reference Books:

1. Subhash C Sharma &Gurucharan Singh (2005), "Civil Engineering Drawing", Standard Publishers
2. Ajeet Singh (2002), "Working with AUTOCAD 2000 with updates on AUTOCAD 200I", Tata- Mc Graw-Hill Company Limited, New Delhi
3. Sham Tickoo Swapna D (2009), "AUTOCAD for Engineers and Designers", Pearson Education,
4. Venugopal (2007), "Engineering Drawing and Graphics + AUTOCAD", New Age International Pvt.Ltd.,
5. Balagopal and Prabhu (1987), "Building Drawing and Detailing", Spades publishing KDR building, Calicut,
6. (Corresponding set of) CAD Software Theory and User Manuals.
7. Malik R.S., Meo, G.S. (2009) Civil Engineering Drawing, Computech Publication Ltd New Asian.
8. Sikka, V.B. (2013), A Course in Civil Engineering Drawing, S.K. Kataria & Sons,

Goals & Outcomes:

The course should enable the students to

i) To develop graphical skills for communicating concepts, ideas and designs of engineering products graphically/ visually as well as understand another person's designs,
ii) and to get exposure to national standards relating to technical drawings using Computer Aided Design and Drafting practice
iii) Develop Parametric design and the conventions of formal engineering drawing
iv) Produce and interpret 2D & 3D drawings
v) Examine a design critically and with understanding of CAD - The student learn to interpret drawings, and to produce designs using a combination of 2D and 3Dsoftware.
vi) Do a detailed study of an engineering artefact
vii) Develop drawings for conventional structures using practical norms.

SECOND YEAR
FOURTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	HU 241	Universal Human Values-II	2	1	0	70	30	-	100	3
2.	CE 242	Fluid Mechanics	3	1	0	70	30	-	100	4
3.	CE 243	Solid Mechanics	3	1	0	70	30	-	100	4
4.	CE 244	Surveying & Geomatics	3	0	0	70	30	-	100	3
5.	CE 245	Materials, Testing & Evaluation	2	1	0	70	30	-	100	3
		SUB-TOTAL	***13***	***4***	***0***				***500***	***17***
		PRACTICAL/DESIGN								
6.	CE 242P	Fluid Mechanics Lab.	0	0	3	-	30	70	100	1.5
7.	CE 244P	Surveying & Geomatics Lab.	0	0	3	-	30	70	100	1.5
8.	CE 245P	Materials, Testing & Evaluation Lab.	0	0	3		30	70	100	1.5
		SUB-TOTAL	***0***	***0***	***9***				***300***	***4.5***
		MANDATORY COURSE								
9.	*NC 241*	Management -1 (Organizational Behavior)	*3*	*0*	*0*		50*			**0**
		TOTAL	**16**	**4**	**9**	-	-	-	**800**	**21.5**

HU241	Universal Human Values	2L:1T:0P	3 credits

1. OBJECTIVE:

The objective of the course is four fold:

1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

2. COURSE TOPICS:

The course has 28 lectures and 14 practice sessions in 5 modules:

Module 1: Course Introduction - Need, Basic Guidelines, Content and Process for Value Education

1. Purpose and motivation for the course, recapitulation from Universal Human Values-I
2. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation-as the process for self-exploration
3. Continuous Happiness and Prosperity-A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario
6. Method to fulfill the above human aspirations: understanding and living in harmony at various levels.

Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking

Module2: Understanding Harmony in the Human Being-Harmony in Myself!

1. Understanding human being as a co-existence of the sentient 'I' and the material 'Body'
2. Understanding the needs of Self ('I') and 'Body' - happiness and physical facility
3. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer)
4. Understanding the characteristics and activities of 'I' and harmony in 'I'
5. Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail
6. Programs to ensure Sanyam and Health.

Include practice sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease

Module 3: Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship

1. Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship
2. Understanding the meaning of Trust; Difference between intention and competence
3. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship
4. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals
5. Visualizing a universal harmonious order in society- Undivided Society, Universal Order-from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives

Module 4: Understanding Harmony in the Nature and Existence - Whole existence as Coexistence

1. Understanding the harmony in the Nature
2. Interconnectedness and mutual fulfilment among the four orders of nature-recyclability and self regulation in nature
3. Understanding Existence as Co-existence of mutually interacting units in all-pervasive space
4. Holistic perception of harmony at all levels of existence.

Include practice sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Module 5: Implications of the above Holistic Understanding of Harmony on Professional Ethics

1. Natural acceptance of human values
2. Definitiveness of Ethical Human Conduct
3. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order
4. Competence in professional ethics:
    a. Ability to utilize the professional competence for augmenting universal human order
    b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems,

   c. Ability to identify and develop appropriate technologies and management patterns for above production systems.
5. Case studies of typical holistic technologies, management models and production systems
6. Strategy for transition from the present state to Universal Human Order:
   a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers
   b. At the level of society: as mutually enriching institutions and organizations
7. Sum-up.

Include practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions e.g. To discuss the conduct as an engineer or scientist etc.

3. READINGS:

Text Book

1. Human Values and Professional Ethics by RR Gaur, R Sangal, GP Bagaria, Excel Books, New Delhi, 2010

Reference Books

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth-by Mohandas Karamchand Gandhi
5. Small is Beautiful-E.F Schumacher.
6. Slow is Beautiful-Cecile Andrews
7. Economy of Permanence-JC Kumarappa
8. Bharat Mein Angreji Raj-Pandit Sunderlal
9. Rediscovering India-by Dharampal
10. Hind Swaraj or Indian Home Rule –by Mohandas K. Gandhi
11. India Wins Freedom- Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi-Romain Rolland (English)

4. MODE OF CONDUCT (2L:1T:0P) (3credits)

Lectures hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them.

Tutorial hours are to be used for practice sessions.

While analysing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self-observation, self-reflection and self-exploration.

Scenarios may be used to initiate discussion. The student is encouraged to take up "ordinary" situations rather than" extra-ordinary" situations. Such observations and their analyses are shared and discussed with other students and faculty mentor,in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and working real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values.

It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

This course is to be taught by faculty from every teaching department, including HSS faculty.

Teacher preparation with a minimum exposure to at least one 8-day FDP on Universal Human Values is deemed essential.

5. ASSESSMENT:

This is a compulsory credit course. The assessment is to provide a fair state of development of the student, so participation in classroom discussions, self-assessment, peer assessment etc. will be used in evaluation.

Example:

Assessment by faculty mentor	: 10 marks
Self-assessment	: 10marks
Assessment by peers	: 10marks
Socially relevant project/Group Activities/Assignments	: 20 marks
Semester End Examination	: 50marks

The overall pass percentage is 40%.

In case the student fails, he/she must repeat the course.

6. OUTCOME OF THE COURSE:

By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.

They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

This is only an introductory foundational input. It would be desirable to follow it up by

a) faculty-student or mentor-mentee programs throughout their time with the institution
b) Higher level courses on human values in every aspect of living. e.g. as a professional

CE 242; CE 242P	Fluid Mechanics	3L:1T:3P	5.5 credits

The objective of this course is to introduce the concepts of fluid mechanics useful in Civil Engineering applications. The course provides a first level exposure to the students to fluid statics, kinematics and dynamics. Measurement of pressure, computations of hydrostatic forces on structural components and the concepts of Buoyancy all find useful applications in many engineering problems. A training to analyse engineering problems involving fluids – such as those dealing with pipe flow, open channel flow, jets, turbines and pumps, dams and spillways, culverts, river and groundwater flow - with a mechanistic perspective is essential for the civil engineering students. The topics included in this course are aimed to prepare a student to build a good fundamental background useful in the application-intensive courses covering hydraulics, hydraulic machinery and hydrology in later semesters.

Module 1: Basic Concepts and Definitions – Distinction between a fluid and a solid; Density, Specific weight, Specific gravity, Kinematic and dynamic viscosity; variation of viscosity with temperature, Newton's law of viscosity; vapour pressure, boiling point, cavitation; surface tension, capillarity, Bulk modulus of elasticity, compressibility.

Module 2: Fluid Statics - Fluid Pressure: Pressure at a point, Pascal's law, pressure variation with temperature, density and altitude. Piezometer, U-Tube Manometer, Single Column Manometer, U-Tube Differential Manometer, Micromanometers, pressure gauges, Hydrostatic pressure and force: horizontal, vertical and inclined surfaces. Buoyancy and stability of floating bodies.

Module 3: Fluid Kinematics-Classification of fluid flow : steady and unsteady flow; uniform and non-uniform flow; laminar and turbulent flow; rotational and irrotational flow; compressible and incompressible flow; ideal and real fluids; one, two and three dimensional flows; Stream line, path line, streak line and stream tube; stream function, velocity potential function. One, two and three dimensional continuity equations in Cartesian coordinates

Module 4: Fluid Dynamics- Equations of motion - Euler's equation; Bernoulli's equation – derivation; Energy Principle; Practical applications of Bernoulli's equation : venturimeter, orifice meter and pitot tube; Momentum principle; Forces exerted by fluid flow on pipe bend; Vortex Flow – Free and Forced;

Module 5: Dimensional Analysis and Similitude - Definitions of Reynolds Number, Froude Number, Mach Number, Weber Number and Euler Number; Buckingham'sπ-Theorem.

Lab Experiments

1. Measurement of viscosity
2. Study of Pressure Measuring Devices
3. Stability of Floating Body
4. Hydrostatics Force on Flat Surfaces/Curved Surfaces
5. Verification of Bernoulli's Theorem
6. Venturimeter
7. Orificemeter
8. Impacts of jets
9. Flow Visualisation –Ideal Flow
10. Length of establishment of flow
11. Velocity distribution in pipes
12. Laminar Flow

Text/Reference Books:

1. Fluid Mechanics and Machinery, C.S.P. Ojha, R. Berndtsson and P. N. Chadramouli, Oxford University Press, 2010
2. Hydraulics and Fluid Mechanics, P M Modi and S M Seth, Standard Book House
3. Theory and Applications of Fluid Mechanics, K. Subramanya, Tata McGraw Hill
4. Fluid Mechanics with Engineering Applications, R.L. Daugherty, J.B. Franzini and E.J. Finnemore, International Student Edition, McGraw Hill.

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

- Understand the broad principles of fluid statics, kinematics and dynamics
- Understand definitions of the basic terms used in fluid mechanics
- Understand classifications of fluid flow
- Be able to apply the continuity, momentum and energy principles
- Be able to apply dimensional analysis

CE 243	Solid Mechanics	3L:1T:0P	4 credits

The objective of this Course is to introduce to continuum mechanics and material modelling of engineering materials based on first energy principles: deformation and strain; momentum balance, stress and stress states; elasticity and elasticity bounds; plasticity and yield design. The overarching theme is a unified mechanistic language using thermodynamics, which allows understanding, modelling and design of a large range of engineering materials. The subject of mechanics of materials involves analytical methods for determining the strength, stiffness (deformation characteristics), and stability of the various members in a structural system. The behaviour of a member depends not only on the fundamental laws that govern the equilibrium of forces, but also on the mechanical characteristics of the material. These mechanical characteristics come from the laboratory, where materials are tested under accurately known forces and their behaviour is carefully observed and measured. For this reason, mechanics of materials is a blended science of experiment and Newtonian postulates of analytical mechanics.

Module 1: Simple Stresses and Strains- Concept of stress and strain, St. Venant's principle, stress and strain diagram, Elasticity and plasticity – Types of stresses and strains, Hooke's law – stress – strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio and volumetric strain – Elastic moduli and the relationship between them – Bars of varying section – composite bars – Temperature stresses. Strain Energy – Resilience – Gradual, sudden, impact and shock loadings – simple applications.

Module 2: Compound Stresses and Strains- Two dimensional system, stress at a point on a plane, principal stresses and principal planes, Mohr circle of stress, ellipse of stress and their applications. Two dimensional stress-strain system, principal strains and principal axis of strain, circle of strain and ellipse of strain. Relationship between elastic constants.

Module 3: Bending moment and Shear Force Diagrams- Bending moment (BM) and shear force (SF) diagrams.BM and SF diagrams for cantilevers simply supported and fixed beams with or without overhangs. Calculation of maximum BM and SF and the point of contra flexure under concentrated loads, uniformly distributed loads over the whole span or part of span, combination of concentrated loads (two or three) and uniformly distributed loads, uniformly varying loads, application of moments.

Module 4: Flexural Stresses-*Theory of simple bending* – Assumptions – Derivation of bending equation: M/I = f/y = E/R - Neutral axis – Determination of bending stresses – Section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections – Design of simple beam sections.

Module 5: Shear Stresses- Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.

Module 6: Slope and deflection- Relationship between moment, slope and deflection, Moment area method, Macaulay's method. Use of these methods to calculate slope and deflection for determinant beams.

Module 7: Torsion- Derivation of torsion equation and its assumptions. Applications of the equation of the hollow and solid circular shafts, torsional rigidity, Combined torsion and bending of circular shafts, principal stress and maximum shear stresses under combined loading of bending and torsion. Analysis of close-coiled-helical springs.

Module 8: Thin Cylinders and Spheres- Derivation of formulae and calculations of hoop stress, longitudinal stress in a cylinder, and sphere subjected to internal pressures.

List of Experiments:

- Tension test
- Bending tests on simply supported beam and Cantilever beam.
- Compression test on concrete
- Impact test
- Shear test
- Investigation of Hook's law that is the proportional relation between force and stretching in elastic deformation,
- Determination of torsion and deflection,
- Measurement of forces on supports in statically determinate beam,
- Determination of shear forces in beams,
- Determination of bending moments in beams,
- Measurement of deflections in statically determinate beam,
- Measurement of strain in a bar
- Bend test steel bar;
- Yield/tensile strength of steel bar;

Text/Reference Books:

1. Timoshenko, S. and Young, D. H., "Elements of Strength of Materials", DVNC, New York, USA.
2. Kazmi, S. M. A., "Solid Mechanics" TMH, Delhi, India.
3. Hibbeler, R. C. Mechanics of Materials. 6th ed. East Rutherford, NJ: Pearson Prentice Hall, 2004
4. Crandall, S. H., N. C. Dahl, and T. J. Lardner. An Introduction to the Mechanics of Solids. 2nd ed. New York, NY: McGraw Hill,1979
5. Laboratory Manual of Testing Materials - William Kendrick Hall
6. Mechanics of Materials - Ferdinand P. Beer, E. Russel Jhonston Jr., John T. D Ewolf – TMH2002.
7. Strength of Materials by R. Subramanian, Oxford University Press, New Delhi.

Outcomes:

On completion of the course, the student will be able to:

- Describe the concepts and principles, understand the theory of elasticity including strain/displacement and Hooke's law relationships; and perform calculations, relative to the strength and stability of structures and mechanical components;
- Define the characteristics and calculate the magnitude of combined stresses in individual members and complete structures; analyze solid mechanics problems using classical methods and energy methods;
- Analyse various situations involving structural members subjected to combined stresses by application of Mohr's circle of stress; locate the shear center of thin wall beams; and
- Calculate the deflection at any point on a beam subjected to a combination of loads; solve for stresses and deflections of beams under unsymmetrical loading; apply various failure criteria for general stress states at points; solve torsion problems in bars and thin walled members;

CE 244; CE 244P	Surveying and Geomatics	3L:0T:3P	4.5 credits

Course Objectives

With the successful completion of the course, the student should have the capability to:

a) describe the function of surveying in civil engineering construction,
b) Work with survey observations, and perform calculations,
c) Customary units of measure. Identify the sources of measurement errors and mistakes; understand the difference between accuracy and precision as it relates to distance, differential leveling, and angular measurements,
d) Be familiar with the principals of recording accurate, orderly, complete, and logical field notes from surveying operations, whether recorded manually or with automatic data collection methods,
e) Identify and calculate the errors in measurements and to develop corrected values for differential level circuits, horizontal distances and angles for open or closed-loop traverses,
f) Operate an automatic level to perform differential and profile leveling; properly record notes; mathematically reduce and check leveling measurements,
g) Effectively communicate with team members during field activities; identify appropriate safety procedures for personal protection; properly handle and use measurement instruments. Be able to identify hazardous environments and take measures to insure one's personal and team safety,
h) Measure horizontal, vertical, and zenith angles with a transit, theodolite, total station or survey grade GNSS instruments,
i) Calculate azimuths, latitudes and departures, error of closure; adjust latitudes and departures and determine coordinates for a closed traverse,
j) Perform traverse calculations; determine latitudes, departures, and coordinates of control points and balancing errors in a traverse. Use appropriate software for calculations and mapping,
k) Operate a total station to measure distance, angles, and to calculate differences in elevation. Reduce data for application in a geographic information system,
l) Work as a team member on a surveying party to achieve a common goal of accurate and timely project completion,
m) Calculate, design and layout horizontal and vertical curves, Understand, interpret, and prepare plan, profile, and cross-section drawings, Work with cross-sections and topographic maps to calculate areas, volumes, and earthwork quantities.

Module 1: Introduction to Surveying-

Principles, Linear, angular and graphical methods, Survey stations, Survey lines- ranging, Bearing of survey lines, Levelling: Plane table surveying, Principles of levelling-booking and reducing levels; differential, reciprocal leveling, profile levelling and cross sectioning. Digital and Auto Level, Errors in levelling; contouring: Characteristics, methods, uses; areas and volumes.

Triangulation and Trilateration -Theodolite survey: Instruments, Measurement of horizontal and vertical angle; Horizontal and vertical control - methods -triangulation - network- Signals. Baseline - choices - instruments and accessories - extension of base lines -corrections - Satellite station - reduction to centre – Inter visibility of height and distances - Trigonometric leveling- Axis single corrections.

Module 2: Curves -

Elements of simple and compound curves – Method of setting out– Elements of Reverse curve - Transition curve – length of curve – Elements of transition curve - Vertical curves

Module 3: Modern Field Survey Systems-
Principle of Electronic Distance Measurement, Modulation, Types of EDM instruments, Distomat, Total Station – Parts of a Total Station – Accessories –Advantages and Applications, Field Procedure for total station survey, Errors in Total Station Survey; Global Positioning Systems- Segments, GPS measurements, errors and biases, Surveying with GPS, Co-ordinate transformation, accuracy considerations.

Module 4: Photogrammetry Surveying-
Introduction, Basic concepts, perspective geometry of aerial photograph, relief and tilt displacements, terrestrial photogrammetry, flight planning; Stereoscopy, ground control extension for photographic mapping- aerial triangulation, radial triangulation, methods; photographic mapping- mapping using paper prints, mapping using stereo plotting instruments, mosaics, map substitutes.

Module 5: Remote Sensing-
Introduction –Electromagnetic Spectrum, interaction of electromagnetic radiation with the atmosphere and earth surface, remote sensing data acquisition: platforms and sensors; visual image interpretation; digital image processing.

List of Practical:
1. To find the distance between two points by means of chaining under the following conditions-
   (a) when there is obstacle to chaining but not ranging.
   (b) When there is obstacle to both chaining and ranging.
2. Study of different Levels and Leveling Staff Practice for temporary adjustment. To find out the reduced levels of given points using Dumpy Level (Reduction by Height of Collimation method).
3. Study of a Tilting (I.O.P.) Level and to find out the reduced levels of given points (Reduction of data by Rise and Fall method)
4. To establish a Bench Mark by Check Leveling with I.O.P. level and closing the work at the starting Bench Mark.
5. To perform Fly Leveling with a I.O.P. level.
6. To draw the longitudinal and cross-sections profiles along a given route.
7. Practice for Temporary adjustments of a Vernier Theodolite and taking Horizontal and Vertical angular measurements, by Reiteration method.
8. (i) Measurement of a horizontal angles by Repetition method at three zeros and four repetitions.
   (ii) Determination of elevation and horizontal distance of a given point using Substance Bar and a Vernier Theodolite.
9. (i) Determination of the Tacheometric constants of a given Theodolite.
   (ii) To determine the gradient between two given points using Tacheometric method.
10 To determine the bearing of a given traverse using Prismatic Compass and plotting of the traverse
11. Establishment of a given traverse using Tacheometric method.

Text/Reference Books:

1. Madhu, N, Sathikumar, R and Satheesh Gobi, Advanced Surveying: Total Station, GIS and Remote Sensing, Pearson India, 2006.
2. Manoj, K. Arora and Badjatia, Geomatics Engineering, Nem Chand & Bros,2011
3. Bhavikatti, S.S., Surveying and Levelling, Vol. I and II, I.K. International,2010
4. Chandra, A.M., Higher Surveying, Third Edition, New Age International (P) Limited, 2002.

5. Anji Reddy, M., Remote sensing and Geographical information system, B.S. Publications,2001.
6. Arora, K.R., Surveying, Vol-I, II and III, Standard Book House, 2015.

Outcomes:
The course will enable the students to:

- Apply the knowledge, techniques, skills, and applicable tools of the discipline to engineering and surveying activities
- Translate the knowledge gained for the implementation of Civil infrastructure facilities
- Relate the knowledge on Surveying to the new frontiers of science like Hydrographic surveying, Electronic Distance Measurement, Global Positioning System, Photogrammetry and Remote Sensing.

CE 245; CE 245P	Materials, Testing & Evaluation	2L:1T:3P	4.5 credits

The objective of this Course is to deal with an experimental determination and evaluation of mechanical characteristics and advanced behavior of metallic and non-metallic structural materials. The course deals with explanation of deformation and fracture behavior of structural materials. The main goal of this course is to provide students with all information concerning principle, way of measurement, as well as practical application of mechanical characteristics.

- Make measurements of behavior of various materials used in Civil Engineering.
- Provide physical observations to complement concepts learnt
- Introduce experimental procedures and common measurement instruments, equipment, devices.
- Exposure to a variety of established material testing procedures and techniques
- Different methods of evaluation and inferences drawn from observations

The course reviews also the current testing technology and examines force applications systems, force measurement, strain measurement, important instrument considerations, equipment for environmental testing, and computers applications for materials testing provide an introductory treatment of *basic skills in material engineering towards (i) selecting material for the design, and (ii) evaluating the mechanical and structural properties of material, as well as the knowledge necessary for a civil engineer.* The knowledge acquired lays a good foundation for analysis and design of various civil engineering structures/systems in a reliable manner.

What will I learn?

- Different materials used in civil engineering applications
- Planning an experimental program, selecting the test configuration, selecting the test specimens and collecting raw data
- Documenting the experimental program including the test procedures, collected data, method of interpretation and final results
- Operating the laboratory equipment including the electronic instrumentation, the test apparatus and the data collection system
- Measuring physical properties of common structural and geotechnical construction materials
- Interpreting the laboratory data including conversion of the measurements into engineering values and derivation of material properties (strength and stiffness) from the engineering values
- Observing various modes of failure in compression, tension, and shear
- Observing various types of material behavior under similar loading conditions

Module 1: Introduction to Engineering Materials
Cements, M-Sand, Concrete (plain, reinforced and steel fibre/ glass fibre-reinforced, light-weight concrete, High Performance Concrete, Polymer Concrete) Ceramics, and Refractories, Bitumen and asphaltic materials, Timbers, Glass and Plastics, Structural Steel and other Metals, Paints and Varnishes, Acoustical material and geo- textiles, rubber and asbestos, laminates and adhesives, Graphene, Carbon composites and other engineering materials including properties and uses of these

Module 2: Introduction to Material Testing
What is the "Material Engineering"; Mechanical behavior and mechanical characteristics; Elasticity – principle and characteristics; Plastic deformation of metals; Tensile test – standards for different material (brittle, quasi-brittle, elastic and so on) True stress – strain interpretation of tensile test; hardness tests; Bending and torsion test; strength of ceramic; Internal friction, creep – fundaments and characteristics; Brittle fracture of steel; temperature transition approach; Background of fracture mechanics; Discussion of fracture toughness testing – different materials; concept of fatigue of materials; Structural integrity assessment procedure and fracturemechanics

Module 3: Standard Testing & Evaluation Procedures
Laboratory for mechanical testing; Discussion about mechanical testing; Naming systems for various irons, steels and nonferrous metals; Discussion about elastic deformation; Plastic deformation; Impact test and transition temperatures; Fracture mechanics – background; Fracture toughness – different materials; Fatigue of material; Creep.

Tutorials *from the above modules covering*, understanding
i) Tests & testing of bricks,
ii) Tests & testing of sand,
iii) Tests & testing of concrete,
iv) Tests & testing of soils,
v) Tests & testing of bitumen & bituminous mixes,
vi) Tests & testing of polymers and polymer based materials,
vii) Tests & testing of metals &
viii) Tests & testing of other special materials, composites and cementitious materials.
ix) Explanation of mechanical behavior of these materials.

Practicals:
1. Gradation of coarse and fine aggregates
2. Different corresponding tests and need/application of these tests in design and quality control
3. Tensile Strength of materials & concrete composites
4. Compressive strength test on aggregates
5. Tension I - Elastic Behaviour of metals & materials
6. Tension II - Failure of Common Materials
7. Direct Shear – Frictional Behaviour
8. Concrete I - Early Age Properties
9. Concrete II - Compression and Indirect Tension
10. Compression –Directionality
11. Soil Classification
12. Consolidation and Strength Tests
13. Tension III - Heat Treatment
14. Torsion test
15. Hardness tests (Brinnel's and Rockwell)
16. Tests on closely coiled and open coiled springs
17. Theories of Failure and Corroboration with Experiments
18. Concrete Mix Design as per BIS

Text/Reference Books:

1. Chudley, R., Greeno (2006), 'Building Construction Handbook' (6th ed.),R. Butterworth- Heinemann
2. Khanna, S.K., Justo, C.E.G and Veeraragavan, A, ' Highway Materials and Pavement Testing', Nem Chand& Bros, Fifth Edition
3. Various related updated & recent standards of BIS, IRC, ASTM, RILEM, AASHTO, etc. corresponding to materials used for Civil Engineering applications
4. Kyriakos Komvopoulos (2011), Mechanical Testing of Engineering Materials, Cognella
5. E.N. Dowling (1993), Mechanical Behaviour of Materials, Prentice Hall International Edition
6. American Society for Testing and Materials (ASTM), *Annual Book of ASTM Standards* (post 2000)
7. Related papers published in international journals

Measurable Outcomes:

One should be able to:

- Calibrate electronic sensors
- Operate a data acquisition system
- Operate various types of testing machines
- Configure a testing machine to measure tension or compression behavior
- Compute engineering values (e.g. stress or strain) from laboratory measures
- Analyze a stress versus strain curve for modulus, yield strength and other related attributes
- Identify modes of failure
- Write a technical laboratory report

NC 241	Management -1 (Organizational Behavior)	3L:0T:0P	0 credits

Module-1

OB: Learning objectives, Definition & Meaning, Why to study OB, An OB model, New challenges for OB Manager

LEARNING: Nature of learning, How learning occurs, Learning & OB Case Study Analysis

Module-2

PERSONALITY: Meaning & Definition, Determinants of Personality, Personality Traits, Personality & OB

PERCEPTION: Meaning & Definition, Perceptual process, Importance of Perception in OB

MOTIVATION: Nature & Importance, Herzberg's Two Factor theory, Maslow's Need Hierarchy theory, Alderfer's ERG theory
Case Study Analysis

Module-3

COMMUNICATION: Importance, Types, Barriers to communication, Communication as a tool for improving Interpersonal Effectiveness

GROUPS IN ORGANISATION: Nature, Types, Why do people join groups, Group Cohesiveness & Group Decision Making- managerial Implications, Effective Team Building

LEADERSHIP: Leadership & management, Theories of leadership- Trait theory, Behavioural Theory, Contingency Theory, Leadership & Followership, How to be an Effective Leader

CONFLICT: Nature of Conflict & Conflict Resolution

TRANSACTIONAL ANALYSIS: An Introduction to Transactional Analysis
Case Study Analysis

Module-4
ORGANISATIONAL CULTURE: Meaning & Definition, Culture & Organisational Effectiveness

HUMAN RESOURCE MANAGEMENT: Introduction to HRM, Selection, Orientation, Training& Development, Performance Appraisal, Incentives

ORGANISATIONAL CHANGE: Importance of Change, Planned Change & OB Techniques

INTERNATIONAL OB: An Introduction to Individual & Interpersonal Behaviour in Global Perspectives Case Study Analysis

THIRD YEAR
FIFTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	CE 351	Mechanics of Materials	3	0	0	70	30	-	100	3
2.	CE 352	Hydraulic Engineering	3	0	0	70	30	-	100	3
3.	CE 353	Structural Engineering	3	1	0	70	30	-	100	4
4.	CE 354	Geotechnical Engineering-I	2	1	0	70	30	-	100	3
5.	CE 355	Hydrology & Water Resources Engineering	2	1	0	70	30	-	100	3
6.	CE356	Transportation Engineering-I	2	1	0	70	30		100	3
		SUB-TOTAL	***15***	***4***	***0***				***600***	***19***
		PRACTICAL/DESIGN								
7.	CE 352P	Hydraulic Engineering Lab	0	0	3	-	30	70	100	1.5
8.	CE 354P	Geotechnical Engineering Lab	0	0	3	-	30	70	100	1.5
9.	CE357P	Internship in industry or at appropriate work place (Not less than 2-weeks)	-	-	-	-	100	-	100	1
		SUB-TOTAL	***0***	***0***	***6***				***300***	***4***
		TOTAL	**15**	**4**	**6**				**900**	**23**

CE 351	Mechanics of Materials	3L:0T:0P	3 credits

The objective of this Course is to introduce to continuum mechanics and material modeling of engineering materials based on first energy principles: deformation and strain; momentum balance, stress and stress states; elasticity and elasticity bounds; plasticity and yield design. The overarching theme is a unified mechanistic language using thermodynamics, which allows understanding, modelling and design of a large range of engineering materials. The subject of mechanics of materials involves analytical methods for determining the strength, stiffness (deformation characteristics), and stability of the various members in a structural system. The behavior of a member depends not only on the fundamental laws that govern the equilibrium of forces, but also on the mechanical characteristics of the material. These mechanical characteristics come from the laboratory, where materials are tested under accurately known forces and their behavior is carefully observed and measured (learnt in the previous course on Materials, Testing & Evaluation). For this reason, mechanics of materials is a blended science of experiment and Newtonian postulates of analytical mechanics.

What will I learn?

- Understand the deformation and strains under different load action and response in terms of forces and moments
- Understand the behaviour under different loading actions
- Application of engineering principles to calculate the reactions, forces and moments
- Understand the energy methods used to derive the equations to solve engineering problems
- Make use of the capabilities to determine the forces and moments for design

Module 1: Deformation and Strain

Description of finite deformation, Infinitesimal deformation; Analysis of statically determinate trusses; Stability of dams, retaining walls and chimneys

Module 2: Generalized state of stress and strain*:*
Stress and strain tensor, Yield criteria and theories of failure; Tresca, Von-Mises, Hill criteria, Heigh-Westerguard's stress space.

Module 3: Momentum Balance and Stresses
Forces and Moments Transmitted by Slender Members, Shear Force and Bending Moment Diagrams, Momentum Balance, Stress States / Failure Criterion

Module 4: Mechanics of Deformable Bodies
Force-deformation Relationships and Static Indeterminacy, Uniaxial Loading and Material Properties, Trusses and Their Deformations, Statically Determinate and Indeterminate Trusses,

Module 5: Constitutive Relationship
Multiaxial Stress and Strain; and Multi axial Stress-strain Relationships

Module 6: Influence lines and Plastic methods of Analysis
Theory of plastic Bending, plastic hinge, Plastic analysis – Statistical and Mechanism method; Moving Loads and Influence lines; Influence line for support reaction, shear Force, Bending moment in determinate beams, Maximum support reactions, maximum bending moments, shear force at a section, load position for max SF and BM at a section.

Module 7: Elasticity and Elasticity Bounds
Stress-strain-temperature Relationships and Thin-walled Pressure Vessels, Stress and strain Transformations and Principal Stress, Failure of Materials,

Module 8: Bending Stress and Strains*;* Deflections and Torsion
Pure Bending, Moment- curvature Relationship, Beam Deflection, Symmetry, Superposition, and Statically Indeterminate Beams, Shear and Torsion, Torsion and Twisting, Energy methods, Strain energy, elastic, complementary and total strain energy, Strain energy of axially loaded bar, Beam in bending, shear and torsion; General energy theorems, Castigliano's theorem, Maxwell Bettie's reciprocal theorem; Virtual work and unit load method for deflection, Application to problems of beams and frames.

Module 9: Structural stability
Stability of columns, Euler's formula, end conditions and effective length factor, Columns with eccentric and lateral load; Plasticity and Yield Design covering 1D-Plasticity – An Energy Approach, Plasticity Models, Limit Analysis and Yield Design

Text/Reference Books:

1. Norris, C.H. and Wilber, J. B. and Utku, S. "Elementary Structural Analysis" Mc Graw Hill, Tokyo, Japan.
2. Timoshenko, S. and Young, D. H., "Elements of Strength of Materials", DVNC, New York, USA.
3. Kazmi, S. M. A., 'Solid Mechanics" TMH, Delhi, India.
4. Hibbeler, R. C. Mechanics of Materials. 6th ed. East Rutherford, NJ: Pearson Prentice Hall,2004
5. Crandall, S. H., N. C. Dahl, and T. J. Lardner. An Introduction to the Mechanics of Solids. 2nd ed. New York, NY: McGraw Hill,1979
6. Gere, J. M., and S. P. Timoshenko. *Mechanics of Materials.* 5th ed. Boston: PWS Kent Publishing, 1970.
7. Ashby, M. F., and D. R. H. Jones. *Engineering Materials, An Introduction to their Properties and Applications.* 2nd ed. Butterworth Heinemann.

8. Collins, J. A. *Failure of Materials in Mechanical Design.* 2nd ed. John Wiley & Sons, 1993.
9. Courtney, T. H. *Mechanical Behavior of Materials.* McGraw-Hill, 1990.
10. Hertzberg, R. W. *Deformation and Fracture Mechanics of Engineering Materials.* 4th ed. John Wiley & Sons, 1996.
11. Nash, W. A. *Strength of Materials.* 3rd ed. Schaum's Outline Series, McGraw-Hill, 1994.
12. Wang C.K. "Indeterminate Structural Analysis", McGraw Hill
13. Reddy C.S. "Basic Structural Analysis"
14. Dr. Punmia B.C., "Strength of Materials", Vol-II, Standard Publishers.
15. Jain A.K. "Advanced Structural Analysis", Nem Chand Bros., Roorkee.

Course Outcomes:

At the end of the course, the student will have

- an ability to apply knowledge of mathematics, science, and engineering
- an ability to design a system, component, or process to meet desired needs
- an ability to identify, formulate, and solve engineering problems
- the broad education necessary to understand the impact of engineering solutions in a global and societal context
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
- an ability to apply principles of engineering, basic science, and math to model, analyze, design and realize physical systems, components or processes

CE 352; CE 352P	Hydraulic Engineering	3L:0T:3P	4.5 credits

Objectives:

To introduce the students to various hydraulic engineering problems like open channel flows and hydraulic machines. At the completion of the course, the student should be able to relate the theory and practice of problems in hydraulic engineering

Module 1: Laminar Flow

Laminar flow through: circular pipes, annulus and parallel plates. Stoke's law, Measurement of viscosity.

Module 2: Turbulent Flow

Reynold's experiment, Transition from laminar to turbulent flow. Definition of turbulence, scale and intensity, Causes of turbulence, instability, mechanism of turbulence and effect of turbulent flow in pipes. Resistance to flow of fluid in smooth and rough pipes, Moody's diagram.

Module 3: Boundary Layer Analysis

Assumption and concept of boundary layer theory. Boundary layer thickness, displacement, momentum & energy thickness, laminar and Turbulent boundary layers on a flat plate; Laminar sub-layer, smooth and rough boundaries.

Module 4: Introduction to Open Channel Flow

Comparison between open channel flow and pipe flow, geometrical parameters of a channel, classification of open channels, classification of open channel flow, Velocity Distribution of channel section.

Module 5: Uniform Flow
Continuity Equation, Energy Equation and Momentum Equation, Characteristics of uniform flow, Chezy's formula, Manning's formula. Factors affecting Manning's Roughness Coefficient "n". Most economical section of channel. Computation of Uniform flow, Normal depth.

Module 6: Non-Uniform Flow
Specific energy, Specific energy curve, critical flow, discharge curve, Specific force, and Critical depth. Gradually Varied Flow: Dynamic Equation of Gradually Varied Flow, Classification of channel bottom slopes, Classification of surface profile, Characteristics of surface profile.

Module 7: Hydraulic Jump
Theory of hydraulic jump, Elements and characteristics of hydraulic jump in a rectangular Channel, length and height of jump, location of jump, types and applications. Energy dissipation. Dynamics of Fluid Flow: Momentum principle, applications: Force on plates, pipe bends, moments of momentum equation,

Module 8: Flow through Pipes:
Losses of head through pipes, Darcy-Weisbach equation, minor losses, total energy equation, hydraulic gradient line, Pipes in series, equivalent pipes, pipes in parallel, siphon, power transmission through pipes, nozzles.

Module 9: Hydraulic machinery:
Hydrodynamic force of jets on stationary and moving flat, inclined, and curved vanes, jet striking centrally and at tip, velocity diagrams, work done and efficiency.
Centrifugal pumps: classification, working, work done, manometric head, losses and efficiencies. Specific speed. Pumps in series and parallel. Reciprocating pumps: Working, Discharge, slip, indicator diagrams.

Hydraulic Turbines: classification of turbines, impulse and reaction turbines, Pelton wheel, Francis turbine and Kaplan turbine. Work done, efficiencies and hydraulic design. Selection of type of turbine. Cavitation.

Practical Work:
1. Flow Visualization
2. Studies in Wind Tunnel
3. Boundary Layer
4. Flow around an Aerofoil / circular cylinder
5. Uniform Flow
6. Velocity Distribution in Open channel flow
7. Venturi Flume
8. Standing Wave Flume
9. Gradually Varied Flow
10. Hydraulic Jump
11. Flow under Sluice Gate
12. Flow through pipes
13. Turbulent flow through pipes
14. Flow visualization
15. Laminar flow through pipes
16. Major losses / Minor losses in pipe

Text/Reference Books:

1. Hydraulics and Fluid Mechanics, P.M. Modi and S.M. Seth, Standard Book House
2. Theory and Applications of Fluid Mechanics, K. Subramanya, Tata McGraw Hill.
3. Open channel Flow, K. Subramanya, Tata McGraw Hill.
4. Open Channel Hydraulics, Ven Te Chow, Tata McGraw Hill.
5. Burnside, C.D., "*Electromagnetic Distance Measurement*," Beekman Publishers, 1971.

Outcomes:

- The students will be able to apply their knowledge of fluid mechanics in addressing problems in open channels.
- They will possess the skills to solve problems in uniform, gradually and rapidly varied flows in steady state conditions.
- They will have knowledge in hydraulic machineries (pumps and turbines).

CE 353	Structural Engineering	3L:1T:0P	4 credits

Objectives:

This course aims at providing students with a solid background on principles of structural engineering design. Students will be exposed to the theories and concepts of both concrete and steel design and analysis both at the element and system levels. Hands-on design experience and skills will be gained and learned through problem sets and a comprehensive design project. An understanding of real-world open-ended design issues will be developed. Weekly recitations and project discussions will be held besides lectures.

Module 1: Introduction-

concepts of energy principles, safety, sustainable development in performance; what makes a structure; principles of stability, equilibrium; what is a structural engineer, role of engineer, architect, user, builder; what do the engineers design, first principles of process of design

Module 2: Planning and Design Process

Materials, Loads, and Design Safety; Behaviour and Properties of Concrete and Steel; Wind and Earthquake Loads

Module 3: Materials and Structural Design Criteria

Introduction to the analysis and design of structural systems. Analyses of determinate and indeterminate trusses, beams, and frames, and design philosophies for structural engineering.

Module 4: Design of Structural Elements

Concrete Elements, Steel Elements, Structural Joints; Theories and concepts of both concrete and steel design and analysis both at the element and system levels. Approximate Analysis Methods as a Basis for Design

Module 5: System Design Concepts

Special Topics that may be Covered as Part of the Design Project Discussions; Cable Structures; Prestressed Concrete Bridges; Constructability and Structural Control; Fire Protection

Module 6: Analysis of Indeterminate Structures

Degree of kinematic indeterminacy, degree of freedom, Analysis of beams and portal frames by Slope Deflection Method, Moment Distribution Method and Kani's method.

Text/Reference Books:

1. Nilson, A. H. *Design of Concrete Structures.* 13th edition. McGraw Hill, 2004
2. Mc Cormac, J.C., Nelson, J.K. Jr., *Structural Steel Design*. 3rd edition. Prentice Hall, N.J., 2003.
3. Galambos, T.V., Lin, F.J., Johnston, B.G., *Basic Steel Design with LRFD*, Prentice Hall,1996
4. Segui, W. T., *LRFD Steel Design*, 2nd Ed., PWS Publishing, Boston.
5. Salmon, C.G. and Johnson, J.E., *Steel Structures: Design and Behavior*, 3rd Edition, Harper & Row, Publishers, New York, 1990.
6. Mac Gregor, J. G., *Reinforced Concrete: Mechanics and Design*, 3rd Edition, Prentice Hall, New Jersey,1997.
7. Nawy, E. G., *Reinforced Concrete: A Fundamental Approach*, 5th Edition, Prentice Hall, New Jersey.
8. Wang C-K. and Salmon, C. G., *Reinforced Concrete Design*, 6th Edition, Addison Wesley, New York.
9. Nawy, E. G. *Prestressed Concrete: A Fundamental Approach*, Prentice Hall, NJ, (2003).
10. Related Codes of Practice of BIS
11. Smith, J. C., *Structural Analysis*, Harpor and Row, Publishers, New York.
12. W. McGuire, R. H. Gallagher and R. D. Ziemian. "Matrix Structural Analysis", 2nd Edition, John Wiley and Sons,2000.
13. NBC, *National Building Code*, BIS(2017).
14. ASCE, *Minimum Design Loads for Buildings and Other Structures, ASCE 7-02*, American Society of Civil Engineers, Virginia, 2002.
15. Wang C.K. "Indeterminate Structural Analysis", McGraw Hill
16. Reddy C.S. "Basic Structural Analysis"
17. Dr. Punmia B.C., "Strength of Materials", Vol-II, Standard Publishers.
18. Jain A.K. "Advanced Structural Analysis", Nem Chand Bros., Roorkee.

Outcomes:

- The students will be able to apply their knowledge of structural mechanics in addressing design problems of structural engineering
- They will possess the skills to solve problems dealing with different loads and concrete and steel
- They will have knowledge in structural engineering

CE 354; CE 354P	Geotechnical Engineering -I	2L:1T:3P	4.5 credits

Module 1: Introduction–

Types of soils, their formation and deposition, Definitions: soil mechanics, soil engineering, rock mechanics, geotechnical engineering. Scope of soil engineering. Comparison and difference between soil and rock. Basic Definitions and Relationships- Soil as three-phase system in terms of weight, volume, voids ratio, and porosity. Definitions: moisture content, unit weights, degree of saturation, voids ratio, porosity, specific gravity, mass specific gravity, etc. Relationship between volume weight, voids ratio- moisture content, unit weight- percent air voids, saturation- moisture content, moisture content- specific gravity etc. Determination of various parameters such as: Moisture content by oven dry method, pycnometer, sand bath method, torsional balance method, nuclear method, alcohol method and sensors. Specific gravity by density bottle method, pycnometer method, measuring flask method. Unit weight by water displacement method, core-cutter method, sand-replacement method, Particle size distribution.

On completion of this module, the students must be able to:

- Understand the different types of soil based on their formation mechanism;
- Understand the various phase diagrams and derive various phase relationships of the soil;
- Perform various laboratory experiments to determine moisture content, specific gravity;
- Perform field experiments to estimate the field density of the soil mass.

Module 2: Plasticity Characteristics of Soil-
Introduction to definitions of: plasticity of soil, consistency limits-liquid limit, plastic limit, shrinkage limit, plasticity, liquidity and consistency indices, flow & toughness indices, definitions of activity and sensitivity. Determination of: liquid limit, plastic limit and shrinkage limit. Use of consistency limits. Classification of Soils-Introduction of soil classification: particle size classification, textural classification, unified soil classification system, Indian standard soil classification system. Identification: field identification of soils, general characteristics of soil in different groups.

On completion of this module, the students must be able to:

- Understand the behaviour of soils based on their moisture contents;
- Perform laboratory experiments to estimate various Atterberg limits and evaluate index properties of soils;
- Classify any soils based on their particle size distribution and index properties;

Module 3: Permeability of Soil-
Darcy's law, validity of Darcy's law. Determination of coefficient of permeability: Laboratory method: constant-head method, falling-head method. Field method: pumping-in test, pumping- out test. Permeability aspects: permeability of stratified soils, factors affecting permeability of soil. Seepage Analysis- Introduction, stream and potential functions, characteristics of flow nets, applications of flow nets, graphical method to plot flow nets.

On completion of this module, the student must be able to:

- Determine the permeability of soils through various laboratory and field tests;
- Analytically calculate the effective permeability of anisotropic soil mass;
- Determine the seepage quantities and pore water pressures below the ground;
- Graphically plot the equipotential lines and flow lines in a seepage flow.

Module 4: Effective Stress Principle-
Introduction, effective stress principle, nature of effective stress, effect of water table. Fluctuations of effective stress, effective stress in soils saturated by capillary action, seepage pressure, quick sand condition.

On completion of this module, the student must be able to:

- Understand the physical significance of effective stress and its relation with pore pressure;
- Plot various stress distribution diagrams along the depth of the soil mass;
- Understand the effect of capillary action and seepage flow direction on the effective stress at a point in the soil mass.

Module 5: Compaction of Soil-
Introduction, theory of compaction, laboratory determination of optimum moisture content and maximum dry density. Compaction in field, compaction specifications and field control.

On completion of this module, the student must be able to:

- Perform laboratory test to determine the maximum dry density and optimum moisture content of the soil;
- Variation in compaction curve with compaction effort and soil type;
- Determine the compactive effort required to obtain necessary degree of compaction in-situ;
- Differentiate among various field methods of compaction and their usage based on the type of soil.

Module 6: Stresses in soils –

Introduction, stresses due to point load, line load, strip load, uniformly loaded circular area, rectangular loaded area. Influence factors, Isobars, Boussinesq equation, Newmark's Influence Chart. Contact pressure under rigid and flexible area,

On completion of this module, the student must be able to:

- Analytically compute the vertical stress in a semi-infinite soil mass due to various loading conditions;
- Plot isobars due various loading conditions.

Module 7: Consolidation of Soil -

Introduction, comparison between compaction and consolidation, initial, primary & secondary consolidation, spring analogy for primary consolidation, interpretation of consolidation test results, Terzaghi's theory of consolidation, final settlement of soil deposits, computation of consolidation settlement and secondary consolidation.

On completion of this module, the student must be able to:

- Understand the basic mechanism of consolidation of soil;
- Determine various consolidation parameters of soil through laboratory test;
- Evaluate ground settlements against time.

Module 8: Shear Strength-

Mohr circle and its characteristics, principal planes, relation between major and minor principal stresses, Mohr-Coulomb theory, types of shear tests: direct shear test, merits of direct shear test, triaxial compression tests, test behaviour of UU, CU and CD tests, pore-pressure measurement, computation of effective shear strength parameters, unconfined compression test, vane shear test

On completion of this module, the student must be able to:

- Determine graphically and analytically the stress state in any plane of the soil mass;
- Perform various shear strength tests and appreciate the different field conditions which they simulate;
- Understand the significance of shear strength parameters in various geotechnical area;
- Evaluate the stiffness of soil using shear strength parameters

Practical Work: List of tests on-

1. Field Density using Core Cutter method.
2. Field Density using Sand replacement method.
3. Natural moisture content using Oven Drying method.
4. Specific gravity of Soils.
5. Grain size distribution by Sieve Analysis.
6. Grain size distribution by Hydrometer Analysis.
7. Consistency limits tests –Liquid limit and Plastic limit
8. Consistency limits test- Shrinkage limit.
9. Permeability test using Constant-head test method.

10. Permeability test using Falling-head method.
11. Compaction test: Standard Proctor test.
12. Compaction test: Modified Proctor test.
13. Relative density.
14. Consolidation Test.
15. Triaxial Test(UU)
16. Vane shear test
17. Direct Shear Test
18. Unconfined Compression Strength Test.

Text/Reference Books:

1. Soil Mechanics by Craig R.F., Chapman &Hall
2. Fundamentals of Soil Engineering by Taylor, John Wiley &Sons
3. An Introduction to Geotechnical Engineering, by Holtz R.D. and Kovacs, W.D., Prentice Hall, NJ
4. Principles of Geotechnical Engineering, by Braja M. Das, Cengage Learning
5. Principles of Foundation Engineering, by Braja M. Das, Cengage Learning
6. Essentials of Soil Mechanics and Foundations: Basic Geotechnics by David F. Mc Carthy
7. Soil Mechanics in Engineering Practice by Karl Terzaghi, Ralph B. Peck, and Gholamreza Mesri.
8. Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering (Civil and Environmental Engineering) by V.N.S. Murthy

CE 355	Hydrology and Water Resources Engineering	3L:0T:0P	3 credits

Module 1: Introduction-
Hydrologic cycle, water-budget equation, applications in engineering.

Module 2: Precipitation:
Forms of precipitation, measurement of precipitation, rain gauge network, mean precipitation over an area, depth-area-duration relationships, maximum intensity/depth-duration-frequency relationship, Probable Maximum Precipitation (PMP).

Module 3: Abstractions from precipitation:
Evaporation process, evaporimeters, analytical methods of evaporation estimation, evapotranspiration, measurement of evapotranspiration, evapotranspiration equations, Interception, depression storage, infiltration, infiltration capacity, measurement of infiltration, classification of infiltration capacities, infiltration indices.

Module 4: Runoff:
Runoff volume, SCS-CN method of estimating runoff volume, flow-duration curve, flow-mass curve, hydrograph, factors affecting runoff hydrograph, components of hydrograph, base flow separation, effective rainfall, unit hydrograph.

Module 5: Ground water and well hydrology:
Aquifer, aquifer properties, geologic formations of aquifers, well hydraulics: steady state flow in wells, equilibrium equations for confined and unconfined aquifers, aquifer tests.

Module 6: Water withdrawals and uses:
Water for agriculture, water for hydroelectric generation; flood control. Water requirement of crops-Crops and cropping pattern, duty and delta; Quality of irrigation water; Soil-water relationships, root zone soil water, infiltration, consumptive use, irrigation requirement, frequency of irrigation; Methods of applying water to the fields: surface, sub-surface, sprinkler and trickle / drip irrigation.

Module 7: Distribution systems:
Canal systems, alignment of canals, canal losses, estimation of design discharge. Design of channels- rigid boundary channels, alluvial channels, Kennedy's and Lacey's theory of regime channels. Water logging: causes, effects and remedial measures. Lining of canals, types of lining.

Module 8: Dams and spillways-
Embankment dams: Classification, design considerations, estimation and control of seepage, slope protection. Gravity dams: forces on gravity dams, causes of failure, stress analysis, elementary and practical profile. Arch and buttress dams. Spillways: components of spillways, types of spillwaygates.

Text/Reference Books:

1. K Subramanya, Engineering Hydrology, Mc-Graw Hill.
2. K N Muthreja, Applied Hydrology, Tata Mc-Graw Hill.
3. K Subramanya, Water Resources Engineering through Objective Questions, Tata McGraw Hill.
4. G L Asawa, Irrigation Engineering, Wiley Eastern
5. L W Mays, Water Resources Engineering, Wiley.
6. J D Zimmerman, Irrigation, John Wiley &Sons
7. C S P Ojha, R Berndtsson and P Bhunya, Engineering Hydrology, Oxford.

Outcomes:
At the end of the course, students must be in a position to:

- Understand the interaction among various processes in the hydrologic cycle
- Apply the application of fluid mechanics and use of computers in solving a host of problems in hydraulic engineering
- Study types and classes of hydrologic simulation models and design procedures for safe and effective passage of flood flows for design of hydraulic structures
- Understand the basic aquifer parameters and estimate groundwater resources for different hydro-geological boundary conditions
- Understand application of systems concept, advanced optimization techniques to cover the socio-technical aspects in the field of water resources
- Apply the principles and applications of remote sensing, GPS and GIS in the context to hydrological extreme flood and drought events in water resources engineering.

CE 356	Transportation Engineering – I	2L:1T:0P	3 credits

Module 1: Highway development and planning-
Classification of roads, road development in India, Current road projects in India; highway alignment and project preparation.

Module 2: Geometric design of highways-
Introduction; highway cross section elements; sight distance, design of horizontal alignment; design of vertical alignment; design of intersections, problems

Module 3: Traffic engineering & control-
Traffic Characteristics, traffic engineering studies, traffic flow and capacity, traffic regulation and control; design of road intersections; design of parking facilities; highway lighting; problems

Module 4: Pavement materials-
Materials used in Highway Construction- Soils, Stone aggregates, bituminous binders, bituminous paving mixes; Portland cement and cement concrete: desirable properties, tests, requirements for different types of pavements Problems

Module 5: Design of pavements-
Introduction; flexible pavements, factors affecting design and performance; stresses in flexible pavements; design of flexible pavements as per IRC; rigid pavements-components and functions; factors affecting design and performance of CC pavements; stresses in rigid pavements; design of concrete pavements as per IRC; problems

Text/Reference Books:

1. Khanna, S.K., Justo, C.E.G and Veeraragavan, A, 'Highway Engineering', Revised 10th Edition, Nem Chand & Bros, 2017
2. Kadiyalai, L.R., ' Traffic Engineering and Transport Planning', Khanna Publishers.
3. Partha Chakraborty, ' Principles of Transportation Engineering, PHI Learning,
4. Fred L. Mannering, Scott S. Washburn, Walter P. Kilareski, 'Principles of Highway Engineering and Traffic Analysis', 4th Edition, John Wiley
5. Srinivasa Kumar, R, Textbook of Highway Engineering, Universities Press, 2011.
6. Paul H. Wright and Karen K. Dixon, Highway Engineering, 7th Edition, Wiley Student Edition, 2009.

On completion of the course, the students will be able to:

- carry out surveys involved in planning and highway alignment
- design the geometric elements of highways and expressways
- carry out traffic studies and implement traffic regulation and control measures and intersection design
- characterize pavement materials and Job mix design
- design flexible and rigid pavements as per IRC

THIRD YEAR
SIXTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	CE 361	Construction Engineering & Management	2	1	0	70	30	-	100	3
2.	CE 362	Design of Concrete Structures	3	1	0	70	30	-	100	4
3.	CE 363	Design of Steel Structures	3	0	0	70	30	-	100	3
4.	CE 364	Environmental Engineering	2	1	0	70	30	-	100	3
5.	CE 365	Software Applications in Civil Engineering	3	0	0	70	30	-	100	3
6.	CE 366	Elective-I	3	0	0	70	30	-	100	*3*
		SUB-TOTAL	***16***	***3***	***0***				***600***	***19***
		PRACTICAL/DESIGN								
7.	CE 364P	Environmental Engineering Lab	0	0	3	-	30	70	100	1.5
8.	CE 367P	Transportation Engineering Lab	0	0	3	-	30	70	100	1.5
		SUB-TOTAL	***0***	***0***	***6***				***200***	***3***
		MANDATORY COURSE								
9.	NC 361	Constitution of India	3	0	0		50*			`
		TOTAL	**19**	**3**	**6**				**800**	**22**

CE 361	Construction Engineering & Management	2L:1T:0P	3 credits

Module 1: Basics of Construction-

Unique features of construction, construction projects- types and features, phases of a project, agencies involved and their methods of execution;

Module 2: Construction project planning-

Stages of project planning: pre-tender planning, pre- construction planning, detailed construction planning, role of client and contractor, level of detail. Process of development of plans and schedules, work break-down structure, activity lists, assessment of work content, concept of productivities, estimating durations, sequence of activities, activity utility data; Techniques of planning- Bar charts, Gantt Charts. Networks: basic terminology, types of precedence relationships, preparation of CPM networks: activity on link and activity on node representation, computation of float values, critical and semi critical paths, calendaring networks. PERT- Assumptions underlying PERT analysis, determining three time estimates, analysis, slack computations, calculation of probability of completion.

Module 3: Construction Methods basics-

Types of foundations and construction methods; Basics of Formwork and Staging; Common building construction methods (conventional walls and slabs; conventional framed structure with block work walls; Modular construction methods for repetitive works; Precast concrete construction methods; Basics of Slip forming for tall structures; Basic construction methods for steel structures; Basics of construction methods for Bridges.

Module 4: Construction Equipment basics-

Conventional construction methods Vs Mechanized methods and advantages of latter; Equipment for Earthmoving, Dewatering; Concrete mixing, transporting & placing; Cranes, Hoists and other equipment for lifting; Equipment for transportation of materials. Equipment Productivities

Module 5: Planning and organizing construction site and resources-
Site: site layout including enabling structures, developing site organization, Documentation at site; Manpower: planning, organizing, staffing, motivation; Materials: concepts of planning, procurement and inventory control; Equipment: basic concepts of planning and organizing; Funds: cash flow, sources of funds; Histograms and S-Curves. Earned Value; Resource Scheduling- Bar chart, line of balance technique, resource constraints and conflicts; resource aggregation, allocation, smoothening and leveling. Common Good Practices in Construction

Module 6: Project Monitoring & Control-
Supervision, record keeping, periodic progress reports, periodical progress meetings. Updating of plans: purpose, frequency and methods of updating. Common causes of time and cost overruns and corrective measures. Basics of Modern Project management systems such as Lean Construction; Use of Building Information Modelling (BIM) in project management; Quality control: concept of quality, quality of constructed structure, use of manuals and checklists for quality control, role of inspection, basics of statistical quality control. Safety, Health and Environment on project sites: accidents; their causes, effects and preventive measures, costs of accidents, occupational health problems in construction, organizing for safety and health.

Module 7: Contracts Management basics-
Importance of contracts; Types of Contracts, parties to a contract; Common contract clauses (Notice to proceed, rights and duties of various parties, notices to be given, Contract Duration and Price. Performance parameters; Delays, penalties and liquidated damages; Force Majeure, Suspension and Termination. Changes & variations, Dispute Resolution methods.

Module 8: Construction Costs-
Make-up of construction costs*;* Classification of costs, time-cost trade-off in construction projects, compression and decompression.

Text/Reference Books:

1. Varghese, P.C., "Building Construction", Prentice Hall India, 2007.
2. National Building Code, Bureau of Indian Standards, New Delhi, 2017.
3. Chudley, R., Construction Technology, ELBS Publishers, 2007.
4. Peurifoy, R.L. Construction Planning, Methods and Equipment, McGraw Hill,2011
5. Nunnally, S.W. Construction Methods and Management, Prentice Hall, 2006
6. Jha, Kumar Neeraj., Construction Project management, Theory & Practice, Pearson Education India, 2015
7. Punmia, B.C., Khandelwal, K.K., Project Planning with PERT and CPM, Laxmi Publications, 2016.

S.No	Module	Tutorials
1	Construction Planning	Develop a WBD structure for the construction of one storeyed building; Develop a bar chart for the construction of this building, including finishing activities, assuming reasonable activity durations.
2	Construction Methods basics	Develop a CPM chart for a 5 span bridge on open foundations. Develop a comparative table for a 10- storeyed building constructed by at least three different methods, listing their pros and cons.

3	Construction Equipment Basics	Develop a Gantt Chart for the construction of a two storeyed precast framed structure, including open foundations, along with list of equipment resources, assuming reasonable quantities and productivities. Develop a bar chart for concreting 1500 sq.m. of a 15cm. thick slab using various equipment for production to placing of concrete at 3m height above ground level; show all equipment resources required, along with a site layout.
4	Planning and Organizing Construction Site and Resources	For the construction of a typical 3 storeyed, framed structure with 400 sq.m. area per floor develop the histograms for the various resources required, showing all intermediate calculations; also, draw S-curves for concrete placing and block work done over the period.
5	Project Monitoring and Control	Write a 500-word note on the advantages of Lean Construction method over conventional project management systems. Write a 500-word note on the Safety and Health precautions you would take for a typical 3 storeyed building with 400 sq. m. plinth area.
6	Contract Management basics	Assuming a 4 month delay in a construction contract of 24 months duration, form 3 groups for arguing the case for or against levying penalty on the contractor; Group A to formulate the contract conditions, Group B to act as Client and Group C to act as the Contractor. One person to act as Arbitrator/ Judge.
7	Construction Costs	Refer to a Standard Schedule of Rates of any PWD (available on the Net), develop the approximate cost of a 3 storey, 400 sqm plinth area building.

On completion of the course, the students will have:

- An idea of how structures are built and projects are developed on the field
- An understanding of modern construction practices
- A good idea of basic construction dynamics- various stakeholders, project objectives, processes, resources required and project economics
- A basic ability to plan, control and monitor construction projects with respect to time and cost
- An idea of how to optimise construction projects based on costs
- An idea how construction projects are administered with respect to contract structures and issues.
- An ability to put forward ideas and understandings to others with effective communication processes

CE 362	Design of Concrete Structures	3L:1T:0P	4 credits

Course Outcomes (COs): At the end of the course, the students will be able to-

CO-1 Explain the principles and design philosophies of reinforced concrete structures
CO-2 Explain serviceability conditions for design of concrete elements.
CO-3 Explain design of beams for shear, torsion and bond
CO-4 Design reinforced concrete elements of beams, slabs, lintels and staircases.
CO-5 Design reinforced concrete flat slabs
CO-6 Design reinforced concrete columns, footings and cantilever retaining walls,

Module 1: Material Properties and Design Philosophies
Properties of concrete and reinforcing steel, characteristic strengths, stress-strain specifications, Working stress, ultimate strength and limit states of design.

Module 2: Analysis and Design of Sections in Bending
Flexure of beams by working stress and limit state methods, singly and doubly reinforced sections, T and L sections.

Module 3: Shear, Bond and Serviceability
Behaviour of beams in shear and bond, design for shear, anchorage and splicing of reinforcement, detailing of reinforcement, Limit states of deflection and cracking, calculation of deflections.

Module 4: Design of Columns
Short and long columns, eccentrically loaded columns.

Module 5: Slabs, Lintels & Staircases
Design of one way and two way slabs; circular slabs, yield line theory for slabs, beam and slab construction, lintels andstaircases, Introduction to flat slabs.

Module 6: Design for Torsion
Design of beams for torsion, design for combined shear, bending moment and torsion

Module 7: Column Footings
Types of footings, Design of Isolated and combined column footings.

Suggested Text Books &References:

1. Dayaratnam P. "Reinforced Concrete Structures', Oxford and IBH Publishing Co.
2. Sinha, S.N., "Reinforced Concrete Design", Tata McGraw Hill Pub. Co., New Delhi.
3. Krishna, J. and Jain O.P. "Plain and Reinforced Concrete", Vol. I, Nem Chand & Bros., Roorkee.
4. Jain, A.K. "Reinforced Concrete – Limit State Design", Nem Chand & Bros., Roorkee.
5. Ram Chandra, "Design of Concrete Structures", Vol. – I, Standard book House, New Delhi.
6. Punmia B.C. "Reinforced Concrete Design", Vol.-I.

CE 363	Design of Steel Structures	3L:0T:0P	3 credits

Course Outcomes: After the completion of the course students will be able to:

CO-1: Design of riveted, bolted and welded connections as per I.S Code

CO-2: Design of tension members as per I.S Code

CO-3: Design of compression members including lacings and battens.
CO-4: Design of flexural members considering both laterally supported and unsupported conditions
CO-5: Design of various types of steel structures and their components.

Module 1: Introduction and design of connections
Structural Steel Sections and their properties, Methods of Design, Riveted, Bolted and Welded connections.

Module 2: Tension members
Types of Tension members, Design of Tension members, Riveted and Welded, Slenderness Ratio, Angles, Gusset Plate.

Module 3: Compression members
Types of compression members, Column Design, Struts and Columns, lacing and battens.

Module 4: Flexural members
Design of Flexural Members considering both laterally supported and unsupported conditions, Rolled and Built-Up Section, Purlins and Gantry Girders

Module 5:
Column Bases, Tubular Structure, Roof Truss Design.

Module 6:
Introduction to Bridge Design, Tank Design, Tower Design

Suggested Text Book & References:
1. S.K. Duggal, "Design of Steel Structures", By Limit State Method as per IS:800-2007
2. S.S. Bhavikatti, "Design of Steel Structures", By Limit State Deiju
3. N. Subramanian, "Design of Steel Structures"
4. IS Code 800 : 2007
5. Steel Table

CE 364; CE 364P	Environmental Engineering	2L:1T:3P	4.5 credits

Module 1: **Water-**
Sources of Water and quality issues, water quality requirement for different beneficial uses, Water quality standards, water quality indices, water safety plans, Water Supply systems, Need for planned water supply schemes, Water demand industrial and agricultural water requirements, Components of water supply system; Transmission of water, Distribution system, Various valves used in W/S systems, service reservoirs and design.
Water Treatment: aeration, sedimentation, coagulation flocculation, filtration, disinfection, advanced treatments like adsorption, ion exchange, membrane processes

Module 2: Sewage-
Domestic and Storm water, Quantity of Sewage, Sewage flow variations. Conveyance of sewage- Sewers, shapes design parameters, operation and maintenance of sewers, Sewage pumping; Sewerage, Sewer appurtenances, Design of sewerage systems. Small bore systems, Storm Water- Quantification and design of Storm water; Sewage and Sullage, Pollution due to improper disposal of sewage, National River cleaning plans, Wastewater treatment, aerobic and anaerobic treatment systems, suspended and attached growth systems, recycling of sewage – quality requirements for various purposes.

Module 3: Air -
Composition and properties of air, Quantification of air pollutants, Monitoring of air pollutants, Air pollution- Occupational hazards, Urban air pollution automobile pollution, Chemistry of combustion, Automobile engines, quality of fuel, operating conditions and interrelationship. Air quality standards, Control measures for Air pollution, construction and limitations

Module 4: Noise-
Basic concept, measurement and various control methods.

Module 5: Solid waste management-
Municipal solid waste, Composition and various chemical and physical parameters of MSW, MSW management: Collection, transport, treatment and disposal of MSW. Special MSW: waste from commercial establishments and other urban areas, solid waste from construction activities, biomedical wastes, Effects of solid waste on environment: effects on air, soil, water surface and ground health hazards. Disposal of solid waste-segregation, reduction at source, recovery and recycle. Disposal methods- Integrated solid waste management. Hazardous waste: Types and nature of hazardous waste as per the HW Schedules of regulating authorities.

Module 6: Building Plumbing-
Introduction to various types of home plumbing systems for water supply and waste water disposal, high rise building plumbing, Pressure reducing valves, Break pressure tanks, Storage tanks, Building drainage for high rise buildings, various kinds of fixtures and fittings used.

Module 7: Government authorities and their roles in water supply, sewerage disposal. Solid waste management and monitoring/control of environmental pollution.

Practical Work: List of Experiments:
1. Physical Characterization of water: Turbidity, Electrical Conductivity, pH
2. Analysis of solids content of water: Dissolved, Settleable, suspended, total, volatile, inorganic etc.
3. Alkalinity and acidity, Hardness: total hardness, calcium and magnesium hardness
4. Analysis of ions: copper, chloride ands ulfate
5. Optimum coagulant dose
6. Chemical Oxygen Demand(COD)
7. Dissolved Oxygen (D.O) and Biochemical Oxygen Demand(BOD)
8. Break point Chlorination
9. Bacteriological quality measurement: MPN,
10. Ambient Air quality monitoring (TSP, RSPM, SOx, NOx)
11. Ambient noise measurement

Text/Reference Books:

1. Introduction to Environmental Engineering and Science by Gilbert Masters, Prentice Hall, New Jersey.
2. Introduction to Environmental Engineering by P. Aarne Vesilind, Susan M. Morgan, Thompson /Brooks/Cole; Second Edition 2008.
3. Peavy, H.s, Rowe, D.R, Tchobanoglous, G. *Environmental Engineering*, Mc-Graw - Hill International Editions, New York1985.
4. Met Calf and Eddy. *Wastewater Engineering, Treatment, Disposal and Reuse*, Tata McGraw- Hill, New Delhi.
5. Manual on Water Supply and Treatment. Ministry of Urban Development, New Delhi.
6. Plumbing Engineering. Theory, Design and Practice, S.M. Patil,1999
7. Integrated Solid Waste Management, Tchobanoglous, Theissen & Vigil. McGraw Hill Publication
8. Manual on Sewerage and Sewage Treatment Systems, Part A, B and C. Central Public Health and Environmental Engineering Organization, Ministry of Urban Development.

Outcomes:
After successfully studying this course, students will:

- Understand the impact of humans on environment and environment on humans
- Be able to identify and value the effect of the pollutants on the environment: atmosphere, water and soil.
- Be able to plan strategies to control, reduce and monitor pollution.
- Be able to select the most appropriate technique for the treatment of water, wastewater solid waste and contaminated air.
- Be conversant with basic environmental legislation.

CE 365	Software Applications in Civil Engineering	3L:0T:0P	3 credits

Course Objectives:
Students are introduced to:

- All kinds of software packages available in various fields of civil engineering.
- Proficiency in applications of these software packages.
- Practical use of software results and their validation by relating them with analytical results by conventional methods

Module 1
General Importance and need of software for modeling, analysis and design in Civil Engineering field, Advantages and limitations of software, causes for errors, validation of software results. Failures due to errors in modeling, data entry and interpretation of software results.

Module 2
Software application in various disciplines of Civil Engineering: Learning and practice of any one software from at least any 4 domain from 14 domain

1. Drafting and drawing: AutoCAD, Civil 3D, Auto plotter, Design and detailing of same using AutoCAD Beams (simply supported, continuous etc), Slabs (one way, two way), Columns, Portal frame, Truss
2. Building information modelling: Revit and archicad, tekla , Navis works, Trimble, AECOsim Building designer , Sketch up
3. Numerical Analysis and Mathematical operations: MATLAB Scilab
4. Structural Analysis and Design: STAAD Pro, ETABS, SAP 2000, SAFE, MIDAS.
5. Finite Element Analysis: ANSYS, ABAQUS, NISA
6. Project Management: Primavera, MS Project
7. Geotechnical Engineering: Geo studio, PLAXIS
8. Quantity Surveying: QS red, CCS Candy
9. Environmental Engineering: Storm CAD, EPANET, Sewer CAD
10. Remote Sensing and Geographical Information System: QGIS, GRAM++, Arc GIS
11. Transportation Engineering: MX Road, HDM, Road estimator
12. Hydraulics and Water Resources Engineering: Water Gems, Water CAD, Flow Master, Culvert Master, Nero solution, Discipulus, HEC-RAS, Arc SWAT, Hydrology: HEC, HMS
13. Different Open source software used for specific problems
14. MS Excel: Conduct concrete mix design for M40 grade concrete or any exercise of Civil Engineering domain.

Term Work

A group of 3-4 students will prepare and give detailed power point presentation on any one software. Presentation should cover salient features, capability of software and should contain some applications from field. The term work shall comprise of:

- At least hands-on working on one Software from any four domain listed above and preparing report of the same.
- Presentation Report on any one software
- Open Source Software report (optional)

Distribution of the Term Work Marks The marks of the term work shall be judiciously awarded depending upon the quality of the term work. The final certification and acceptance of term work warrants the satisfactory and appropriate completion of the design report/ assignments and the minimum passing marks to be obtained by the students. The following weightage of marks shall be given for different components of the term work:

- Software Report : 16 marks
- Presentation : 4 marks
- Attendance : 5 marks

Further, while giving weightage of marks on the attendance, the following guidelines should be resorted to:

- 75%-80% : 03 marks;
- 81%-90% : 04 marks;
- 91%-100% : 05 marks

Recommended Readings:

1. Software manuals
2. Refereed Journal papers on Software applications.

NPTEL course like MATLAB programming for numerical computation by Dr. Niket Kaisare from IIT Madras and so on for other softwares.

CE 366	**Elective -1**	**3L:0T:0P**	**3 credits**

Students will select subjects from the basket of professional electives from **Annexure-II**

CE 367P	**Transportation Engineering Lab**	**0L:0T:3P**	**1.5 credits**

Practical Work: List of tests on-

1. CBR test on soil
2. Field compaction test
3. Impact test on aggregates.
4. Crushing test on aggregates.
5. Hardness test on aggregates.
6. Soundness test on aggregates.
7. Shape test on aggregates.
8. Specific gravity on aggregates.

9. Penetration test on bitumen.
10. Ductility test on bitumen.
11. Softening point test on bitumen.
12. Viscosity test on Tar.
13. Flash and fire point on bitumen.
14. Specific gravity test on bitumen.
15. Benkelman Beam pavement deflection test
16. Tests on unmodified bitumen and modified bitumen with polymers
17. Bituminous mix design and tests on bituminous mix-Marshall method
18. Road roughness test using Bump Integrator

NC 361	Constitution of India	3L:0T:0P	0 credits

Constitution of India – Basic features and fundamental principles

The Constitution of India is the supreme law of India. Parliament of India cannot make any law which violates the Fundamental Rights enumerated under the Part III of the Constitution. The Parliament of India has been empowered to amend the Constitution under Article 368, however, it cannot use this power to change the "basic structure" of the constitution, which has been ruled and explained by the Supreme Court of India in its historical judgments. The Constitution of India reflects the idea of "Constitutionalism" – a modern and progressive concept historically developed by the thinkers of "liberalism" – an ideology which has been recognized as one of the most popular political ideology and result of historical struggles against arbitrary use of sovereign power by state. The historic revolutions in France, England, America and particularly European Renaissance and Reformation movement have resulted into progressive legal reforms in the form of "constitutionalism" in many countries. The Constitution of India was made by borrowing models and principles from many countries including United Kingdom and America.

The Constitution of India is not only a legal document but it also reflects social, political and economic perspectives of the Indian Society. It reflects India's legacy of "diversity". It has been said that Indian constitution reflects ideals of its freedom movement; however, few critics have argued that it does not truly incorporate our own ancient legal heritage and cultural values. No law can be "static" and therefore the Constitution of India has also been amended more than one hundred times. These amendments reflect political, social and economic developments since the year 1950. The Indian judiciary and particularly the Supreme Court of India has played an historic role as the guardian of people. It has been protecting not only basic ideals of the Constitution but also strengthened the same through progressive interpretations of the text of the Constitution. The judicial activism of the Supreme Court of India and its historic contributions has been recognized throughout the world and it gradually made it "as one of the strongest court in the world".

Contents:

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the fundamental rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy – Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India
9. Amendment of the Constitutional Powers and Procedure

10. The historical perspectives of the constitutional amendments in India
11. Emergency Provisions : National Emergency, President Rule, Financial Emergency
12. Local Self Government – Constitutional Scheme in India
13. Scheme of the Fundamental Right to Equality
14. Scheme of the Fundamental Right to certain Freedom under Article 19
15. Scope of the Right to Life and Personal Liberty under Article 21.

FOURTH YEAR
SEVENTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	CE 471	Geotechnical Engineering-II	3	0	0	70	30	-	100	3
2.	CE 472	Transportation Engineering-II	3	0	0	70	30	-	100	3
3.	CE 473	Engineering Economics, Estimation & Costing	2	1	0	70	30	-	100	3
4.	CE474	Open Elective-I	3	0	0	70	30	-	100	3
		SUB-TOTAL	***11***	***1***	***0***				***400***	***12***
		PRACTICAL/DESIGN								
5.	CE473P	Estimation & Costing Practice	0	0	4	-	30	70	100	2
6.	CE 475P	Project-1 (Project work and seminar)	0	0	12	-	100	200	300	3
7.	CE276P	Internship in industry or at appropriate work place (Not less than 2-weeks)	-	-	-	-	100	-	100	1
8.		*SUB-TOTAL*	***0***	***0***	***16***				***500***	***6***
		SUB-TOTAL								
		TOTAL	**11**	**1**	**16**				**900**	**18**

CE 471	Geotechnical Engineering -II	3L:0T:0P	3 credits

Course Outcomes: After the completion of the course students will be able to: -

CO-1 Plan soil investigation.
CO-2 Analyze the stability of earth retaining structures.
CO-3 Calculate bearing capacity of shallow and pile foundations.
CO-4 Calculate settlement of shallow and pile foundations.
CO-5 Analyze stability of slopes
CO-6 Analyze response of block foundations under vertical vibrations

Module 1: Earth Pressure and Retaining Structures
Earth pressure at rest, Active and passive earth pressure computations using Rankine's and Coulomb's earth pressure theories, Culmann's graphical construction; Additional earth pressure due to surcharge and earthquake loading. Stability analysis for retaining walls. Choice of backfill material and importance of drainage.

Module 2: Foundations
Common types of foundations with examples. Brief illustration of situations where each one of them is adopted. Basis for design.

(a) Shallow Foundations
Types and their selection, Terminology; Bearing capacity-Terzaghi's equation; Computation of bearing capacity In cohesionless and cohesive soils, Effect of various factors on bearing capacity; Use of field test data. Settlement Components of settlement; Limits of settlement; Streses in soil below loaded areas; Bossiness equation for vertical stress; Concept of pressure bulb; Newmark chart; Estimation of settlement of footings and rafts on sand using penetration and load test data; Estimation of settlement of footings/rafts on cohesive soils using consolidation test data.

(b) Pile Foundations
Situations where adopted. Types of piles, Outline of steps involved in proportioning; Bearing capacity and settlement of single and group of piles, Proportioning with field/lab. data as input.

Module 3: Soil Exploration
Purpose, Methods of soil exploration, Boring, sampling; Standard penetration test; Static and dynamic cone tests. Correlations between penetration resistance and strength parameters; Plate load test. Planning of soil investigation, Number of bore holes and depth of exploration; Types of tests to suit soil conditions.

Module 4: Embankment Slopes
Examples of embankments – Road and earth dam embankments. Modes of failure and the usual protective measures, Slope inclinations usually adopted.
Stability Analysis; Infinite slopes and the concept of factor safety, Friction circle method; Method of slices; Bishop's simplified method; Acceptable values of factor of safety; Critical conditions for the stability of earth dams, and approximate analysis.

Module 5: Introduction to Machine Foundations
Types of machines and their foundations; Terminology; Design criteria; Field methods of determining design parameters – Cyclic plate load test; Block vibration test; Response of block foundations under vertical vibrations.

Suggested Text Books & References:

1. Gopal Ranjkan and Rao A.S.R., "Basic and Applied Soil Mechanics", (Revised Edition) New Age, New Delhi.
2. Peck, R.B., Hanson, W.E. and Thornburn, W.H., "Foundation Engineering", 2nd Edition, John Wiley, New York.
3. Tomlinson, M.J., "Foundation Design and Construction", 5th Edition, ELBS, Singapore.
4. Alam Singh, "Soil Engineering in Theory and Practice", Vol. II, Asia Publishing House, New Delhi.

CE 472	Transportation Engineering -II	3L:0T:0P	3 credits

Course Outcomes: After the completion of the course, the students will be able to:

CO-1 Identify requirements of various component parts of permanent way
CO-2 Design railway track curves and gradients.
CO-3 Design points and crossings.
CO-4 Explain interlocking and modern signal systems
CO-5 Identify various component parts of harbor and dock
CO-6 Explain design considerations of various component parts of harbor and dock

Module 1: Permanent Way Component parts
Types of rail sections creep, wear and failure in rails, Rail joints, Welding of rails, SWR and LWR sleeper's requirements and types. Rail fittings, bearing plates, anti- creep devices, devices, check and guard rails. Ballast requirements, Specifications, Formation, cross section, drainage.

Module 2: Geometric Design
Alignment, horizontal curves, super elevation, equilibrium cant and cant deficiency, Length of transition curves. Gradients and grade compensation, vertical curves.

Module 3: Points and Crossing
Design of simple turn out, various types of track junction and their configurations.

Module 4: Signalling and Interlocking
Control of train movements and monitoring, types of signals, principle of interlocking, Modernisation of railways and railway tracks, High speed tracks.

Module 5: Harbours
Types of harbours, Size and accessibility, Tides, wind and wave. Dynamic effect of wave action Breakwaters and their classification, mound construction.

Module 6: Docks
Types of Docks, Shape and size, Caissons for dock entrances, Floating docks and their design considerations.

Suggested Text Books & References:

1. Aggarwal, M.M., "Railway Engineering", Student Edition, Prabha & Co., New Delhi.
2. Saxena, S.C. and Arora, S.P., "A Text Book of Railway Engineering", Dhanpat Rai & Sons.
3. Mundrey, J.S., "Railway Track Engg.", Tata McGraw Hill Publishing Company Ltd., New Delhi.
4. Track Manuals of Indian Railways.
5. Indian Railways Permanent Way Manual.
6. Gautam H. Oza and Hasmukh Pranshanker Oza, "Docks and Harbour Engineering" Charotar Publishing House Pvt. Ltd, New Delhi.

CE473; CE473P	Engineering Economics, Estimation & Costing	2L:1T:4P	5 credits

Module 1: Basic Principles and Methodology of Economics
Demand/Supply – elasticity – Government Policies and Application. Theory of the Firm and Market Structure. Basic Macro- economic Concepts (including GDP/GNP/NI/Disposable Income) and Identities for both closed and open economies. Aggregate demand and Supply (IS/LM). Price Indices (WPI/CPI), Interest rates, Direct and Indirect Taxes (**3 lectures**)

Module 2: Public Sector Economics –
Welfare, Externalities, Labour Market. Components of Monetary and Financial System, Central Bank –Monetary Aggregates; Commercial Banks & their functions; Capital and Debt Markets. Monetary and Fiscal Policy Tools & their impact on the economy – Inflation and Phillips Curve. (**2 lectures**)

Module 3: Elements of Business/Managerial Economics and forms of organizations. Cost & Cost Control –Techniques, Types of Costs, Lifecycle costs, Budgets, Break even Analysis, Capital Budgeting, Application of Linear Programming. Investment Analysis – NPV, ROI, IRR, Payback Period, Depreciation, Time value of money (present and future worth of cash flows). Business Forecasting – Elementary techniques. Statements – Cash flow, Financial. Case Study Method. (**3 lectures**)

Module 4: Indian economy -
Brief overview of post-independence period – plans. Post reform Growth, Structure of productive activity. Issues of Inclusion – Sectors, States/Regions, Groups of people (M/F), Urbanization. Employment–Informal, Organized, Unorganized, Public, Private. Challenges and Policy Debates in Monetary, Fiscal, Social, External sectors. (**2 lectures**)

Module 5: Estimation / Measurements for various items-
Introduction to the process of Estimation; Use of relevant Indian Standard Specifications for the same, taking out quantities from the given requirements of the work, comparison of different alternatives, Bar bending schedules, Mass haul Diagrams, Estimating Earthwork and Foundations, Estimating Concrete and Masonry, Finishes, Interiors, MEP works; BIM and quantity take-offs; adding equipment costs; labour costs; rate analysis; Material survey-Thumb rules for computation of materials requirement for different materials for buildings, percentage breakup of the cost, cost sensitive index, market survey of basic materials. Use of Computers in quantity surveying (**7 lectures**)

Module 6: Specifications-
Types, requirements and importance, detailed specifications for buildings, roads, minor bridges and industrial structures. **(3 lectures**)

Module 7: Rate analysis-
Purpose, importance and necessity of the same, factors affecting, task work, daily output from different equipment/ productivity. (**3lectures**)

Module 8: Tender-
Preparation of tender documents, importance of inviting tenders, contract types, relative merits, prequalification. general and special conditions, termination of contracts, extra work and Changes, penalty and liquidated charges, Settlement of disputes, R.A. Bill & Final Bill, Payment of advance, insurance, claims, price variation, etc. Preparing Bids-Bid Price buildup: Material, Labour, Equipment costs, Risks, Direct & Indirect Overheads, Profits; Bid conditions, alternative specifications; Alternative Bids. Bid process management (**6 lectures**)

Module 9: Introduction to Acts pertaining to-Minimum wages, Workman's compensation, Contracts, Arbitration, Easement rights. (**1 lecture**)

Term Work Assignments may include:
1. Deriving an approximate estimate for a multistoried building by approximate methods.
2. Detailed estimate for the following with the required material survey for the same.
   (a) Ground plus three storied RCC Framed structure building with block work walls
   (b) bridge with minimum 2 spans
   (c) factory building
   (d) roadwork
   (e) cross drainage work
   (f) Ground plus three storied building with load-bearing walls
   (g) Cost of finishes, MEP works for (f) above
3. Preparation of valuation report in standard Government form.
4. Assignments on rate analysis, specifications and simple estimates.
5. Detailed estimate of minor structure.
6. Preparation of Bar bending schedule.

Text/Reference Books:

1. Mankiw Gregory N. (2002), *Principles of Economics*, Thompson Asia
2. V. Mote, S. Paul, G. Gupta(2004), *Managerial Economics*, Tata Mc-Graw Hill
3. Misra, S.K. and Puri (2009), *Indian Economy*, Himalaya
4. Pareek Saroj (2003), *Textbook of Business Economics*, Sunrise Publishers
5. M Chakravarty, Estimating, Costing Specifications & Valuation
6. Joy P K, Handbook of Construction Management, Macmillan
7. B.S. Patil, Building & Engineering Contracts

8. Relevant Indian Standard Specifications.
9. World Bank Approved Contract Documents.
10. FIDIC Contract Conditions.
11. Acts Related to Minimum Wages, Workmen's Compensation, Contract, and Arbitration
12. Typical PWD Rate Analysis documents.
13. UBS Publishers & Distributors, Estimating and Costing in Civil Engineering: Theory and Practice including Specification and Valuations, 2016
14. Dutta, B.N., Estimating and Costing in Civil Engineering (Theory & Practice), UBS Publishers,2016

On completion of the course, the students will:

- Have an idea of Economics in general, Economics of India particularly for public sector agencies and private sector businesses
- Be able to perform and evaluate present worth, future worth and annual worth analyses on one of more economic alternatives.
- Be able to carry out and evaluate benefit/cost, life cycle and breakeven analyses on one or more economic alternatives.
- Be able to understand the technical specifications for various works to be performed for a project and how they impact the cost of a structure.
- Be able to quantify the worth of a structure by evaluating quantities of constituents, derive their cost rates and build up the overall cost of the structure.
- Be able to understand how competitive bidding works and how to submit a competitive bid proposal.

CE474	**Open Elective - I**	**3L:0T:0P**	**3 credits**

Students will select the course from the basket of open electives.

CE475P	**Project - I**	**0L:0T:12P**	**6 credits**

FOURTH YEAR
EIGHT SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				Credit
			L	T	P	Theory	Sess.	Pract.	Total	
1.	CE 481	Elective-II	3	0	0	70	30	-	100	3
2.	CE 482	Elective-III	3	0	0	70	30	-	100	3
3.	CE 483	Elective-IV	3	0	0	70	30	-	100	3
4.	CE484	Open Elective-II	3	0	0	70	30	-	100	3
		SUB-TOTAL	***12***	***0***	***0***				***400***	***12***
		PRACTICAL/DESIGN								
5.	CE485P	Project-2 (Continued from VII Semester, Project work, seminar and internship in industry or at appropriate work place)	0	0	12		100	200	300	6
		SUB-TOTAL	***0***	***0***	***12***				***300***	***6***
		TOTAL	**12**	**0**	**12**				**700**	**18**

CE 481	**Elective - II**	**3L:0T:0P**	**3 credits**

Students will select subjects from the basket of professional electives from Annexure-II

CE 482	**Elective - III**	**3L:0T:0P**	**3 credits**

Students will select subjects from the basket of professional electives from Annexure-II

CE 483	**Elective - IV**	**3L:0T:0P**	**3 credits**

Students will select subjects from the basket of professional electives from Annexure-II

CE484	**Open Elective - II**	**3L:0T:0P**	**3 credits**

Students will select the subject from the basket of open electives from Annexure-I

CE 485P	**Project - II**	**0L:0T:12P**	**6 credits**

ANNEXURE - I

OPEN ELECTIVE COURSES (OECs)

The students will have options of selecting the electives from the different tracks/threads depending on the specialization one wishes to acquire. **There should be at least two Electives from the Open Elective Course choices (OEC); the rest two can be taken from the other threads, if intended. This is provided in the following:**

Open Elective Courses [OECs]

1. Soft Skills and Interpersonal Communication
2. ICT for Development
3. Human Resource Development and Organizational Behavior
4. Cyber Law and Ethics
5. Introduction to Philosophical Thoughts
6. Comparative Study of Literature
7. Indian Music System
8. History of Science & Engineering
9. Introduction to Art and Aesthetics
10. Economic Policies in India
11. Metro Systems and Engineering
12. Subjects offered by other Departments Under Manipur University

	Metro Systems and Engineering	**3L:0T:0P**	**3 credits**

GENERAL: Overview of Metro Systems; Need for Metros; Routing studies; Basic Planning and Financials

CIVIL ENGINEERING-Overview and construction methods for: Elevated and underground Stations; Viaduct spans and bridges; Underground tunnels; Depots; Commercial and Service buildings. Initial Surveys & Investigations; Basics of Construction Planning &Management, Construction Quality & Safety Systems. Traffic integration, multimodal transfers and pedestrian facilities; Environmental and social safeguards; Track systems-permanent way. Facilities Management

ELECTRONICS AND COMMUNICATION ENGINEERING- Signaling systems; Automatic fare collection; Operation Control Centre (OCC and BCC); SCADA and other control systems; Platform Screen Doors.

MECHANICAL & TV + AC: Rolling stock, vehicle dynamics and structure; Tunnel Ventilation systems; Air conditioning for stations and buildings; Fire control systems; Lifts and Escalators

ELECTRICAL: OHE, Traction Power; Substations- TSS and ASS; Power SCADA; Standby and Back-up systems; Green buildings, Carbon credits and clear air mechanics.

ANNEXURE - II

PROFESSIONAL ELECTIVE COURSE TRACKS-
CIVIL ENGINEERING [PEC-CE]

The following Seven Mandatory Professional Specialized Tracks offer electives in the respective Tracks:

Track	Professional Core Courses (PCC-CE)
I	Transportation Engineering
II	Construction Engineering & Management
III	Environmental Engineering
IV	Hydraulics
V	Hydrology & Water Resources Engineering
VI	Structural Engineering
VII	Geotechnical Engineering

The Professional Elective Courses (PEC-CE) are shown in different tracks. *The list is suggestive. The actual list of electives will depend on the availability of faculty and their research interests*. **However, there should be courses available in each track/thread.** *On-line MOOC courses may contribute up to 20% of the credits, with in-house examination being conducted.* ***Please refer to Annexure-I of this document for key syllabus phrases for the course listed below.***

I Transportation Engineering

1. Pavement Materials
2. Pavement Design
3. Public Transportation Systems
4. Traffic Engineering and Management
5. Urban Transportation Planning.
6. Geometric Design of Highways
7. Airport Planning and Design
8. Railway Engineering
9. Intelligent Transportation Systems
10. Highway Construction and Management
11. Port and Harbour Engineering
12. High Speed Rail Engineering
13. Transportation Economics
14. Infrastructure Planning and Design

II Construction Engineering & Management

1. Construction Productivity
2. Building Construction Practice
3. Construction Project Planning & Systems
4. Construction Cost Analysis
5. Sustainable Construction Methods
6. Construction Engineering Materials.
7. Contracts Management
8. Construction Equipment & Automation
9. Repairs & Rehabilitation of Structures

III Environmental Engineering

1. Ecological Engineering
2. Environmental Systems
3. Transport of Water and Wastewater
4. Environmental Laws and Policy
5. Physico-Chemical Processes for Water and Wastewater Treatment
6. Biological Processes for Contaminant Removal
7. Rural Water Supply and Onsite Sanitation Systems
8. Water and Air Quality Modelling
9. Solid and Hazardous Waste Management
10. Air and Noise Pollution and Control
11. Environmental Impact Assessment and Life Cycle Analyses
12. Sustainable Engineering &Technology

IV Hydraulics

1. Design of hydraulic structures/Irrigation Engineering
2. Pipeline Engineering
3. Open Channel flow
4. River Engineering
5. Hydraulic modelling
6. Basics of computational hydraulics
7. Transients in closed conduits
8. Urban Hydrology and Hydraulics
9. Groundwater

V Hydrology & Water Resources Engineering

1. Water Quality Engineering
2. Surface Hydrology
3. Environmental Fluid Mechanics
4. Water Resources Field Methods

VI Structural Engineering

1. Reliability Analysis of Structures
2. Engineering Risk & Uncertainty
3. Decision and Risk Analysis
4. Engineering Materials for Sustainability
5. Concrete Materials
6. Wood Structures
7. Masonry Structures
8. Structural Analysis-I
9. Structural Analysis-II
10. Advanced Structural Analysis
11. Structural Analysis by Matrix Methods
12. Structural Mechanics
13. Reinforced Concrete
14. Concrete Technology
15. Design of Concrete Structures-I
16. Design of Concrete Structures-II
17. Prestressed Concrete
18. Design of Steel Structures
19. Metal Structure Behaviour-I
20. Metal Structure Behaviour-II
21. Bridge Engineering
22. Industrial Structures

23. Design of Structural Systems
24. Structural Dynamics
25. Earthquake Engineering
26. Civil Engineering Design-I
27. Civil Engineering Design-II
28. Geographic Information Systems and Science
29. Modelling and Analysis of Uncertainty
30. Systems Engineering &Economics

VII Geotechnical Engineering

1. Soil Mechanics-I
2. Soil Mechanics-II
3. Foundation Engineering
4. Geotechnical Design
5. Structural Geology
6. Offshore Engineering
7. Rock Mechanics
8. Environmental Geo-technology

SYLLABUS FOR BASKET OF ELECTIVE COURSES OF ELECTED TRACKS

IMPORTANT NOTE: Only keywords/topics of the course/subject is mentioned. This is in order to detail or condense as per the requirement and assign appropriate credits. Suggested credit for any course is either 2 or 3. Prerequisites are to be decided by the concerned faculty keeping in mind the track/thread/stream of courses taken by the student earlier.

Systems Engineering & Economics:
Introduction to the formulation and solution of civil engineering problems. Major topics are: engineering economy, mathematical modeling, and optimization. Techniques, including classical optimization, linear and nonlinear programming, network theory, critical path methods, simulation, decision theory, and dynamic programming are applied to a variety of civil engineering problems.

Engineering Risk & Uncertainty.
Identification and modeling of non-deterministic problems in civil engineering design and decision making. Development of stochastic concepts and simulation models and their relevance to real design and decision problems in various areas of civil engineering.

Concrete Materials.
Examines the influence of constituent materials (cements, aggregates and admixtures) on the properties of fresh and hardened concrete; Recycled aggregates recovered from construction and demolition wastes; M-Sand; Light-weight aggregates; Use of Fly Ash in concrete; Fibre-reinforced concrete with various types of metallic and non-metallic fibres; various types of concrete such as Self Compacting Concrete, High Performance Concrete, etc.; mix design; handling and placement of concrete; Effect of revibration of concrete; behavior of concrete under various types of loading and environment; test methods. Laboratory practice is an integral part of the course.

Pavement Materials. Soil -
Classification, characteristics, compaction, evaluation of soil strength; stabilized pavement materials; Aggregates: requirements, properties and tests on road aggregates for flexible and rigid pavements. Bitumen: Origin, preparation, properties and tests, constitution of bituminous road binders; requirements; Criterion for selection of different binders. Bituminous Emulsions and Cutbacks: Preparation, characteristics, uses and tests, Bituminous Mixes: Mechanical properties: Resilient modulus, dynamic modulus and fatigue characteristics of bituminous mixes. bituminous mix design methods and specifications. Weathering and Durability of Bituminous Materials and Mixes. Performance based Bitumen Specifications; Super pave mix design method: design example problems. Cement Concrete for Pavement Construction: Requirements, and design of mix for CC pavement, IRC and IS specifications and tests, joint filler and sealer materials.

Pavement Design.
Introduction: Types and component parts of pavements, Factors affecting design and performance of pavements. Highway and airport pavements. Stresses and Deflections in Flexible Pavements: Stresses and deflections in homogeneous masses. Burmister's two layer theory, three layer and multi-layer theories; wheel load stresses, various factors in traffic wheel loads; ESWL of multiple wheels. Repeated loads and EWL factors; sustained loads. Pavement behaviour under transient traffic loads. Flexible Pavement Design Methods For Highways and Airports: Empirical, semi-empirical and theoretical approaches, development, principle, design steps, advantages; design of flexible pavements as per IRC; Stresses in Rigid Pavements: Types of stresses and

causes, factors influencing the stresses; general considerations in rigid pavement analysis, EWL; wheel load stresses, warping stresses, frictional stresses, combined stresses. Rigid Pavement Design: Types of joints in cement concrete pavements and their functions, joint spacings; design of CC pavement for roads and runways as per IRC, design of joint details for longitudinal joints, contraction joints and expansion joints. IRC method of design by stress ratio method. Design of continuously reinforced concrete pavements; Maintenance, repair and rehabilitation of pavements including design of bituminous and concrete overlays as per IRC

Geometric Design of Highways:
Introduction: Classification of rural highways and urban roads. Objectives and requirements of highway geometric design; Design Controls: Topography, vehicle characteristics and design vehicle, driver characteristics, speed, traffic flow and capacity, levels of service, pedestrian and other facilities, environmental factors; Design Elements: Sight distances, Horizontal alignment - design considerations, stability at curves, super elevation, widening, transition curves; curvature at intersections, vertical alignment - grades, ramps, design of summit and valley curves, combination of vertical and horizontal alignment including design of hair pin bends, design of expressways, IRC standards and guidelines for design problems; Cross Section Elements: Right of way and width considerations, roadway, shoulders, kerbs traffic barriers, medians, frontage roads; Facilities for pedestrians, bicycles, buses and trucks, Pavement surface characteristics - types, cross slope, skid resistance, unevenness; Design Considerations: Design considerations for rural and urban arterials, freeways, and other rural and urban roads; Design Of Intersections: Characteristics and design considerations of at-grade intersections;; Rotary intersections; Grade separations and interchanges -; Design of Parking lots

Airport Planning and Design:
Aircraft characteristics; Aircraft performance characteristics: Airport planning and air travel demand forecasting: Airport Site Selection; Geometric Design of the Airfield: Determination of Runway Capacity and Delay - Taxiway and Gate Capacity - Holding Aprons - Terminal Aprons – Airport drainage - Function of Airport Passenger and Cargo Terminal - Design of Air Freight Terminals - Airport access - Airport Landside planning - Capacity; Air Traffic Management: Navigational aids: ground based systems, satellite based systems – Air traffic control and surveillance facilities – Airfield lighting - air traffic management.

Intelligent Transportation Systems:
Introduction to Intelligent Transportation Systems (ITS) – Definition of ITS and Identification of ITS Objectives, Historical Background, Benefits of ITS - ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection. Telecommunications in ITS – Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Vehicle – Road side communication – Vehicle Positioning System; ITS functional areas – Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS); ITS User Needs and Services – Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management; Automated Highway Systems - Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries.

Railway Engineering.
Railway track gauge, alignment of railway lines, engineering surveys and construction of new lines, tracks and track stresses; rails, sleepers; ballast; subgrade and formation, rack fittings and fastenings, creep of rails, geometric design of track, curves and super-elevation, points and crossings, track junctions and simple track layouts; rail joints and welding of rails; track maintenance, track drainage; modern methods of track maintenance, rehabilitation and renewal of track; tractive resistance and power, railway stations and yards; railway tunneling; signaling and interlocking; maintenance of railways and high speed trains.

High Speed Rail Engineering.
Development, engineering, design and construction of high-speed rail (HSR) passenger transport systems with particular emphasis on the unique engineering elements of HSR technology. Key elements of HSR systems and subsystems including: core systems (trains, power, signal, communication and control), track system and civil infrastructure (earthwork, bridges, viaducts and tunnels). Also covered are basic design and construction of HSR stations and rolling stock maintenance facilities.
Prerequisite:

Urban Transportation Planning:
Urban morphology - Urbanization and travel demand – Urban activity systems and travel patterns – Systems approach – Trip based and Activity based approach - Urban Transportation Planning – Goals, Objectives and Constraints - Inventory, Model building, Forecasting and Evaluation - Study area delineation – Zoning - UTP survey; Trip generation models - Trip classification - productions and attractions – Trip rate analysis - Multiple regression models - Category analysis - Trip distribution models – Growth factor models, Gravity model and Opportunity modes; Modal split models – Mode choice behavior – Trip end and trip interchange models - Probabilistic models - Utility functions - Logit models - Two stage model. Traffic assignment – Transportation networks – Minimum Path Algorithms - Assignment methods – All or Nothing assignment, Capacity restrained assignment and Multi path assignment - Route-choice behavior; Land use transportation models – Urban forms and structures - Location models - Accessibility – Land use models - Lowry derivative models - Quick response techniques - Non-Transport solutions for transport problems; Preparation of alternative plans - Evaluation techniques - Plan implementation - Monitoring - Financing of Project – urban development planning policy - Case studies.

Pavement Construction and Management:
Flexible Pavement Construction: Earthwork, compaction and construction of embankments, specifications of materials, construction methods and field control checks for various types of flexible pavement materials in sub-base, base, binder and surface course layers and their choice; Cement Concrete Pavement Layers: Specifications and method of cement concrete pavement construction; Construction of interlocking block pavements, Quality control tests; Construction of various types of joints; Soil Stabilized Pavement Layers: Principlesofgradation/proportioningofsoil-aggregatemixesandcompaction;Designfactors,mixdesign, construction control and quality control checks for mechanical, soil-cement, soil-bitumen and soil-lime stabilization methods. Use of additives, Numerical problems on mix design and applications; Pavement Evaluation - Pavement Distress - Functional and structural condition of pavements, Pavement distress survey, Functional condition evaluation of pavements- Roughness, Skid Resistance. Structural evaluation of pavements - nondestructive testing, Benkelman beam and Falling Weight Deflectometer, Pavement strengthening based on deflection as per IRC, Maintenance and rehabilitation techniques; Pavement Management Systems - Pavement Management Systems-

Components, structure, data requirements, Project level and Network level needs, Pavement performance prediction – concepts, modelling techniques– AASTHO, CRRI and HDM models, Budget forecasting for maintenance and rehabilitation, Ranking and optimization methodologies, life cycle costing,

Transportation Economics:
Introductory Concepts in Transportation Decision Making: Overall transportation project development, budgeting, financial planning, the process of transportation project development, models associated with transportation impact evaluation; Transportation costs - Classification of transportation costs, transportation agency costs, transportation user costs, general structure and behavior of cost functions and road pricing. Estimating Transportation Demand and Supply - supply equilibration, dynamics of transportation demand and supply, elasticity of travel demand and supply, classification of elasticity; Vehicle operating costs: Fuel costs - Maintenance and spares, Depreciation - Crew costs - Value of travel time savings - Accident costs. Economics of traffic congestion - Pricing policy; Economic analysis of projects - Methods of evaluation - Cost- benefit ratio, first year rate of return, net present value, and internal-rate of return methods; Indirect costs and benefits of transport projects; Financing of road projects - methods – Private Public Partnership (PPP) - Toll collection - Economic viability of Design-Build-Operate-Transfer Schemes Risk Analysis – Value for Money analysis - Case Studies.

Port and Harbour Engineering:
Harbour Planning: Types of water transportation, water transportation in India, requirements of ports and harbours, classification of harbours, selection of site and planning of harbours, location of harbour, traffic estimation, master plan, ship characteristics, harbour design, turning basin, harbour entrances, type of docks, its location and number, Site investigations – hydrographic survey, topographic survey, soil investigations, current observations, tidal observations; Docks and Repair Facilities: Design and construction of breakwaters, berthing structures - jetties, fenders, piers, wharves, dolphins, trestle, moles, Harbour docks, use of wet docks, design of wet docks, repair docks, lift docks, dry docks, keel and bilge blocking, construction of dry docks, gates for dry docks, pumping plant, floating docks, slipways, locks, size of lock, lock gates, types of gates; Navigational Aids: Requirements of signals, fixed navigation structures, necessity of navigational aids, light houses, beacon lights, floating navigational aids, light ships, buoys, radar; Dredging and Coastal Protection: Classification, types of dredgers, choice of dredger, uses of dredged materials, coastal erosion and protection, sea wall, revetment, bulkhead, coastal zone and beach profile; Port facilities: Port development, port planning, port building facilities, transit sheds, warehouses, cargo handling facilities, container handling terminal facilities, shipping terminals, inland port facilities. Inland waterways, Inland water transportation in India, classification of waterways, economics of inland waterways transportation, national waterways.

Traffic Engineering and Management:
Traffic Forecast: General travel forecasting principles, different methods of traffic forecast - Mechanical and analytical methods, Demand relationships, methods for future projection; Design Hourly Volume For Varying Demand Conditions: Concept of Design vehicle units and determination of PCU under mixed traffic conditions, Price-volume relationships, demand functions. Determination of design hourly volume; critical hour concept; Highway Capacity: Factors affecting capacity, level of service; Capacity studies - Capacity of different highway facilities including unsignalised and signalised intersections. Problems in Mixed Traffic flow; Case studies; Accident Analysis: Analysis of individual accidents and statistical data; Methods of representing

accident rate; Factors in traffic accidents; influence of roadway and traffic conditions on traffic safety; accident coefficients; Driver strains due to roadway and traffic conditions; Traffic Flow Theory: Fundamental flow relationship and their applications, Traffic flow theories and applications; Shock waves; Queuing theory and applications; Probabilistic Aspects Of Traffic Flow: Vehicle arrivals, distribution models, gaps and headway distribution models; gap acceptance merging parameters, delay models, applications; Simulation: Fundamental principle, application of simulation techniques in traffic engineering - formulation of simulation models, Case studies. Formulation of system models.

Public Transportation Systems: Public Transport: Definitions, modes of public transport and comparison, public transport travel characteristics, trip chaining, technology of bus, rail, rapid transit systems, basic operating elements; Transit Network Planning: Planning Objectives, principles, considerations, transit lines – types, geometry and characteristics, transit routes and their characteristics, timed transfer networks, prediction of transit usage, evaluation of network, accessibility considerations; Transit Scheduling: Components of scheduling process, determination of service requirements, scheduling procedure, marginal ridership, crew scheduling; Transit Agency and Economics: Organizational structure of transit agency, management and personnel, transit system statistics, performance and economic measures, operations, fare structure; Design of Facilities: Design of bus stops, design of terminals – principles of good layout, types of layout, depot location, twin depot concept, crew facilities and amenities.

Infrastructure Planning and Management:
Introduction: Definition of basic terminologies, role of infrastructure in economic development, types of infrastructure, measurement of infrastructure capacity, bases for quantification of demand and supply of various types of infrastructure, Indian scenario in respect of adequacy and quality. Infrastructure Planning: Goals and objectives of infrastructure planning; Identification and quantification of the casual factors influencing the demand for infrastructure; review and application of techniques to estimate supply and demand for infrastructure; use of econometric, social and land use indicators and models to forecast the demand and level of service of infrastructure and its impact on land use; critical review of the relevant forecasting techniques; infrastructure planning to identify and prioritize preferred areas for development; Integration of strategic planning for infrastructure at urban, regional and national levels; case studies in infrastructure planning. Infrastructure Management: Concepts, Common aspects of urban and rural infrastructure management systems; pavement and bridge management systems, Integrated infrastructure management, Case studies; Emerging trends in infrastructure: Overview of Public-Private Sector Participation in infrastructure projects, Understanding stakeholders' concerns, regulatory framework, risk management in infrastructure projects, publicpolicy for infrastructure Sectoral Overview: Highways, railways, waterways, airports, urban and rural infrastructure: roads, housing, water supply, sanitation – case study examples.

Construction Productivity.
Definition of Productivity, Impact of productivities on construction duration and costs; Measuring productivities of construction equipment, Staff and Labour and typical benchmarks for the same; Productivity analysis from Daily Progress Reports; Lean Construction concepts of Value Adding activities, Non-Value Adding Activities and Non-Value Adding but Necessary Activities; Productivity measurements by special Lean Construction-oriented field methods such as Work Sampling, Take time analysis, Foreman Delay Surveys; Productivity improvement measures such as Value Stream Mapping, Location-Based management Systems, 5S, good Housekeeping, etc.; use of specialist software such as Vico for productivity studies

Building Construction Practice.
Specifications, details and sequence of activities and construction co-ordination – Site Clearance – Marking – Earthwork - masonry – stone masonry – Bond in masonry - concrete hollow block masonry – flooring – damp proof courses – construction joints – movement and expansion joints – pre cast pavements – Building foundations – basements – temporary shed – centering and shuttering – slip forms – scaffoldings – de-shuttering forms – Fabrication and erection of steel trusses – frames – braced domes – laying brick — weather and water proof – roof finishes – acoustic and fire protection; Sub Structure Construction- Techniques of Box jacking – Pipe Jacking -under water construction of diaphragm walls and basement-Tunnelling techniques – Piling techniques - well and caisson - sinking cofferdam - cable anchoring and grouting-driving diaphragm walls, sheet piles - shoring for deep cutting - well points - Dewatering and stand by Plant equipment for underground open excavation; Super Structure Construction- Launching girders, bridge decks, off shore platforms – special forms for shells - techniques for heavy decks – in-situ pre-stressing in high rise structures, Material handling - erecting light weight components on tall structures - Support structure for heavy Equipment and conveyors -Erection of articulated structures, braced domes and space decks;

Construction Equipment & Automation:
Conventional construction methods Vs Mechanized methods and advantages of latter; Equipment for Earthmoving, Dewatering; Concrete mixing, transporting & placing; plastering machines; Prestressing jacks and grouting equipment; Cranes, Hoists and other equipment for lifting; Equipment for transportation of materials. Equipment Productivities; Use of Drones for spread out sites; Use of robots for repetitive activities

Contracts Management. Contract Management
Introduction, Importance of Contracts, Overview of Contract Management, Overview of Activities in Contract Management; Planning and People- Resource Management; Types of Contracts, Parties to a Contract; Contract Formation, Formulation of Contract, Contract Start-Up, Managing Relationships; Common contract clauses (Notice to proceed, rights and duties of various parties, notices to be given, Contract Duration and Price. Performance parameters; Delays, penalties and liquidated damages; Force Majeure, Suspension and Termination. Changes & variations, Notices under contracts; Conventional and Alternative Dispute Resolution methods. Various Acts governing Contracts; Contract Administration and Payments- Contract Administration, Payments; Contract Management in Various Situations-Contract Management in NCB Works, Contract Management in ICB Works Contracts, Contract of Supply of Goods- Design, Supply and Installation Contracts, Contract Management in Consultancy,; Managing Risks and Change- Managing Risks, Managing Change; Contract Closure and Review-Ending a Contract, Post-Implementation Review; Legal Aspects in Contract Management- Contract Management Legal View, Dispute Resolution, Integrity in Contract Management; Managing Performance- Introduction, Monitoring and Measurement

Construction Project Planning& Systems.
Definition of Projects; Stages of project planning: pre- tender planning, pre-construction planning, detailed construction planning, role of client and contractor, level of detail. Process of development of plans and schedules, work break-down structure, activity lists, assessment of work content, concept of productivities, estimating durations, sequence of activities, activity utility data; Techniques of planning- Bar charts, Gantt Charts. Networks: basic terminology, types of precedence relationships, preparation of CPM networks: activity on link and activity on node representation, computation of float values, critical and semi critical paths, calendaring

networks. PERT- Assumptions underlying PERT analysis, determining three time estimates, analysis, slack computations, calculation of probability of completion. Allocation of Resources- materials, equipment, staff, labour and finance; resource levelling and optimal schedules; Project organisation, documentation and reporting systems. Control & monitoring; Temporary Structures in Construction; Construction Methods for various types of Structures; Major Construction equipment; Automation & Robotics in Construction; Modern Project management Systems; Advent of Lean Construction; Importance of Contracts Management; Planning and organizing construction site and resources- Site: site layout including enabling structures, developing site organization, Documentation at site; Manpower: planning, organizing, staffing, motivation; Materials: concepts of planning, procurement and inventory control; Equipment: basic concepts of planning and organizing; Funds: cash flow, sources of funds; Histograms and S-Curves. Earned Value; Resource Scheduling- Bar chart, line of balance technique, resource constraints and conflicts; resource aggregation, allocation, smoothening and levelling. Common Good Practices in Construction; *Project Monitoring & Control*- Supervision, record keeping, periodic progress reports, periodical progress meetings. Updating of plans: purpose, frequency and methods of updating. Common causes of time and cost overruns and corrective measures. Basics of Modern Project management systems such as Lean Construction; Use of Building Information Modelling (BIM) in project management; Quality control: concept of quality, quality of constructed structure, use of manuals and checklists for quality control, role of inspection, basics of statistical quality control. Safety, Health and Environment on project sites: accidents; their causes, effects and preventive measures, costs of accidents, occupational health problems in construction, organizing for safety and health.

Construction Cost Analysis.

Introduction to the application of scientific principles to costs and estimates of costs in construction engineering; concepts and statistical measurements of the factors involved in direct costs, general overhead costs, cost markups and profits; and the fundamentals of cost recording for construction cost accounts and cost controls.

Repair & Rehabilitation of Structures.

Maintenance and Repair Strategies Maintenance, Repair and Rehabilitation, Facets of Maintenance, importance of Maintenance, Various aspects of Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration; Strength and Durability Of Concrete- Quality assurance for concrete – Strength, Durability and Thermal properties, of concrete – Cracks, different types, causes – Effects due to climate, temperature, Sustained elevated temperature, Corrosion – Effects of cover thickness; Special Concretes- Polymer concrete, Sulphur infiltrated concrete, Fibre reinforced concrete, High strength concrete, High performance concrete, Vacuum concrete, Self-compacting concrete, Geopolymer concrete, Reactive powder concrete, Concrete made with industrial wastes; Techniques for Repair and Protection Methods- Non-destructive Testing Techniques, Epoxy injection, Shoring, Underpinning, Corrosion protection techniques – Corrosion inhibitors, Corrosion resistant steels, Coatings to reinforcement, cathodic protection; Repair, Rehabilitation and Retrofitting of Structures- Evaluation of root causes; Underpinning & shoring; some simple systems of rehabilitation of structures; Guniting, shotcreting; Non-Destructive testing systems; Use of external plates, carbon fibre wrapping and carbon composites in repairs. Strengthening of Structural elements, Repair of structures distressed due to corrosion, fire, Leakage, earthquake – Demolition Techniques – Engineered demolition methods – Case studies.

Sustainable Construction Methods.
Types of foundations and construction methods; Basics of Formwork and Staging; Common building construction methods (conventional walls and slabs; conventional framed structure with blockwork walls); Modular construction methods for repetitive works; Precast concrete construction methods; Basics of Slip forming for tall structures; Basic construction methods for steel structures; Basics of construction methods for Bridges; Identification of cutting edge sustainable construction materials, technologies, and project management strategies for use in the construction industry and evaluation of their potential to reduce the negative environmental impacts of construction activity. Examination of the current LEED for New Construction rating system, and case study analysis of highly successful recent "green construction projects" through student team assignments and presentations. Preparation for the LEED Green Associate professional licensing exam.

Engineering Materials for Sustainability.
Environmental impact of materials; life-cycle assessment; material selection to optimize performance; design, evaluation, and production of green construction materials. Prerequisite:

Ecological Engineering.
Characteristics of rivers and lakes which affect the management of domestic and industrial wastewaters; chemical hazards assessment, surveillance and bio monitoring, and review of regulations governing effluents.

Stream Ecology. Description of physical, chemical, and biological characteristics in streams and rivers including an integrated treatment of the environmental factors affecting the composition and distribution of biota; emphasizes the application of ecological engineering principles in aquatic ecosystem protection.

Environmental Systems.
Introduction to the concepts and applications of environmental systems analysis. Application of mathematical programming and modeling to the design, planning and management of engineered environmental systems, regional environmental systems, and environmental policy. Economic analysis, including benefit-cost analysis and management strategies. Concepts of tradeoff, non- inferior sets, single and multi-objective optimization. Practical application to case studies to convey an understanding of the complexity and data collection challenges of actual design practice.

Water Quality Engineering.
Fundamental theory underlying the unit processes utilized in the treatment of water for domestic and industrial usage, and in the treatment of domestic and industrial wastewaters.

Transport of water and wastewater.
The objective of the course is to make students gain insight into how the water and wastewater gets transported through conduits and open channels, and use the same for the design, operation and maintenance of these systems. Water Supply Systems: Storage requirements, impounding reservoirs, intake structures, pipe hydraulics, design of distribution systems, distribution and balancing reservoirs, pipe materials, appurtenances, design for external loads, maintenance and operation. Sanitary Sewerage Systems: Flow estimation, sewer materials, hydraulics of flow in sewers, sewer lay out, sewer transitions, materials for sewers, appurtenances, manholes, sewer design, conventional and model based design, sewage pumps and pumping stations, corrosion prevention, operation and maintenance, safety.

Storm water Drainage Systems: Drainage layouts, storm runoff estimation, hydraulics of flow in storm water drains, materials, cross sections, design of storm water drainage systems, inlets, storm water pumping, operation and maintenance

Environmental Laws and Policy.
Overview of environment, nature and eco system, Concept of laws and policies, Origin of environmental law, Introduction to environmental laws and policies, Environment and Governance, sustainable development and environment, understanding climate change, carbon crediting, carbon foot print etc., Introduction to trade and environment. International environmental laws, Right to Environment as Human Right, International Humanitarian Law and Environment, environment and conflicts management, Famous international protocols like Kyoto.

Physico-Chemical Processes for water and wastewater treatment.
The Objective of this course is to provide an in depth understanding of physical and physico-chemical processes used for water and wastewater treatment systems and to provide capability to design such systems. Water purification in natural systems, physical processes, chemical processes and biological processes. Primary, secondary and tertiary treatment. Unit operations, unit processes. Aeration and gas transfer**.** Sedimentation, different types of settling, sedimentation tank design. Coagulation and flocculation, coagulation processes, stability of colloids, destabilization of colloids, destabilization in water and wastewater treatment, transport of colloidal particles, design aspects. Filtration: filtration processes, Hydraulics of flow through porous media, Rate control patterns and methods, Filter effluent quality parameters, mathematical model for deep granular filters, slow sand filtration, rapid sand filtration, pre-coat filtration, design aspects. Disinfection: Types of disinfectants, Kinetics of disinfection, chlorination and its theory, Design of Chlorinators. Precipitation: Hardness removal, Iron, Mn, and heavy metal removal; Adsorption, adsorption equilibria and adsorption isotherm, rates of adsorption, Sorption kinetics in batch reactors, continuous reactors, factors affecting adsorption. Ion Exchange-exchange processes, materials and reactions, methods of operation, Application, design aspects. Membrane Processes, Reverse osmosis, Ultrafiltration, Electrodyalisis

Biological processes for contaminant removal.
Understanding of basics of microbiology, metabolism and energetic, bio kinetic parameter, reactors and reactor analyses. Characterization of waste. Aerobic, anaerobic and anoxic systems. Suspended and attached growth biological systems. Activated Sludge process and process modifications, Process design considerations, Treatment Ponds and aerated Lagoons, aerobic pond, facultative pond, anaerobic ponds, polishing ponds, constructed wet lands etc. Attached Growth Biological Treatment Systems, Trickling Filters, Rotating Biological Contactors, Activated Biofilters, Moving bed biological reactor (MBBR), Sequential Batch reactors (SBR), Membrane Biological Reactors (MBR) etc. Anaerobic processes, Process fundamentals, Standard, high rate and hybrid reactors, Anaerobic filters, Expanded /fluidized bed reactors, Upflow anaerobic sludge blanket reactors, Performance and design aspects, Expanded granular bed reactors, Two stage/phase anaerobic reactors. Sludge Digestion, anaerobic digestion, aerobic digestion

Rural water supply and onsite sanitation systems.
Attributes of water supply systems, drinking water quality. Relationships between diseases and water quality, hygiene and sanitation. Need for water treatment. Point of use water treatment systems, filters, bio-sand filters, disinfection systems for rural areas, chlorination, Solar disinfection systems, removal of arsenic, fluoride and iron. Onsite sanitation systems: Nexus between water quality and sanitation. Importance of

hydrogeology on selection of onsite sanitation systems, Design of Septic tanks, single pit and double pit toilets. Small bore systems, bio digesters, reed beds, constructed wetlands, sludge/septage management systems.

Air and Noise Pollution Control.

Air pollutants, Sources, classification, Combustion Processes and pollutant emission, Effects on Health, vegetation, materials and atmosphere, Reactions of pollutants in the atmosphere and their effects-Smoke, smog and ozone layer disturbance, Greenhouse effect. Air sampling and pollution measurement methods, principles and instruments, Ambient air quality and emission standards, Air pollution indices, Air Act, legislation and regulations, control principles, Removal of gaseous pollutants by adsorption, absorption, reaction and other methods. Particulate emission control, settling chambers, cyclone separation, Wet collectors, fabric filters, electrostatic precipitators and other removal methods like absorption, adsorption, precipitation etc. Biological air pollution control technologies, Indoor air quality. Noise pollution: Basics of acoustics and specification of sound; sound power, sound intensity and sound pressure levels; plane, point and line sources, multiple sources; outdoor and indoor noise propagation; psychoacoustics and noise criteria, effects of noise on health, annoyance rating schemes; special noise environments: Infrasound, ultrasound, impulsive sound and sonic boom; noise standards and limit values; noise instrumentation and monitoring procedure. Noise indices. Noise control methods.

Solid and hazardous waste management.

Solid Wastes: Origin, Analysis, Composition and Characteristics. Integrated Solid Waste Management System: Collection, Storage, Segregation, Reuse and Recycling possibilities, Transportation, Treatment / Processing and Transformation Techniques, Final Disposal. Management of: Municipal, Biomedical, Nuclear, Electronic and Industrial Solid Wastes and the rules and regulations. Introduction to Hazardous wastes, Definition of Hazardous waste, The magnitude of the problem; Hazardous waste: Risk assessment, Environmental legislation, Characterization and site assessment, Waste minimization and resource recovery, Transportation of hazardous waste, Physical, chemical and biological treatment, Ground water contamination, Landfill disposal, Current Management Practices, Environmental audit, Pollution Prevention, Facility Development and operation, Site Remediation: Quantitative risk assessment, site and subsurface characterization, Containment, remedial alternatives.

Water and Air Quality Models.

Introduction to Mathematical Models: water quality model development, calibration and verification cost: benefit analysis using models, Model requirements and limitations. D.O. Models for Streams: Dissolved oxygen model for streams sources and sinks of dissolved oxygen estimation of system parameters Streeter Phelps model oxygen 'sag' curve- determination of deoxygenation and re-aeration coefficients- Benthal oxygen demand mass transport mechanisms- Models for Estuary and Lakes: Physical chemical and biological processes in estuaries; Air quality models: Micrometeorological processes, wind rose, dispersion, coefficients and stability classes, Gaussian and dispersion model, Stack height computation, Regional air quality models, Source inventories and significance.

Environmental impact assessment and life cycle analyses.

Evolution of EIA: Concepts of EIA methodologies, Screening and scoping; Rapid EIA and Comprehensive EIA; General Framework for Environmental Impact Assessment, Characterization and site assessment. Environmental Risk Analysis, Definition of Risk, Matrix Method. Checklist method, Fault tree analysis, Consequence Analysis;

Socioeconomic aspects, measures of effectiveness of pollution control activities; Environmental Legislation; Introduction to Environmental Management Systems; Environmental Statement - procedures; Environmental Audit: Cost Benefit Analysis; Life Cycle Assessment; Resource Balance, Energy Balance & Management Review; Operational Control; Case Studies on EIA.

Hydraulic Structures/Irrigation Engineering: This course should discuss key issues in designing irrigation channels and hydraulic structures used in irrigation systems; Estimation of crop water requirement; Design of lined and unlined channels; Analysis for surface and sub-surface flow at hydraulic structures; Design of barrages and weirs; Design of Head and cross regulators; Design of canal falls, transitions and cross drainage works; Design principles for gravity and earthen dams

Pipeline Engineering:
The course should cover key issues for designing and operating pipelines for transmission and distribution of water; Analysis of flow in water transmission and water distribution systems (pump & gravity); optimal design and operation of systems for achieving different goals (including latest tools available for optimization); Extended period simulations, Software for WDN analysis and design, Rehabilitation of pipeline systems; Water auditing, online monitoring and control, leak and burst detection; transient analysis and surge protection; Appurtenances (valves / flow meters etc.); Selection of pipe material; Jointing details; Pipe laying and testing; Structural design for buried and surface mounted pipes

Unsteady Open Channel Flow:
This course should discuss how to analyze for unsteady flows in open channels; Derivation of 1-D and 2-D shallow water flow equations; Consideration for non-hydrostatic pressure distribution; Basics of numerical methods: Finite-Difference and Finite Element Methods; Latest shock capturing Finite Volume methods for solving 1-D and 2-D shallow water flow equations; Dam break flow; Flood routing in large channel networks, Flood routing in compound channels; Flood routing in channels with flood plains, Surface irrigation flow modeling

River Engineering:
Knowledge about river behavior is essential for practicing hydraulic and water resources engineers. River Morphology (Bars; Bends and Meanders, Thalweg; Braiding; Bifurcations etc.); Sediment Transport Mechanics (Bed forms, Bed Load transport, Transport of suspended sediment, Critical Shear stress, Sediment Transport Equations); Aggradation and Degradation; Local Scour at Bridge Piers and other Hydraulic Structures. Measurements in Rivers (Stage measurements, Channel geometry, Discharge, Sediment samplers and suspended and bed load measurement), Physical river Models (fixed and movable bed models; sectional models, distorted Models), Mathematical models for aggradations, degradation and local scour, River Protection and Training Works (Revetments, Dikes, Gabions, Spurs, Bank Protective measures and Bed control structures), Design of river training and flood protection structures, Diversion and Cofferdams; River regulations systems; Dredging and Disposal, River restoration

Hydraulic Modeling:
The main objective of this course is to introduce various concepts which will help in designing physical hydraulic models. Basics of Hydraulic Modelling (similarity mechanics, model laws, distinction between numerical and hydraulic models, classification of hydraulic modelling, materials used in the model, scale effect, design, construction, operation and interpretation of the results); Role of instrumentation and data processing; Gravity dominated models (modelling of energy dissipaters, overflow

spillways, siphon spillways, bridge piers, vortex formation, cavitation, flow induced vibrations); Gravity friction models: (pumped flow models, ship models, surge tank models); Friction dominated models; River models with fixed and mobile bed; Basin and reservoir models; Tidal models with fixed and mobile bed; estuarine models; harbor and breakwater models, models of offshore structures; Hybrid and Analogue models; Scope and limitations of hydraulic modelling, complementary aspects of numerical and hydraulic modelling.

Basics of Computational Hydraulics.
Derivation of governing equations for flow and transport in surface and sub-surface (saturated and unsaturated flow); Equations for reactive transport; Coupled surface and sub-surface flow models; Basics of finite difference, finite element and finite volume methods (consistency, stability, convergence, order of accuracy, computational efficiency); application of numerical methods for solving flow and transport equations, fully coupled and iteratively coupled models; Model simplification, Parameter estimation (Model calibration and validation), Computational Fluid Dynamics (CFD) software for three-dimensional turbulent flow modeling, Software for sub-surface flow simulation

Transients in Closed Conduits:
This course should cover key issues for understanding the unsteady flow in pipes (water hammer) and designing for surge protection**;** Differential equations for unsteady pipe flow; Characteristic method for solution; Formulation of boundary conditions; transients in pumping mains (power failure; pump start up); transients in penstocks of hydro-electric schemes; analysis for transient control using surge tanks; air chambers; air valves; pressure regulating valves etc.; Emphasis should be on development of computer programs for transient analysis; awareness about commercially available software for transient analysis

Groundwater Engineering:
The main objective is to provide sufficient knowledge to the students about the groundwater hydrology, well hydraulics and well construction, geo-physical explorations, groundwater quality and management of groundwater resources; Problems and perspectives regarding groundwater in India; Hydrogeology: Darcy's Equation; flow characteristics; general flow equations; unsaturated flow; Well Hydraulics: Steady and unsteady radial flows in aquifers; partially penetrating wells; multiple well systems; characteristic well losses; specific capacity, Surface and Subsurface investigations (Geologic methods; remote sensing; geophysical explorations; electrical resistivity and seismic refraction), Water Wells: Construction; completion, development, protection and rehabilitation of wells; Groundwater quality; Groundwater Management: Basin management, investigations, conjunctive use, modeling, artificial recharge; Saline water intrusion

Surface Hydrology.
Study of descriptive and quantitative hydrology dealing with the distribution, circulation, and storage of water on the earth's surface; discusses principles of hydrologic processes and presents methods of analysis and their applications to engineering and environmental problems.

Environmental Fluid Mechanics.
Incompressible fluid mechanics with particular emphasis on topics in analysis and applications in civil engineering areas; primary topics include principles of continuity, momentum and energy, kinematics of flow and stream functions, potential flow, laminar motion, turbulence, and boundary-layer theory.

Hydraulic Analysis and Design.
Hydraulic analysis and design of engineering systems: closed conduits and pipe networks; hydraulic structures, including spillways, stilling basins, and embankment seepage; selection and installation of hydraulic machinery.

Urban Hydrology and Hydraulics.
Hydraulic analysis and design of urban, highway, airport, and small rural watershed drainage problems; discussion of overland and drainage channel flows; hydraulics of storm-drain systems and culverts; determination of design flow; runoff for highways, airports, and urban areas; design of drainage gutters, channels, sewer networks, and culverts.

Groundwater. Physical properties of groundwater and aquifers, principles and fundamental equations of porous media flow and mass transport, well hydraulics and pumping test analysis, role of groundwater in the hydrologic cycle, groundwater quality and contamination.

Water Resources Field Methods.
Scientific principles of measurement technologies and protocols used for water-resources measurements and experimental design of field-scale water-resources and environmental studies. Planning field studies; instruments and protocols for surface-water, ground- water, and water-quality sampling; description of data quality. One-half-day laboratory field trips to stream flow monitoring stations and groundwater monitoring wells nearby.

Structural Analysis-I.
Direct stiffness method of structural analysis; fundamentals and algorithms; numerical analysis of plane trusses, grids and frames; virtual work and energy principles; introduction to the finite element method for plane stress and plane strain.

Structural Analysis-II.
Analysis of building frames; Kani's, moment distribution and other methods and Approximate methods; Stiffness matrix method; Application to simple problems of beams andframes; Flexibility matrix method; Application to simple problems of beams and frames; Moving loads for determinate beams; Different load cases, Influence lines for forces for determinate beams; Influence lines for pin-jointed trusses; Influence lines for indeterminate beams using Muller Breslau principle. Influence lines for Arches and stiffening girders.

Advanced Structural Analysis.
Elasticity: Introduction, Components of strain and strain, Hooke's law, Plane stress and plane strain, Equations of equilibrium and compatibility, Boundary conditions, Two dimensional problems in rectangular and polar coordinates, Bending of simple and cantilever beams; Model Analysis: Structural similitude, Direct and indirect model analysis, Model material and model making, Measurement for forces and deformations; Introduction to Finite element method for structural analysis; Review of principle of virtual work, Ritz method, Discretization of domain, Basic element shape, Discretization process; Application of finite element method to one and two-dimensional plane stress strain elements.

Structural Mechanics.
Beams under lateral load and thrust; beams on elastic foundations; virtual work and energy principles; principles of solid mechanics, stress and strain in three dimensions; static stability theory; torsion; computational methods.

Construction Engineering Materials.
Design, production, application, specification, and quality control of construction materials unique to civil engineering. Stones, bricks, mortars, Plain, Reinforced & Prestressed Concrete, Construction Chemicals; Structural Steel, High Tensile Steel, Carbon Composites; Plastics in Construction; 3D printing; Recycling of Construction & Demolition wastes

Design of Steel Structures.
Properties of materials; loads and stresses, Design of semi-rigid, rigid and moment resistant connections; Built-up sections Design of tension members subjected to axial tension and bending, splicing of tension member, Design of compression members, Beam-column connections, Design of columns and their bases Design of flexural members and Plate girder; loads, specification and design Industrial buildings; loads, design of purlins, trusses, bracings; gantry girders; Introduction to Plastic analysis; Simple cases of beams and frames; All design steps/process to as per the most recent BIS code of practices

Metal Structure Behavior- I.
Introduction to the design of metal structures; behavior of members and their connections; and theoretical, experimental, and practical bases for proportioning members and their connections.

Metal Structure Behavior-II.
Metal members under combined loads; connections, welded and bolted; moment-resistant connections; plate girders, conventional behavior, and tension field action.

Reinforced Concrete.
Study of the strength, behavior, and design of reinforced concrete members subjected to moments, shear, and axial forces; extensive discussion of the influence of the material properties on behavior.

Concrete Technology.
Concrete; Properties of ingredients, tests, Production of concrete, mixing, compaction curing, Properties of fresh concrete; Defects in Concrete, Concrete additives.; Behavior of concrete in tension and compression, shear and bond, Influence of various factors on test results, Time dependent behavior of concrete -creep, shrinkage and fatigue; Concrete mix design; Proportioning of concrete mixes, basic considerations, cost specifications, factors in the choice of mix proportion, different method of mix design. Quality control, Behavior of concrete in extreme environment; temperature problem in concreting, hot weather, cold weather and under water conditions, Resistance to freezing, sulphate and acid attack, efflorescence, fire resistance; Inspection and testing of concrete- Concrete cracking, types of cracks, causes and remedies Non-destructive tests on concrete; Chemical tests on cement and aggregates; Special concrete; types and specifications, Fibre reinforced and steel Fibre reinforced concrete, Polymer concrete, Use of admixtures; Deterioration of concrete and its prevention Repair and rehabilitation.

Design of Concrete Structures-I.
Study of the strength, behavior, and design of indeterminate reinforced concrete structures, Load and stresses, load combinations, Working stress and limit state approach. Analysis and design of sections in bending – working stress and limit state method, Rectangular and T-sections, Beams with reinforcement in compression, One-way slab. Design for shear and bond, Mechanism of shear and bond failure, Design of

shear using limit state concept, Development length of bars; Design of sections in torsion. Design of two-way slabs; Design of flat slab – direct method; Circular slab; Slab type staircase, Placement of reinforcement in slabs; Voided slab. Design of compression members, Short column, Columns with uni-axial and bi-axial bending; Long columns, use of design charts. Design of foundation; Wall footing, Isolated and combined footing for columns. All designs to be as per the most recent BIS standards as applicable

Design of Concrete Structures-II.

Design of continuous beams and building frames, Moment redistribution, Estimation of wind and seismic loads, Desirable features of earthquake resistant construction, Detailing for earthquake resistant construction – ductility criteria; Water tank and staging; Introduction, Design criteria, Design of rectangular and circular water tank, Design of Intze tank, Staging for overhead tank; Introduction to bridge engineering, Investigation for bridges, IRC loadings, Design of slab culvert; Design of Masonry walls and columns; Pre-stressed concrete, Introduction, pre-stressing system, losses in pre-stress, Design of simple span girders, Design of end block; Design of staircases; Design of cantilever and counter-forte type retaining wall; All design steps/process to as per the most recent BIS code of practices

Bridge Engineering.

General; classification of bridges, site selection, geometric and hydraulic design consideration, loading standards for highway and railway bridges, general design consideration; optimum spans; Concrete bridges: culverts; Slab, T-beam, box girder bridges, balanced cantilever bridge, cable stayed bridge, extrados bridges; arch bridge; Special requirements for Prestressed Concrete bridges; Steel bridges: plate girder bridge, truss bridge, suspension cable bridge, cable stayed bridge; Substructures: design of piers and abutments, pile and well foundations, bearings and expansion joints, special wearing coats; seismic design considerations; Aerodynamic stability considerations; special durability measures; provisions for inspection and maintenance;

Construction Practice.

Building planning, site selection, orientation from environmental and other factors, principles of planning buildings, open air spaces, requirement of parts of buildings, lighting and ventilation, requirements of various rooms, Building bye laws. Components of building and their purpose and types; foundations, walls, columns, roofs, doors, windows; Bands and openings in the buildings; seismic requirements; Mechanical, Electrical & Plumbing (MEP) works in buildings; Vertical transport in structures; Building finishes; Basic design of foundation of buildings, Terms used in brick masonry, Bonds and types of mortars. Excavation, dewatering, shoring, underpinning and scaffolding, drilling, blasting, well sinking and pile driving, cofferdams, form work-fabrication and use. Construction techniques for special structures such as slip forming and other special formwork systems for high-rise buildings, Damp proofing; causes and effect of dampness, materials and methods of damp proofing; Termite proofing: pre and post construction treatment; Thermal insulation, methods of thermal insulation, thermal insulation of roofs and exposed walls; Doors and windows, Staircases: parts and type of stairs, dimensioning of stair case. Internal and external painting- types and methods of application; various types of finishes; Fire protection- fire hazards, characteristics of fire-resisting materials and common building materials; Cracks in walls, floors and ceilings-causes and repairs techniques; Routine maintenance of buildings and structures.

Design of Structural Systems.
The whole structural design process including definition of functional requirements, selection of structural scheme, formulation of design criteria, preliminary and computer- aided proportioning, and analysis of response, cost, and value.

Reliability Analysis of Structures.
Role of reliability in civil engineering; Historical background, random events, random variables, model uncertainty; Common probabilistic models; Important statistical parameters and their estimations, normal, lognormal, extreme value distribution; Fundamental concept of structural reliability; Derivation of stress-strength interface equation, graphical representation, Cornel reliability index, reliability and failure probability computations for simple linear functions; Second moment concepts, First order second moment theory, Has ofer-Lind transformation, Linear and non-linear limit state functions, Solution schemes, geometric interpretation of solution scheme, Rackwitz-Fiessler transformation, First order reliability method; Stochastic models for material strength and loads, Reliability assessment of structural component and simple civil engineering structures.

Masonry Structures.
Introduction to analysis, design and construction of masonry structures. Mechanical properties of clay and concrete masonry units, mortar, and grout. Compressive, tensile, flexural, and shear behavior of masonry structural components. Strength and behavior of unreinforced bearing walls. Detailed design of reinforced masonry beams, columns, structural walls with and without openings, and complete lateral-force resisting building systems.

Prestressed Concrete.
Study of strength, behavior, and design of pre-stressed reinforced concrete members and structures, with primary emphasis on pre-tensioned, precast construction; emphasis on the necessary coordination between design and construction techniques in pre-stressing.

Wood Structures.
Mechanical properties of wood, stress grades and working stresses; effects of strength-reducing characteristics, moisture content, and duration of loading and causes of wood deterioration; glued- laminated timber and plywood; behavior and design of connections, beams, and beam-columns; design of buildings and bridges; other structural applications: trusses, rigid frames, arches, and pole-type buildings; and prismatic plates and hyperbolic paraboloids.

Structural Dynamics.
Analysis of the dynamic response of structures and structural components to transient loads and foundation excitation; single-degree-of-freedom and multi-degree-of-freedom systems; response spectrum concepts; simple inelastic structural systems; and introduction to systems with distributed mass and flexibility.

Earthquake Engineering.
Theory of Vibrations; Concept of inertia and damping - Types of Damping - Difference between static forces and dynamic excitation - Degrees of freedom - SDOF idealization - Equations of motion of SDOF system for mass as well as base excitation - Free vibration of SDOF system - Response to harmonic excitation - Impulse and response to unit impulse Duhamel integral; Multiple Degree of Freedom System; Two degree of freedom system - Normal modes of vibration - Natural frequencies - Mode shapes - Introduction to MDOF systems - Decoupling of equations of motion - Concept of mode

superposition (No derivations); Elements of Seismology; Causes of Earthquake - Geological faults - Tectonic plate theory - Elastic rebound – Epicentre; Hypocentre - Primary, shear and Raleigh waves - Seismogram - Magnitude and intensity of earthquakes - Magnitude and Intensity scales - Spectral Acceleration - Information on some disastrous earthquakes; Response of Structures to Earthquake; Response and design spectra - Design earthquake - concept of peak acceleration - Site specific response spectrum - Effect of soil properties and damping - Liquefaction of soils - Importance of ductility - Methods of introducing ductility into RC structures Design Methodology IS 1893, IS 13920 and IS 4326 - Codal provisions - Design as per the codes - Base isolation techniques - Vibration control measures - Important points in mitigating effects of earthquake on structures

Industrial Structures.

Industrial steel building frames: Types of frames, bracing, crane girders and columns, workshop sheds, trussed bents, Pressed steel tank, circular tank; Transmission and Communication towers: Types and configuration, Analysis and design; Chimneys; Loads and stresses in chimney shaft, Earthquake and wind effect, Stresses due to temperature difference, combined effect of loads and temperature, temperature. Design of chimney; Silos and Bunkers; Jassen's theory, Airy's theory, Shallow and deep bins, Rectangular bunkers with slopping bottom, Rectangular bunkers with high side walls; Steel stacks; introduction, force acting on a steel stack, design consideration, design example of stacks; Concrete Shell Structures: Folded plate and cylindrical shell structures; Introduction, structural behavior of long and short shells, beam and arch action, analysis and design of cylindrical shell structures, Analysis and design of folded plates; Machine foundations; introduction, machine vibration, structural design of foundation to rotary machines, impact machines, vibration characteristics, design consideration of foundation to impact machine, grillage, pile and raft foundation.

Foundation Engineering.

Analysis and design of foundations, types of foundations, bearing capacity and settlement of foundations; ground movements due to construction; analysis and design of excavations, retaining walls, cuts & excavations and sheet piles, slopes and underground structures.

Reference books:

1. A. Singh, Modern Geotechnical Engineering, 3rd Ed., CBS Publishers, New Delhi, 1999.
2. B.M. Das, Principles of Foundation Engineering, 5th Ed., Thomson Asia, Singapore, 2003.
3. N. Som, Theory and Practice of Foundation Design, Prentice Hall, New Delhi, 2003.

After successful completion of this course, the students would:

a. learn about types and purposes of different foundation systems and structures.
b. have an exposure to the systematic methods for designing foundations.
c. be able evaluate the feasibility of foundation solutions to different types of soil conditions considering the time effect on soil behaviour.
d. have necessary theoretical background for design and construction of foundation systems.

Soil Mechanics-I.
Composition and structure of soil; water flow and hydraulic properties; stress in soil; compaction and compressibility of soils; consolidation characteristics, settlement analysis; shear strength of soils; basics of unsaturated soils; experimental measurements.

Reference books:
1. Soil Mechanics by Craig R.F., Chapman & Hall
2. Principles of Geotechnical Engineering, by Braja M. Das, Cengage Learning

On successful completion of this course, the students:
- Should be able to assess soil behavior with the mineralogy present and advanced soil testing of soils such as in thermal, chemical, magnetic fields.
- Should be able to do seepage analysis for finding discharge calculation and stability of structure.
- Should have knowledge about stress paths and get introduced to critical state soil mechanics
- Should be in a position to do various laboratory experiments to determine design parameters according field application.

Soil Mechanics-II.
Application of soil mechanics to determine earth pressures, analysis of retaining walls, cuts & excavations and sheet piles, stability of slopes, instrumentation.

Reference books:
1. Soil Mechanics by Craig R.F., Chapman &Hall
2. Principles of Geotechnical Engineering, by Braja M. Das, Cengage Learning

On successful completion of this course, the students:
- Should be able design retaining wall subjected to various loads with the knowledge of earth pressure theories.
- Should be able to design sheet pile wall with different methods.
- Should get familiarized with different construction practices for excavation with advantages and disadvantages of each method.
- Should be able to determine the safety analysis for slopes with different methods proposed in the syllabus.
- Should get introduced with the commercial softwares for analyzing the stability of slopes and retaining walls.

Geotechnical Design.
Subsurface site evaluation; integrated design of retaining walls, foundations, pavements, and materials for airports, highways, dams, or other facilities.

Reference books:
1. Analysis and Design of Substructures: Limit State Design by Swami Saran

Upon completion of the course, the student would be:
1. Well acquainted with the various investigation specifications as per the infrastructure to be build on the proposed site.
2. knowing about the properties of materials required for the constructing a desired infrastructure
3. familiar with design concepts of various foundation systems
4. familiar with design of transportation facilities

Decision and Risk Analysis.
Development of modern statistical decision theory and risk analysis, and application of these concepts in civil engineering design and decision making; Bayesian statistical decision theory, decision tree, utility concepts, and multi-objective decision problems; modeling and analysis of uncertainties, practical risk evaluation, and formulation of risk-based design criteria, risk benefit trade-offs, and optimal decisions.

Sustainable Design Engineering & Technology.
Quantitative sustainable design (QSD) and how to navigate engineering decision-making. Economic (life cycle costing, techno-economic assessment) and environmental (life cycle assessment: LCA) sustainability assessments, and how to link these tools to design decisions under uncertainty. Design of engineered technologies individually and in teams, with special attention to water infrastructure and bioenergy production. Semester-long design project that includes components from two of the following three CEE sub-disciplines: environmental, hydraulic, geotechnical.

Structural Geology.
Description, classification, and origin of earth structures. Ways in which the continental crust can deform; link scales of structure from the field, outcrops, hand specimen, thin section by integrating analytical techniques with practical examples. Theoretical and meso to microscale analysis of structures developed through a linked series of lectures and practicals; practical 2D strain analysis; 3D strain concepts; incremental strain, kinematics and polyphase deformations; fold construction and classes; fault evolution and section balancing; fault rock microstructures; fault and fold mechanics, current concepts in plate tectonics, cross-section construction techniques, structural interpretation of seismic data, structural styles in different tectonic settings (thrust and fold belts, rifts, strike and slip, gravity tectonics, inversion), structural geology of reservoir units.

Reference books:
1. Ghosh, S.K., Structural Geology: Fundamentals and Modern Developments, Elsevier; First edition

On successful completion of this course the students will be able to:
- Acquire knowledge on the geometry and type of structures present in earth.
- Understand and describe the features formed in rocks when subjected to stress.
- Understand the impact of structural geology to active tectonic settings
- Understand micro and macro scale deformation mechanisms (viz., brittle, ductile).
- Portray 2D and 3D strain analysis for various deformation behaviours.
- Interpret graphs and models used in structural geology to understand and demonstrate poly phase deformations.

Civil Engineering Design-I.
Concept of design and its contribution to the quality of life; Civil Engineering Design, the role of geomatics, the environment, and scientific laws in design; Introduction to the design of buildings and Civil Engineering Infrastructure, site appraisal; Risk and vulnerability in design; Health and safety in Civil Engineering Design, environmental impact assessment; Civil Engineering drawing, CAD techniques, introduction to GIS techniques.

Civil Engineering Design-II.
Innovation and creativity in conceptual design; sustainability; health and safety; investigative procedures. The use of analysis, synthesis and optimization in design; project planning, networks and graphs. Design of embankments, dams; drainage design; route location and alignment design of roads; assessment of natural hazard impacts and environmental impacts.

Offshore Engineering.
Introduction to offshore structures, codes of practice, offshore project management, deep water, offshore site investigations, geophysical methods; offshore sediment sampling, in-situ testing, geological aspects; development of design stratigraphies.

Structural Analysis by Matrix Methods.
Analysis of truss and frame structures using flexibility and stiffness methods of matrix analysis; computer applications.

Geographic Information Systems and Science.
Investigation of geographic information systems (GIS) and science (GI Science) including theory and applications areas. A major portion of the course will be based on use of a current widely-used GIS computer software system. Aspects of geographic data entry and editing, spatial analysis, and map development and display will be considered. Relationship of GIS to the Global Positioning System (GPS) and satellite generated data will be addressed.

Rock Mechanics.
Determination of physical properties of rocks, failure criterion, rock mass classification, stress around mine openings, strain and displacement of the rock mass, rock reinforcement and support, subsidence.

Reference books:
1. Engineering Rock Mechanics: An Introduction to the Principles by J. A. Hudson and J. P. Harrison
2. Rock Mechanics: For Underground Mining by Barry H.G. Brady
3. Fundamentals of Rock Mechanics, 4th Edition, John Conrad Jaeger, Neville G. W. Cook, Robert Zimmerman

On successful completion of this course the students will be able to:
1. Define the properties (viz., physical, mechanical) of rocks and failure criterion of rockmass.
2. Use engineering rock mass classification (RMR, Q-system, RQD)
3. Analyse the stress distribution in-situ and around an opening in underground structures (viz., mine openings, tunnels).
4. Determine the relation between strain and displacement components of rockmass.
5. Perform field Instrumentation techniques and laboratory studies.
6. Understand the fundamentals of ground subsidence.

Modeling and Analysis of Uncertainty.
Appreciation and understanding of uncertainties and the conditions under which they occur, within the context of the engineering problem-solving pedagogy of measurements, models, validation, and analysis. Problems and concerns in obtaining measurements; tabular and graphical organization of data to minimize misinformation and maximize information; and development and evaluation of models. Concepts will be supported with computer demonstration. Applications to problems in engineering are emphasized.

Environmental Geotechnology.
A consideration of technical and scientific aspects of key geo- societal issues. Case studies and analysis of current and historic databases will be used to illustrate topics including, but not limited to, impact of climate change, energy resources, water and soil pollution, and health risks posed by heavy metals and emerging pollutants.

Reference books:

1. Introduction to Environmental Geotechnology by Hsai – Yang Fang
2. CDEEP, IITB video lectures on course CE 488 and CE 641 by Prof. D. N. Singh

Upon successful completion of this course, the student would:

1. Have an exposure to interdisciplinary issues pertaining to environment and geotechnical engineering
2. Be trained to develop sustainable and environmentally sound solutions for geotechnical problems
3. Understand the relevance of various legal aspects involved in addressing environmental consequences associated with geotechnical issues

Ground Improvement Techniques.
Introduction, ground modification by vibro-replacement, stone columns, preloading and prefabricated drains, Reinforced earth structures, Introduction to geotextiles and geomembranes, applications of geotextiles, design methods using geotextiles, geogrids, geonets, geomembranes, geotubes, grouting, deep mixing, PVDs, vacuum consolidation.

Reference books:

1. Principles and Practice of Ground Improvement by Jie Han
2. Ground Improvement Techniques by P. Purushothama Raj

Upon successful completion of this course, the students would:

- gain competence in properly devising alternative solutions to difficult and earth construction problems and in evaluating their effectiveness before, during and after construction.
- understand different approaches to the ground modification.