COURSE STRUCTURE

1st semester

Sl. No.	Course Code	Course Name	L-T-P	Credit
1	HUL 1101	Communicative English	2-0-0	2
2	MAL 1101	Engineering Mathematics I	3-1-0	4
3	CHL 1101	Engineering Chemistry	3-0-0	3
4	BEE 1101	Basic Electrical Engineering	3-0-0	3
5	MEL 1101	Engineering Mechanics	3-0-0	3
6	BEP 1101	Basic Electrical Engineering Laboratory	0-0-3	1.5
7	CHP 1101	Engineering Chemistry Laboratory	0-0-3	1.5
8	MEP 1101	Engineering Mechanics Laboratory	0-0-3	1.5
9	HUP 1101	Language Laboratory	0-0-2	1
10	OBE 1101	Outcome Based Education	1-0-0	AUDIT
Total			**14-1-11**	**20.5**

2nd semester

Sl. No.	Course Code	Course Name	L-T-P	Credit
1	HUL 1202	Social Sciences	2-0-0	2
2	MAL 1202	Engineering Mathematics II	3-1-0	4
3	PHL 1201	Engineering Physics	3-0-0	3
4	CSL 1201	Computing Fundamentals	3-0-0	3
5	MEL 1202	Engineering Drawing	0-0-4	2
6	CSP 1201	Introduction to Computer Programming Laboratory	0-0-3	1.5
7	PHP 1201	Engineering Physics Laboratory	0-0-3	1.5
8	MEP 1203	Workshop	0-0-3	1.5
9	ECL 1201	Basic Electronics Engineering	3-0-0	3
10	EAA 1201	Extra Academic Activity	-	-
Total			**14-1-13**	**21.5**

3rd Semester

Sl. No.	Course Code	Course Name	L-T-P	Credit
1	CEL 1301	Mechanics of Solids	3-1-0	4
2	CEL 1302	Fluid Mechanics	3-1-0	4
3	CEL 1303	Geomatics Engineering	3-0-0	3
4	CEL 1304	Engineering Geology	2-0-2	3
5	HUL 1301	Managerial Economics	3-0-0	3
6	MAL 1301	Mathematical Methods	3-0-0	3
7	CEP 1301	Strength of Materials Laboratory	0-0-2	1
8	CEP 1302	Fluid Mechanics Laboratory	0-0-2	1
Total			**17-2-6**	**22**

4th semester

Sl. No.	Course Code	Course Name	L-T-P	Credit
1	CEL 1401	Structural Analysis	3-1-0	4
2	CEL 1402	Hydraulic Engineering	3-1-0	4
3	CEL 1403	Transportation Engineering	3-1-0	4
4	CEL 1404	Civil Engineering Materials	3-0-0	3
5	MAL 1401	Numerical Methods and Probability Theory	3-0-0	3
6	CEP 1401	Construction Materials Laboratory	0-0-2	1
7	CEP 1402	Hydraulic Engineering Laboratory	0-0-2	1
8	CEP 1403	Geomatics Engineering Laboratory	0-0-2	1
Total			**15-3-6**	**21**

5th semester

Sl. No.	Course Code	Course Name	L-T-P	Credit
1	CEL 1501	Analysis of Indeterminate Structures	3-1-0	4
2	CEL 1502	Design of Reinforced Concrete Structures	3-1-0	4
3	CEL 1503	Geotechnical Engineering	3-1-0	4

4	CEL 1504	Water Resources Engineering	3-0-0	3
5	CEL 1505	Water and Wastewater Engineering	3-0-0	3
6	CEP 1501	Geotechnical Engineering Laboratory	0-0-2	1
7	CEP 1502	Environmental Engineering Laboratory	0-0-2	1
Total			**15-3-4**	**20**

6th semester

Sl. No.	Course Code	Course Name	L-T-P	Credit
1	CEL 1601	Design of Steel Structures	3-1-0	4
2	CEL 1602	Analysis and Design of Geotechnical Systems	3-1-0	4
3	CEL 1603	Pavement Engineering	3-0-0	3
4	CEL 1604	Air pollution and Waste Management	3-0-0	3
5	CEL 1605	Civil Engineering Drawing, Estimation and Costing	2-0-2	3
6	CEP 1601	Transportation Engineering Laboratory	0-0-2	1
7	CEP 1602	Design of Innovative Infrastructure Systems	0-0-2	1
Total			**14-2-6**	**19**

7th semester

Sl. No.	Course Code	Course Name	L-T-P	Credit
1	CED 1701	Project I	0-0-10	5
2	CEL 1701	Construction Technology and Project Management	3-0-0	3
3	CEL 17XX	Departmental Elective I	3-0-0	3
4	CEL 17XX	Departmental Elective II	3-0-0	3
5	CEL 17XX	Open Elective I	3-0-0	3
6	CEP 1701	Modelling and Simulation Laboratory	0-0-2	1
7	CEP 1702	Industrial Viva	0-0-2	1
Total			**12-0-14**	**19**

8th semester

Sl. No.	Course Code	Course Name	L-T-P	Credit
1	CED 1801	Project II	0-0-20	10
2	CEL 18XX	Open Elective II	3-0-0	3
3	CEP 1801	Grand Viva	0-0-2	1
Total			**3-0-22**	**14**

Semester/Year	1st sem	2nd sem	3rd sem	4th sem	5th sem	6th sem	7th sem	8th sem
Credit	20.5	21.5	22	21	20	19	19	14
Total								**157**

LIST OF ELECTIVES

Departmental Elective I&II

1. Design of Hydraulic Structures (CEL 17XX)
2. Design of Foundation and Retaining Structures (CEL 17XX)
3. Bridge Engineering (CEL 17XX)
4. Ground Improvement Techniques (CEL 17XX)
5. Advanced Reinforced Concrete Design (CEL 17XX)
6. Pavement Asset Management (CEL 17XX)
7. Geotechnical Earthquake Engineering (CEL 17XX)
8. Road Safety and Management (CEL 17XX)
9. Environmental Chemistry and Microbiology (CEL 17XX)
10. Hazardous Waste Management and Site Remediation (CEL 17XX)

Open Elective I&II

1. Sustainable Engineering (CEL 1XXX)
2. Environmental Impact Assessment (CEL1XXX)
3. Finite Element Methods (CEL 1XXX)
4. Design of Earthquake Resistant Structures (CEL 1XXX)
5. Environment and Energy (CEL 1XXX)
6. Optimization Techniques (CEL 1XXX)
7. Artificial Neural Networks (CSL1XXX)
8. Soft Computing (CSL1XXX)
9. Innovation and Entrepreneurship (MEL1805)

COURSE SYLLABUS

CEL 1301 MECHANICS OF SOLIDS (3 - 1 -0)

1. Course Description:

Strength of Materials introduces you to the concept of stress, strain and deformation of solid and state of stress. It will also introduce the elastic constants and mechanical properties. The concept of shear force and bending moment diagram is discussed. It also focuses on the concepts of bending stresses, shear stresses in beams and compressive stresses in columns and struts, thin and thick cylinder under internal and external pressure. The behaviour of structural elements under flexure, torsion is emphasized. Also, failure theories are briefly introduced at the end of the course.

2. Learning Outcome:

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

- Determine the strength parameters of the materials.
- Know more about the concepts of stress and strain.
- Determine shear force, bending moment, bending and shear stress distribution.
- Analyze the stresses of different compression members subjected to different load.
- Understand the concept of thin and thick cylinders.
- Analyze members subjected to torsion.
- Know the different failure theories.

3. Broad Course Outline:

- Stress and strain.
- Elastic constants and Mechanical properties
- Members in uniaxial state of stress
- Shear Force and Bending Moment Diagram
- Theory of simple bending
- Columns and struts
- Thin and thick cylinders
- Torsion of Circular Shafts
- Failure theories

4. Text Books:

a) Timoshenko and Gere, Mechanics of Materials, CBS Publishers, New Delhi, 1996.
b) Beer and Johnston, Mechanics of Materials, McGraw Hill International Edition, 1995.
c) E. Popov, Engineering Mechanics of Solids, Prentice Hall of India Pvt. Ltd., 1998.

5. Reference Books:

a) L. S. Srinath, Advanced Mechanics of Solids, Tata Mc Graw Hill Publishing Company Limited, 2009.

b) R. Subramanian, Strength of Materials, Oxford University Press, 2010.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Concept of stress, normal stress and shear stress, artesian components of stress at a point, Concept of strain, normal and shear strain, Poisson's ratio, Volumetric strain, Concept of strain energy, Principal stress and strain, Mohr's circle	7
2	Hooke's law, Modulus of rigidity and bulk modulus-Relation between E, G and K, Proof stress, Stress-strain diagrams for brittle and ductile materials, Hardness and impact strength.	5
3	Members in uniaxial state of stress: Uniform cross section and tapered bars subjected to uniaxial tension and compression, Composite bars.	5
4	Types of supports-Types of determinate beams- -Shear force and Bending moment diagrams- Principles of Superposition	7
5	Assumptions-Theory of simple bending- Bending stresses in beams-Discussion of efficiency of various shapes of cross sections, Flexural shear stress distribution in various shapes of cross section of beams.	5
6	Direct and Bending stresses- Euler's critical load for columns with ordinary end conditions - Slenderness ratio and effective length of a column - Rankine's Formula - IS Code formula - Critical load of eccentrically loaded columns.	5
7	Introduction, thin cylinders under internal pressure, difference between thick and thin cylinders, Lame's theory, thick cylinders under internal pressure and external pressure.	5
8	Theory of pure torsion in solid and hollow circular shafts-Torsional shear stresses and angle for twist-transmission of power.	4
9	Maximum Principal Stress Theory, Maximum Principal Strain Theory, Maximum Shear Stress Theory, Total Energy Theory, Distortion energy theory	4
Total Number of Hours		48

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1302 FLUID MECHANICS (3 - 1 - 0)

1. Course Description:

To introduce the students to a systematic study of the mechanistic principles of fluid. It focuses on the concepts of the fluid flow, kinematics of flow and dynamics of fluid flow.

2. Learning Outcome:

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

- Calculate different properties of fluid
- Determine fluid pressure and their measurement.
- Apply the concepts of fluid flow and kinematics of flow
- Apply the concepts of dynamics of flow.
- Apply the concepts of continuity equation and momentum equation.
- Identify the laminar and turbulent flow.

3. Broad Course Outline:

- Introduction.
- Principles of Fluid Statics.
- Description of fluid flow.
- Kinematics of Flow.
- Fluid Dynamics.
- Dimensional Analysis and Similitude.
- Boundary layer theory.
- Laminar and turbulent flow through pipes.

4. Text Books:

a) S K Som, Gautam Biswas, S Chakraborty. Introduction to Fluid Mechanics and Fluid Machines. McGraw Hill Education. 3rd Ed., 2017.

b) Donald F. Elger, Barbara A. LeBret, Clayton T. Crowe, John A. Roberson. Engineering Fluid Mechanics. Wiley. 12th Ed., 2019.

5. Reference Books:

a) Merle C. Potter, David C. Wiggert, Midhat Hondzo. Mechanics of Fluids. CL Engineering. 5th Ed., 2016.

b) Martin Marriott. Nalluri and Featherstone's Civil Engineering Hydraulics. Wiley-Blackwell. 6th Edition, 2016.

6. Session Plan:

Sl. No.	Topics Covered	Hours (Tentative)

1	Physical properties of fluids: Compressibility, Elasticity, and Viscosity, Ideal and Real fluids, Concepts of shear stress, Newtonian and Non-Newtonian fluids; Continuum principle	6
2	Stress at a point, pressure, Pascal's law, Pressure-density-height relationships, Manometers, Buoyancy, Hydrostatic forces on submerged plane and curved surfaces.	6
3	Velocity field, one & two-dimensional flow analysis, circulation and vorticity, stream function and velocity potential function, potential flow, standard flow patterns, combination of flow patterns, flownet.	6
4	Principle of conservation of mass, energy and momentum: Control volume approach; Euler's equation along a streamline; Bernoulli's equation and its applications; Reynolds transport theorem, Steady flow and uniform flow, momentum and angular momentum equations and their applications.	12
5	Dimensional Homogeneity, Buckingam's-π theorem, dimensionless numbers, similitude.	4
6	Concepts of boundary layer flows, Laminar and Turbulent boundary layers, Integral momentum equation of boundary layer flows, Boundary layer separation and control, Drag and lift: Skin-friction and form drag, drag on sphere; cylinder and flat plate; Lift.	6
7	Navier-Stokes equations, Laminar flow through pipes, turbulent flow, Reynolds equations, Prandtl's mixing length theory, Velocity distribution over a flat plate and in a pipe section, Darcy-Weisbach equation, friction factor, Moody diagram, minor losses, flow in pipe networks, Venturimeter, orifice meter.	8
	Total Number of Hours	48

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1303 GEOMATICS ENGINEERING (3 - 0 - 0)

1. Course Description:

Introduces the theoretical concepts of Geomatics for Civil Engineering. The main aim is to provide knowledge of the basic engineering spatial measurements needed to plan and construct an infrastructure.

2. Learning Outcome:

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

- Carry out preliminary surveying in the field of civil engineering applications.
- Utilize standard surveying instruments
- Complete leveling and contouring for a site
- Apply the principles of GPS and GIS

3. Broad Course Outline:

- Basic concepts of Geomatics
- Basic Principles and Types of surveying
- Distance Measurement
- Angular Measurement
- Plane Table Surveying
- Levelling and Contouring
- Theodolite survey
- Introduction to remote sensing and GIS techniques
- Total Station

4. Text Books:

a) NN Basak, Surveying & Levelling, McGraw Hill Education
b) SK Duggal, Surveying Vol. 1 & Vol. 2, McGraw-Hill

5. Reference:

a) TP Kanetkar & SV Kulkarni, Surveying & Levelling Vol. 1 & Vol. 2, Pune Vidyarthi Griha Prakashan
b) B.C. Punmia, A. K. Jain, A. K. Jain, Surveying-I & II, Laxmi Publications
c) T. M. Lillesand and R. W. Kiefer, Remote Sensing and Image Interpretation, John Wiley & Sons.
d) G. Joseph, Fundamentals of Remote Sensing, Universities Press

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Basic concepts of Geomatics: A brief intro. to the concept of surveying, mapping, remote sensing and GIS; Necessity of Geomatics; Basic measurements; Units of measurement	3
2	Basic Principles and Types of surveying and introduction to the common tools of surveying: Traversing; Triangulation, Trilateration, closing errors in traversing and their adjustment.	3

3	Distance Measurement: Chain and Tapes; Optical Distance Measurement; Electronic Distance Measurement; Errors and corrections in Distance Measurement, considerations for earth curvature and refraction.	6
4	Angular Measurement: Direction, Azimuth, Meridian; Compass; Sources of Errors, Propagation of errors.	3
5	Plane Table Surveying, types; 2-point problem and 3-point problem.	3
6	Levelling and Contouring: principles of simple and differential levelling; Introduction to dumpy level and electronic level instruments; Determination of heights; Block levelling; Characteristics and methods of contouring; Sources of errors and their corrections.	5
7	Theodolite survey, Repetition and reiteration methods, latitudes & departures; Tacheometry	5
8	Introduction to remote sensing and GIS techniques, LIDAR, InSAR. Introduction to GPS, surveying using DGPS and remote sensing techniques, survey using drones, construction survey.	5
9	Total Station: Operating principle, link with linear, angular and vertical measurements.	3
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1304 ENGINEERING GEOLOGY (2 - 0 - 2)

1. Course Description:

Engineering Geology deals with the study of earth formation. It will introduce you to different types of minerals, crystals and rocks found in the earth. The properties of these minerals and rocks will be studied in detail in the course for engineering purposes. Phenomenons occurring inside the earth that will lead to earthquakes and landslides will be introduced. The study of soil using resistivity and seismic refraction methods will also be emphasized. Dams and tunnels which require proper soil investigation for construction are also discussed at the end of the course.

2. Learning Outcome:

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

- Identify minerals, crystals, rocks
- Know the properties of different rocks and minerals
- Know the causes and effects of earthquake and landslide
- Perform sub surface investigation
- Perform geological investigation

3. Broad Course Outline:

- General geology
- Mineralogy
- Petrology
- Structural geology
- Engineering properties of rock
- Ground water
- Earthquakes and landslides
- Subsurface Investigations

4. Text Books:

a) K.V.G.K. Gokhale, Principles of Engineering Geology, BS Publications, 2009.
b) David George Price, "Engineering Geology: Principles and Practice", Springer, 2009.

5. Reference Books:

a) Parbin Singh., Engineering and General Geology, Katson Publishers, 2009.
b) N. Chenna Kesavulu, "Text book of Engineering Geology", Mac Millan Ltd., New Delhi, 2009.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Branches and scope of geology, Importance of geology in Civil engineering. Earth surface features and internal structure, weathering of rocks.	3
2	Definition of a crystal and mineral, physical properties in mineral identification, rock forming minerals and their identification – quartz and its varieties, feldspar, hornblende, olivine, mica, garnet, kyanite, calcite, talc, bauxite, corundum, gypsum, fluorite, apatite, beryl, barite, asbestos, magnetite, hematite	6
3	Formation and classification of rocks – Igneous, Sedimentary and metamorphic rocks, their texture and structures, properties of granite, pegmatite, dolerite,	6

	gabbro, charnockite, basalt, sandstone, conglomerate, breccia, limestone, shale, laterite, schist, gneiss, quartzite, marble, khondalite and slate	
4	Outcrop, Strike and dip, types and classifications of folds, faults, joints, unconformities	4
5	Drilling, Core recovery, RQD, Sample preparation, tests on rock samples - compression, tensile, shear and slake durability tests.	4
6	Water tables, aquifers, occurrence of ground water in different geological formations, springs, selection of a site for well sinking and ground water investigations.	6
7	Causes and effects of earthquakes and landslides, Remedial measures to prevent damage for engineering structures	4
8	Soil Profile, Geophysical methods – Electrical Resistivity and Seismic refraction methods.	3
Total Number of Hours		36

7. Evaluation plan:

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEP 1301 STRENGTH OF MATERIALS LABORATORY (0 - 0 - 2)

1. Course Description:
The lab session will includes experiments on

- Finding Young's Modulus, Torsional strength, hardness and tensile strength of given specimens.
- Finding Impact value and crushing value on coarse aggregates.
- Finding stiffness of open coiled and closed coiled springs.
- Finding physical properties of given coarse aggregate, fine aggregate and cement samples.

2. Learning Outcome:
On completion of the course, the students will be able to:

- Evaluate Young's modulus
- Evaluate torsional strength, hardness and tensile strength of given specimen.
- Find stiffness of open coiled and close coiled springs.

3. Broad Course Outline:

- Test for flexural rigidity
- Torsion test
- Tensile test
- Hardness test
- Impact test
- Compression test
- Test on springs

CEP 1302 FLUID MECHANICS LABORATORY (0 - 0 - 2)

1. Course Description:
Introduces the basic concepts of fluid mechanics through experiments.

2. Learning Outcome:
On completion of the course, the students will be able to:

- Calibrate flow measuring devices used in pipes, tanks and channels.
- Measure discharge in pipes.
- Determine fluid and flow properties
- Differentiate laminar and turbulent flows.

3. Broad Course Outline:

- Calibration of Venturimeter, Orifice meter (discharge measuring device in pipes).
- Calibration of Orifice and Mouthpiece (discharge measuring device in Tanks).
- Calibration of Triangular Notch and Rectangular notch (discharge measuring device in Channels).
- Measurement of Viscosity of water.
- Determination of Darcy Friction Factor, relative roughness for laminar and turbulent flows.
- Determination of minor losses in pipes

CEL 1401 STRUCTURAL ANALYSIS (3 - 1 - 0)

1. Course Description:
Structural Analysis introduces you to different types of structures and loads on the structures. The different methods of analysis of determinate and indeterminate structures are also discussed. Analysis of trusses, arches and cables are discussed in detail. Later, it focuses on the Force method of analysis of indeterminate structures. Lastly, it emphasizes the concepts of influence line diagrams.

2. Learning Outcome:

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

- Use various methods of analysis of determinate structures.
- Use force method of analysis of indeterminate structures.
- Apply the concept of ILD and moving loads on beams, frames and arches.

3. Broad Course Outline:

- Types of Structures and Loads
- Methods of Analysis
- Analysis of Trusses.
- Arches and Cables.
- Deflections.
- Analysis of Indeterminate structures by Force Method.
- Influence lines.

4. Text Books:

a) C.S. Reddy, Basic structural Analysis, 3rd Edition, McGraw Hill Education (India) Pvt. Ltd.
b) R. C. Hibbeler, Structural Analysis, 2nd Edition, Tata McGraw Hill, 2005.

5. Reference Books:

a) G.Pandit and S.Gupta, Theory of Structures, Vol-1, Tata McGraw Hill, New Delhi, 1999.
b) T.S. Thandavamoorthy, Structural Analysis, Oxford University Press, 2011.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Different types of structures, Loads on structural system.	4
2	Static and kinematic indeterminacy, Equilibrium equations, Compatibility requirements, Introduction to Force and Displacement methods of analysis.	5
3	Analysis of plane truss, compound truss, complex truss, space truss.	5
4	Arches and Suspension cables, Three hinged arches and Suspension cables	5
5	Deflection of beams, Various methods for calculation of Deflection: Moment area theorem, Conjugate beam method, Double Integration method, Energy methods: Principle of minimum potential energy, principle of virtual work, Castigliano's theorem.	10

6	Reciprocal theorem, Force Method of Analysis of Beams, Frames and Trusses.	9
7	Influence lines for reaction bending moment and shear force diagrams for simply supported beams - stresses in members of statically determinate pin jointed plane frames due to moving loads, Muller-Breslau Principle with applications to determinate and indeterminate structures, Qualitative ILD for continuous beams, frames and arches.	10
Total Number of Hours		48

7. Evaluation plan:

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1402 HYDRAULIC ENGINEERING (3 - 1 - 0)

1. Course Description:
To introduce the students to applications of fluid mechanics to civil engineering and to hydraulic machines.

2. Learning Outcome:
On completion of the course, the students will be able to:

- Determine the properties of flow through channels and pipes.
- Calculate forces and work done by a jet on fixed or moving plate and curved plates
- Estimate the flow measurement in open channels.
- Select the type of turbine required with reference to available head of water and discharge
- Determine the characteristics of hydraulic machines (centrifugal pump and reciprocating pump).

3. Broad Course Outline:

- Introduction to Free surface flows.
- Uniform flow in Open channels.
- Steady Gradually Varied Flow.
- Steady Rapidly Varied flow.
- Unsteady flow.
- Introduction to sediment transport

- Flow measurement in open channels.
- Principles of impingement of jets.
- Hydraulic Similitude
- Turbines.
- Centrifugal pump.
- Reciprocating pump.

4. Text Books:

a) Martin Marriott. Nalluri and Featherstone's Civil Engineering Hydraulics. Wiley-Blackwell. 6th Edition, 2016.

5. Reference Books:

a) S K Som, Gautam Biswas, S Chakraborty. Introduction to Fluid Mechanics and Fluid Machines. McGraw Hill Education. 3rd Ed., 2017.
b) Donald F. Elger, Barbara A. LeBret, Clayton T. Crowe, John A. Roberson. Engineering Fluid Mechanics. Wiley. 12th Ed., 2019.
c) Merle C. Potter, David C. Wiggert, Midhat Hondzo. Mechanics of Fluids. CL Engineering. 5th Ed., 2016.
d) Pavel Novak, Vincent Guinot, Alan Jeffrey, Dominic E. Reeve. Hydraulic Modelling: An Introduction - Principles, Methods and Applications. CRC Press. 1st Ed., 2010.
e) K Subramanya. Flow in Open Channels. McGraw-Hill. 5th Ed., 2019.
f) P. Novak, A.I.B. Moffat, C. Nalluri, R. Narayanan. Hydraulic Structures. CRC Press. 4th Ed., 2007.

6. Session/Lecture Wise Plan:

Sl. No.	Topics Covered	Hours (Tentative)
1	Comparison between pipe and channel flows, classification of channels and basic equations of flow.	4
2	Specific energy, Critical flow, Channel transitions, Uniform flow formulae, best hydraulic sections.	4
3	Non uniform flow in open channels, gradually varied flow equation, Type of GVF profiles, Computation of GVF profiles.	6
4	Steady Rapidly Varied flow: Hydraulic jump in a horizontal rectangular channel, specific force, Computation of energy loss.	4
5	Celerity of gravity wave, Monoclonal rising wave, Positive and Negative surges, St. Venant's equations, Method of characteristics, Hydraulic routing.	4
6	Incipient motion and Shield's theory	3

7	Broad and sharp- crested weirs, free overall, and flow over spillways, sluice gates.	4
8	Impact of jet on a stationary vertical plate, stationary inclined plate, and stationary curved plate, hinged plate, moving vertical and inclined plates, moving curved plate and on series of moving flat and curved vanes fixed on the periphery of circular rim.	4
9	Review of Dimensional analysis, Similarity laws, and Model studies.	3
10	Turbines classification, impulse turbines-Pelton wheel, Reaction turbines - Francis and Kaplan Turbines, Governing of a Francis Turbine, Performance of turbines - specific speed and their significance.	4
11	Centrifugal pump-Description and working, Head, discharge and efficiency of a centrifugal pump, pressure rise in the pump, minimum starting speed of a pump,cavitation, priming, multistage pumps, characteristic curves.	4
12	Reciprocating pump-Description and working-types-discharge and slip-power required to drive the pump, Indicator diagram, Air vessel, work done against friction with and without air vessels.	4
	Total Number of Hours	48

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1403 TRANSPORTATION ENGINEERING (3 - 0 - 0)

1. Course Description:

Transportation engineering deals with application of principles of engineering on planning, analysis and design of different transportation modes including physical infrastructure to provide for the safe, rapid, comfortable, convenient, economical and environmentally compatible movement of people and goods. It is essential that different components of transportation infrastructure are planned, designed, built and maintained in an optimal manner. In this course, students will be introduced to different essential components of road related aspects such as road development process, geometric design of road elements, components of traffic stream and traffic studies. Further introduction to other modes of transportation such as air and rail modes are included in this course.

2. Learning Outcome:

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

- Understand transportation systems, modes and steps involved in road development process

- Design geometrics of roads such as different sight distances, horizontal and vertical alignment elements.
- Understand concepts in traffic engineering such as components of traffic steam characteristics, traffic studies and signal design
- Elementary aspects of airport and railway engineering.

3. Broad Course Outline:

- Transportation system and modes,
- Classifications of roads, Road development process
- Road alignment and Geometric design of roads
- Fundamentals of Traffic Engineering
- Introduction to Airport Engineering and Railway Engineering

4. Text Books:

a) Khisty, C. Jotin and Lall, B. Kent., Transportation Engineering and Planning, 3rd Edition, Pearson India, 2001
b) Venkataramaiah, C., Transportation Engineering Vol-I and Vol-II, 1st Edition, University Press, 2016.
c) Khanna S.K and Justo, C.E. G., Highway Engineering, 10th Edition, Khanna Publishers, New Delhi.

5. Reference Books:

a) Kadiyali, L.R and Lal, N.B. Principles and Practices of Highway Engineering, 7th Edition, Khanna Publishers, New Delhi, 2017.
b) Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi, 2013.
c) Roess, R.P, Prassas E.S and W.R. Mcshane. W.R Traffic Engineering, 5th Edition, Pearson Education, Inc., New Jersey, 2019
d) Planning and Design of Airports- 5th Edition, Robert Horonjeff, Francis X. McKelvey, William J. Sproule, Seth B. Young, 5 th edition, MC Graw Hill, 2010
e) Chandra, S and Agarwal, M.M, Railway Engineering, First Edition, Oxford University Press, New Delhi
f) Relevant Indian Roads Congress (IRC) guidelines

6. Session/Lecture Wise Plan:

Sl. No.	Topics Covered	Hours (Tentative)
1	Introduction to Transportation Engineering: Need for Transportation System, Transport Demand and Supply, Passenger Transportation/Goods Transportation, Different Modes of Transportation, Classification of roads- urban and non-urban, 20-year road development plans of India and salient features	5

2	Road Infrastructure Development Process: Prioritization, Feasibility Study, Preliminary Project Report, Detailed Project Report. Selection of Highway Alignment: Alternative alignments and evaluation	4
3	Geometric Design of Roads: Functional Classification, Design Elements and Controls, Cross Section Elements; Factors affecting geometric design elements; Sight Distances-Stopping, Overtaking, Decision, Intermediate, Headlight and Intersection Sight Distance; Horizontal Alignment- Horizontal Curve, Superelevation, Transition Curve, Extra Widening, Setback Distance; Topography, Vertical alignment -Gradient, Types of gradients, Grade Compensation, Critical Length of Grade, Design of Summit and Valley Curve.	9
4	**Traffic Engineering**: Introduction, Components of traffic system, Traffic Stream Characteristics: Uninterrupted Flow Facilities, Interrupted Flow Facilities, Macroscopic and Microscopic parameters, Fundamental Relationships, Passenger Car Equivalency/Unit, Traffic studies on flow and speed, peak hour factor, accident study, statistical analysis of traffic data; Traffic signs; Signal design by Webster's method; Types of intersections; Highway capacity	7
5	**Airport Engineering**: Introduction to Air transportation, Airport layout and components; Runway – orientation, wind rose diagrams, geometric standards, basic runway length, correction of runway length; Taxiway- Geometric standards and high-speed exit taxiway design	6
6	**Railway Engineering**: Introduction, Geometric design of railway track – Gradients, Circular Curves, Cant, Cant Deficiency, Transition Curves, Salient features of high speed rail tracks	5
	Total Number of Hours	36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1404 CIVIL ENGINEERING MATERIALS (3 - 0 - 0)

1. Course Description:

Concrete Technology introduces you to the different materials for construction like bricks, wood products, steel and aluminum, concrete and new materials such as fly ash, AAC bricks, geopolymer etc. The course focuses on concrete, its making materials and properties. Different tests available for determining strength of concrete are discussed. The course also emphasizes factors influencing properties of fresh and hardened concrete. Lastly, it focuses on the concepts of mix design of concrete. Some special types of concrete are also introduced at the end of the course.

2. Learning Outcome:

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

- Know more about the different materials for construction.
- Test all the concrete materials as per IS code.
- Determine the properties of fresh and hardened of concrete.
- Design the concrete mix using IS code method.
- Know about special types of concrete and their applications.

3. Broad Course Outline:

- Introduction to building materials
- Cement.
- Aggregates.
- Water and admixtures
- Fresh concrete.
- Hardened concrete.
- Durability.
- Concrete Mix design.
- Special concrete.

4. Text Books:

a) M.S. Shetty, Concrete Technology, S Chand Co., Publishers, 2006.
b) M.L. Gambhir, Concrete Technology Theory and Practice, Tata McGraw Hill Publishers, 5th Edition.

5. Reference Books:

a) A.M. Neville, Properties of Concrete, Longman Publishers, 2004.
b) S.K. Sharma, Civil Engineering Construction Materials, Khanna Publishing, 2019.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Brick and clay products, Timber and wood based products, steel and aluminium, Cement, new materials - fly ash, AAC brick, Geopolymer.	5
2	Cement, Different test on cement as per Indian standards, Bogue's compounds, Hydration of cement, Gel formation, pore & capillary water.	5
3	Fine and coarse aggregate, Tests on aggregates as per Indian standards, Bulking of sand, Sieve analysis – Grading.	4

4	Quality of water, Types of chemical and mineral admixtures	3
5	Properties of fresh concrete- Workability – different tests of workability- Factors influencing workability compaction, finishing, curing.	5
6	Tests on hardened concrete as per IS codes – Relationship between different strengths – factors influencing strength, NDT techniques.	4
7	Factors influencing durability – Chemical effects on concrete- Carbonation, Sulphate attack, Chloride attack.	4
8	Different methods of mix design – factors affecting mix design – exercises.	3
9	Heavy density concrete, underwater concrete, self-compacting concrete, light weight concrete, mass concrete.	3
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEP 1401 CONSTRUCTION MATERIALS LABORATORY (0 - 0 - 2)

1. Course Description:
The Lab sessions would include experiments on:

- Cement.
- Aggregates.
- Concrete.
- Non-destructive test equipments
- Mix design.

2. Learning Outcome:
On completion of the course, the students will be able to:

- Conduct Quality Control tests on concrete making materials.
- Conduct Quality Control tests on fresh & hardened concrete.
- Design and test concrete mix.
- Conduct Non-destructive tests on concrete.

3. Broad Course Outline:

- Determination of Fineness and Specific Gravity of cement
- Determination of consistency of standard Cement Paste
- Determination of initial and Final Setting times of Cement
- Determination of Compressive Strength of Cement.
- Determination of Fineness modulus of Coarse and Fine Aggregates
- Determination of percentage of voids, Bulk density, Specific Gravity of coarse and Fine
- Aggregates.
- Workability Tests: Slump Cone Test, Compaction factor test, Vee-Bee consistometer Test
- Preparing and curing concrete specimens for tests & Determination of compressive strength of concrete cubes
- Experiments to demonstrate the use of non-destructive test equipment like rebound hammer, ultrasonic pulse velocity, permeability, corrosion and core cutter.
- Mix Design: IS Code method

CEP 1402 HYDRAULIC ENGINEERING LABORATORY (0 - 0 - 2)

1. Course Description:
Introduces the practical engineering concepts of Hydraulics.

2. Learning Outcome:
On completion of the course, the students will be able to:

- Determine Manning's and Chezy's coefficients for smooth and rough channels.
- Determine Energy loss in Hydraulic jump.
- Test the performance of pumps and turbines.
- Compute drag coefficients.

3. Broad Course Outline:

- Determination of Manning's and Chezy's coefficients for smooth and rough channels by gradually varied flow method.
- Determination of Energy loss in Hydraulic jump.
- Determination Velocity distributions in open channels.
- Computation of pressure drag coefficient for flow past a cylinder in a subsonic wind tunnel.
- Performance Characteristics of single stage centrifugal pump, multi stage centrifugal pump, submersible pumps, and varying speed centrifugal pumps.
- Performance Characteristics of Pelton turbine, Francis turbine, and Kaplan turbine**.**

CEP 1403 GEOMATICS ENGINEERING LABORATORY (0 - 0 - 2)

1. Course Description:
Introduces the practical engineering concepts of Geomatics for Civil Engineering. The main aim is to provide knowledge of handling basic and advanced survey instruments such as Theodolite, Tacheometry, Total Station and GPS.

2. Learning Outcome:
On completion of the course, the students will be able to:

- Use conventional surveying tools such as chain/tape, compass, plane table, level in the field of civil engineering applications such as structural plotting and highway profiling
- Apply modern surveying techniques such as Theodolite, EDM and Total Station.
- Represent data using GIS software

3. Broad Course Outline:

- Introduction to equipments
- Tape and compass traversing: Closed traversing; determination of the distance between two inaccessible points with a compass.
- Traversing using plane table surveying
- Levelling: Adjustment to Dumpy level; differential leveling, and profile leveling; Longitudinal and cross-sectioning
- Contouring: Block contouring, radial contouring Exp.
- Theodolite Traversing – Measurements of horizontal angles; Determination of elevation of an object
- Tacheometry – Determination of heights and distances by Tangential Tacheometry Exp.
- Total Station – Determination of distance and difference in elevation between two inaccessible points
- Mapping using Global Positioning System (GPS)
- Representation of raster and vector data using QGIS.

CEL 1501 ANALYSIS OF INDETERMINATE STRUCTURES (3 - 1 - 0)

1. Course Description:
The course is designed to understand the classical methods of analysis of framed structures for external loads. It also highlights the approximate methods of analysis. Analysis of multistory frames for lateral load is discussed in the course. It also focuses on the Matrix method of structural analysis.

2. Learning Outcome:
At the end of the course, the student will be able to:

- Apply the displacement method of analysis

- Apply the approximate method of analysis
- Analyze structures for lateral loads
- Analyze indeterminate structures using matrix method of analysis

3. Broad Course Outline:

- Classical method of analysis of framed structures
- Approximate methods of analysis
- Lateral load analysis
- Matrix Methods of Structural Analysis

4. Text Books:

a) Hibbeler. R. C, Structural Analysis, Pearson Prentice Hall, 2012.
b) L.S. Negi, Theory and Problems in Structural Analysis, Tata McGraw Hill Pub, 2008.

5. Reference Books:

a) Wang C.K., Intermediate Structural Analaysis, Tata Mc Graw Hill Publishers, 2010.
b) W. Weaver and J. M. Gere, Matrix analysis of framed structures, CBS Publishers, 2nd edition, 2004.

6. Session/ Lecture Wise Plan

Sl. No	Topics	Hours (Tentative)
1	Slope deflection method, Moment distribution method, effect of symmetry and anti- symmetry, sway correction	12
2	Substitute frame methods for gravity load	12
3	Portal and Cantilever methods	10
4	Local and global stiffness matrices, assembly, band storage, solution of resulting simultaneous algebraic equation, boundary conditions, applications to plane and space truss, analysis of plane frame, grid and three dimensional frame	14
Total Number of Hours		48

7. Evaluation plan

Sl no.	**Type of evaluation**	**Weightage**
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1502 DESIGN OF REINFORCED CONCRETE STRUCTURES (3 - 1 - 0)

1. Course Description:

Design of R.C. structures introduces you to the concepts of working stress method and limit state method. The codal provisions of IS 456:200 used for design will be discussed. It focuses on the design of singly reinforced sections with the three modes of failure-balanced, over- reinforced and under-reinforced. It focuses on the design of doubly reinforced sections. Later the concepts of shear and bond design of RC structures are studied. The design of RC flanged beams, slabs-one way and two way slab, continuous slabs and beams, columns and footings are studied in detail.

2. Learning Outcome:

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

- Apply the fundamental concepts of working stress method and limit state method.
- Use IS code of practice for the design of concrete elements.
- Know more about the concepts of bond.
- Design the beams, slab, column and footing.
- Draw various RC structural elements.

3. Broad Course Outline:

- Introduction.
- Design philosophies.
- Analysis and Design of Singly Reinforced Beams.
- Analysis and Design of Doubly Reinforced Beams.
- Analysis and Design of Flanged Beams.
- Shear and Bond design of RC.
- Design of RC Slabs.
- Design of Continuous Slab and Beams.
- Design of RC Columns.
- Design of RC Footings.
- Design for Serviceability.

4. Text Books:

a) S. Unnikrishna Pillai, Devdas Menon, Reinforced Concrete Design, Tata McGraw Hill Education, 2003.
b) N. Subramanian, design of Reinforced Concrete Structures, Oxford University Press, 2013.

5. Reference Books:

a) P.C. Varghese, Limit State Design of Reinforced Concrete, 2nd Edition, PHI, 2009.
b) IS 456:2000, IS 3370 (Part-IV), BIS 2000.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Review of Concrete making materials- Structural concrete- Grades- properties of Concrete- Modulus of elasticity-flexural strength-Characteristic and Design values-Partial safety factor.	3
2	Objectives of RC design -Working stress method- comparison of design approaches. Limit State method- Assumptions- Stress-Strain behavior of Steel and Concrete- Stress block parameters	3
3	Analysis of Singly Reinforced RC Section- Neutral axis-Balanced-Under Reinforced-Over Reinforced Sections- Moment of Resistance- Design parameters- Design examples.	4
4	Necessity of Doubly Reinforced sections- Analysis of Doubly Reinforced RC Section- Moment of Resistance- Design parameters- Design.	4
5	Analysis of flanged RC section- Singly and Doubly reinforced-Effective flange width- Moment of Resistance- design examples.	4
6	Shear forces in RC-Shear Resistance of RC- Truss analogy- design of Vertical stirrups-Bent- up bars- Limitation- Bond failure in RC- Check for bond resistance-Development length-Design for shear and bond.	5
7	Equilibrium torsion and Compatibility torsion, General behavior of RC structures in Torsion, Design strength in Torsion, Design examples.	5
8	Design of One and Two way slabs: Effect of edge conditions- Moment of resistance-Torsion reinforcement at corners- Design examples.	4
9	Effect of continuity - analysis of continuous beam/slab- Moment and shear coefficients for continuous beam/slab- Critical sections.	4
10	Design principles of RC columns- Assumptions- Rectangular and Circular columns- Helical reinforcement- Minimum eccentricity-Use of Interaction diagrams for Axial load and Moment.	4
11	RC footings - Minimum depth of footing- Safe bearing capacity- Design for Bending-Shear in One way and Shear in Two way- Transfer of load at base of column.	5
12	Concept of Serviceability- Deflection- Span to depth ratio- Short term-Long term deflection due to Shrinkage, Creep- Cracking-Crack width calculation.	3
Total Number of Hours		48

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1503 GEOTECHNICAL ENGINEERING (3 - 1 - 0)

1. Course Description:

Geotechnical Engineering introduces the importance of soil mechanics in the domain of civil engineering. The course deals with the primary concepts of the composition, classification as well as physical and engineering characterization of soil. It focuses on the soil water interaction phenomena like capillarity, permeability, seepage, flow nets, generation of pore pressures, and effective stress characteristics. The course also highlights the stress-strain related behaviour of soils inclusive of stress distribution, compaction, consolidation and shear strength of soils. Various field and laboratory investigations related to estimate the shear strength parameters of soils are addressed in this course. Further, the course addresses the issues of slope stability and the associated mechanics of soil.

2. Learning Outcome:

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

- Characterize and classify soils
- Identify shear strength parameters from field and laboratory investigation
- Compute and analyze the consolidation characteristics of soil
- Understand the principles of compaction and its control
- Analyze stability of soil slopes

3. Broad Course Outline:

- Physical properties of soil
- Classification of Soils
- Soil Water
- Compaction of Soils
- Stress distribution in Soils.
- Consolidation
- Shear Strength
- Stability of Soil Slopes

4. Text Books:

a) G. Ranjan and A.S.R. Rao, Basic and Applied Soil Mechanics, New Age International Pvt. Ltd, New Delhi, 2016.

b) V.N.S. Murthy, A Textbook of Soil Mechanics and Foundation Engineering, CBS Publications, New Delhi. 2015.
c) B. M. Das, Principles of Geotechnical Engineering, Cengage Learning India Pvt. Ltd., New Delhi, 2017.

5. Reference Books:

a) Singh, Soil Engineering: Vol-I Fundamentals and General Principles, CBS Publishers and Distributors, 2012.
b) K. R. Arora, Soil Mechanics and Foundation Engineering, Standard Publishers and Distributors, 2009.
c) J. K. Mitchell, and J. Soga, Fundamentals of Soil Behavior, John Wiley & Sons, 2005
d) M. Budhu, Soil Mechanics and Foundations, John Wiley & Sons, 2016.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Soil formation- Development of soil mechanics- Importance of soil engineering- Major soil deposits of India, Basic definitions and relationships: 3-phase soil system, Volumetric relationships and weight volume relationships, Determination of index properties: Water content, Specific gravity, Grain size distribution by sieve and hydrometer analysis, Relative density, Atterberg's limits and indices.	5
2	Classification of soil systems – Particle size classification, Textural classification, AASHTO classification, Unified soil classification and Indian soil classification- Field identification of soils.	4
3	Types of soil water, Capillarity in soils, Permeability of soils, Darcy's law, Determination of permeability of soils, Permeability of stratified soils, Absolute coefficient of permeability, Factors affecting permeability- Effective stress principle- Effective stress under different field conditions. Seepage pressure- Quick sand condition. Seepage and Flownets (seepage velocity, exit gradient, uplift pressure), Seepage flow through earth dams, Piping failure.	6
4	Definition and importance of compaction – Standard Proctor compaction test, Modified compaction test- Factors affecting compaction- Influence of compaction on soil properties – Field compaction and its control.	5
5	Importance of estimation of stresses in soils –Boussinesq's and Westergaard's theories for point loads, uniformly loaded circular and rectangular areas, pressure bulb, variation of vertical stress under point load along the vertical and horizontal planes – Newmark's influence chart.	6
6	Types of compressibility and consolidation, Primary consolidation and secondary consolidation – Stress history of clay, normally consolidated soil, over consolidated soil and under consolidated soil- pre consolidation pressure and its determination- Estimation of consolidation settlements -Terzaghi's 1-D consolidation theory – Coefficient of consolidation and its determination using consolidometer.	8

7	Definition and use of shear strength - Source of shear strength- Normal and Shear stresses on a plane – Mohr's stress circle- Mohr-Coulomb failure theory- Measurement of shear strength, Drainage conditions -Direct shear test, Triaxial shear test, Unconfined compression test and vane shear test – Factors affecting shear strength of granular soils and cohesive soils.	7
8	Types of slopes – Types of slope failures – Slip circle Method--Method of slices, Bishop's method (original and simplified), Morgenstern method, Spencer method, Determination of centre of most critical slip circle – Taylor's stability charts and their use. Stabilization of soil slopes.	7
Total Number of Hours		48

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1504 WATER RESOURCES ENGINEERING (3 - 0 - 0)

1. Course Description:

To introduce the students to the scientific study of the hydrological processes and to derive hydrological and hydraulic loadings for water engineering structures like dams and barrages. It also introduces basic irrigation systems, canal systems and its design. Introduction to the basics of storage and diversion structures used in water resources engineering.

2. Learning Outcome:

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

- Identify and characterize the precipitation and their measurement.
- Apply the concepts of rainfall runoff relationship for computing water and sediment yield from catchment.
- Estimate the peak discharge and learn concepts of flood and flood routing.
- Assess the irrigation needs of crops
- Apply the design concepts of canal, canal structures, dam and water diversion structures.

3. Broad Course Outline:

- Hydrologic Cycle
- Precipitation, Infiltration and Evapotranspiration
- Evaporation
- Runoff and Hydrographs, Unit hydrograph
- Statistical analysis

- Floods and Flood routing
- Groundwater and well hydrology
- River basins and watershed management;
- Irrigation Water Requirement
- Canal systems
- Design of canal structures
- Gravity dams
- Water diversion structures

4. Text Books:

a) K. Subramanya, Engineering Hydrology, Tata Mc Graw Hill Pub. Co., New Delhi. 5th Ed., 2021.
b) G.L. Asawa, Irrigation and Water Resources Engineering. New Age Publishers. 1st Ed., 2005.

5. Reference Books:

a) Sharad Jain, Vijay Singh. Engineering Hydrology: An Introduction to Processes, Analysis, and Modeling. McGraw-Hill Education. 2019.
b) P. Novak, A.I.B. Moffat, C. Nalluri, R. Narayanan. Hydraulic Structures. CRC Press. 4th Ed., 2007

6. Session/Lecture Wise Plan:

Sl. No.	Topics Covered	Hours (Tentative)
1	Description of Hydrologic Cycle Precipitation, Infiltration and Evapotranspiration: Forms of precipitation, measurement, depth-duration and intensity- duration frequency relations.	4
2	Evaporation – process, measurement, and estimation, Infiltration process, measurement and estimation. Evapotranspiration measurement and estimation	2
3	Runoff and Hydrographs: Rainfall Runoff correlations, Flow duration curve, Mass curve, Droughts and floods, Factors affecting flow hydrograph Unit hydrograph, its analysis and S-curve hydrograph, Synthetic and instantaneous unit hydrographs	6
4	Statistical analysis; Risk, reliability, and safety factor, Flood frequency studies Rational method, Time Area curves; Design flood; Channel and flood routing	4
5	Groundwater and well hydrology: Flow equations, Confined and unconfined flow; Well hydraulics; Steady and unsteady flow, Well losses, Specific capacity	2
6	River basins and watershed management; Water resources - storages and their yields; Water logging; Streams and their gauging; River morphology; Types of floods and drought, and their management; Capacity of reservoirs	2

7	Irrigation types of irrigation systems, Soil-water plant relationship: Classification of soil water- soil moisture contents- depth of soil water available to plants; root zone soil water; permanent and ultimate wilting point Depth of water applied during irrigation- Duty of water and delta improvement of duty, command area and intensity of irrigation, consumptive use of water and Evapotranspiration irrigation efficiencies- assessment of irrigation water, frequency of irrigation.	4
8	Canal systems - alignment of canals, canal losses, Design of channels - channels carrying clear and sediment laden water, alluvial channels carrying clear and sediment laden water, Lacey's theory of regime channels. Canal outlets: non-modular, semi-modular and modular outlets. Water logging: causes, effects and remedial measures. Lining of canals, economics of lining, types of lining. Drainage of irrigated lands: necessity, methods	3
9	Canal structures- Surface and sub-surface flow considerations for design of canal structures: hydraulic jump, seepage forces, uplift forces. Silt exclusion devices, Canal falls, cross regulator, distributary head regulator. Cross drainage works: their classification and their application areas; Canal falls and escapes	3
10	Cross section of overflow and spillway blocks; ogee spillway and energy dissipators. Forces on gravity dams, Stability analysis; causes of failure, stress analysis.	3
11	Design of weirs and barrages on permeable foundation; Different units of head works, types of weirs, sediment control in canals, river training for canal head works. Theories of seepage for design of weirs: Khosla-Bose-Taylor method of independent variables	3
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1505 WATER AND WASTEWATER ENGINEERING (3 - 0 - 0)

1. Course Description:

This course will cover the topics of Water and Waste Water Quality and Treatment: Basics of water quality standards – Physical, chemical and biological parameters; Water quality index; Unit processes and operations; Water requirement; Water distribution system; Drinking water treatment. Sewerage system design, quantity of domestic wastewater, primary and secondary treatment. Effluent discharge standards; Sludge disposal; Reuse of treated sewage for different applications.

2. Learning Outcome:

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

- Identify the sources of water and water demand, evaluate the water quality and calculate WQI.
- Do the basic design of water supply network, sewerage system, calculate sewage load.
- Perform the design calculations for various unit operations and processes for water and wastewater treatment, physico-chemical and biological treatment methods including disinfection.
- Identify the treatment and resource recovery options for biosolids (sewage sludge) and residuals from water treatment plants.

3. Broad Course Outline:

- Requirements for water supply systems.
- Physical, chemical and biological characteristics of water.
- Design of drinking water treatment plants and distribution systems
- Generation and collection of wastewater.
- Design of sewerage systems; primary, secondary and tertiary wastewater treatment systems.
- Biological wastewater treatment systems
- Sludge disposal and handling
- Effluent disposal and wastewater reuse.

4. Text Books:

a) Qasim, S., Motley, E., & Zhu, G. (2000). Water works engineering: planning, design and operation. Prentice Hall.
b) Metcalf & Eddy (2003). Wastewater Engineering: Treatment, disposal and reuse. New Delhi: Tata-McGraw Hill.

5. Reference Books:

a) CPHEEO. (1999). Manual on water supply and treatment. Ministry of Urban Development, New Delhi;
b) CPHEEO. (2013). Manual on sewerage and sewage treatment systems. Ministry of Urban Development, New Delhi;
c) Peavy, H., Rowe, D., & Tchobanoglous, G. (1985). Environmental Engineering. NY, US: McGraw Hill International Ed

6. Session/Lecture Wise Plan:

Sl. No.	Topics Covered	Hours (Tentative)
1	General requirement for water supply, sources, quality and quantity of water, intake, pumping and transportation of water.	3

2	Physical, chemical and biological characteristics of water and their significance.	2
3	Engineered systems for water treatment: aeration, sedimentation, softening, coagulation, filtration, adsorption, ion exchange, and disinfection.	9
4	Water distribution system	2
5	Generation and collection of wastewater, sanitary, storm and combined sewerage systems, Quantities of sanitary wastes and storm water, Design of sewerage system	3
6	Primary, secondary and tertiary treatment of wastewater; Wastewater disposal standards. Basics of microbiology	3
7	Biological wastewater treatment systems: Aerobic processes - activated sludge process and its modifications, trickling filter, RBC, Anaerobic Processes- conventional anaerobic digester, High rate and hybrid anaerobic reactors	10
8	Sludge digestion and handling. Disposal of effluent and sludge, onsite sewage treatment system and decentralized wastewater treatment system, Treated wastewater reuse.	4
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEP 1501 GEOTECHNICAL ENGINEERING LABORATORY (0 - 0 - 2)

1. Course Description:
The Lab sessions would include experiments on different tests on soils to find out its properties.

2. Learning Outcome:
On completion of the course, the students will be able to:

- Determine index properties of soils.
- Classify soils.
- Determine engineering properties of soils.

3. Broad Course Outline:

- Sieve analysis
- Consistency limits

- Specific gravity
- Permeability tests
- Unconfined compression test
- SPT test
- Direct shear test
- Core cutter and sand replacement method
- Compaction test
- California bearing ratio test
- Vane shear test
- Triaxial test
- Consolidation test
- Plate load test

CEP 1502 ENVIRONMENTAL ENGINEERING LABORATORY (0 - 0 - 2)

1. Course Description:

The Lab sessions would include experiments on:

- Physical properties of water
- Chemical properties of water
- Break point chlorination test
- Determination of residual chlorine
- Determination of dissolved oxygen
- Determination of COD, BOD
- Jar test
- Total solids, Total dissolved solids and Settleable solids

2. Learning Outcome:

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

- Determine physical, chemical and biological characteristics of water and wastewater.
- Determine optimum dosage of coagulant.
- Determine break - point chlorination
- Assess the quality of water and wastewater.

3. Broad Course Outline:

- Determination of pH

- Determination of Conductivity
- Determination of Acidity of water
- Determination of Alkalinity of Water
- Determination of Chlorides
- Determination of Hardness of water
- Determination of Fluorides
- Determination of Available Chlorine in bleaching powder
- Conducting Break Point Chlorination Test
- Determination of Residual Chlorine
- Determination of Dissolved Oxygen
- Determination of Chemical Oxygen Demand
- Determination of Biochemical Oxygen Demand
- Conducting Jar test for determining optimum dosage of coagulant
- Determination of Total Solids, Total Dissolved Solids & Settelable Solids

CEL 1601 DESIGN OF STEEL STRUCTURES (3 - 1 - 0)

1. Course Description

Design of Steel Structures introduces you to the design guidelines followed by engineers and designers for building or designing steel structures. The main objective of the course is to learn to use IS 800:2007 code of practice for the design of different structural elements such as compression, tension and flexural members. It introduces you to different design philosophies used in design. The course also gives an idea of different types of connections used in steel structures.

2. Learning Outcome

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

- Apply The IS Code Of Practice For The Design Of Steel Structural Elements
- Design Compression And Tension Members Using Simple And Built-Up Sections
- Calculate Forces On Various Members Of Truss And Design Them
- Analyze And Design Welded And Bolted Connections.
- Design Welded Connections For Both Axial And Eccentric Forces

3. Broad Course Outline

- Introduction
- Methods of Structural Design
- Design of Steel Connections

- Design of tension Members
- Design of Compression Members
- Design of Beams
- Design of Beam Columns
- Design of Column Splices and Column Base
- Design of Eccentric Connections
- Design of Plate Girder

4. Text Books:

a) Subramanian N, Design of Steel Structures, Oxford University Press, New Delhi 2008.
b) L. S. Negi, Design of Steel Structures, Tata McGraw Hill, 2008.

5. Reference Books:

a) S. S. Bhavikatti, Design of Steel Structures, I. K. Innternational Pvt. Ltd., 2009.
b) S K Duggal, Design of Steel Structures, Tata McGraw Hill Education, 2000.

6. Session/Lecture Wise Plan

Sl. No	Topics	Hours (Tentative)
1	General, Types of Steel, Properties of steel, Structural steel sections.	2
2	Introduction, Design Philosophies, Working Stress method, Ultimate Stress method, Load and Resistant factor, Limit State Method, Partial safety factor, Load, Load combinations, General aspects in the design.	4
3	Introduction to plastic theory, Plastic moment, Plastic section modulus, Plastic hinge concept, Cross section classification.	4
4	Riveted connections, Bolted connections, Assumptions, Failure of bolted joints , Strength of bolted joints, Design examples, Design of Welded connections, Butt weld- fillet weld, Design examples.	5
5	Modes of Failure of Tension member, Analysis of Tension members, Example, Design steps, Design examples, Lug angles.	5
6	Strength of Compression members, Design Compressive strength, Example on analysis of Compression members, Design of Angle struts, Design Examples, Built up Columns, Design of Lacing, Design of Battens, Design Examples, Design of Roof members.	5
7	General, Lateral Stability of Beams, Bending Strength of Beams, Plastic Section Modulus, Design Examples.	5

8	Behavior of members under combined loading, Modes of Failures, Design Examples.	5
9	Design of Column Splice-Design Examples- Design of Column Base- Slab Base- Gusseted Base- Design Examples.	5
10	Design of Brackets- Type-1 and Type 2 – Moment Resistant connections - Design Examples.	3
11	Design of Plate Girder: General- Components of Plate Girder- Optimum depth – Bending Strength – Shear Strength – Shear Buckling- Simple Post critical method- Tension Field method- Stiffeners-Bearing- Transverse stiffeners - Design Examples.	5
Total Number of Hours		48

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1602 ANALYSIS AND DESIGN OF GEOTECHNICAL SYSTEMS (3 - 1 - 0)

1. Course Description

The course intimates about the various exploratory and non-destructive field investigation techniques associated with the subsurface exploration and characterization. The course provides an explanation of the lateral earth pressure theories and their utility in the analysis and designing of rigid and flexible earth retention systems. It explains the concept of bearing capacity and estimation of the various types of bearing capacities including both stress and settlement considerations. Different aspects of foundations related to shallow foundations, pile foundation and well foundation are also discussed. The estimation of the settlement of various types of foundations are also explained. An introduction to the foundations in difficult conditions such as footings resting on slope, expansive and collapsible soils, are also provided. A preliminary idea about ground improvement, geosynthetic engineering and reinforced soil structure is included.

2. Learning Outcome

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

- Carry out soil investigation for any civil engineering construction
- Analyze earth retaining structures for any kind of soil medium
- Estimate bearing capacity
- Design proper foundations for any kind of shallow foundation system

- Estimate pile and pile group capacity for any kind of soil including group efficiency and negative skin friction

3. Broad Course Outline

- Soil exploration
- Lateral earth pressure
- Bearing capacity of soil
- Settlement of foundation
- Shallow foundation
- Pile foundation
- Well foundation

4. Text Books:

a) Murthy V.N.S, A Textbook of Soil Mechanics and Foundation Engineering, CBS publications, Delhi, 2015.
b) B. M. Das, Principles of Foundation Engineering, Cengage Learning India Pvt. Ltd., New Delhi, 2017.
c) J.E. Bowles, Foundation Analysis and Design, McGraw Hill Education, 2017.

5. Reference Books:

a) M. Tomlinson, Pile Design and Construction Practice, Taylor and Francis, 2018.
b) G. Ranjan, A. S. R. Rao, Basic and applied soil mechanics, New age International Pvt. Ltd., Delhi, 2016.
c) S.R. Kaniraj, Design Aids in Soil Mechanics & Foundation Engineering, Tata McGraw Hill, 1988.

6. Session/Lecture Wise Plan

Sl. No	Topics	Hours (Tentative)
1	Introduction and different methods, Direct methods, Semi-direct and Indirect methods; Sampling in soils and rocks; subsurface exploration program, Preparation of bore logs and preparation of exploration report, SPT, CPT, PLT and VST, geophysical exploration techniques	6
2	Lateral earth pressure theory, Different types of earth pressures, Rankine's active and passive earth pressures, pressure distribution diagram for lateral earth pressures against retaining walls for different conditions in cohesion less and cohesive soils, Coulomb's active and passive earth pressure theory, Culmann's graphical construction, Problem solving, Sheet pile wall and Braced cut.	7
3	Types of shallow foundations and choice, basic requirements, Significance of these foundations. Basic Definitions, Factors affecting bearing capacity, Estimation of Bearing capacity by different methods, Analytical methods and	8

	codal provisions, Terzaghi's and Meyerhof methods and calculations, Field measures, SPT, CPT and Plate load tests, Base bearing capacity analysis	
4	Settlement analysis, Types of foundation settlement, Components of settlements - their estimation, Allowable settlement values, Effects, Causes and remedial measures of total and differential settlements	7
5	Classification and uses, Load carrying capacity calculations by different methods, static methods, dynamic methods, in-situ penetration tests, piles load test; Negative skin friction; under reamed pile foundations; Pile groups, Necessity, Efficiency, Group capacity and settlements	8
6	Types of caissons and their construction; Different shapes of wells, component parts and forces; Estimation of bearing capacity; sinking of wells and remedial measures for tilts and shifts, Codal provisions	7
7	Foundations on slopes, foundations on expansive and collapsible soil, Introduction to soil improvement, Introduction to Geosynthetic Engineering and Reinforced soil structures	5
Total Number of Hours		48

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1603 PAVEMENT ENGINEERING (3 - 0 - 0)

1. Course Description

Road infrastructure plays a key contributor to the development of the nation. In this course different concepts related to pavement engineering such as types of pavements, function of pavements, different materials used in pavements are introduced. Different tests to be conducted on pavements materials and test methods are discussed. Analysis and design of both flexible and rigid pavements as per Indian Roads Congress (IRC) guidelines are also included in this course. Further construction of different layers of bituminous, concrete pavements and maintenance of pavements are also discussed in this course.

2. Learning Outcome

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

- Types of pavements and function of pavements
- Evaluation of different pavement materials
- Design of flexible and rigid pavements
- Pavement construction aspects and maintenance

3. Broad Course Outline

- Pavement Engineering: Introduction, types of pavements
- Tests on pavement materials
- Analysis and design of pavements
- Pavement construction and maintenance

4. Text Books:

a) Harold N Atkins, Highway Materials, Soils and Concretes, Pearson Ed, 2002
b) Kadiyali, L.R and Lal, N.B. Principles and Practices of Highway Engineering, 7th Edition, Khanna Publishers, New Delhi, 2017.
c) Huang, Y.H. Pavement Analysis and Design, Second Edition, Pearson, 2004.
d) Partha Chakraborty and Animesh Das, Principles of Transportation Engineering, 2nd Edition, 2017

5. Reference Books:

a) Relevant Indian Roads Congress (IRC) guidelines
b) Specifications for Roads and Bridge works, Ministry of Road Transport and Highways (MoRTH), New Delhi, 5th edition, 2013.
c) Prithvi Singh Kandhal , Bituminous pavement construction in India, PHI Learning, 2016.

6. Session/Lecture Wise Plan

Sl. No.	Topics	Hours (Tentative)
1	Introduction to Pavement Engineering: Pavement types; pavement composition; function of different pavement layers; Functional and structural performance of different types of pavements.	04
2	Soil - as embankment, subgrade and shoulder materials, classification; Physical properties; tests; specifications; Aggregates - used in granular, bituminous, cement treated and cement concrete layers; tests for different physical properties; specifications; Bituminous binders - Bitumen, emulsion, cutback, modified binders and foam bitumen: production; tests for physical properties; grading of bitumen, selection of grade of bitumen, specifications- IS; Bituminous mixes: Types of bituminous mixes; Marshall mix design; Mix specifications; Introduction to Superpave mix design	11
3	Design philosophy of flexible and rigid pavements; Design factors: Traffic factors - lane distribution factor, axle load spectrum, standard axle, equivalent axle load factor, vehicle damage factor, design life; material factors; environmental factors; performance models and criteria; Flexible pavement design approaches: Analysis of Flexible Pavements; Design of flexible pavement as per IRC:37; Rigid pavement design: Stresses in rigid pavements - Westergaard's theory and assumptions, stresses due to curling, stresses due to loading, frictional stresses; types and design of joints; Introduction to IRC:58 pavement design approach	12

4	Introduction, Construction of bituminous pavement: Subgrade, granular Subbase base (GSB), water bound macadam (WBM), wet mix macadam (WMM), dense bituminous macadam, bituminous concrete layers; Construction of cement concrete pavement: Subgrade, dry lean concrete (DLC), cement concrete layer; Quality control aspects of bituminous and concrete pavements; Typical failure of flexible and rigid pavements, causes for failures and remedial measures	9
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1604 AIR POLLUTION AND WASTE MANAGEMENT (3 - 0 - 0)

1. Course Description

This course will cover the topics of Air Pollution: Types of pollutants, their sources and impacts, air pollution control, air quality standards, Air quality Index and limits. Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

2. Learning Outcome

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

- Identify the sources of air pollutants, types of pollutants, and impacts
- Do the basic design of air pollution control, understand the basics of air quality standards, calculation of air quality index and limits.
- Calculate the amount of waste produced in any urban/rural area, develop the understanding of waste characterization methods.
- Do the basic design of waste collection and transportation systems
- Perform the design calculations for various engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal) – Compost, Anaerobic Digestion, Sanitary Landfills
- Introduction to the concept of Circular Economy.

3. Broad Course Outline

- Sources of air pollutants, types of pollutants, and impacts
- Basic design of air pollution control, basics of air quality standards, development of air quality index (AQI) and health limits

- Quantification of waste generation, understanding of the importance of waste characterization for design of waste treatment systems including source segregation
- Design of waste collection and transportation systems
- Development of various engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal) – compost, anaerobic digestion (biomethanation), sanitary landfills
- Introduction to the concept of circular economy as part of waste resource recovery

4. Text Books:

a) Wark K., Warner C.F., and Davis W.T., (1998), "Air Pollution - Its Origin and Control", Harper & Row Publishers, New York
b) Solid Waste Technology & Management, 1 & 2, by Thomas H Christensen. Wiley Publications; 1st edition. ISBN:9781405175173
c) Tchobanoglous G., Theissen H., and Eliassen R. (1991), "Solid Waste Engineering - Principles and Management Issues", McGraw Hill, New York

5. Reference Books:

a) CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation, Government of India, New Delhi, 2016.
b) Peavy, H., Rowe, D., & Tchobanoglous, G. (1985). Environmental Engineering. NY, US: McGraw Hill International Ed.

6. Session/Lecture Wise Plan

Sl. No.	Topics	Hours (Tentative)
1	Air pollutants-Sources, classification, Combustion processes and pollutant emission, Effect on Health, vegetation, materials and atmosphere.	2
2	Atmospheric diffusion of pollutants and their analysis, Transport, transformation and deposition of air contaminants on a global scale, Air sampling and pollutant measurement methods, principles and instruments.	3
3	Ambient air quality and emission standards, control, Air quality index (AQI) Removal of gaseous pollutants by adsorption, absorption, reaction and other methods.	6
4	Particulate emission control, settling chambers, cyclone separation, Wet collectors, fabric filters, electrostatic precipitators and other removal methods.	5
5	Introduction to Waste Management, Waste Legislation and Regulations, Waste Generation and Characterization: Approaches and Methods, Residential Waste, Commercial and Institutional Waste, Industrial Waste.	4
6	Waste Collection and Transport: Source Segregation, collection of segregated waste, systems, design and organization of collection and transport systems. Waste transfer station.	4

7	Biological waste treatment: Aerobic treatment, Compost plants. Anaerobic treatment, Biodigester. Mass balance of the system, Unit Processes, Design of the systems. Overall economics and operational issues. Example case studies.	6
8	Landfilling (Basics and overview). Gas collection and Leachate collection system and treatment. Introduction to Circular Economy	6
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1605 CIVIL ENGINEERING DRAWING, ESTIMATION AND COSTING (2 - 0 - 2)

1. Course Description

Quantity surveying and public works will help you understand the importance of estimates under different conditions. It will help you know about the rate analysis and bill preparations. The course emphasizes the idea of specification writing. It will also help you understand the valuation of land and buildings.

2. Learning Outcome

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

- Apply different types of estimates
- Carry out analysis of rates and bill preparation
- Demonstrate the concept of specification writing
- Handle contracts and tender
- Carry out valuation of assets

3. Broad Course Outline

- Introduction to estimates
- Analysis of rates
- Specifications
- Contracts
- Tenders
- Valuation

4. Text Books:

a) M. Chakraborti, Estimation, costing, specifications and valuation in civil engineering, National Halftone Co. Calcutta, 2005.
b) Rangawala, Estimating, Costing and Valuation, Charotar Publishing House Pvt. Ltd., 2014.

5. Reference Books:

a) B. N. Dutta, Estimation and costing in civil engineering: theory and practice, UBS Publishers Distributors Ltd, 2006.
b) G. S. Birdie, Estimation and costing in civil engineering, Dhanpat Rai Publishing Co. Ltd.

6. Session/Lecture Wise Plan

Sl. No	Topics	Hours (Tentative)
1	Doors and Windows: Glazed and panelled doors of standard sizes; Glazed and panelled windows of standard sizes. Stairs: Proportioning and design of dog-legged and open well RCC stair case for an office / Residential building. Foundations: Spread foundation for walls and columns; Footing for an RCC column, raft and pile foundations. Functional Design of Buildings: To draw the line diagram, plan, elevation and section of residential buildings (flat, pitched roof) with schedule of openings	8
2	Purpose of estimating; Different types of estimates - their function and preparation; Building estimates: Schedule of rates, Units of measurements, units of works; Road Estimates – Volume of earthwork, Different methods, Earthwork for hill roads; Railway and canal works – Estimates for a new track railway line; earthwork in canals.	8
3	Preparation for analysis of rates. Quantity of materials per unit rate of work, labour estimate.	6
4	Necessity, types of specifications, specifications for different civil engineering materials.	5
5	Essentials of contracts, types of engineering contracts – advantages and disadvantages.	4
6	Purpose, difference between value and cost, qualifications and functions of a valuer, scrap & salvage value, sinking fund, capitalized value.	5
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30

2	Internal evaluation	20
3	End semester examination	50
Total		100

CEP 1601 TRANSPORTATION ENGINEERING LABORATORY (0 - 0 - 2)

1. Course Description

Transportation Engineering laboratory session would include experiments on

- Test on road aggregates
- Test on bitumen
- Test on soil
- Volume studies
- Speed studies

2. Learning Outcome

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

- Characterize different pavement materials and know the specification
- Collect traffic data and analyze the data for different applications

3. Broad Course Outline

- **Tests on road aggregate**: Shape test, impact test, abrasion test, specific gravity test and water absorption test
- **Tests on bitumen**: Penetration test, ductility test, stripping test, softening point test, flash and fire point test, viscosity test on bitumen, short term aging
- **Test on soil**: California Bearing Ratio (CBR) on soil
- **Traffic studies**: Traffic volume and Speed studies

CEP 1602 DESIGN OF INNOVATIVE INFRASTRUCTURE SYSTEMS (0 - 0 - 2)

1. Course Description:

The objective of the course is to provide students with tools to develop Innovative Infrastructure Systems in all the areas of Civil Infrastructure. The course will explore ways to support sustainable development strategies of the countries concerned in developing their existing and new infrastructures in terms of mitigating and adapting to various upcoming threats such as climate change. Focus will be on how to transfer theoretical knowledge to practical solutions. The course will include readings of theoretical background with a clear and significant potential for practical application of the theory. Case studies will be included, and the students will be assigned a group project where they can take one infrastructure project from Mizoram or any other northeast state (preferably) or from other parts of India and come up with innovations to solve any issues associated with the present infrastructure system. The

tools for problem solving will be open and flexible and all sorts of innovations from the student groups will be welcome.

2. Learning Outcomes:

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

- Understand the basic challenges of incorporation of innovation in the infrastructure projects
- Critically analyze the impacts of upcoming threats such as climate change and incorporate sustainable thinking in the infrastructure design
- Transfer the theoretical knowledge from different courses to practical solutions
- Work on a Group Design Project based on real world issues from Mizoram and/or Northeast as appropriate.

3. Broad Course Outline:

- Fundamentals of Infrastructure Management
- Review of Infrastructure Issues from the state of Mizoram and other states in Northeast, Identifications of particular problem to address as part of the Innovative Design Projects
- Formulation of Design Teams and Brain Storming Group Sessions to evaluate different possible design options
- Project Review and Feedback for further improvements
- Feedback on Final project preparation and design calculations
- Report preparation, class presentations and Final Report submission

CEL 1701 CONSTRUCTION TECHNOLOGY AND PROJECT MANAGEMENT (3 - 0 - 0)

1. Course Description:

Construction Technology and Project Management introduces you to the concepts of engineering economics, it focuses on the importance of Project Management, the role of a project manager. It focuses on the knowledge and processes involved in construction projects. Later it focuses on the different types of equipments used for construction. Lastly it mainly focuses on the finance in construction.

2. Learning Outcome:

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

- Able to make a correct decision.
- Know more about the role of a project manager.
- Emphasize the importance of project management.
- Take up a project on construction in a well-planned and systematic way.
- Know more about the different equipments for construction.
- Estimate the required finance in construction projects.
- Know more about entrepreneur and entrepreneurship.

3. Broad Course Outline:

- Introduction to Engineering Economics
- Project Management
- Construction Project
- Construction Equipment and Management
- Entrepreneur and Entrepreneurship

4. Text Books:

a) F. Harris, R. MacCaffer and F. Edum-Fotwe, Modern Construction Management, Blackwell publishing, 2006.
b) C. J. Schexnayder and R. E. Mayo, Construction Management Fundamentals, McGraw Hill, New Delhi, 2003.
c) Peurifoy, Construction Planning, Equipment and Method, Tata McGraw Hill Educations, 2010.

5. Reference Books:

a) B.C. Punmia and K.K. Khandelwal, Project Planning and Control with PERT and CPM, Motilal UK Books of India, 2002.
b) S.C. Sharma, Construction Equipment and Management, Khanna Publishers.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Engineering decision makers, Engineering and Economics, Problem solving and decision making, Intuition and analysis, economic models, demand and supply, interest rate, economic analysis of engineering projects, project feasibility reports, problems on above.	5
2	Importance of Project Management, Role of Project manager.	3
3	Stakeholders in construction project, Different types of projects, similarities & dissimilarities in projects. Time, Scope & Money, Knowledge areas & Processes involved in construction projects, WBS of a major work, with examples, Planning, monitoring & executing, Planning, sequencing, scheduling, Bar Charts, Networks, CPM, PERT, Upgrading, Cash flow diagram	12
4	Introduction, Management of construction, Materials management, equipments management in construction projects, earth moving equipments, hoisting equipments, factors for selecting equipment.	8
5	Concept of Entrepreneur, characteristics of an Entrepreneur, distinction between an Entrepreneur and a Manager, Functions of Entrepreneur, Types of Entrepreneur, Concept of Entrepreneurship, Role of Entrepreneurship in Economic Development.	8

Total Number of Hours	36

7. Evaluation plan:

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEP 1701 MODELLING AND SIMULATION LABORATORY (0 - 0 - 2)

1. Course Description:

The Lab sessions would include application of different Civil Engineering software to solve illustrative/practical problems.

2. Learning Outcome:

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

- Identify a suitable software for solving Civil Engineering Problems
- Formulate a problem based on background information
- Identify inputs for different software
- Analyze the output of different software

3. Broad Course Outline:

- Structural Engineering
  - STAAD
- Geotechnical Engineering
  - PLAXIS
- Hydraulic and Water Resources Engineering
  - HEC-RAS
  - EPANET
- Environmental Engineering
  - Life Cycle Analysis

DEPARTMENTAL ELECTIVE – I (CEL 17XX)

CEL 17XX DESIGN OF HYDRAULICS STRUCTURES (3 - 0 - 0)

1. Course Description:

Introduces the practical engineering concepts of the structures used for water resources engineering, especially in the field of irrigation and hydropower engineering. The three main types of hydraulic structures, that is, storage structures (dams), diversion structures (weirs and barrages, and conveyance structures (canals and canal structures) are discussed in the light of the design and constructional perspectives.

2. Learning Outcome:

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

- Quantify various forces acting on hydraulic structures.
- Design dams and channel systems.
- Design different types of cross drainage works.

3. Broad Course Outline:

- Introduction of hydraulic structures.
- River engineering.
- Design of dams.
- Diversion headworks.
- Spillway design.
- Cross drainage structures.
- River training works.

4. Text Books:

a) S.K. Garg, Irrigation Engineering & Hydraulic Structures, Khanna Publishers, Delhi.
b) P.N. Modi, Irrigation Water Resources & Water Power Engg, Standard Book House.

5. Reference Books:

a) G.L. Asawa, Irrigation and Water Resources Engineering. New Age Publishers. 1st Ed., 2005.
b) P. Novak, A.I.B. Moffat, C. Nalluri, R. Narayanan. Hydraulic Structures. CRC Press. 4th Ed., 2007

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)

1	Hydraulic structure classification, with examples: Storage (dams), diversion (weirs and barrages) and conveyance (canals and canal structures) and their applications in irrigation and hydropower.	3
2	Planning the location of a dam and reservoir for storage from topo-sheets (conforming to topography of the region) and preparing elevation-volume curve of reservoir; Determining the size of dam based on water availability, demand, elevation-storage curve and using mass-curve method.	3
3	Types of dams commonly used in practice: concrete gravity and embankment (earth and rockfill), and choosing the appropriate dam for a project based on site requirements; Components of a gravity dam: non-overflow and overflow blocks, spillway gates and piers, bridge, galleries and adits; Grout curtain and drainage holes	3
4	Forces on concrete gravity dams and stress analysis under different combinations of loadings (following IS: 6512 Criteria for design of solid gravity dams).	3
5	Selection of an appropriate spillway and energy dissipator for the dam-reservoir project; significance of “jump rating curve” and “tailwater rating curve” in selecting the energy dissipater (following IS: 10137 Guideline for selection of spillways and energy dissipators)	3
6	Design of ogee spillway (following IS: 6934 Hydraulic design of high ogee overflow spillways - recommendations) and the hydraulic jump type stilling basin (following IS 4997: Criteria for design of hydraulic jump type stilling basins with horizontal and sloping apron).	3
7	Design of earthen and rockfill embankment dams – including details for seepage control such as core, filter, drainage blanket, rock toe, clay core and trench (following IS: 8826 Guidelines for design of large earth and rockfill dams and IS:12169 Criteria for design of small embankment dams).	3
8	Layout of a barrage along with appurtenant structures , such as diversion head works, canals, piers and abutments, divide wall, spillway and undersluice bays, silt excluder.	3
9	Surface hydraulics of barrages and weirs – flow distribution in spillway and undersluice bays (following IS: 6966 Part 1 Hydraulic design of barrages and weirs - guidelines).	3
10	Seepage flow analysis below barrages and weirs; computation of uplift pressure from Khosla-Bose-Taylor theory (using complex variables); Force and stability computation of barrage structure.	3
11	Canal layout for irrigation and hydropower; canal structures (aqueducts, siphon aqueducts, super passage, etc.); Construction details of canal structures.	3

12	Hydraulic and structural design of canals (lined and unlined) for irrigation and hydropower channels. Layout planning for canals.	3
Total Number of Hours		36

7. Evaluation plan:

Sl. no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		**100**

CEL 17XX DESIGN OF FOUNDATION AND RETAINING STRUCTURES (3 - 0 - 0)

1. Course Description:

Design of foundation and retaining structures describes the principles, analysis and design criteria of foundation and retaining structures. It discusses the modified and advanced bearing capacity and earth pressure theories for addressing the design of special foundation and retaining structures on difficult subsoil condition. Both analytical and numerical aspects, including software based approaches, for analysis and design makes the course better suited for advanced learning and practical real-case applications.

2. Learning Outcome:

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

- Apply understanding of advanced bearing capacity and earth pressure theories.
- Analyse and design for special cases of shallow and deep foundations.
- Analyse and design of various retention systems.
- Analyze and design of special foundations.
- Analyse and design foundations located in difficult subsoil conditions.

3. Broad course outline:

- Advanced bearing capacity and stability theories
- Design of special shallow and deep foundation structures
- Design of special types of foundations.
- Design of special types of retaining structures.

4. Text Books:

a) G. Ranjan and A.S.R. Rao, Basic and Applied Soil Mechanics, New Age International, 2nd Edition, 2006.
b) J.E. Bowles, Foundation Analysis and Design, Tata McGraw-Hill International, 5th Edition, 2012.
c) B.M. Das, Principles of Foundation Engineering, Thomson Indian Edition, 2003.
d) V.N.S. Murthy, Advanced Foundation Engineering, Geotechnical Engineering Series, CBS Publishers, 2nd Edition, 2010.

5. Reference Books:

a) S. Saran, Analysis and Design of Substructures, Oxford and IBH publication, New Delhi, 2006.
b) B.M. Das, Shallow Foundations: Bearing Capacity and Settlement, CRC Press, 2nd Edition, 2009.
c) L.C. Reese and W.F. Van Impe, Single Piles and Pile Groups under Lateral Loading. Taylor and Francis, 2nd Edition, 2011.
d) M.J. Tomlinson, Pile Design and Construction Practice, CRC Press, 5th Edition, 2007.
e) Clayton, Milititsky and Woods, Earth Pressure and Earth-Retaining Structures, Taylor and Francis, 1996.
f) M.G. Spangler and R.L. Handy, Soil Engineering, Harper & Row, 1982.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Introduction to shallow foundations (Types and choice of shallow foundation, Minimum depth of shallow foundation, Different types of failure, Bearing capacity theories by Terzaghi and Meyerhof), General bearing capacity theory, Bearing capacity and design of shallow foundations for special cases (compressible soils, eccentric and oblique loading, interference of footings, footings resting on rocks, slopes and stratified soils, dynamic bearing capacity, etc.), Design of combined rectangular and trapezoidal foundations, Flexible and rigid design of mat foundations, Settlement and contact pressure beneath footings, Estimation of settlements for special cases, Numerical analysis and design of foundations (PLAXIS, GeoStudio, etc.)	11
2	Introduction to pile foundations (Types and classification, methods of construction, type of failure, load carrying capacity of single and group of piles, negative skin friction), Design of single vertical and batter piles and pile groups subjected to different loading conditions (lateral, eccentric, active and passive leading), Uplift resistance of piles, Effect of pile driving on adjacent ground, Dynamic load capacity of piles (Use of Engineering news formula and Hiley's formula), Design of drilled pier, Caisson and well foundations	8
3	Foundations on expansive, collapsible and frozen soils, Annular and ring foundations for chimneys and cylindrical structures, Piled-raft foundation for tall structures, Floating and buoyant foundations for structures resting on very soft soils, Large diameter monopile foundations for offshore platforms and windmills.	5

4	Lateral earth pressure theories and coefficients of earth pressure, Advanced earth pressure theories (considering pseudo-static, pseudo-dynamic, dynamic and externally applied loads), Modification of Rankine and Coulomb theories, Arching in soils and its applications, Analysis and design of underground conduits and tunnels, Stability analysis and design of retaining walls (gravity, semi-gravity, cantilever, counterfort, shelved and MSE walls), Sheet piles and Anchored bulkheads, Cellular cofferdams, Braced excavations and open cuts, Slurry trenches and Diaphragm walls, Bored pile walls and earth anchors.	9
5	Software based numerical analysis and design of projects related to shallow, deep and special foundations, and various retention systems; Softwares such as PLAXIS 2D and 3D, Geo-Studio to be used for the project.	3
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 17XX BRIDGE ENGINEERING (3 - 0 - 0)

1. Course Description

Bridge engineering focuses on certain features required for analysis and design of bridge such as structural configuration, loading standards and specifications (IRC, IRS and AASHTO guidelines). It mainly emphasizes on design of reinforced concrete bridges. Also, a brief introduction to steel and concrete bridges has been included. Different components of bridge structure are also included in this course.

2. Learning Outcome

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

- Different loads acting on bridges
- Components of bridge structures
- Design codes and standards for bridges
- Analyze and design of RCC bridges.
- Understand the basic knowledge on design and analysis of steel bridges.

3. Broad Course Outline

- History of Bridges Construction and Types of Bridges
- Bridge Classification
- Superstructure and Substructure Design of Bridges

- Standards and Codes for Bridge Design
- Loads Acting on a Bridges

4. Text Books:

a) R.M. Barker and J.A. Puckett, "Design of Highway Bridges: An LRFD Approach", 4th Edition, Wiley Publications, 2021.
b) M.G. Aswani, V.N. Vazirani and M.M. Ratwani, "Design of Concrete Bridges", Khanna Publishers, 1995.
c) R.N. Krishna, "Prestressed Concrete Bridges", CBS Publishers, 2016.

5. Reference Books:

a) IRC:5-1998, "Standard Specifications and code of practice for road bridges".
b) IRC:6 –2000, "Standard specifications and code of practice for road bridges".
c) IRC:21-2000, "Standard specifications and code of practice of road bridges".
d) IRC:112-2011, "Code of practice for concrete road bridges".

6. Sessional/Lecture Wise Plan

Sl. No	Topics	Hours (Tentative)
1	Historical evolution of different bridge types: Stone masonry bridges, timber bridges, iron bridges, steel arch and truss bridges, reinforced concrete bridges, box girder bridges, prestressed concrete bridges, cable stayed bridges, suspension bridges. Bridge classification based on different criteria: function, material of construction, connections and inter-span relations, bridge inspection and maintenance	10
2	Superstructure design: standard specifications and loads, dead loads, standard live loads from IRC Bridge code, impact effects, temperature effects, shrinkage effects, deformation stresses. Superstructure design examples: reinforced concrete slab bridge design, steel girder bridge design, prestressed concrete box-girder bridge design. Superstructure design through software applications. Types of bridge superstructure elements: bearings and joints, piers, abutments, foundations	16
3	Substructure design: standard specifications and loads, hydrologic forces, wind loads, seismic forces, barge/ship impact forces, earth pressure. Substructure design examples: pier design, abutment design	10
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 17XX GROUND IMPROVEMENT TECHNIQUES (3 - 0 - 0)

1. Course Description:

Ground improvement techniques introduce the necessity and principles of ground improvement and different ground improvement techniques. Further, it emphasizes on soil stabilisation with admixtures like cement, lime, calcium chloride, fly ash and bitumen. In the later part, it focuses on grouting and reinforced earth structures. Lastly, it introduces Geo- synthetic materials and its applications.

2. Learning Outcome:

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

- Have information about the necessity and principles of ground improvement.
- Understand the different techniques for ground improvement.
- Explain and analyze the stabilization of soil with different materials.
- Have better knowledge on geo-synthetic materials.

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3. Broad course outline:

- Introduction to Ground Improvement.
- Ground Modification Techniques.
- Soil Stabilization and soil reinforcement.
- Introduction to Geo- synthetics and their applications.

4. Text Books:

a) P. Raj, Ground Improvement Techniques, Laxmi Publications, New Delhi, 1999.
b) M.R. Hausmann, Engineering Principles of Ground Modification, McGraw – Hill International Editions, 1990.
c) R.M. Koerner, Designing with Geosynthetics, Prentice hall, 2006.

5. Reference Books:

a) S.K. Shukla, Geosynthetics and their Applications, Thomas Telford, 2002.
b) C. V. J. Varma, A.R.G. Rao and G. V. Rao, Engineering with Geosynthetics, Tata McGraw Hill, 1994.
c) S. Saran, Reinforced Soil and its Engineering Applications, IK Publishing House, New Delhi, 2011.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Introduction, Necessity and objectives for ground improvement, Introduction to ground improvement techniques	2

2	Mechanical modification, Principles of mechanical modifications, Methods of compaction, Shallow compaction, Deep compaction techniques, Vibro-floatation, Blasting, Dynamic consolidation, Pre- compression and compaction piles, Hydraulic modification, Methods of dewatering, Physical and chemical modification.	12
3	Stabilisation with admixtures - cement, lime, calcium chloride, fly ash and bitumen; Grouting, Grouting materials and methods, Reinforced earth technology, Concept of soil reinforcement, Reinforcing materials, Backfill criteria, Design of reinforcement for internal stability, Applications of reinforced earth structures (reinforced embankments, Pavement subgrades and foundations), Soil nailing and Earth anchors.	12
4	Geo-Synthetics- Types, category, materials; Functions and Property characterization, Testing methods, Field Applications, Case studies.	6
5	Software based numerical analysis and design of projects related to reinforced earth structures. Software such as PLAXIS 2D and 3D, Geo-Studio to be used for the project.	4
Total Number of Hours		36

7. Evaluation plan:

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 17XX ADVANCED REINFORCED CONCRETE DESIGN (3 - 0 - 0)

1. Course Description:

Advanced Reinforced concrete design will help the students to grasp the basic concept of concrete structural design. This course will also enable the students to carry out design of engineering structures in accordance to Indian standard code. Designing of structures other than buildings such as water tanks and others special structures are presented in this course. This course also highlights the various steps in carrying out the analysis of frame structures.

2. Learning Outcome:

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

- Analyze and design continuous and deep beams
- Analyze and design of multi-storey frame structures
- Design of water tanks for different shapes and conditions
- Design of special engineering structures such as silo, culverts, etc.
- Design different types of foundation/footing for a structure

3. Broad Course Outline:

- Continuous and Deep Beams Design
- Multi-storey Frame Analysis
- Water Tank Design
- Special Structures Design
- Advanced Foundation Design

4. Text Books:

a) S.U. Pillai, and D. Menon, "Reinforced Concrete Design", 3rd Edition, Tata McGraw-Hill, 2017.
b) N.K. Raju, "Structural Design and Drawing: Reinforced Concrete and Steel", Universities Press (India) Pvt. Ltd., 2005.

5. Reference Books:

a) S.S. Bhavikatti, "Advanced RCC Design", New Age Publishers, 2006..
b) T. Paulay, and M.J.N Priestley, "Seismic Design of Reinforced Concrete and Masonry Buildings", John Wiley & Sons Inc., 1992.
c) IS:456-2000, "Plain and Reinforced Concrete-Code of Practice".
d) IS:13920-2016, "Ductile Detailing of Reinforced Concrete Structures".
e) SP-16, "Design Aid for IS:456-2000".

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Continuous Beams and Deep Beams: pattern-loading use of co-efficient from IS:456, Design consideration including redistribution of moments, design for flexure and shear.	5
2	Multi storey structures: Introduction to space frame and plane frames, substitute frame method, Design of portal frame for analyzed data.	8
3	Water retaining structures general requirements as per IS 3370, Design of water tanks on ground; circular and rectangular tanks-fixed base and with different end conditions.	9
4	Design of Retaining Wall, Silo, Culverts, Chimney.	6
5	Design of Strap footing; Strip footing; Mat/Raft foundation, Pile foundation	8
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30

2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 17XX PAVEMENT ASSET MANAGEMENT (3 - 0 - 0)

1. Course Description:

Pavement Asset Management introduces the construction strategy about highway engineering and related studies. It focuses mainly on the improvement techniques on various types of pavement construction. Various improvement steps including maintenance are also included in it.

2. Learning Outcome:

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

- Understand the importance of transportation, characteristics of road transport, highway planning, alignment and surveys.
- Know about the pavement materials and design.
- Understand the pavement construction, distresses in pavements and maintenance options.
- Learn the characteristics, properties and testing procedures of aggregate and bitumen.

3. Broad Course Outline:

- Introduction to highway and their classification.
- Highway survey.
- Stresses in pavements.
- Pavement construction materials and their properties.
- Highway drainage.
- Strengthening of pavement.

4. Text Books:

a) Chakroborti and Das, Principles of Transportation Engineering, Prentice Hall India LearningPrivate Limited,2003.
b) Y.H, Huang, Pavement Analysis and Design, Pearson education, 2008.
c) S.K. Khanna & C.E.G. Justo Highway Engineering, Nem Chand & Bros,2001.

5. Reference Books:

a) H. M. Atkins, Highway Materials, soil and concrete, Prentice Hall, 2003.
b) MORTH, Specifications for Road and Bridge works, 5th revision, Ministry of Road, Transport and Highway, 2013.
c) Guidelines for Design of Flexible Pavements IRC:37-2012.
d) Guidelines for Design of Rigid Pavements IRC:58-2011.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	History of road development, Road planning in India, Modes of transportation, their importance and limitations.	3
2	Surveys and investigations, Project estimates, Highway – planning, surveys and alignments.	3
3	Pavement components and their functions, Factors influencing the design of pavements, Sub grade soil investigation and properties, Desirable properties of subgrade soil, Road aggregates and bituminous materials, Bituminous Binders, Penetration Grade, Emulsions, Cut backs and Modified Binders	7
4	Stresses in flexible pavements, Layered system concepts, Westergaard's theory and assumptions, Stresses due to curling, Stresses and deflections due to loading, Frictional stresses, Warping stresses, Combined stresses, Tyre pressure, Contact pressure, ESWL, EWLF and EAL concepts, Vehicle damage factors, Boussinesq's equations, Burmister's two layer and three layer theories, Considerations in rigid pavement analysis.	7
5	Design of flexible and rigid pavements as per IRC, Testing of aggregates, binders and mixes; IRC specifications for materials, Construction of low-cost roads-WBM, WMM, C.C. roads; Tools, Equipments and plants, Highways in hilly region and waterlogged areas, Resilient modulus and modulus of sub-grade reaction, Dynamic modulus, Flow time and flow number of bituminous mixes, Distresses in flexible and rigid pavements, Use of geo-synthetics in pavements.	8
6	Surface and sub-surface drainage, Various techniques of surface and sub-surface drainage.	4
7	Evaluation and strengthening of existing pavements, design of Overlays, Pavement management system, Salient features of hilly roads.	4
Total Number of Hours		36

7. Evaluation plan:

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 17XX GEOTECHNICAL EARTHQUAKE ENGINEERING (3 - 0 - 0)

1. Course Description:

This course elucidates the basics of earthquake seismology including the cause of earthquakes, plate tectonics, earthquake fault sources, theory of vibrations, propagation of seismic waves, and

quantification of earthquake in terms of the intensity and magnitude of earthquake. The course will emphasize on the earthquake ground motions and their characteristics and measurement methodologies. The application of the codal provisions to estimate design earthquakes and design spectra for development of site specific studies will be provided. A broad understanding on liquefaction and its evaluation and hazard assessment will be provided. Finally, influence on earthquake induced forced on the seismic design of shallow and deep foundations, foundations in liquefiable soils, and seismic design of retaining walls and slope stability will be addressed.

2. Learning Outcome:

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

- Analyze and discuss different types of seismic waves and risks.
- Compare and contrast alternative solutions to earthquake problems.
- Select techniques and methodologies appropriate to seismic hazards.
- Suggest possible solutions to reduce earthquake problems.

3. Broad course outline:

- Introduction
- Inertia And Theory Of Vibrations
- Wave propagation
- Liquefaction And Its Evaluation
- Seismic Slope Stability And Retention systems

4. Text Books:

a) S. L. Kramer Geotechnical Earthquake Engineering, Pearson Education India, 2003
b) K. Kumar, Basic Geotechnical Earthquake Engineering, New Age International Pvt Ltd, 2017
c) B. M. Das, Principles of Soil Dynamics, Cl-Engineering, 2016.

5. Reference Books:

a) R. Day, Geotechnical Earthquake Engineering Handbook, McGraw Hill Education, 2012.
b) B. B. Prasad, Advanced Soil Dynamics and Earthquake Engineering, PHI, 2010.
c) I. Towhata, Geotechnical Earthquake Engineering, Springer, 2010.
d) T. Kokusho, Earthquake Geotechnical Case Histories for Performance-Based Design: ISSMGE TC4 2005-2009, CRC Press, 2009.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Introduction, cause and strength of earthquake, seismic waves, seismic risks and seismic hazards: Mitigation of seismic hazards, seismology and earthquakes, strong ground motion, seismic hazard analysis; Engineering problems involving soil dynamics.	5

2	Engineering problems involving soil dynamics; Role of inertia; Theory of Vibrations: Single and two- degrees of freedom systems, vibration measuring instruments, Vibration absorption and isolation techniques. Measurement of small strain and large strain dynamic soil properties: Field and Laboratory tests. Selection of design values.	8
3	Theory of dynamics and seismic response, the nature and attenuation of ground motion. Wave propagation in unbounded media: in semi-infinite bodies, in layered soils and attenuation of stress waves; Determination of site characteristics, local geology and soil condition, site investigation and soil test, Determination of design earthquake, response spectra and accelerograms as design earthquake, criteria for earthquake resistant design.	9
4	Liquefaction: evaluation of liquefaction hazards, effects of liquefaction; Site response to earthquake, liquefaction of saturated cohesion-less soils, seismic response of soil structure system, shallow foundation, pile foundation, foundation in liquefiable ground. A seismic design of earth retaining structures.	9
5	Seismic slope stability analysis, Seismic bearing capacity and earth pressures, Soil improvement for remediation of seismic hazards, Codal provisions, Case studies.	5
Total Number of Hours		36

7. Evaluation Plan:

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 17XX ROAD SAFETY AND MANAGEMENT (3-0-0)

1. Course Description:

This course will introduce the students to road safety and several influencing the crashes of vehicles on a highway as well as urban roads. This course will dealt with the various engineering concepts concerning road safety. In this course, the students will also learn to utilize various crash data pertaining to accidents and other road mishaps.

2. Course Outcome:

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

- Understand various factors for road accidents and mishaps
- Various engineering concepts concerning road safety
- Utilize crash and other accident data
- Carry out road safety audit
- Introduce various road safety management

3. Broad Course Outline:

- Introduction to Road Safety
- Factors Influencing Road Crashes
- Road Safety Engineering
- Reactive Safety Evaluation Methods
- Road Safety Audit
- Road Safety Countermeasures

4. Text Books:

a) Measuring Road Safety with Surrogate Events. Author: Andrew Tarko, Publisher: Elsevier Science
b) Observational Before/After Studies in Road Safety: Estimating the Effect of Highway and Traffic Engineering Measures on Road Safety. Author: Ezra Hauer, Publisher: Pergamon Press.
c) Motor Vehicle Accident Reconstruction and Cause Analysis. 5th Edition. Authors: Limpert Rudolf, Publisher: Lexas Publishing, Charlottesville, VA.
d) Statistical and Econometric Methods for Transportation Data Analysis. 2nd Edition. Authors: Simon Washington, Matthew G. Karlaftis, Fred Mannering, Panagiotis Anastasopoulos. Publisher: Chapman & Hall/ CRC Press.

5. Reference Books:

a) Highway Safety Manual, 1st Edition, American Association of State Highway and Transportation Officials (AASHTO).
b) Ministry of Road Transport & Highways (MoRTH), Government of India: Road accidents in India 2019. (2020)
c) A policy on Geometric Design of Highways and Streets, AASHTO, 7th edition ,2018
d) Federal Highway Administration: The safe system approach. U.S. Department of Transportation. FHWA-SA-20-015.
e) PIARC (World Road Association): Road safety manual, A guide to practitioners. Version 3. (2019)
f) Global Road Safety Facility – The World Bank: Guide for road safety interventions: Evidence of What works and what does not work. Washington DC. (2021)
g) Relevant IRC Guidelines

6. Session/Lecture Wise Plan:

Sl No	Topics	Hours (Tentative)
1	**Introduction to Road Safety:** Definition, Road traffic crash scenario in urban and rural areas; Consequences of road traffic crashes: Economic losses.	3
2	**Factors Influencing Road Crashes:** Vehicular factors, Road-Environment related factors, Human factors, Other factors. Road User Characteristics (Traffic characteristics, PIEV theory, Human limitations, Physical and Psychological characteristics).	6

3	**Road Safety Engineering:** Introduction, Different ways to deal with the road safety issues (Proactive and Reactive approaches). Safety in Road Design, Road Signs and Markings.	4
4	**Reactive Safety Evaluation Methods (Uses of Crash Data & Analysis):** Need for crash data, Crash data characteristics, Crash data collection system. Crash data representation, Identification of Hazardous locations (Blackspots) and Techniques , Before-after naïve, before-after with comparison, Empirical Bayes Method. Safety Performance Functions; Network Screening and Potential for safety improvement (PSI)- blackspot treatment. Applications of statistical methods on crash data, Soft-computing techniques used in crash data analysis.	10
5	**Road Safety Audit** (RSA): Introduction, Different Stages of road safety audit, RSA process, RSA checklists, Site visit, Safe System Approach , Surrogate Safety Measures & Traffic Conflict Techniques, Road Traffic Safety at intersections; Accident in Rural Areas and Hill Road Safety; Case studies.	7
6	**Road Safety Countermeasures and management:** Evidence based approach, Interventions, Accident Reconstruction, Roadside Hazard Management, Non-engineering measures of Road Safety: Trauma Care ; speed management, case studies.	6
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 17XX ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY (3-0-0)

1. Course Description:

The objective of the course is to provide students with basic concepts from environmental chemistry and microbiology for understanding and solving environmental problems. Major topics relevant for environmental engineering from chemistry and microbiology will be covered. The major focus of the course will be the application of these science concepts in addressing the environmental problems encountered in the natural and engineered systems.

2. Learning Outcomes:

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

- Understand the basic concepts from environmental chemistry and microbiology for understanding and solving environmental problems.
- Understand the basic concepts in chemistry, concept of chemical equilibria, equilibrium constants and activity, reaction kinetics, acid, and bases, polyprotic acids and bases, acidity,

alkalinity, carbonate system, pH-Ct, buffers, and solubility reactions, nuclear chemistry, nitrogen chemistry and chlorination.

- Comprehend the basic concepts of environmental microbiology are: Introduction, the bacteria, the fungi, the algae, protozoa and other higher forms, viruses, pathogens and disease, microbial growth and enumeration, control of microorganisms, microbial diversity and metabolic pathways for remediating contaminated water, solid and hazardous waste, and soil.

3. Broad Course Outline:

- Review of basic concepts in chemistry, concept of chemical equilibria, equilibrium constants and activity, reaction kinetics, acid and base, polyprotic acids and bases, acidity, alkalinity,
- Carbonate system, pH-Ct, buffers, and solubility reactions
- Nuclear chemistry, nitrogen chemistry and chlorination
- Environmental microbiology topics to be covered are Introduction, the bacteria, the fungi, the algae, protozoa and other higher forms, viruses, pathogens, and disease
- Microbial growth and enumeration, control of microorganisms
- Microbial diversity and metabolic pathways for remediating contaminated water, solid and hazardous waste, and soil.

4. Text Books:

a) Dutt P K, (2014) General & Inorganic Chemistry, 15th edition, Sarat Book House, Kolkata, ISBN: 978-8187169031
b) Tortora GJ, Funke BR, and Case CL (2018) Microbiology: An Introduction. Addison-Wesley; 13th edition ISBN: 978-0134605180.

5. Reference Books:

a) Sawyer CN, McCarty PL, Parkin GF (2000) Chemistry for Environmental Engineering and Science, Tata McGraw Hill, New Delhi
b) Peavy, H., Rowe, D., & Tchobanoglous, G. (1985). Environmental Engineering. NY, US: McGraw Hill International Ed

6. Session/Lecture Wise Plan:

Sl No	Topics	Hours (Tentative)
1	Concepts of acids, bases and salts, strengths of acids and bases, buffers, acid-base indicators, choice of indicators; Concept of chemical equilibrium, solubility and solubility product, activity, Le Chatelier principle	6
2	Reaction kinetics, rate and order of a reaction, determination of order, Reaction mechanism, rate determining step, catalysts, activation energy	6
3	Radioactivity and nuclear chemistry, Nitrogen chemistry and chlorination	6
4	Introduction and overview of environmental applications; major groups of microbes: bacteria, fungi, algae, protozoa and virus. Cell chemistry, biology and microscopy	6
5	Microbial Metabolism, Microbial Growth and Control	6

6	Pathogens and diseases, Metabolic Diversity and Biogeochemical Cycles	6
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 17XX HAZARDOUS WASTE MANAGEMENT AND SITE REMEDIATION (3-0-0)

1. Course Description:

The course will cover the concepts and details of Hazardous wastes (HW), Risk assessment, Environmental legislation associated with HW along with its Characterization and site assessment of contaminated sites. The course will also cover the principles of waste minimization, resource recovery, treatment and disposal methods.

2. Learning Outcomes:

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

- Understand the concepts and details of Hazardous wastes, Definition of Hazardous waste.
- Assess the magnitude of the problem, perform Risk assessment, review Environmental legislation, and perform Characterization and site assessment.
- Understand the framework of Waste minimization and resource recovery.
- Do the basic design of Chemical, physical and biological treatment processes, basic design of waste Transportation infrastructure.
- Assess groundwater contamination if any, perform basic design of Landfill.
- Do basic design of Contaminant Management from Mismanaged Hazardous Waste – Fate and Transport of the contaminant in the environmental systems.
- Control and treatment of contaminants from Hazardous waste.

3. Broad Course Outline:

- To introduce the concepts and details of Introduction to Hazardous wastes, Definition of Hazardous waste,
- The magnitude of the problem, Risk assessment, Environmental legislation, Characterisation and site assessment,
- Waste minimisation and resource recovery,
- Chemical, physical and biological treatment, Transportation of hazardous waste,
- Groundwater contamination, Landfill disposal.
- Contaminant Management from Mismanaged Hazardous Waste – Fate and Transport of the contaminant in the environmental systems.
- Control and treatment of contaminants from Hazardous waste

4. Text Books:

a) Hazardous Waste Management by Michael D LaGrega; Phillip L Buckingham; and Jeffrey C Evans, McGraw-Hill, 2nd Edition, ISBN 9780071181709
b) William C. Blackman, Jr., (2001), "Basic Hazardous Waste Management", ISBN 9781566705332, CRC Press, 488 Pages.

5. Reference Books:

a) Cristiane Q. Surbeck, Jeff Kuo (2022) Site Assessment and Remediation for Environmental Engineers, ISBN 9780367709730, by CRC Press, 322 Pages
b) Peavy, H., Rowe, D., & Tchobanoglous, G. (1985). Environmental Engineering. NY, US: McGraw Hill International Ed.

6. Session/Lecture Wise Plan:

Sl No	Topics	Hours (Tentative)
1	Part-1: Fundamentals. Hazardous Waste. The Legal Framework. Process Fundamentals. Fate and Transport of Contaminants. Toxicology	9
2	Part-2: Current Management Practices. Environmental Audits. Pollution Prevention. Facility Development and Operations	9
3	Part-3: Treatment and Disposal Methods. Physicochemical Processes. Biological Methods. Stabilization and Solidification. Thermal Methods. Land Disposal	9
4	Part-4: Site Remediation. Quantitative Risk Assessment. Site and Subsurface Characterization. Remedial Technologies. Evaluation and Selection of Remedial Actions and Corrective Measures	9
Total Number of Hours		36

7. Evaluation plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

OPEN ELECTIVE

CEL 1XXX SUSTAINABLE ENGINEERING (3-0-0)

1. Course Description:

The Sustainable Construction and Design course discusses in detail the sustainable practices in structural engineering and construction industry. With the construction and use of our built environment responsible for 39% of global greenhouse gas emissions, there is a need for sustainable practices to reduce the environmental impacts. To address these challenges, the construction industry has endorsed sustainable construction methods to ensure that construction projects minimize their environmental impacts while supporting the economic wellbeing and social welfare of the communities in which they are developed. In this course, you'll delve into environmental, economic, and social sustainability, understanding what it is and how it relates to the construction industry. With this knowledge, you'll be able to explore the environmental implications of built assets as well as potential solutions such as sustainable materials, building design and construction practices. You'll unpack the barriers to economic, and social sustainability before learning how to navigate these challenges with tools and techniques. By the end of the course, the students will have the knowledge and skills to implement sustainability in the structural engineering to help build a better future.

2. Learning Outcome:

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

- Define sustainable development (economic, environmental, and social), circular economy, and their relationship with structural engineering
- Learn about innovative circular design principles such as design for adaptability, design for disassembly, design for longevity, design for service, and design for material recovery
- Learn about reversible designs allowing disassembly and reassembly, designing for deconstruction, reuse, renovation, retrofitting, refurbishment, and repurpose
- Examine the properties of common construction materials and understand the transition toward sustainable materials, along with their behaviours under different environments, short- or long-term
- Learn about construction and demolition waste management and material upcycling technologies
- Learn about the role of renewable energy in construction industry, and design concepts of green building, energy use efficiency, and carbon neutrality
- Learn how to assess the environmental impacts of materials, and construction projects using life cycle analysis

3. Broad Course Outline:

- The concept of sustainability (Sustainability and Building Industry)
- Sustainable Design in Practice
- Sustainable Construction Materials

- Construction and Demolition waste management and material upcycling technologies.
- Renewable energy in construction industry, and design concepts of green building, energy use efficiency, and carbon neutrality
- Life Cycle Assessment
- Economics and Social aspects of Sustainability

4. Text Books:

a) The Philosophy of Sustainable Design by Jason F. McLennan, Ecotone Publishing Co., 2004.
b) Green Building Fundamentals by Mike Montoya, Pearson, 2nd edition, 2010.
c) Sustainable Construction - Green Building Design and Delivery by Charles J. Kibert, John Wiley & Sons, 2nd edition, 2008.

5. Reference Books:

a) Sustainable Construction and Design by Regina Leffers, Prentice Hall, 2009.
b) Sustainable Construction and Building Materials by Bibhuti Bhusan Das, Narayanan Neithalath, 2018
c) Energy Efficient Buildings In India by Mili Majumdar The Energy Research Institute.
d) Energy-Efficient Building Systems Lal Jayamaha McGraw Hill Publication.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Unsustainable practices in construction industry, environmental impacts, Definitions of sustainable development (economic, environmental, and social), circular economy and its relationship with structural engineering.	4
2	Innovative circular design principles, design for adaptability, design for disassembly, design for longevity, design for service, and design for material recovery; Reversible designs allowing disassembly and reassembly, designing for deconstruction, reuse, renovation, retrofitting, refurbishment, and repurpose.	6
3	Properties of common construction materials, Sustainable materials – Rammed earth, Bamboo & Timber, Bioplastics & biocomposites, Composite Roofing Shingles, Smart glass, Mycelium, Precast concrete & green concrete, 3D Printed materials, etc., Short- or long-term behaviours under different environments and cost economics.	7
4	Construction and Demolition (C&D) waste definitions; Composition & Characteristics; C&D waste Management Rules, 2016; Collection, Transportation and Disposal; Processing, Material Recovery, Recycling – challenges and competence with conventional building materials, and Upcycling Techniques.	8
5	Conservation & energy efficiency concepts; Solar energy fundamentals & practices in building design; optimal orientation of building, shadow analysis; Heating and ventilation design- Human thermal comfort, climatological factors, material	7

	specifications; Concept of cost/benefit of energy conservation & carbon footprint estimation. Energy efficient lighting system design; Green buildings; Carbon Neutrality.	
6	Life cycle assessment – Basic Overview, Life cycle inventory (LCI), life cycle impact assessment (LCIA), Concepts of economic sustainability, and social sustainability.	4
Total Number of Hours		36

7. Evaluation Plan

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1XXX ENVIRONMENTAL IMPACT ASSESSMENT (3 - 0 - 0)

1. Course Description:

Environmental impact assessment (EIA) introduces the importance of environmental impact due to various man-made activities. It also describes about the laws and regulations related to environmental protection act. EIA helps in identifying alternative with lesser impact on the environment. It focuses on the concept of environmental management system with an aim to protect our environment.

2. Learning Outcome:

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

- Analyse the environmental impacts of proposed projects.
- Categorize the type of ELA required for proposed projects.
- Predict and assess the impact of proposed projects on the environment.
- Use mathematical tools to predict the environmental impacts.
- Propose proper mitigation measures to avoid environmental impacts.
- Summarise the ELA report with suitable environmental management plan.

3. Broad Course Outline:

- Environmental components
- Environmental impact assessment.
- Environmental audit.
- Impact mitigation strategy.
- Effects of assessment in the components of environment.

- Risk assessment.
- Case studies in various fields.

4. Text Books:

a) S.K. Garg, Sewage Disposal and Air Pollution Engineering - Environmental Engineering (Vol. II), Khanna Publishers, 2015.
b) L.W. Canter, Environmental Impact Assessment, McGraw Hill Inc., New Delhi, 1996.

5. Reference Books:

a) S.K. Shukla and P.R. Srivastava, Concepts in Environmental Impact Analysis, Common Wealth Publishers, New Delhi, 1992.
b) Ministry of Envirement, Forest and Climate Change website (http://envfor.nic.in/).

6. Session/Lecture Wise Plan:

Sl. No.	Topics	Hours (Tentative)
1	Environment and its components, Ecological imbalances, Carrying capacity and sustainable development.	3
2	Evolution and Need of EIA, Current scenario in India, Types and role, EIA as sustainable development, Requirement in Indian policies, Procedures and cycles, Screening, Scoping, Impact prediction, Assessment of alternatives, EIA report.	5
3	Basic of environmental audit, Audit items, Audit procedure, Safety audit, Environmental Impact Statement (EIS), Rapid EIA, Public participation, Post environmental audit.	7
4	Environmental monitoring and legislation, Mitigation measure strategies, Environmental management, Appropriate settlement of industries and projects for minimizing impacts.	6
5	Prediction and assessment of impact on land, water, air, noise and energy, flora and fauna, Socio economic impact.	4
6	Environmental risk assessment- Basic concepts, use and methods; Types of risks- Physical, chemical, biological; Hazard identification, Exposure assessment, Consequence assessment, Risk estimation, Risk minimization techniques. measures, Risk assessment techniques	8
7	Case studies such as Cement, Pesticide Petrochemical, Metal, Pharmaceuticals Industries, Road, Rail, Dam and Thermal power projects, Mining works.	3
Total Number of Hours		36

7. Evaluation plan:

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30

2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1XXX FINITE ELEMENT METHODS (3 - 0 - 0)

1. Course Description:
The finite element method is a powerful tool for numerical solution of wide range of engineering problems. The course introduces the concept of finite element modelling approach for various problems encountered in civil, mechanical and aerospace applications.

2. Learning Outcome:
At the end of the course, the student will be able to:

- Understand concepts of variational methods and weighted residual methods in finite element method
- Understand and use various shape functions in finite element formulation
- Understand global, local and natural coordinates
- Understand formulation of two-dimensional and three-dimensional problems
- Apply finite element method solutions to structural problems

3. Broad Course Outline:

- Fundamental concepts
- One-dimensional problems
- Two-dimensional problems
- Three-dimensional problems
- Application to structures
- Formulations for plates

4. Textbooks:

a) R.D. Cook, D.S. Malkus and M.E. Plesha, "Concepts and Applications of Finite Element Analysis", John Wiley & Sons, 2002.
b) J.N. Reddy, "An Introduction to the Finite Element Method", Tata McGraw Hill, 2003.
c) S.S. Rao, "Finite Element Method in Engineering", Butterworth Heinemann, 1999.

5. Reference Books:

a) O.C. Zienkiewicz, "The Finite Element Method", Tata McGraw-Hill, 1977.
b) K.J. Bathe, "Finite Element Procedures", Prentice Hall, 1995.
c) Y.M. Desai, T.I. Eldho and A.H. Shah, "Finite Element Method with Applications in Engineering", Pearson, 2011.

6. Sessional/Lecture Wise Plan

Sl. No	Topics	Hours (Tentative)
1	Principles of discretisation; Element stiffness mass formulation based on direct, variational and weighted residual techniques and displacements, hybrid stress and mixed approaches, shape functions and numerical integrations, convergence.	9
2	Displacement formulations for rectangular, triangular and isoparametric elements for two dimensional and axisymmetric stress analysis; Thin and Thick plates and shells, Semi-analytical formulations	12
3	Three dimensional elements and degenerated forms; Stiffener elements and modifications such as use of different coordinate systems, use of nonconforming modes and penalty functions	11
4	Application to layered composite plate/shells, bridge, roof, nuclear and offshore structures	9
5	Hybrid stress and mixed formulations for plates	7
Total Number of Hours		48

7. Evaluation Plan

Sl No	Type of Evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1XXX DESIGN OF EARTHQUAKE RESISTANT STRUCTURES (3 - 0 - 0)

1. Course Description:

Design of earthquake resistant structures introduces the importance of incorporating seismic design in design of structures. Various concepts related to ground motion and its related hazards are introduced at the beginning of the course. It also focuses on how seismic load on buildings can be estimated for ductility considerations required for design of RC structures. Later, the course details the design of earthquake resistant structures and ductile detailing as per IS 13920:2016.

2. Learning Outcome:

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

- Understand the concepts of ground motion.
- Understand concepts of structural dynamics and its importance in earthquake engineering.

- Know the importance of ductility and its implementation in earthquake resistant structures.
- Design the earthquake resistant buildings.

3. Broad course outline:

- Introduction to Engineering Seismology
- Characteristics of strong ground motions
- Estimation of Seismic load in buildings.
- Earthquake resistant design and ductile detailing.

4. Text Books:

a) P. Agarwal and M. Shrikhande, "Earthquake Resistant Design of structures", Prentice Hall of India Pvt. Ltd, 2006.
b) T. Paulay and M.J.N Priestley, "Seismic Design of Reinforced Concrete and Masonry Buildings", Wiley, 1992.
c) A.K.Chopra, "Dynamics of structures", Prentice Hall, 1995.

5. Reference Books:

a) R. Park and T. Paulay, "Reinforced Concrete Structures", Wiley India, 2009
b) IS:1893(1)-2016, "Criteria for Earthquake Resistant – Design of structures".
c) IS:4326-1993, "Earthquake Resistant Design and Construction of Building".
d) IS:13920-2016, "Ductile detailing of concrete structures subjected to seismic force".
e) IS:15988-2013, "Seismic Evaluation and Strengthening of Existing Reinforced Concrete Buildings".

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Structure of earth, faults, plate tectonics, seismic waves, intensity scale, magnitude scale, Richter magnitude, Seismic Moment and Moment Magnitude.	7
2	Strong Motion, Accelerographs, Accelerograms, Characteristics, Side effects, Definitions, Seismic Hazards, Seismic Vulnerability, Seismic Risks.	8
3	Provisions of IS 1893, 2016: Design Response Spectrum; Irregularities in buildings; Equivalent static method, Response Spectrum Method.	10
4	Introduction to Earthquake Resistant Design: Role of Ductility, Beam Column connection design, Joint shear, Strong column weak beam criterions; Ductile Detailing and Shear wall design as per IS 13920, 2016, Introduction to Seismic Evaluation and retrofitting of buildings: Provisions of IS 15988, 2013.	11
Total Number of Hours		36

7. Evaluation plan:

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1XXX ENVIRONMENT AND ENERGY (3 - 0 - 0)

1. Course Description:

It describes the understanding between people and the environment and also develops the ability to communicate environmental information. It also develops an understanding of how natural resources and the environment affect quality of life and the quest for sustainable development.

2. Learning Outcome:

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

- Analyze and discuss different environmental situations.
- Compare and contrast alternative solutions to environmental problems.
- Select techniques and methodologies appropriate to different environmental situations.
- Suggest possible solutions to specific environmental problems.

3. Broad Course Outline:

- Introduction to Environmental Science
- Human population and Environment.
- Ecosystems: Concepts and Fundamentals.
- Environmental Health and Toxicology.
- Energy Resources.
- Climate Change and Global Warming.

4. Text Books:

a) D.B. Botkin and E.A. Keller, Environmental Science: Earth as a Living Planet, John Wiley and Sons, Inc, 2013.
b) E. Bhaucha, Environmental Studies, University Press India, 2005.
c) S J.G. Henry and G.W. Heinke, Environmental Science and Engineering, Prentice Hall, U.S., 1996.

5. Reference Books:

a) G.F. Boyle, Renewable Energy- Power for a Sustainable Future, Oxford University Press, U.K., 2012.
b) J. Cowie, Climate Change: Biological and Human Aspects, Cambridge University Press, U.K., 2007.

c) N. Dogra and S. Srivastava, Climate Change and Disease Dynamics in India, The Energy and Resource Institute (TERI) Press, New Delhi, 2012.
d) D.D. Chiras, Environmental Science, Jones and Bartlett Publishers Inc, 2012.

6. Session/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Enviromental Science- History, Sustainability and Carrying Capacity, Chemistry of the environment, Systems and surroundings, Environmental composition and segments.	4
2	Basic concepts of population dynamics, Demographic transition, Longevity and its effect on population growth.	3
3	Basic characteristics, Ecological communities and food chains, Ecosystems as Systems, Biological production and ecosystem energy flow, Biological production and biomass, Energy efficiency and transfer efficiency, Ecological stability and succession, Chemical cycling and succession, Ecological restoration and its significance.	9
4	Environmentally transmitted infectious diseases, Effect of pollution due to toxic heavy metals, organic compounds, nuclear radiation, thermal pollution, electromagnetic radiation; Hormonally active agents and their effect on body, Dose-Response curve, Threshold effects, Ecological gradients, Tolerance limit, Acute and chronic effects.	8
5	Energy sources, Consumption, Sustainable energy, Biomass as alternative energy source, Biomass Classification and uses; Biomass as cleaner production, Biomass as feed stock for fuel production, Life-cycle analysis of waste from generation to degradation.	7
6	Atmospheric structure, Greenhouse effects, Solar cycle, Albedo effects on climate and weather, Effects on global 5TH warming in temperature, sea level, glaciers, river flow, biological diversity, agricultural productivity and human health.	5
Total Number of Hours		36

7. Evaluation plan:

Sl no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		100

CEL 1XXX Optimization Techniques (3-0-0)

1. Course Description:

In this course, the students will be introduce to simple linear programming and methods involved in linear programming. The integer programming relevant to various civil engineering examples are also included. The complex non linear programming and various methods such as quadratic programming will also be introduced to the students.

2. Learning Outcome:

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

- Understand the concept of linear programming.
- Understand the concept and application of integer programming
- Understand the concept and application of non-linear programming.
- Solve real world examples using engineering optimization techniques

3. Broad Course Outline:

- Simplex Method
- Duality Theorems
- Branch and Bound Algorithm
- Non Linear Programming
- Multi-objective Optimization

4. Text Books:

a) S.S. Rao, "Engineering Optimization: Theory and Practice", Wiley, 2009.
b) F.H. Hillier and G. J. Liberman, "Introduction to Operations Research", McGraw-Hill, 2010.
c) W.L. Winston, "Operations Research: Applications and Algorithm", 4th Edition, Cengage Learning, 1994.

5. Reference Books:

a) A. Ravindran, D.T. Phillips and J.J. Solberg, "Operations Research: Principles and Practice", Wiley, 1987.
b) K. Deb, "Optimization for Engineering Design", Prentice Hall, 2013.
c) M.C. Joshi and K.M. Moudgalay, "Optimization: Theory and Practice", Narosa, 2004.
d) K. Deb, "Multi-objective Optimization using evolutionary algorithms", Wiley, 2009.

6. Sessional/Lecture Wise Plan:

Sl. No	Topics	Hours (Tentative)
1	Formulating linear programs, Graphical solution of linear programs. Special cases of linear program, The Simplex Method: Converting a problem to standard form. The theory of the simplex method, The simplex algorithm,	12

	Special situations in the simplex algorithm, Obtaining initial feasible solution, Duality and sensitivity analysis: Sensitivity analysis, Shadow prices, Dual of a normal linear program Duality theorems, Dual simplex method.	
2	Formulating integer programming problems. The branch-and-bound algorithm for pure integer programs. The branch-and-bound algorithm for mixed integer programs.	9
3	Introduction to non-linear programming (NLP), Convex and concave functions, NLP with one variable, Line search algorithms. Multivariable unconstrained problems, constrained problems, Lagrange Multiplier, The Karush-Kuhn-Tucker (KKT) conditions. The method of steepest ascent, Convex combination method, penalty function methods, Quadratic programming, Dynamic programming Evolutionary algorithms such as Genetic Algorithm. Concepts of multi-objective optimization, Markov Process, Queuing Models	15
Total Number of Hours		36

7. Evaluation Plan

Sl. no.	Type of evaluation	Weightage
1	Mid semester examination	30
2	Internal evaluation	20
3	End semester examination	50
Total		**100**

ELECTIVES FROM OTHER DEPARTMENTS

ARTIFICIAL NEURAL NETWORK

L T P Course Code: CSL1XXX Credit:3
3-0-0

Introduction: Basic Concepts of Neural Networks, Inference and Learning, Models-Classification Models, Association Model, Optimization Models, Self-Organization Models. **Lecture: 5**

Learning: Supervised and Unsupervised Learning, AI Learning, Neural Network Learning, and Genetic Algorithms.
Lecture: 7

Neural Networks: Rule -Based Neural Networks, Radial Basics Function Networks (RBFN), Network Training, Network Revision, Issues, Example of Theory Revision, Decision of Theory Revision, Decision Tree-Based Neural Networks, Constraint-Based Neural Networks, Learning Rules.
Lecture: 10

Mathematical Modeling: Mathematical Modeling in General, The Applications of Neural Networks, Neural Networks as Mathematical Models, Knowledge-Based Approaches. **Lecture: 6**

Methods: Introduction, Symbolic Methods and Neural Network Methods. **Lecture: 4**

Structures and Sequences: Introduction, Connectionist Representation, A Hybrid Network Approach.
Lecture: 3

Learning Spatiotemporal Patterns: Introduction, Spatio-temporal Neural Networks, Learning Procedures, and Knowledge Procedures. **Lecture: 5**

TOTAL LECTURE: **40**

Text Books:

1. “Neural Networks” by Simon Haykin, Pearson Education/PHI
2. “Neural Networks Algorithms, Applications, and Programming Techniques” by James A. Freeman, David M. Skapura, PHI

Reference Books:

1. “Neural Network using MATLAB 6.0”, by Sivanandam, Tata McGraw Hill
2. “Neural Network: A classroom Approach”, by Satish Kumar, Tata McGraw Hill

SOFT COMPUTING

L T P Course Code: CSL1XXX Credit:3
3 0 0

Unit-I: Machine Learning & AI - Introduction, hierarchical perspective and foundations. Rote Learning, Learning by Advice, learning in problem solving: inductive learning, explanation based learning, learning from observation and discovery, learning by analogy, and introduction to formal learning theory. Biological neurons and brain, models of biological neurons, artificial neurons and neural networks, Early adaptive nets Hopfieldnets, back error propagation competitive learning lateral inhibition and feature maps, Stability - Plasticity and noise saturation dilemma, ART nets, cognition and recognition. **Lecture: 12**

Unit-II: Neural nets as massively parallel, connectionist architecture, Application in solving problems from various are as e.g. AI, Computer Hardware, networks, pattern recognition sensing and control etc. **Lecture: 8**

Unit –III: Basics of Fuzzy Sets: Fuzzy Relations – Fuzzy logic and approximate reasoning – Design Methodology of Fuzzy Control Systems – Basic structure and operation of fuzzy logic control systems. **Lecture: 10**

Unit –IV: Networks – Feedback networks – Supervised and unsupervised learning approaches – Neural Networks in Control Systems. **Lecture: 7**

Unit- V: Basics of Genetic Algorithms: Evolution of Genetic Algorithm Applications. **Lecture: 3**

TOTAL LECTURE: 40

Text Books:

1. P H Winston – “Artificial Intelligence” - Pearson Education
2. E Charniak and W Midermott – “Introduction to Artificial Intelligence” - Pearson Education

Reference Books:

1. Bishop, “Neural Networks for Pattern Recognition”, OUP
2. Cohen, “Empirical Methods for AI”, PHI
3. Haykin, “Neural Network”, Pearson Education/PHI
4. “Artificial Neural Network”, Vikas Bose
5. “Neural Network Fundamentals with graphs, Algorithms and Applications”, – TMH

MEL1805: Innovation and entrepreneurship

1. **Course** Description:

Innovation and entrepreneurship introduces you to the concept of Evolvement of entrepreneurship from economic theory, Entrepreneurship and characteristics of entrepreneurs, Need for education on entrepreneurship, Competency and entrepreneurial competencies. Creativity as a prerequisite to innovation, Innovation and entrepreneurship. Self-assessment and window Self-reflecting self-awareness, Decision-making, Leadership, Motivation. Concept of a planning paradigm for a new venture, Founstase growth model, Fundamentals of feasibility plan. An introduction to patents, trademarks and spy rights, intellectual property right, Business opportunity identification, Need, scope and characteristics of a small scale business industry. Marketing concept, Fundamentals of marketing, Distribution, Promotion, Pricing, Marketing strategy, Break-even analysis. Total quality management, ISO standards, Management information system, Concept of Intellectual Property Right (IPR), Patent, Copyright, and Trademark. Project planning and preliminary project report.

2. **Learning Outcome:**

On completion of the course, the students will be able to: • Differentiate between Entrepreneur and Intrapreneur and appraise the importance of entrepreneurship in economic growth. • Justify the need, objectives of Entrepreneurship Development Programs. • Appraise the steps involved in setting up a business and business project reports. • Justify the need of financing and accounting.

3. **Broad Course Outline:**

• Introduction
• Entrepreneurship and characteristics of entrepreneurs
• Need for education on entrepreneurship
• Concept of a planning paradigm for a new venture
• Marketing concept

4. **Text & Reference Books**:

• Shankar: Entrepreneurship: Theory & Practice: McGraw-Hill
• Hisrich: Entrepreneurship, by: McGraw-Hill, (Special Indian Edition), 6e
• A.K. Singh: Entrepreneurship Development & Management: Laxmi Publication
• David H. Holt: Entrepreneurship: - new venture creation: Prentice Hall Publication