K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Empowered Autonomous Institute, affiliated to Shivaji University, Kolhapur)

M. Tech. Structural Engineering

Curriculum Structure and Evaluation Scheme (NEP 2020)

To be implemented for 2025-27 and 2026-28 Batch

F. Y. M. Tech.						**Semester: I**					
Course Code	**Course**	**Teaching Scheme**				**Evaluation Scheme**					
							Theory Marks			**Practical Marks**	
		L	**T**	**P**	**Credits**	**Scheme**	Max	Min. % for passing		Max	Min. % for passing
CES 1206	Design of Prestressed Concrete Structures	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
CES 1036	Advanced Structural Analysis	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
CES 1056	Structural Dynamics and Earthquake Engineering	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
	Program Elective-I	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
	Program Elective- II	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
CES 1076	Computer Aided Design of Steel Structures Lab	--	--	04	02	ISE	--	--		50	50
						ESE	--	--		50	50
CES 1096	Structural Simulation and Modelling Lab	--	--	04	02	ISE	--	--		50	50
						ESE	--	--		50	50
SHP 5513	Technical Communication	02	--	--	01	ISE	--	--		100	50
	TOTAL	**17**	--	**08**	**20**						

Total Contact Hours/week : 25

Total Credits : 20

ISE = In Semester Evaluation, ESE = End Semester Exam

RAJARAMBAPU INSTT. OF TECHNOLOGY * RAJARAMNAGAR CIVIL ENGG. DEPT.

K.E.S. Rajarambapu Institute of Technology * Rajaramnagar Autonomous 415 414

Program Elective-I

Sr. No.	Course Code	Course
1.	CES1016	Advanced Solid Mechanics
2.	CES1136	Theory of Plates and Shells
3.	CES1215	Structural Health Monitoring
4.	CES1196	Design of RCC Bridges

Program Elective-II

Sr. No.	Course Code	Course
1.	SHP5172	Numerical Methods for Structural Engineers
2.	CES1161	Soil Structure Interaction
3.	CES1182	Repair and Rehabilitation of Structures
4.	CES1171	Design of Tall Buildings

F. Y. M. Tech						**Semester: II**					
Course Code	**Course**	**Teaching Scheme**				**Evaluation Scheme**					
							Theory Marks			**Practica lMarks**	
		L	**T**	**P**	**Credits**	**Scheme**	Max	Min. % for passing		Max.	Min. % for passing
CES 1226	Design of Steel Structures	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
CES 1046	Design of Concrete Structures	04	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
	Program Elective – III	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
	Program Elective – IV	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
CES 1066	Research Methodology and IPR	02	01	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
CES 1086	Computer Aided Design of Concrete Structures Lab	--	--	04	02	ISE	--	--		50	50
						ESE	--	--		50	50
CES 1110	Structural Testing Lab	--	--	04	02	ISE	--	--		50	50
						ESE	--	--		50	50
CES 1116	Mini Project	--	--	02	01	ISE	--	--		100	50
	*Internship	-	-	-	-	-	-	-		-	-
	TOTAL	**15**	**01**	**10**	**20**						

Total Contact Hours/week : 26
Total Credits : 20

ISE = In Semester Evaluation, ESE = End Semester Exam

***Note-** Student has to complete industry internship of two weeks after second semester however its evaluation will be carried out in third semester.

Program Elective-III

Sr. No.	Course Code	Course
1.	CES1146	Advanced Earthquake Engineering
2.	CES1241	Design of Foundations
3.	CES1026	Finite Element Analysis
4.	CES1141	Design of Formwork

Program Elective-IV

Sr. No.	Course Code	Course
1.	CES1192	Structural Optimization
2.	CES1162	Design of Composite Structures
3.	CES1151	Prefabrication and Modular Construction
4.	CES1156	Advanced Concrete Technology

S. Y. M. Tech.						**Semester: III**				
Course Code	**Course**	**Teaching Scheme**				**Evaluation Scheme**				
							Theory Marks		**Practical Marks**	
		L	**T**	**P**	**Credits**	**Scheme**	Max	Min. % for passing	Max	Min. % for passing
CES 2016	Industry Internship	--	--	--	01	ISE	--	--	100	50
	Open Elective	03	--	--	03	ESE	100	40	--	--
CES 2036	Dissertation Phase I	--	--	12	06	ISE	--	--	100	50
CES 2056	Dissertation Phase II	--	--	20	10	ISE	--	--	100	50
						ESE	--	--	100	50
	TOTAL	**3**	**--**	**32**	**20**					

Total Contact Hours/week : 35
Total Credits : 20

ISE = In Semester Evaluation, ESE = End Semester Exam

Open Elective

Sr. No.	Course Code	Course
1.	MOE2012	Artificial Intelligence - Machine Learning
2.	MOE2022	Creative Thinking: Techniques and Tools
3.	MOE2032	MOOC Course
4.	MOE2041	Energy Audit and Management
5.	MOE2062	Augmented Reality and Virtual Reality
6.	MOE2072	Industrial Instrumentation
7.	MOE2082	Advanced Mechatronics systems
8.	MOE2091	Disaster Management

Note for Open Elective

An Open Elective course is included in the curriculum of S. Y. M. Tech (Semester-III), under which students need to learn either MOOC course or courses offered by department.

Guidelines for MOOC course under Open Elective

1. If students opt for MOOC course as an Open Elective, he/she should select this course from NPTEL platform only.
2. As three credits are allotted to open elective, selected MOOC course must be of minimum 8 weeks or 30 hours.
3. Students need to solve assignments given by platform and also, give the final certification exam at allotted NPTEL exam center.
4. Student must secure certification of NPTEL platform within program duration, otherwise he/she will not be eligible for final evaluation.
5. If student fails in NPTEL certification course, he or she should reregister for the course in the next semester.

Guidelines for other courses mentioned under Open Elective:

1. Student can opt for course mentioned in the curriculum.
2. While selecting the course, students must take care that selected course from the list is not learned in UG or PG first year curriculum.
3. Lectures of these courses will be conducted by concerned department faculty by online mode.
4. Evaluation of these courses will be as mentioned in the curriculum.

S. Y. M. Tech						Semester: IV				
Course Code	Course	Teaching Scheme				Evaluation Scheme				
		L	T	P	Credits	Scheme	Theory Marks		Practical Marks	
							Max	Min.% for passing	Max	Min.% for passing
CES 2026	Dissertation Phase III	--	--	16	08	ISE	--	--	100	50
CES 2046	Dissertation Phase IV	--	--	24	12	ISE	--	--	100	50
						ESE	--	--	100	50
	TOTAL		--	**40**	**20**					

Total Contact Hours/week : 40
Total Credits : 20

ISE = In Semester Evaluation, ESE = End Semester Exam

Class: **First Year M. Tech Structural Engineering**	Semester-I
Course Code: **CES 1206**	Course Name: **Design of Prestressed Concrete Structures**

L	T	P	Credits
03	**-**	**--**	**03**

Course Description:
The course "Design of Prestressed Concrete Structures" equips students with comprehensive knowledge of prestressing concepts, materials, and structural behavior. It introduces the advantages and limitations of prestressed concrete, the types and systems of prestressing, and the guidelines for material quality as per IS codes. Students will learn to analyze prestressed members using stress, strength, and load-balancing concepts and design key elements such as beams, end blocks, pipes, and tanks. By covering both statically determinate and indeterminate structures, the course emphasizes practical applications in real-world engineering projects. This knowledge is essential for designing efficient and durable structures, addressing modern engineering challenges, and advancing professional expertise in structural engineering.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Explain the concept, material requirement and behavior of the pre-stressed concrete.
2. Determine losses of prestress in pretensioning and post-tensioning concrete.
3. Analyze and design pre-stressed concrete beams and end block.
4. Analyze and design the pre-stressed concrete pipes and tanks.

Prerequisite: Reinforced Concrete Structures, Strength of materials, Concrete Technology

Course Content

Unit No	Description	Hrs
01	**Prestress Concrete: Types, Materials, Systems:** Concept of concrete pre-stressing, advantages & disadvantages of pre-stressed concrete, I.S. recommendations for quality of materials for pre-stressed concrete -high strength concrete and high tensile steel, Classification of types of pre-stressing, systems of pre-stressing.	04
02	**Analysis of pre-stress concrete elements:** Analysis of pre-stress concrete elements - Stress concept, Strength concept and Load balancing concept, analysis for ultimate strength, Shear and principal stresses, mechanism of shear resistance in prestress concrete beams, ultimate shear resistance of pre-stress concrete members, pre-stress concrete members in torsion, IS:1343-2012 code recommendations.	08
03	**Losses in prestress:** Introduction to losses of pre-tensioning and post-tensioning concrete,	06

	immediate and time dependent losses, Loss due to elastic deformation of concrete, shrinkage of concrete, creep of concrete, relaxation of stress in steel, friction and anchorage slip.	
04	**Design of statically determinate prestress concrete beams and end bock** Design of statically determinate pre-stress concrete beams- rectangular, T and I Sections. Design of end block by IS code method.	**06**
05	**Analysis and design of statically indeterminate prestress concrete beams** Analysis and Design of two span continuous beams (statically indeterminate), choice of cable profile, linear transformation and concordancy.	**06**
06	**Analysis and design of prestress pipes and tanks** Analysis and design of cylindrical structures in pre-stressed concrete- pipes and tanks.	**06**

References -

Codes of Practice:

- IS 1343:2012 Code of Practice for Prestressed Concrete

Text Books:

- N. Krishna Raju, "Prestressed Concrete", McGraw Hill Education.
- Sinha. N. C. and Roy. S. K., "Fundamentals of Prestressed Concrete", S. Chand & Company Pvt. Ltd., New Delhi.

Reference Books:

- Lin, T.Y. and Burns, "Design of Prestressed Concrete Structures", N.H, John Wiley and Sons.
- S. Ramamrutham, "Design of Reinforced Concrete Structures", Dhanpat Rai Publishing Company.
- N. Rajaopalan, "Prestressed Concrete", Alpha Science International Ltd.

Class: **First Year M. Tech. Structural Engineering**	Semester: **I**
Course Code : **CES 1036**	Course Name: **Advanced Structural Analysis**

L	T	P	Credits
03	**-**	**-**	**03**

Course Description:
Advanced Structural analysis is offered as core course at the first semester of Civil Structural Engineering post graduate program. This course focuses on basic concepts and different analytical tools for understanding the behavior of statically indeterminate structures. The various units covered in the course are Influence Line Diagram, analysis of beam curved in plan, beam column, cables and suspension bridges along with the matrix methods of analysis. This course is intended to build the ability in the students to identify indeterminate structures, and to analyze the structures.

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

1. Construct Influence Line Diagram (ILD) for reactions, S.F. and B.M. for indeterminate structures
2. Draw SFD, BMD and TMD for beams curved in plan
3. Analyse the beam-columns element, cables and suspension bridges subjected to various loading conditions.
4. Analyse the structures by using the stiffness & flexibility matrix method
5. Determine location of shear center of the beam cross section.

Prerequisite: Engineering Mathematics, Engineering Mechanics, Solid Mechanics and Theory of Structures

Course Content

Unit No.	Description	Hrs
01	**Influence Lines Diagrams:** Physical Significance, Muller Breslau's Principle, Moment distribution method, ILD for propped cantilever, fixed beams, continuous beam, portal frames and two hinged arches.	06
02	**Beams Curved in Plan:** Analysis of determinate and indeterminate beams curved in plan such as cantilever and circular arch, semi-circular beams fixed at two ends subjected to point load and udl, simply supported semi-circular beams, circular ring beam.	06
03	**Beam Columns:** Governing differential equation, geometric and material nonlinearity, analysis of beam- columns simply and fixed supported at ends with concentrated load, moment and uniformly distributed load, magnification factor	06

04	**Stiffness Matrix method:** Stiffness matrices for beam, truss, plane frame, pin and rigid jointed space frame element on member axis, transformation of matrices on structure axes, overall joint stiffness matrix and nodal vector, assembly rules, calculation of member end forces	**06**
05	**Flexibility Matrix Method:** Flexibility and stiffness matrices relation, analysis of continuous beams, trusses and plane frames.	**04**
06	**a. Shear centre and Unsymmetrical bending:** Position of shear centre, shear flow, shear centre of various sections, unsymmetrical bending **b. Cables and suspension bridges:** Shape of cable, anchor cable, temperature stresses, moving loads, two hinged and three hinged stiffened bridge.	**08**

References:

Text Books:

- Vazirani and Ratwani, "Advanced Theory of Structures & Matrix method", Khanna Publisher, Delhi.
- Reddy C.S., "Basic structural Analysis", Tata McGraw Hill, Delhi.
- Pandit & Gupta, "Structural Analysis - A matrix approach", Tata McGraw Hill, Delhi.
- Negi and Jangid, "Structural Analysis", Tata McGraw Hill Pub. Co. Delhi

Reference Books:

- Timoshenko and Gere, "Strength of Materials", East West Press Ltd.
- Gere and Weaver, "Matrix Analysis of Framed Structures", CBS Publishing, Delhi.
- N. Krishnaraju and D.R. Gururaja, "Advanced Mechanics of Solids & Structures", Narosa Pub. House Delhi.
- A. Ghali and A.M. Navellie, "Structural Analysis: A Unified Classical and Matrix Approach", CRC Press.
- K.U. Muthu and H. Narendra, "Indeterminate Structural Analysis", Wiley Pub.

Class: **First Year M. Tech. Structural Engineering**	Semester: **I**
Course Code: **CES 1056**	Course Name: **Structural Dynamics and Earthquake Engineering**

L	T	P	Credits
03	**-**	**-**	**03**

Course Description:

Most civil engineering structures are subjected to time-varying loads, either due to natural events or human activities. Understanding the dynamic behavior of structures under such loading conditions is crucial. This course is designed to develop a comprehensive understanding of the dynamic characteristics and responses of structural systems. It begins with an introduction to the formulation of dynamic governing equations for structural systems. The course covers free and forced vibration analyses of single-degree-of-freedom (SDOF) and multi-degree-of-freedom (MDOF) systems. A significant focus is placed on the evaluation of lateral forces on buildings, using methods outlined in IS 1893.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Explain various concepts related to engineering seismology and conceptual design
2. Analyze the response of single and multi-degree freedom systems by fundamental theory of vibration.
3. Determine lateral loads developed on multistoried structures under seismic condition using equivalent static and response spectrum method.

Prerequisite: Engineering Mathematics, Engineering Mechanics, Structural analysis.

Course Content

Unit No.	Description	Hrs
01	**Introduction to Dynamics:** Overview and importance of structural dynamics, Concept of degrees of freedom, Sources of vibration, Types of excitations, Principle of virtual displacement, Application of Newton's laws, D' Alembert's principle, Single degree of freedom systems, Mathematical modelling of dynamic system, Equivalent stiffness.	**04**
02	**Single Degree of Freedom (SDOF) Systems:** Analysis for undamped, damped free vibration, Estimation of damping by logarithmic decrement method, response to undamped and damped SDOF system to harmonic excitation, half power bandwidth method of damping evaluation. Response to support motion and force transmission to foundation, response of SDOF system to general dynamic loading, Duhamel's integral	**08**
03	**Multiple Degree of Freedom (MDOF) System:** Idealization of multi-story shear building as MDOF system, Equations of motion for two story, Natural frequencies of vibration, modes and mode shapes of MDOF system. Orthogonality of modes, Normalization of Modes.	**08**
04	**Engineering Seismology and Conceptual Design:** Earthquake phenomenon, Cause of earthquakes, Seismic waves, Terms associated with earthquakes, Magnitude/Intensity of an earthquake, Seismic zones of India,	**05**

	Seismic forces, Behavior of RCC and Masonry structure under earthquake loading, Effect of Architectural features, Twisting of building.	
05	**Earthquake Resistant Design:** Introduction to IS code provisions regarding earthquake, seismic design requirements, regular and irregular configurations, basic assumptions, design earthquake loads, basic load combinations, seismic methods of analysis.	05
06	**Computation of Seismic Forces on the Structure:** Computation of lateral forces by equivalent static and response spectrum method, determination of base shear, lateral distribution of base shear as per IS 1893	06

References:

Codes of Practice:

- IS 1893:2016, Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards

Text Books:

- Chopra A. K. "Structural Dynamics and Introduction of Earthquake Engineering".
- Mario Paz, "Structural Dynamics Theory and Computation", CBS Publisher.
- P. Agarwal & M. Shrikhande, "Earthquake Resistant Design of Structures", Prentice Hall Publications.

Reference Books:

- Clough R.W. & J. Penzien, "Dynamics of Structures", Mc Graw Hill Education.
- Willaim Thomson, "Theory of Vibration with applications" CRC Press.
- David Dowrick, "Earthquake Resistant Design and Risk Reduction",Willey Publication.

Class: - **First Year M. Tech. Structural Engineering**	Semester-**I**
Course Code: **CES 1076**	Course Name: **Computer Aided Design of Steel Structures Lab**

L	T	P	Credits
-	-	04	02

Course Description:
This laboratory course is mainly focusing on analysis and design of steel structures using renowned software's like STAAD- Pro, ETABS and SAP etc. Students are expected to design various steel structures and prepare excel sheet of the same.

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

1. Analyze and design of the steel structures such as truss, towers, steel building frame and hoarding board etc. using standard software packages.
2. Prepare excel sheet for load calculation and for design of steel beam, column and connection.
3. Interpret the results of analysis and design obtained from the software.

Prerequisite: Limit State Design of Steel Structures

Course Content

Project No.	Description	Lab Sessions
1.	Preparation of Excel sheet for load calculation, design of beam	4
2.	Design and drawing of industrial shed	8
3.	Design of steel building (Frame)	4
4.	Design of hoarding boards	4
5.	Design of communication tower	4

References

Code of Practice:

- IS: 800 (2007) General Construction in Steel - Code of Practice, Bureau of Indian Standards.
- IS: 875 (Part 3), (2015), Wind Loads on Buildings and Structures, Bureau of Indian Standards.
- Hand Book No. 1 (SP 16) or Steel Table, (1964), Handbook for Structural Engineers, Bureau of Indian Standards.

Text Books:

- Shiyekar M. R., "Limit State Design in Structural Steel", PHI Learning.
- Sai Ram K. S., "Design of Steel Structures", Pearson Education.

Reference Books:

- Duggal S. K, "Design of Steel Structures", Tata Mc-Graw Hill publishing company Ltd., New Delhi.
- Subramanian N., "Design of Steel Structures", Oxford University Press, New Delhi.

Class: - **First Year M. Tech. Structural Engineering**	Semester-I
Course Code: **CES 1096**	Course Name: **Structural Simulation and Modelling Lab**

L	T	P	Credits
-	-	04	02

Course Description:
The course provides an ability to interpret the response of structural elements/whole structure using software packages such as ANSYS, ABAQUS. The course develops a firm foundation for research and practice in Structural Engineering.

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

1. Apply principles of structural mechanics to model and analyze beams, frame and truss.
2. Evaluate the effects of stress concentrations in steel plates with opening of various shapes
3. Analyze thermal stress distributions in structural elements under varying temperature conditions.
4. Analyze the concrete and steel beams strengthened with GFRP (Glass Fiber Reinforced Polymer) or CFRP (Carbon Fiber Reinforced Polymer)

Prerequisite: Structural Mechanics, Analysis of Structures, Design of steel structures, Design of concrete structures

Course Content

Expt. No.	Description	Lab Sessions
1	Introduction to ANSYS/ABAQUS, modelling, loading	4
2	Analysis of Cantilever beam(RCC and Steel) with different loading conditions, varying spans.	4
3	Analysis of Simply Supported beam (RCC and Steel) with different loading conditions, varying spans and support conditions	4
4	Analysis of steel plate with opening of various shapes	2
5	Thermal Stress Analysis of structural elements	2
6	Analysis of column with different loading conditions, varying height and support conditions	2

7	Analysis of truss	2
8	Analysis of beams strengthened with GFRP, CFRP	2
9	Analysis of Blast Loading for walls	2

References

Codes of Practice:

- Bureau of Indian Standards IS 456: 2000. Indian standard code of practice for plain and reinforced concrete. New Delhi, BIS.
- Indian Standard Methods of Tests for Strength of Concrete IS 516: 2004

Text Books:

- M. J. Fagan, "Finite Element Analysis: Theory and Practice"
- T. R. Chandrupatla and A.D. Belegundu, "Introduction to Finite Elements in Engineering"

Manual

- Kent L. Lawrence, "ANSYS Workbench Tutorial"
- Dassault Systems, "ABAQUS Analysis User's Manual"

Reference Books:

- Alfaiate, J., Pires, E.B., & Martins, J.A.C., "A Finite Element Analysis of Non Prescribed Crack Propagation in Concrete", Computers & Structures.

Class: **First Year M. Tech. Structural Engineering**	Semester- I
Course Code: **SHP 5513**	Course Name: **Technical Communication**

L	T	P	Credits
02	-	-	01

Course Description:
This course is designed to help students in improving skills that will enable them to produce well designed technical documents and to deliver impressive oral presentations. The course focuses on principles of effective writing and on types of documents common in technical fields. While the emphasis will be on writing, oral communication of technical information will form an important component of the course, as well. The course assists students in preparing them for oral presentations in various professional contexts.

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

1. Construct grammatically correct sentences in different types of technical writing, such as reports and proposals.
2. Apply technical writing skills to improve readability of documents.
3. Demonstrate professional skills required in job interviews and at workplace.

Prerequisite: English language.

Course Content

Unit No.	Description	Hrs.
01	**Planning and Preparation:** Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.	04
02	**Paraphrasing and Plagiarism:** Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism.	03
03	**Sections of Research Paper:** Sections of a Paper, Abstracts, Introduction, Review of the Literature, Methods, Results, Discussion, Conclusions, and The Final Check.	03
04	**Sections of Research Paper:** Key skills needed when writing a Title, key skills needed when writing an Abstract, key skills needed when writing an Introduction, skills needed when writing a Review of the Literature.	04

05	**Sections of Research Paper:** Skills needed when writing the Methods, skills needed when writing the Results, skills needed when writing the Discussion, skills needed when writing the Conclusions, useful phrases, how to ensure good quality of the paper at the time of submission.	**04**
06	**Professional skills:** Resume Writing, e-Mails, Interview skills, Dos and Don'ts while Answering, FAQs, GROUP DISCUSSION: Structured and Unstructured GD, Opening and Closure, Showing Agreement and Disagreement.	**06**

References:

Text Books:

- Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London.

Reference Books:

- Day R, How to Write and Publish a Scientific Paper, Cambridge University Press,
- Goldbort R, Writing for Science, Yale University Press (available on Google Books).
- Jeff Butterfield, Soft Skills for Everyone, Cengage Learning India Private Limited.
- John Seely, Oxford Guide to Effective Writing and Speaking; Oxford University Press.
- Thomas N. Huckin and Leslie A. Olsen, Technical Writing and Professional.
- Communication for Nonnative Speakers of English; Tata McGraw Hills, International Edition.

Class: **First Year M. Tech. Structural Engineering**	Semester: **I**
Course Code : **CES 1016**	Course Name: **Advanced Solid Mechanics**

L	T	P	Credits
03	**-**	**-**	**03**

Course Description:
It consists of study of stress, strain and displacement of deformable bodies and relationship between them. Also, torsion of solid non-circular cross sections and thin tubes is included in this course. Plasticity, yield criteria and elasto-plastic loading for beams and thick cylinders are also studied in this course.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Analyze bodies for stresses and strains.
2. Analyze prismatic bars and tubes subjected to torsion.
3. Analyze beams and thick cylinders for elasto-plastic loading.

Prerequisite: Engineering Mathematics, Structural analysis.

Course Content

Unit No.	Description	Hrs
01	**Stress:** Basic concepts of continuum, concept of stress, equilibrium equations, stress on oblique plane, stress transformation, principal stresses, stress invariants, deviatoric stresses, maximum shear stress, octahedral stresses, plane stress.	06
02	**Strain:** Strain at a point, concept of strain, strain components, compatibility equations, strain transformation, principal strains, strain invariants, deviatoric strains, maximum shear strain, octahedral strains, plane strain.	06
03	**Stress-strain relations:** Generalized Hooke's law, stress strain relationship for isotropic material, strain displacement and compatibility relations, Airy's stress function and its applications.	06
04	**Torsion:** Torsion of Prismatic Bars: Saint Venant's method, Prandtl's membrane analogy, torsion of elliptical, triangular and rectangular bar, torsion of thin tubes.	06
05	**Plasticity:** Strain Hardening, Idealized Stress- Strain curve, yield criteria, von Mises yield criterion, Tresca yield criterion, plastic stress-strain relations, principle of normality and plastic potential, isotropic hardening.	06
06	**Elasto-Plastic loading:** Beams under elasto-plastic condition, collapse load, plastic hinge, elasto-plastic	06

	deflections of beams of rectangular cross sections, residual stresses, thick-walled cylinders.	

References:

Text Books:

- Timoshenko S.P. & Goodier J. N., "Theory of Elasticity", McGraw Hill International Editions.
- Sadhu Singh, "Theory of Elasticity", Khanna Publishers.
- Sadhu Singh, "Theory of Elasticity", Khanna Publishers.

Reference Books:

- Kazimi S. M. A., "Solid Mechanics", Tata McGraw Publishing Company Limited.
- Srinath L.S, "Advanced Mechanics of Solids", McGraw Publishing Company Limited.
- Valiappan, "Continuum Mechanics" McGraw Publishing Company Limited.

Class: **-First Year M. Tech Structural Engineering**	Semester-**I**
Course Code: **CES 1136**	Course Name: **Theory of Plates and Shells**

L	T	P	Credits
03	**-**	**--**	**03**

Course Description:
This course, deals with the theory of plate and shell structures, using the membrane and bending theories for various types of shells and their applications. In this course, thin plate will be analysed by Classical Plate Theory Bending Buckling problems will be discussed for Plates.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Analyse various problems using different theories based on plates and shells.
2. Derive equilibrium equations related with different theories of plates and shells.

Prerequisite: Theory of Structural Analysis.

Course Content

Unit No	Description	Hrs
01	**Fundamental concepts of plate analysis:** Elasticity approach to solution, Stress, Strain, Plane Stress and Strain, Constitutive relationships, Equilibrium Equations	06
02	**Classical plate theory:** Assumptions, boundary conditions, Stress Resultants, General Equations	06
03	**Analysis of plate by Navier's method:** Simply supported plates and various boundary and loading conditions. Problems.	06
04	**Analysis of plate by Levy's method:** Simply supported plates and various boundary and loading conditions. Problems	06
05	**Membrane theory of Shells:** Introduction, Types of theories, membrane theory of cylindrical Shell equilibrium equations, limitations, problems	06
06	**Bending theory of Shells:** Equilibrium equation, Bending theory, synclastic and anticlastic shell, problems on bending theory	06

Reference:

Text Books:

- Timoshenko, S., "Theory of plates and shells", McGraw Hills Book Comp.
- Chandrashekhar K, "Theory of Plates", Universities Press (India).
- Chandrashekhar K, "Analysis of Thin Concrete Shells", New Age International Pvt. Ltd.

Reference Books:

- Ramaswamy, "Design of concrete shell roofs", CBS publishers and distributors New Delhi.
- Reddy J. N., "Theory and analysis of elastic plates and shells", Taylor & Francis.

Class: **First Year M. Tech Structural Engineering**	Semester-I
Course Code: **CES 1215**	Course Name: **Structural Health Monitoring**

L	T	P	Credits
03	--	--	03

Course Description:
Structural Health Monitoring (SHM) deals with assessment, evaluation and technical diagnosis of different structural systems of strategic importance. SHM involves the observation and analysis of a system over time using periodically sampled response measurements to monitor changes to the material and geometric properties of engineering structures such as bridges and buildings. Extensive knowledge of SHM shall lead to a clear understanding of risk and reliability assessment of structures, which is currently mandatory for structures of strategic importance like bridges, offshore structures etc. The course covers concept of SHM, different instruments/sensors used in SHM systems, static and dynamic field-testing methods, structural assessment and retrofitting and applications of SHM.

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

1. Discuss the concept and various components of SHM
2. Identify suitable Sensors and Instruments required in SHM for in-service performance structures.
3. Assess the health of structures using different techniques of SHM
4. Select the appropriate strengthening and retrofitting techniques for regaining the structural strength.
5. Design the sensor layouts of SHM for the civil engineering structures

Prerequisite: Concrete Technology, RCC Structures, Steel Structures

Course Content

Unit No	Description	Hrs
01	**Introduction of Structural Health Monitoring (SHM):** Necessity of SHM, SHM Vs. NDE, concept of SHM, components of SHM, Methods of SHM - local and Global techniques for SHM, challenges in SHM, factors affecting the health of structures, SHM scheme, various steps in SHM, damage diagnostic methods, challenges in SHM, Experimental modal analysis, operational modal analysis and combined methods,	05

02	**Sensors and Instrumentation for SHM** Sensors for measurements: Basics of sensors, transducers and actuators, classification of sensors, working principles of various types of sensors like electrical resistance strain gages, vibrating wire strain gauges, fiber optic sensors, temperature sensors, accelerometers, displacement transducers, load cells, LVDT, crack propagation measuring sensors, corrosion monitoring sensors, pressure sensors, data acquisition – data transmission – data processing – storage of processed data – knowledgeable information processing, Concept of smart materials & smart structures with SHM.	**07**
03	**Static and Dynamic Field-Testing Methods of SHM:** Static Field-Testing Methods: Types of Static Tests- Load test, Concrete core trepanning, flat jack techniques, Static Response Measurement. Dynamic Field-Testing Methods: Types of dynamic field test, stress history data, dynamic response methods, hardware for remote data acquisition systems, remote structural health monitoring, measured forced vibration-impact excitation, step relaxation test, shaker excitation method.	**06**
04	**Vibration Based SHM Techniques**: Use and demonstration of dynamic properties of structures for damage detection and SHM, ambient vibration test, acoustic emission technique, electromechanical impedance technique, wave propagation-based techniques, fiber optics-based techniques, remote & wireless SHM techniques.	**06**
05	**Structural Assessment and Retrofitting of Structures** Introduction to health assessment of structures, structural damages and failures, causes of distress, regular maintenance, principles of structural assessment, classification and levels of assessment. Fundamental of retrofitting, methods of retrofitting, materials for retrofitting (conventional and smart materials), selection of retrofitting methods.	**08**
06	**Applications of SHM:** Applications of SHM on buildings, bridges, offshore structures, Dams, Tunnels, future of SHM	**04**

References:

Text Books:

- Daniel Balageas, Claus Peter Fritzen, Alfredo Guemes, "Structural Health Monitoring", John Wiley and Sons.
- Douglas E Adams, "Health Monitoring of Structural Materials and Components, Methods with Applications", John Wiley and Sons

Reference Books:

- J. P. Ou, H. Li and Z. D. Duan, "Structural Health Monitoring and Intelligent Infrastructure", Vol1, Taylor and Francis Group, London.
- Victor Giurglutiu, "Structural Health Monitoring with Wafer Active Sensors", Academic Press Inc.
- Journal Papers on this subject

Class: **-First Year M. Tech Structural Engineering**	Semester-**I**
Course Code: **CES 1196**	Course Name: **Design of RCC Bridges**

L	T	P	Credits
03	**-**	**--**	**03**

Course Description:
Design of RCC bridges will focuses on the various aspects of Bridge engineering along with bringing out the advanced theories of Bridge engineering. The topics covers overall analysis of bridge engineering including design of super-structure, sub- structure, foundation, and hydrological properties along with details of other bridge components.

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

1. Determine various loadings on bridge.
2. Analyze and design of super-structure of bridge.
3. Analyze and design of sub-structure of bridge.

Prerequisite: Design of Reinforced concrete structures, Bridge engineering

Course Content		
Unit No	**Description**	**Hrs**
01	**Introduction:** Introduction, types, geometric design parameters, loading standards.	**06**
02	**Design of slab for short span bridges:** Design of deck slab, slab culvert, box culvert.	**06**
03	**Design of Girders for long span bridges:** Analysis by using Pieguads and Courbon's theory, design of longitudinal and cross girders.	**06**
04	**Multi-span bridges:** Analysis and Design of deck slab for Multi-span bridges and flyovers.	**08**
05	**Foundation design:** Design of bridge foundation, piers, abutments, wing walls.	**06**
06	**Bearing and joints:** Design of various joints, bearings for various types of bridges.	**04**

References:

Code of Practice:

- IRC-6: Standard specifications and code of practice for road bridges
- IRC-78: Code of practice for the design of foundations and substructures of road bridges
- IRC-112: Code of practice for the design of concrete road bridges
- IRC-SP-82: Code of practice for the design of causeways and submersible bridges
- IS: 875, Part –I: Code of practice for design loads for buildings and structures

Text Books:

- Raina V.K, "Concrete Bridge Practice", Tata McGraw Hill. Delhi.
- Punmia B.C., Jain Ashok Kumar, "Reinforced Concrete Structures", Laxmi Publications.
- Jagadish & Jayaram, "Design of Concrete Bridges", Tata McGraw Hill.

Reference Books:

- D. Johnson Victor, "Essentials of Bridge Engineering", Oxford & IBH publishing Co. Ltd., New Delhi,
- N. Krishna Raju, "Design of Bridges", Oxford & IBH publishing Co. Ltd., New Delhi
- Jaikrishna and O.P Jain, "Plain and Reinforced Concrete", Nemchand & Bros, Roorkee

Class: **First Year M. Tech Structural Engineering**	Semester-I
Course Code: **SHP 5172**	Course Name: **Numerical Methods for Structural Engineers**

L	T	P	Credits
03	-	--	03

Course Description:
The course introduces students to the formulation, methodology and techniques for numerical solution of engineering problems. The course intends to build the competency in the students to apply the knowledge of mathematics to the solution of engineering problemsand to analyze it. The course covers the topics: Error Analysis, Locating Roots of Equations, Interpolations, Curve Fitting, Roots of Polynomials, Elements of Matrix Algebra

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

1. Apply numerical methods for error analysis.
2. Compute the roots of the given equations and polynomials
3. Apply the relevant numerical method for interpolating the polynomial.
4. Develop the equation to be fitted to the given data.
5. Solve problems involving linear algebraic equations

Prerequisite: Engineering Mathematics

Course Content

Unit No.	Details of Content	Hrs.
01	**Error Analysis:** Approximation and rounding off errors: Significant figures, Accuracy and precision, Error definitions, Round-off errors, Truncation errors and the Taylor series: The Taylor series, Taylor series approximation of polynomial, Taylor series expansion to approximation a function with infinite number of derivatives, the remainder for the Taylor Series expansion, Using the Taylor series to estimate truncation errors, Control of numerical errors, Blunders, formulation errors and data uncertainty.	06
02	**Locating Roots of Equations:** Graphical approach, Bisection method, False-position method, Newton-Raphson method, The Secant method, Modified Secant method	06

03	**Interpolations:** Introduction, Finite differences, Relation between operators, Differences of a polynomial, Factorial notation, Missing term technique, Lagrange"s interpolation formula, Newton's Divided difference formula.	06
04	**Curve Fitting:** Motivation, Mathematical background: Simple statistics, The Normal distribution, Linear regression: Criteria for a "Best" fit, Least Squares Fit of a Straight line, Quantification of error of Linear regression, Linearization of Nonlinear relationships: Linearization of a Power Equation $y = ax^b$, Polynomial regression, Multiple Linear regression	06
05	**Roots of Polynomials:** Polynomials in Engineering and Science, Computing with Polynomials: Polynomial Evaluation and Differentiation, Polynomial Deflation, Muller"s Method, Bairtow"s Method, Case Studies in Civil Engineering	06
06	**Elements of Matrix Algebra**: Gaussian Elimination method, Pitfalls of Elimination Methods, Techniques for improving Solutions, Gauss Jordan method, LU-decomposition, LU-decomposition Version of Gaussian Elimination method, Doolittle Decomposition, Crout Decomposition, Case Studies in Civil Engineering	06

References:

Text Books:

- Steven C. Chapra & Raymond P. Canale, "Numerical Methods for Engineers" McGraw Hill Education.
- Sastry S. S, "Introductory Methods of Numerical Analysis, Prentice Hall of India.

Reference Books:

- Atkinson K. E., J. Wiley and Sons, "An Introduction to Numerical Analysis". Shaum Series
- Scheid F, "Theory and Problems of Numerical Analysis". McGraw Hill Book Company
- E. Ward Cheney and David R. Kincaid, "Numerical Methods and Applications"

Class: **First Year M. Tech. Structural Engineering**	Semester: **I**
Course Code: **CES 1161**	Course Name: **Soil-Structure Interaction**

L	T	P	Credits
03		**-**	**03**

Course Description:

The course focuses on the analysis and design of civil engineering structures under seismic conditions. It covers the design of reinforced concrete elements to meet ductility requirements as per IS 13920:2016, including detailed calculations and drawings. Seismic analysis of elevated circular water tanks is covered using analytical and numerical methods to evaluate lateral loads with accuracy. Advanced vibration control techniques, such as tuned mass dampers and base isolation systems, are explored to mitigate structural response.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Identify situations where soil-structure interaction is likely to occur and assess its impact on the behavior of a structure.
2. Analysis and design of Beam on Elastic Foundation.
3. Analyze finite and infinite length beams and plates on isotropic elastic medium.
4. Analyze Axially and Laterally Loaded Piles and Pile Groups.

Prerequisite: Geotechnical Engineering, Structural analysis. Design of RCC Structures

Course Content

Unit No.	Description	Hrs
01	**General soil-structure interaction problems:** Contact pressures and soil-structure interaction for shallow foundations, concept of sub grade modulus, effects/parameters SE influencing subgrade modulus.	06
02	**Soil Foundation Interaction Analysis:** Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models.	06
03	**Beam on Elastic Foundation:** Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness.	06
04	**Plate on Elastic Medium:** Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.	06
05	**Elastic Analysis of Pile:** Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.	06
06	**Laterally Loaded Pile:**	06

	Load deflection prediction for laterally loaded piles, Sub-grade reaction and elastic analysis, Interaction analysis.	

References:

Text Books:

- Selva durai, A. P. S., "Elastic Analysis of Soil-Foundation Interaction",
- Poulos, H. G., and Davis, E. H., "Pile Foundation Analysis and Design",

Reference Books:

- Scott, R. F., "Foundation Analysis"
- State of Art Report, Institution of Structural Engineers, "Structure Soil Interaction"

Class: **First Year M. Tech Structural Engineering**	Semester-I
Course Code: **CES 1182**	Course Name: **Repair and Rehabilitation of Structures**

L	T	P	Credits
3	--	--	3

Course Description:

Concrete structures are subjected to constant deterioration due to effects of ageing, inadequate maintenance, severe environmental exposure, penetration of catalytic agencies such as moisture, gases like CO2 & oxygen, chloride ions, industrial pollutants etc. This deterioration needs to be timely arrested before it leads to irreparable damage making it very important to repair and upgrade (retrofit/strengthening) the current stock of deteriorated and deficient structures. This course has been designed with an aim to give the students an insightinto the subject of concrete repair, its protection and strengthening. Various materials used in carrying out repair works forms the important aspect of this course. It also includes preventive measures on various aspects and provides the information on inspection, assessment procedure for evaluating a damaged structure, causes of deterioration and testing techniques and methods for strengthening the existing structures.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Identify the causes of distress and deterioration of concrete structure.
2. Explain the stages of condition assessment of buildings.
3. Interpret and evaluate of ND test result data.
4. Describe the procedures of various repair and strengthening techniques.

Prerequisite: Concrete Technology, Design of Reinforced Concrete Elements

Course Content

Unit No.	Description	Hrs
01	**Introduction:** Need for Repair and Rehabilitation of structures, distress in structures. Definitions and terminologies, deterioration of RC structures, physical,chemical and other causes.	06
02	**Condition Assessment of Structures:** Condition assessment of concrete structures, exposure conditions, stages visual inspection, on situ and laboratory testing of concrete, Interpretation and reporting of NDT results, preparation of report, Case studies of condition assessment of distressed due to corrosion, fire, leakage, earthquake,landslide.	06
03	**Fiber Reinforced Polymer Composites:** Introduction to composite, types and phases of composites, Fiber reinforced	06

	polymer composites, types of fibers and their properties, stress- strain relationship, applications. Types of resins and their characteristics.	
04	**Materials of Repair** Factors considered in the selection of repair method, repair stages. Materials for repair: desirable properties of materials, special mortar and concretes, concrete chemicals, special cements and high grade concrete – expansive cement.	**06**
05	**Repair Techniques:** Repairs using mortars, Dry pack and Epoxy bonded dry pack, preplaced aggregate concrete, gunite or shotcrete, grouting, polymer impregnation, resin injection, routing and sealing, stitching, surface patching. shoring andunderpinning.	**06**
06	**Strengthening Techniques:** section enlargement, composite construction, post tensioning, flexural and shear strengthening of beam, strengthening of columns, footings.	**06**

References:

Text Books:

- Modi Poonam I., Patel Chirag N., "Repair and Rehabilitation of Concrete Structures", PHI Learning Pvt. Ltd.
- Shetty M.S., "Concrete Technology", S. Chand &Company Ltd.

Reference Books:

- Vidivelli B., "Rehabilitation of Concrete Structures", Standard Publisher.
- Ravi Shankar K., Krishnamurthy T.S., "Structural Health Monitoring, Repair and Rehabilitation of Concrete Structures", Allied Publishers.
- Handbook on repair and rehabilitation of RCC buildings, CPWD, Government ofIndia.

RAJARAMBAPU INSTT. OF TECHNOLOGY RAJARAMNAGAR CIVIL ENGG. DEPT.

K.E.S. Rajarambapu Institute of Technology Rajaramnagar Autonomous 415 414

Class: **First Year M. Tech. Structural Engineering**	Semester: **I**
Course Code : **CES 1171**	Course Name: **Design of Tall Buildings**

L	T	P	Credits
03	**-**	**-**	**03**

Course Description:

This course introduces students to the principles and practices of designing tall buildings, with an emphasis on structural forms, loading conditions, and serviceability. Students will explore factors influencing the development of tall structures, including design criteria, stability, stiffness, and human comfort. They will study various loading types gravity, wind, impact, and combinations as per Indian Standards (BIS). Structural systems such as rigid frames, braced frames, shear walls, and wall-frame systems are analyzed for performance and applications. Advanced topics include modeling techniques for approximate and accurate analysis, addressing P-Delta effects, and high-rise behavior. The course also examines the role of foundations, soil-structure interaction, and fire safety in the context of tall buildings. This course equips students with the knowledge and analytical skills needed to design efficient, resilient, and code-compliant tall buildings. It bridges theoretical concepts with real-world applications, enabling learners to address complex challenges in modern structural engineering.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Describe the development of tall building structure including loading and other serviceability parameters.
2. Discuss various types of loads, combinations and their influence on tall buildings.
3. Demonstrate various types of structural forms and its applications.
4. Modelling for analysis of Rigid frame building structure.
5. Analyze the shear wall system, wall frame system of tall buildings.

Prerequisite: Structural Analysis, Design of Concrete Structures

Course Content

Unit No.	Description	Hrs
01	**Tall Buildings:** Introduction, Factors affecting growth, Height and structural form, Tall building structure, Philosophy, Design criteria Design process, Design philosophy, Loading, Strength and Stability, Stiffness and Drift limitations, Human comfort criteria, Creep, shrinkage and temperature effects, Fire, Foundation settlement and soil-structure interaction.	06
02	**Loading on Tall Buildings:** Introduction, Gravity loading including live load and its reduction – Impact load due to elevators, Construction loads. Wind loading, Load Combinations as per BIS-Methods of Design	06
03	**Structural Form:** Introduction, Braced frame structures, Rigid frame structures, In-filled frame Structures, Flat plate and Flat slab structures, Shear wall structures including coupled walls, Dual structures (wall frame structures), Framed-Tube structures Outrigger Braced 45 Structures, Suspended structures, Core structures, Space	06

	Structures, Hybrid Structures Different R.C. floor systems.	
04	**Modeling for Analysis:** Introduction, Approaches to analysis, Assumptions, High-Rise Behavior Modeling for Approximate analysis, Modeling for Accurate Analysis, P-Delta effects, Wide Column Deep beam analogies etc. Rigid Frame Structures: Introduction, Rigid frame behavior, Approximate Determination of member forces caused by gravity loading, Approximate Analysis of member forces caused by horizontal loading, Approximate analysis for Drift	**06**
05	**Shear Wall Structures:** Introduction, Behavior of shear wall structures, Analysis of proportionate wall systems and Non proportionate structures and its behavior, Effects of Discontinuities at Base coupled shear wall structure Behaviour, Methods of Analysis	**06**
06	**Wall - Frame (Dual) Structures:** Introduction, Behavior of symmetric wall frames, Approximate theory for wall frames	**06**

References:

Codes of Practice:

- Bureau of Indian Standards IS 456: 2000. Indian standard code of practice for plain and reinforced concrete. New Delhi, BIS.
- IS 1893 (Part 1): 2016
- IS 13920: 2016
- IS 875 (Part 1 to Part 5)
- IS 16700: 2017: Criteria for structural safety of Tall Concrete Buildings.

Text Books:

- Bryan Stafford Smith and Alex Coull, "Tall Building Structures Analysis and Design", Wiley India Pvt. Ltd.
- Bungale S. Taranath, "Wind and Earthquake Resistant Buildings", Structural Analysis and Design, Marcel Dekker.

Reference Books:

- John D Holmes, "Wind Loading of Structures", Spon Press.
- Pankaj Agarwal and Manish Shrikhande, "Earthquake Resistant Design of Structures", PHI Learning Private Limited, New Delhi.

Class: **First Year M. Tech. Structural Engineering**	Semester: **II**
Course Code : **CES 1226**	**Course Name:** Design of Steel Structures

L	T	P	Credits
03	**-**	**-**	**03**

Course Description:

This course deals with the design of special steel structures. It covers the topics such as the welded, bolted and riveted connections, design methods, and stability analysis of steel structures. It also includes the design of steel structures for specific loads and conditions to design the pre-engineered buildings, hoarding structures, plate girders and castellated beams etc.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Analyze and design connections of steel structural elements.
2. Design of pre-engineered buildings, hoarding structures, and beams with web openings.
3. Design the plate and steel truss bridge girder.

Prerequisite: Mechanics of Structures, Design of Steel Structures

Course Content

Unit No.	Description	Hrs.
01	**Connections:** Bolted connections, behaviour of bolted connections, design strength, block shear failure, eccentrically loaded connections, beam and column splices, welded connections, design of welds for truss members, angle seat connections, web angles and end plate connections, moment resistant connections, beam and column splices.	04
02	**Design of Pre-engineered buildings:** Applications of PEB, Pre-Engineered Building Components, Analysis of PEB frame under the influence of dead, live, collateral, wind, Seismic and other applicable loads. Serviceability limits as per code, PEB design methodology, Design parameters of PEB frames, Section sizes as per manufacturing limitations, Analysis and design of rigid frames. Rigid frame moment connection, Shear connection- anchor bolt and base plate design (pinned and fixed)	08
03	**Design Plate girder:** Introduction, plate buckling, web buckling in shear, tension field action, design of plate girder.	06
04	**Design of Steel Beams with Web Openings:** Shape of the web openings, practical guide lines, and Force distribution and failure patterns, Analysis of beams with perforated thin and thick webs, Design of laterally restrained beams for given sectional properties, Vierendeel girders.	08

05	**Design of Bridge Truss Girder:** Types of truss bridges, component parts of a truss bridge, economic Proportions of trusses, self-weight of truss girders, design of bridge, compression members, tension members; wind load on truss girder bridges; wind effect on top lateral bracing; bottom lateral bracing; portal Bracing; sway bracing, design of lacing	06
06	**Design of Hoarding Structures:** Analysis and design of hoarding structures under dead, live and wind load condition as per codal provisions.	04

References:

Codes of Practice:

- IS: 800 (2007) General Construction in Steel - Code of Practice, Bureau of Indian Standards.
- IS: 875 (Part 3), (2015), Wind Loads on Buildings and Structures, Bureau of Indian Standards.
- Hand Book No. 1 (SP 16) or Steel Table, (1964), Handbook for Structural Engineers, Bureau of Indian Standards.

Text Books:

- Duggal, S.K., "Design of Steel Structures", Tata Mc-Graw Hill publishing company Ltd.
- Sairam, K. S., "Design of Steel Structures", Pearson publication.
- Shah, V. L. and Gore V., "Limit State Design of Steel Structures", Structures Publication.
- Shiyekar, M. R., "Limit State Design in Structural Steel", PHI Learning

Reference books

- Subramanian, N., "Design of Steel Structures", Oxford University Press.
- Dayaratnam, "Design of Steel Structures", Wheeler Publishing.
- Chandra R., "Design of Steel Structures", Standard Book House.
- Arya, A.S. and Ajamani J.L., "Design of Steel Structures", Nemchand and Bros.
- Vazirani and Ratwani, "Design of Steel Structures", Khanna Publishers.
- Punmia, B. C., Jain & Jain, "Design of Steel Structures", Laxmi Publication.

Class: **First Year M. Tech Structural Engineering**	Semester: **II**
Course Code : **CES 1046**	Course Name: **Design of Concrete Structures**

L	T	P	Credits
04	**-**	**-**	**03**

Course Description:

This course delves into concepts of reinforced concrete design, focusing on flat slabs, combined footings, raft and pile foundations, retaining walls, and overhead water tanks. Students will engage in the design and detailing of these structural elements, considering practical applications and adherence to Indian Standards (IS 456:2000). The course emphasizes structural stability, safety, and serviceability, providing learners with the skills necessary to address real-world challenges in structural engineering. By the end of the course, students will gain expertise in designing complex structures and be prepared for upcoming engineering roles.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Design reinforced concrete flat slab, combined footing, raft footing and pile foundation.
2. Design cantilever and counterfort retaining wall.
3. Design overhead circular water tank with flat base.

Prerequisite: Design of Reinforced Concrete Structures, Mechanics of Structures.

Course Content

Unit No.	Description	Hrs.
01	**Flat slab:** Introduction, methods of analysis of flat slab, design of flat slab, detailing of reinforcement.	08
02	**Combined Footing:** Introduction, Design of rectangular and trapezoidal combined footing, detailing of reinforcement.	08
03	**Raft footing:** Introduction, Analysis of raft footing, Design of raft footing, Introduction to pile raft footing, detailing of reinforcement.	08
04	**Pile foundation:** Introduction to pile foundations, structural design of reinforced concrete piles, design of pile cap up to four piles group. Detailing of reinforcement.	08
05	**Cantilever and counter fort retaining walls:** Introduction, classification, stability requirements of retaining wall, design of	08

	cantilever and counterfort retaining wall, detailing of reinforcement.	
06	**Overhead water tanks:** Analysis and design of overhead circular water tanks with flat bottom, spherical and conical tank roofs, and ring beams. Detailing of reinforcement in the components of overhead water tank.	08

References:

Codes of Practice:

- IS 456 (2000): Plain and Reinforced Concrete - Code of Practice, B.I.S. New Delhi
- SP 16:1980 Design Aids for Reinforced Concrete to IS 456, B.I.S. New Delhi.

Text Books:

- Punmia B. C., Jain A. K. "Limit State Design of Reinforced Concrete (As per IS 456:2000)", Laxmi Publications Pvt. Ltd.
- Bhavikatti S. S., "Advance R.C.C. Design", New Age International Publishers.
- Shah M. G. and Kale C. M., "R.C.C. Theory and Design", Trinity Press, New Delhi.

Reference Books:

- Karve S. R. and Shah V. L., "Illustrated Design of Reinforced Concrete Buildings", Assorted Editorial Publications.
- Karve S. R. and Shah V. L., "Handbook of Reinforced Concrete Design (as per IS: 456 - 2000)", Structures Publications.
- Pillai S. U. and Menon D., "Reinforced Concrete Design", McGraw Hill Education (India) Pvt. Ltd.
- Bhatt P., Mac Ginley T. J. Choo B. S., "Reinforced Concrete Design Theory and Examples", CRC Press.

Class: - **First Year M. Tech. Structural Engineering**	Semester-II	**L**	**T**	**P**	**Credits**
Course Code : **CES 1066**	**Course Name: Research Methodology & IPR**	**02**	**01**	**--**	**03**

Course Description:

Research Methodology and Intellectual Property Rights (IPR) is offered as a core course in second semester of structural engineering PG program. It focuses on formulating research problems, literature review, collection and design of data etc. Also it includes effective technical writing, technical report and paper, and research proposal.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Formulate a research problem.
2. Analyze research related information
3. Prepare and present research proposal/paper by following research ethics
4. Make effective use of computers and computing tools to search information, analyze information and prepare report.
5. Describe nature and processes involved in development of intellectual property rights

Prerequisite: Introduction to Research

Content		
Unit No	**Description**	**Hrs**
01	**Research Problem:** Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.	**06**
02	**Data Collection:** Effective literature studies approaches, Plagiarism, Research ethics, Approaches of investigation of solutions for research problem, data collection, Data analysis with software, interpretation, Necessary instrumentations	**06**
03	**Technical writing:** Effective technical writing, how to write technical report and paper, Developing a Research Proposal, Format of research proposal, presentation and assessment by a review committee	**06**

04	**Nature of Intellectual Property:** Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. **International Scenario:** International cooperation on Intellectual Property, Procedure for grants of patents, Patenting under PCT.	**06**
05	**Patent Rights:** Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications.	**06**
06	**New Developments in IPR:** Administration of Patent System, New developments in IPR; IPR of Biological Systems, Computer Software etc., Traditional knowledge Case Studies, IPR and IITs.	**06**

References:

Text Books:

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students", Juta & Co Ltd
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction", Juta Academic
- Ranjit Kumar, "Research Methodology: A Step by Step Guide for beginners", SAGE Publication.

Reference Books:

- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd.
- Mayall , "Industrial Design", McGraw Hill.
- Niebel , "Product Design", McGraw Hill.
- Asimov, "Introduction to Design", Prentice Hall.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", Wolters Kluwar.
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand.

Class: **-First Year M. Tech. Structural Engineering**	Semester-**II**
Course Code: **CES 1086**	Course Name: **Computer Aided Design of Concrete Structures Lab.**

L	T	P	Credits
-	-	04	02

Course Description:
This laboratory course is mainly focusing on analysis and design of concrete structures using renowned software's like STAAD- Pro, ETABS and SAFE etc. Students are expected to design various RCC structures and prepare excel sheet and drawing of the same.

Course Outcomes:

1. Analyze and design of the RCC structures such as building, retaining wall, flat slab and foundations using standard software packages.
2. Design RCC Beam, column and slab using excel sheet.
3. Interpret the results of analysis and design obtained from the software.

Prerequisite: Design of Concrete Structures

Course Content		
Project No	**Description**	**Lab sessions**
01	Preparation of Excel sheet for design of beam, column and slab	06
02	Design of RCC building (G+4)	06
03	Design of elevated water tank.	04
04	Design of flat slab.	04
05	Design of cantilever retaining wall	04

References

Code of Practice:

- IS:3370- 1 to 4- Code of Practice for concrete structures for the storage of liquids.
- IS:456- 2000- Code of Practice for Plane and Reinforced concrete structures

Reference Books:

- Sinha and Roy, "Fundamentals of Reinforced Concrete", S. Chand and CompanyLtd, New Delhi.
- Varghese P. C., "Limit State Design of Reinforced Concrete", Prentice Hall ofIndia, New Delhi.

Class: - **First Year M. Tech. Structural Engineering**	Semester-II
Course Code: **CES 1110**	Course Name: **Structural Testing Lab**

L	T	P	Credits
-	-	04	02

Course Description:
This laboratory course provides practical experience in advanced concrete technology and structural testing. Students will conduct experiments including mix designs for high-strength concrete, self-compacting concrete as well as beam, column and slab testing. Additionally, non-destructive evaluations and corrosion measurements will be performed. This hands-on course reinforces theoretical concepts and equips students with essential skills for modern structural engineering practices.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Design different grades of special concrete mixes.
2. Identify the failure mechanisms of RC structural members.
3. Estimate the concrete quality of existing structures using NDT methods.
4. Evaluate dynamic response of structural members subjected to harmonic motion.

Prerequisite: Concrete Technology, Mechanics of Structures, Design of concrete structures, Structural Dynamics, Prestressed concrete.

Course Content

Expt. No.	Description	Lab Sessions
01	Mix Design of Special Concretes as per IS:10262-2019. (any one) 1. High strength concrete 2. Self-compacting concrete 3. High performance concrete	04
02	Preparation of special concrete and testing it for properties in fresh state	02
03	Casting of concrete cubes, beam and column	02
04	Demonstration of the prestressing equipment's and stressing process.	02
05	Non-Destructive testing of existing concrete members through rebound hammer, Ultrasonic pulse velocity meter, carbonation test, core test and GPR	02

06	Testing of Concrete cubes exposed to elevated temperature	02
07	Dynamics of three storied building frame subjected to harmonic base motion.	02
08	Dynamics of single span and continuous beam.	02
09	Testing of special concrete in hardened state.	02
10	Flexural Test of RC beam using loading frame.	02
11	Compression Test of RC column using loading frame.	02

References

Code of Practice:

- IS 10262:2019 Code of Practice for concrete Mix Design
- IS 1343:2012 Code of Practice for Prestressed Concrete

Text Books:

- H.G. Harris and G.M. Sabnis, "Structural Modeling and Experimental Techniques", CRC Press.
- E. Bray and R. K. Stanley, "Non Destructive Evaluation", CRC Press

Reference Books:

- J.F. Doyle, "Modern Experimental Stress Analysis", John Wiley and Sons
- J.W. Dally and W.F. Riley, "Experimental Stress Analysis", McGraw Hill

Class: **First Year M. Tech. Structural Engineering**	Semester- **II**
Course Code: **CES 1116**	Course Name: **Mini Project**

L	T	P	Credits
-	-	02	01

Laboratory Work (Mini Project):

The "Mini Project" course offers students an opportunity to explore advanced topics in structural engineering. Students choose a topic in consultation with their supervisor, focusing on dissertation work, societal problems, or special structures using standard software. The students should apply any tool such as software, mathematical method, and development of programming, experimental method for solving selected problem. Here parametric study is not expected. This course emphasizes practical application, fostering skills such as problem identification, report preparation, and effective communication. Students are expected to develop lifelong learning abilities and deliver presentation, showcasing their findings. A comprehensive report must be submitted to the Department Post Graduate Committee (DPGC) in both hard and soft copy formats.

Course Outcomes:

1. Identify relevant research problems in structural engineering through literature review
2. Formulate clear and concise objectives.
3. Analyze structural engineering problems using appropriate tools and techniques.
4. Validate the results of research work from literature by principle of replication
5. Prepare a detailed technical report and present project findings clearly and confidently.

Class: **First Year M. Tech. Structural Engineering**	Semester: **II**
Course Code: **CES 1146**	Course Name: **Advanced Earthquake Engineering**

L	T	P	Credits
03	**--**	**-**	**03**

Course Description:

The course focuses on the analysis and design of civil engineering structures under seismic conditions. It covers the design of reinforced concrete elements to meet ductility requirements as per IS 13920:2016, including detailed calculations and drawings. Seismic analysis of elevated circular water tanks is covered using analytical and numerical methods to evaluate lateral loads with accuracy. Advanced vibration control techniques, such as tuned mass dampers and base isolation systems, are explored to mitigate structural response.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Design RCC structural elements for ductility requirements as per IS 13920 2016.
2. Explain vibration control and seismic vulnerability assessment techniques
3. Evaluate lateral load developed on elevated circular water tank under seismic condition as per IS 1893 Part 2.
4. Determine natural frequency of elements/systems using Analytical/numerical method.

Prerequisite: Engineering Mathematics, Structural analysis. Design of RCC Structures

Course Content

Unit No.	Description	Hrs
01	**Ductility considerations in Earthquake Resistant Design of RC Buildings:** Introduction- Impact of Ductility, Requirements for Ductility, Assessment of Ductility, Factors-Affecting Ductility, Ductile Detailing Considerations as per IS 13920 2016. Behavior of Beams, Columns and Joints in RC buildings during Earthquakes-Vulnerability of Open Ground Storey and Short Columns during Earthquakes.	07
02	**Vibration Control Techniques in Seismic Design:** Cyclic Loading Behavior of Reinforced Concrete Elements, Modern Concepts, Base Isolation, Dampers, Adoptive Systems.	05
03	**Water Tank:** Seismic design of Elevated RC Circular Water Tanks, Ductility Requirements, Types of Ductility, Factors Affecting Ductility. IS Code Provisions.	06
04	**Seismic Design of Shear Wall:** Lateral Load Resisting System, Architectural Aspects of Shear Wall, Types of Shear Wall as per IS 13920 2016, Failure Modes of Shear Wall, Seismic Behavior of Shear Wall, Design and Detailing of Squat Shear Wall as per IS 13920 2016	06
05	**Numerical Methods and Continuous system:** Numerical methods of frequency analysis, Rayleigh's Method and Matrix Iteration Methods, Stadola Method, Newmrks Method, Dynamics of Continuous Systems: Free Longitudinal Vibration of Bars, Flexural Vibration of Beams	07

06	**Seismic Vulnerability Assessment:** Seismic Assessment Method, Seismic Assessment Steps, Seismic Design Philosophy, Seismic Assessment Codes, Non-Linear Modeling, Fragility Curves	05

References:

Codes of Practice:

- IS 1893:2016, Criteria for Earthquake Resistant Design of Structures, Part I and II Bureau of Indian Standards
- IS 13920:2016, Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces- Code of Practice

Text Books:

- Agarwal P. & M. Shrikhande, "Earthquake Resistant Design of Structures", Prentice Hall Publications.
- Jai Krisna, A. R. Chandrashekharan, "Elements of Earthquake Engineering", Chandra, South Asian Publishers Private Limited.
- Mallick A. K., "Principles of Vibration Control". Prentice Hall Publications.
- Dr. H. J. Shah, "Reinforced Concrete Volume II", Charotar Publishing House Private Limited

Reference Books:

- Madhujit Mukophadhyay, "Structural Dynamics Vibrations and Systems", Publisher: ANE
- Clough R.W. and J. Penzien, "Dynamics of Structures", McGraw Hill Education.

Class: **First Year M. Tech. Structural Engineering**	Semester: **II**
Course Code: **CES 1241**	Course Name: **Design of Foundations**

L	T	P	Credits
03	--	--	03

Course Description:
The first module focuses on various concepts and introductory information about different foundations. The design concepts of different types of foundations such as raft, pile and machine foundations. It also includes software applications. The idea behind these is the theory & numerical analysis, visit to site, model study & studying various practical and equipment related This course intends to build the competency in the student to identify various needs of construction industry.

Course Outcomes:
At the end of this course student will be able to:
1. Explain various types of foundations and their design procedures
2. Design different types of foundations.
3. Perform the analysis and design of various types of foundation using available software's.

Pre-requisite: Soil Mechanics and Design of RCC Structures

Course Content

Unit No	Description	Hrs
01	**Introduction:** Bearing capacity of shallow foundation, design criteria, factors affecting bearing capacity, factors influencing selection of depth of foundation, modes of shear failures, types of shallow foundations, contact pressure under rigid and flexible footings, Terzaghi's, Meyerhof, Hansen's bearing capacity theories, IS code method	06
02	**Shallow Foundation:** Introduction to types of foundations, design of isolated footing, continuous footing and combined footing. RCC Design of shallow foundation; principles of design of footing, design of isolated footings and strip footing.	06
03	**Raft Foundation:** Design of Combined Footing and Raft Foundations	06
04	**Deep Foundation:** Design of deep foundation- RCC Design of pile foundation and pile cap.	06

05	**Machine Foundation:** Types of Machine Foundations General Requirements of Machine Foundations and Design Criteria, Dynamic Loads, Physical Modeling and Response Analysis, Analysis by Lysmer and Richart, General Analysis of Machine-Foundation-Soil Systems Using Analog Models, General Equations of Motion, Methods of Solution Framed Foundation	**06**
06	**Foundations for special structures:** Design of foundations for seashore structures and elastic foundations.	**06**

References:

Text Books:

- Winterkorn H.F. & Fang H.Y, "Foundation Engineering Hand Book", Van Nostand Reinhold Company.
- Kasmalkar B.J., "Foundation Engineering", Pune Vidyarthi Griha Prakashan.
- Naik N.V, "Foundation Design Manual", Dhanpat Rai and sons.

Reference Books:

- Bowles J.E., "Foundation Analysis and Design" Tata McGraw Hill Book Company. Poulos, H.G. and Davis, E.H. Pile "Foundation Analysis and Design", John Wiley and Sons, New York.
- Mohan, Dinesh, "Pile Foundations", Oxford & IBH Pub. Co. Pvt. Ltd., Delhi.
- Swami Saran, "Soil Dynamics and Machine Foundation", Galgotia Publications Pvt. Ltd., New Delhi.
- Teng W. C., "Foundation Design", Prentice Hall of India Pvt. Ltd., New Delhi

Class: **First Year M. Tech. Structural Engineering**	Semester: **II**
Course Code: **CES 1026**	Course Name: **Finite Element Analysis**

L	T	P	Credits
03	---	--	03

Course Description:
This course focuses on basic concept and finite element procedure. The course includes FEM steps, variational methods, discretization, selection of polynomials, application to springs, bars subjected to axial forces. Element properties, shape function and isoparametric elements. Development of force and nodal displacement vector, element stiffness matrix for truss, beam, plane and space frame, transformation of matrices. Also includes 2D and 3D elements, plane stress and stain problems, Pascal's triangle, convergence requirements and compatibility conditions. It also includes Axisymmetric elements, development of element stiffness matrix. formulation of stiffness matrix for plate and shell elements. It also includes finite element application, use of commercial FEA software and the result interpretation.
The objective of the course is to apprise the students about the basics of the Finite Element Technique, a numerical tool for the solution of different classes of problems in solid mechanics. Different application areas will be dealt with after introducing the basic aspects of the method. major emphasis will be on the solution of problems related to Civil Engineering. It is intended to cover the analysis methodologies for 1-D, 2-D and 3-D problems

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

1. Explain finite element method procedure and analyze 1D problem
2. Analyze the framed structures, 2D and 3D elements
3. Explain shape function and isoparametric element
4. Derive element stiffness matrix for plate and shell element
5. Analyze structural system problems using commercial software

Prerequisite: Engineering Mathematics, Engineering Mechanics and Analysis of structures.

	Course Content	
Unit No.	**Description**	**Hrs**
01	**Introduction to Finite Element Analysis:** Introduction, Basic Concepts of Finite Element Analysis, Introduction to Elasticity, Steps in Finite Element Analysis. Principle of minimum potential energy, discretization, nodes, element incidence, displacement model, application to	06

	springs, bars with constant and variable cross sections subjected to axial forces, nodal equilibrium equations, assembly of global stiffness	
02	**Element Properties:** Convergence and compatibility requirement, Pascal's triangle , Element aspect ratio, Natural Coordinates , Triangular Elements , Rectangular Elements , Lagrange and Serendipity Elements, shape function, Isoparametric Formulation ,Stiffness Matrix of Isoparametric Elements	06
03	**Analysis of Frame Structures:** Stiffness of Truss Members, Analysis of Truss, Stiffness of Beam Members, Finite Element Analysis of Continuous Beam, Plane Frame Analysis , Analysis of Space Frame	06
04	**Two and Three Dimensional Solids:** Constant Strain Triangle, Linear Strain Triangle, Rectangular Elements, Numerical Evaluation of Element Stiffness, Computation of Stresses, Axisymmetric Element, Finite Element Formulation of Axisymmetric Element, Finite Element Formulation for 3 Dimensional Elements	06
05	**Plates and Shells:** Introduction to Plate Bending Problems, Finite Element Analysis of Thin Plate, Finite Element Analysis of Skew Plate, Introduction to Finite Strip Method , Introduction and Classification of shell, Finite Element Analysis of Shell.	06
06	**Computer Implementation:** FEM procedure, Pre-processing, solution, post-processing, use of commercial FEA software, Result interpretation, work out problems.	06

References:

Text Books:

- O. C. Zienkiewicz and Y.K. Cheung, "The Finite Element Method in Structural and Soild Mechanics", McGraw Hill, London
- Desai Y.M., Eldho T. I., A.H. Shah, "Finite Element Method with application in Engineering", Pearson, Delhi.

Reference Books: -

- C.S. Krishnamurthy, "Finite Element Analysis", Tata McGraw-Hill
- David V. Hutton, "Fundamentals of Finite Element Analysis", McGraw Hill
- D. Maity, "Computer Analysis of Framed Structures", I.K. International Pvt. Ltd. New Delhi
- Erik G. Thompson, "Introduction to the Finite Element Method: Theory, Programming and Applications", John Wiley
- H. C. Martin and G. F. Carey, "Introduction to Finite Element Analysis - Theory and Application", New York, McGraw-Hill
- Irving H. Shames, Clive L. Dym, "Energy and Finite Element Methods in Structural Mechanics", New Age International

- K. Bathe, "Finite Element Procedures", Prentice-Hall of India, New Delhi, India
- M. Mukhopadhyay, "Matrix, Finite Element, Computer and Structural Analysis", Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India
- P.E. Ceruzzi, "A History of Modern Computing", The MIT Press, Cambridge, MA,
- R. D. Cook, "Concepts and Applications of Finite Element Analysis", Wiley S.S.
- Rao, "Finite Element Analysis", Elsevier Butterworth-Heinemann
- W. Weaver Jr. and J. M. Gere, "Matrix Analysis of Framed Structure", CBS Publishers & Distributors, New Delhi, India
- Chandrupatla T. R. & Belegundu, "Introduction to the Finite Element in Engineering", Prentice Hall of India, pvt. Ltd.
- Reddy J.N., "An introduction to the Finite Element Method", Tata McGraw Hill Pub.

Class: **First Year M. Tech. Structural Engineering**	Semester: II
Course Code : **CES 1141**	Course Name: **Design of Formwork**

L	T	P	Credits
03	**-**	**-**	**03**

Course Description:

This course mainly focuses on types and design of false work required for concrete structures (i.e. formwork). Although cost of formwork contributes significantly to the total reinforced concrete construction cost and formwork failure will result in a very complicated construction problem, formwork design is often neglected and left to the foreman to design. Therefore, in this course emphasis is given on materials used for form work, design of various formworks for regular structural members, design of formwork for special structures, some special formwork systems and failure of formwork.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Design the form work for Beams, Slabs, columns, Walls and Foundations.
2. Design the form work for Special Structures.
3. Explain the working of flying formwork.
4. Judge the formwork failures through case studies.

Prerequisite: Concrete Technology, Strength of Material

Course Content

Unit No.	Description	Hrs
01	**Introduction:** Introduction to formwork system, Requirements of formwork and Factors affecting Selection of Formwork	06
02	**Formwork Materials:** Timber, Plywood, Steel, Aluminium, Plastic, and Accessories. Horizontal and Vertical Formwork Supports.	06
03	**Formwork Design:** Concepts, Formwork Systems and Design for Foundations, Walls, Columns, Slab and Beams..	06
04	**Formwork Design for Special Structures:** Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower, Bridges.	06
05	**Flying Formwork:** Table Form, Tunnel Form, Slip Form, Formwork for Precast Concrete, Formwork Management Issues –Pre- and Post-Award..	06
06	**Formwork Failures:** Causes and Case studies in Formwork Failure, Formwork Issues in Multi-Story Building Construction.	06

References:

Code of Practice:

- IS 14687: 1999, False work for Concrete Structures - Guidelines, BIS.

Text Books:

- Purify, "Formwork for Concrete Structures", McGraw Hill India.
- Kumar Neeraj Jha, "Formwork for Concrete Structures", Tata McGraw Hill Education.

Class: **-First Year M. Tech Structural Engineering**	Semester-**II**
Course Code: **CES 1192**	Course Name: **Structural Optimization**

L	T	P	Credits
03	**-**	**--**	**03**

Course Description:
Structural optimization can be defined as the process of finding the optimal parameters, which yield maximum or minimum value of an objective function, subject to certain set of specified requirements called constraints. Such problem of optimization is known as constrained optimization problems or nonlinear programming problems. Most design optimization problems in structural engineering are highly nonlinear, involving mixed (discrete and continuous) design variables under complex constraints, which cannot be solved by traditional calculus - based methods and enumerative strategies. The course provides the knowledge of applying optimization algorithms to obtain optimum design of structures. The course intends to improve understanding of the mathematical basics and formulation to solve optimization problems and also help students enable to choose an appropriate optimization tool.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Explain the basic concepts of different approaches used for optimization of structural problems.
2. Formulate structural optimization problems
3. Apply different techniques for optimization of structural engineering problems.

Prerequisite: Reinforced Concrete Structures, Design of Steel Structures.

Course Content

Unit No	Description	Hrs
1.	**Introduction:** Introduction to optimization, Design variables, Objective function, constraints, fully stressed design, Engineering applications of optimization, Formulation of structural optimization problems as programming problems. Optimization Techniques: Classical optimization techniques, single variable optimization, multivariable optimization with no constraints, unconstrained minimization techniques, Lagrange multipliers techniques and feasibility techniques.	**07**
2.	**Linear Programming:** Review of Linear Algebra: Vector spaces; basis and dimension; canonical	**06**

	forms. Linear programming, standard form of linear programming, geometry of linear programming problems, solution of a system of linear simultaneous equations, pivotal production of general systems of equations, simplex algorithms, revised simplex methods, duality in linear programming.	
3.	**Non-linear Programming:** Non-linear programming fundamentals, one dimensional minimization methods, elimination methods, golden section method, interpolation methods, quadratic and cubic methods. Unconstrained Optimization: Direct search and gradient methods; one dimensional search algorithms. Constrained Optimization: direct methods, the complex methods, cutting plane method, exterior penalty function	**06**
4.	**Genetic Algorithms:** Introduction–basic concept, working principle, Binary coding, Fitness function, Genetic Operators, Selection schemes, sharing and inching, genetic modelling, discrete size and topology / shape optimization, Simple Genetic Algorithm (SGA) and Variable length Genetic Algorithm (VGA) application to problems.	**06**
5.	**Simulated Annealing (SA):** Problem formulation- steps involved in SA application to RCC retaining wall, and pre-stressed concrete structure design, etc.	**05**
6.	**Artificial Neural Networks:** ANN based approaches for structural optimization problems, Introduction-basic concept of ANN- Architectures and learning methods of NN- Back propagation networks, structural applications.	**06**

References:

Text Books:

- Haftka, Raphael T., Gurdal, Zafer, "Elements of Structural Optimization", Springer.
- Cherkaev Andrej, Variational, "Methods for Structural optimization", Springer.
- Rao, S. S., "Engineering Optimization Theory and Applications", New Age International publication, New Delhi.
- Arora, J.S., "Introduction to Optimum Design", McGraw-Hill Book Company.
- Rajasekaran, S. and Vijaya Lakshmi Pai, G.A., "Neural networks, Fuzzy logic, and Genetic Algorithms", Synthesis and Application, PHI.
- Deb, K., "Optimization for Engineering Design: Algorithms and Examples", Prentice Hall.

Reference Books:

- Morrisv A.J., "Foundations of Structural Optimization -A Unified Approach", John Wiley and Sons

RAJARAMBAPU INSTT. OF TECHNOLOGY RAJARAMNAGAR CIVIL ENGG. DEPT.

K.E.S. Rajarambapu Institute of Technology Rajaramnagar Autonomous 415 414

Class: **First Year M. Tech. Structural Engineering**	Semester: **II**
Course Code: **CES 1162**	Course Name: **Design of Composite Structures**

L	T	P	Credits
03	--	--	03

Course Description:
Design of Composite structures is offered as program elective course ay the second semester of Civil Structural engineering post graduate program. This course focuses on design of composite structure includes the Composite Floors, Composite Beams and Composite Columns used individually or in varying combinations to make the design cost-effective and efficient to the desired performance and service requirements as this is fast gaining acceptance in the non-residential multi-storey building sector of India.

Course Outcomes:
At the end of this course student will be able to:
1. Design of composite structural elements like beams, columns, floors, trusses.
2. Design of Multi-storey commercial and residential composite building.
3. Design of composite girder bridges.

Prerequisite: Design of structural elements.

Course Content

Unit No	Description	Hrs
01	**Introduction:** Introduction of composite structures, benefits of composite structures, Introduction to IS, BS and Euro codal provisions. **Composite beams:** elastic behaviour of composite beams, Shear Connectors, Ultimate load behavior, Serviceability limits, Effective breadth of flange, Interaction between shear and moment, Basic design consideration and design of composite beams.	06
02	**Composite Floors:** Structural elements, Profiled sheet decking, Bendingresistance, Serviceability criterion, Analysis for internal forces and moments	06
03	**Composite Columns:** Composite Column design, Fire Resistance. Encased columns, partially encased columns, Materials, Concrete filled circular tubular sections, local buckling of steel sections, Effective elastic flexible	06

	stiffness, resistance of members to axial compressions,	
04	**Composite Trusses:** Design of truss, Configuration, Application range, Analysis and Design aspects	**06**
05	**Composite Frames:** Design of Multi-storey commercial and residential composite building, Design basis, load calculations.	**06**
06	**Design of Composite Construction in Bridges:** IRC specifications andcode of practice for loads and composite construction. Composite Deck Slab Design of Cantilever Portion of deck Slab. Design of longitudinal girders.	**06**

References –

Code of Practice:

- IS:11384-1985 Code of Practice for Composite Construction in Structural Steel and Concrete, Bureau of Indian Standards, New Delhi.

Text Books:

- Johnson R. P., "Composite Structures of Steel and Concrete", Oxford Blackwell Scientific Publications.
- Owens. G.W, & Knowels. P. "Steel Designs Manual", Steel Concrete Institute (UK) Oxford Black; well Scientific Publications.

Reference Books:

- INSDAG teaching resources for structural steel design Vol II, Institute for Steel Development and Growth Publishers, Calcutta
- INSDAG Handbook on Composite Construction: Multi-Storey Buildings, Institutefor Steel Development and Growth Publishers, Calcutta.
- INSDAG Design of Composite Truss for Building, Institute for Steel Developmentand Growth Publishers, Calcutta
- INSDAG Handbook on Composite Construction: Bridges and Flyovers, Institute for Steel Development and Growth Publishers, Calcutta.

RAJARAMBAPU INSTT. OF TECHNOLOGY RAJARAMNAGAR CIVIL ENGG. DEPT.

K.E.S. Rajarambapu Institute of Technology Rajaramnagar Autonomous 415 414

Class: **First Year M. Tech. Structural Engineering**	Semester: **II**
Course Code : **CES 1151**	Course Name: **Prefabrication and Modular Construction**

L	T	P	Credits
03	**-**	**-**	**03**

Course Description:

The course covers the manufacturing of prefabricated elements, quality control, design principles, load-bearing behavior, seismic considerations, structural connections, transportation, assembly and the integration of building services. Through an in-depth analysis of various applications and case studies, students gain insights into the practical implementation of these construction methods in residential, commercial and specialized structures.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Explain current trends and challenges in prefabrication and modular construction.
2. Analyze the design principles and load-bearing behavior of prefabricated concrete elements, including considerations for handling, erection and seismic loads.
3. Identify the types of structural connections in prefabricated systems and understand their design details.
4. Plan and execute the logistics, transportation, site preparation and assembly of prefabricated elements and modular units, including the building services and finishes.

Prerequisite: Structural Analysis and Design of Concrete Structures.

Course Content

Unit No.	Description	Hrs
01	**Current Trends:** Overview of prefabrication and modular construction, Historical development and current trends, Advantages and challenges of construction using prefabricated elements, Comparison with cast-in place construction, Manufacturing of prefabricated Elements, Quality control in manufacturing, Types of prefabricated concrete elements.	06
02	**Design Principles:** Design principles for prefabricated concrete elements, Load-bearing behavior of prefabricated elements, handing and erection stresses, Behavior of prefabricated structures under seismic loads.	06
03	**Connections:**	06

	Types of structural connections in prefabricated systems. Connection details and joint design for prefabricated and modular structures.	
04	**Transportation and Installation:** Transportation, Assembly and Installation - Logistics and transportation of prefabricated elements and modular units, Site preparation and foundation systems, Assembly and erection techniques for prefabricated and modular structures, Integration of building services and finishes.	**06**
05	**Applications:** Applications and Case Studies - Applications of construction using prefabricated elements in various types of structures, Applications of modular construction in residential, commercial and special structures, Case studies of successful prefabricated and modular construction projects, Future trends and innovations in prefabrication and modular construction.	**06**
06	**Case Studies:** Applications of modular construction in residential, commercial and special structures, Case studies of successful prefabricated and modular construction projects, Future trends and innovations in prefabrication and modular construction.	**06**

References:

Text Books:

- Structural Precast Concrete Handbook, Building and Construction Authority.
- Ryan E. Smith, "Prefab Architecture: A Guide to Modular Design and Construction", John Wiley and Sons, Inc.,

Reference Books:

- Structural design manual, "Precast concrete connection details", Society for the studies in the use of precast concrete, Netherland Betor Verlag
- Gerostiza C.Z., Hendrikson C. and Rehat D.R., "Knowledge Based Process Planning for Construction and Manufacturing", Academic Press Inc.

Class:- **First Year M. Tech. Structural Engineering**	Semester-II
Course Code : CES 1156	**Course Name : Advanced Concrete Technology**

L	T	P	Credits
03	--	--	03

Course Description:
The Advanced Concrete Technology course focuses on properties of newly developed concrete and their ingredients such as supplementary cementitious materials, artificial sand, chemical and mineral admixtures etc. The quality control and durability aspects of the concrete are also considered in the course content. The course throws light on various types of special concretes, mix design methods, manufacturing processes, tests on fresh and hardened concrete. The course aims to give updated information in the field of concrete technology involving modern trends and techniques.

Course Outcomes:
1. Describe various special processes and techniques involved in various concreting jobs.
2. Identify reasons affecting durability of concrete / concrete structures /elements.
3. Design concrete mix for special concretes using IS: 10262-2019
4. Analyse quality of concrete elements using appropriate destructive and non-destructive testing methods.

Prerequisite: Concrete Technology

Course Content		
Unit No	**Description**	**Hrs**
01	**Admixtures & Construction Chemicals:** Admixtures: mineral and chemical admixtures, various dispersion mechanisms of admixtures, effect of admixtures on concrete properties, Use of relevant IS codes.	06
02	**Special Concretes:** Light-weight concrete, foamed concrete, Sulphur infiltrated concrete, high strength concrete, high performance concrete, self-compacting concrete, pervious concrete, polymer concrete, fibre-reinforced concrete, high density and radiation-shielding concrete. Use of relevant IS codes.	06
03	**Special techniques of concreting:** Sprayed concrete, underwater concrete, ferrocement, gunite/shotcrete, grouting, vacuum concrete, mass concrete, slip form construction, pumped	06

	concrete, concrete for liquid retaining structures, hot and cold weather concreting, Ready mixed concrete. Use of relevant IS codes.	
04	**Durability of concrete and concrete construction:** Introduction, significance, permeability of concrete, surface wear, reinforcement corrosion, fire resistance, frost damage, sulphate attack, alkali silica reaction, delayed ettringite formation, durability of concrete in sea water, short-term tests to assess long-term behaviour. Use of relevant IS codes.	06
05	**Concrete Mix Design:** Different methods of mix design, Acceptance criteria, Mix design of normal concrete by IS, BS and ACI method of mix design, comparison between IS, BS and ACI method of mix design. Mix design of high strength, high-performance concrete, self-compacting concrete, mass concrete by IS method.	06
06	**Testing of Hardened Concrete** Non-destructive testing methods of concrete: rebound hammer test, pulse velocity method, probe penetration, break off maturity method, stress wave propagation method, electrical methods, magnetic methods, nuclear methods and radioactive methods. Tests on hardened concrete, Core cutting and testing of concrete. Use of relevant IS codes.	06

References -

Code of Practice:

- IS:10262-2019

Text Books:

- M.S. Shetty, "Concrete Technology", S. Chand & Company Pvt. Ltd., New Delhi.
- M. L. Gambhir, "Concrete Technology", Tata McGraw-Hill Publications.

Reference Books:

- P. Kumar Mehta &Paulo J. M. Monteiro, "Concrete Microstructure, Properties and Material", McGraw-Hill, New York.
- A. M. Neville, "Properties of Concrete", Prentice Hall India Learning Private Limited.
- Krishna Raju, "Design of Concrete Mixes", Prentice Hall India Learning Private Limited.
- A.R. Santhakumar, "Concrete Technology", S. Chand & Company Pvt. Ltd., New Delhi.

Class: **S. Y. M. Tech. Structural Engineering**	Semester- **III**
Course Code: **CES 2016**	Course Name: **Industry Internship**

L	T	P	Credits
-	-	-	01

Field Work:

The "Industry Internship" course provides students with practical exposure to the field of structural engineering through hands-on training in a professional environment. During a two-week internship, students work in an organization as employees, immersing themselves in the work culture and understanding the latest advancements in structural engineering. This experience bridges the gap between academic learning and industry practices, fostering professional skills, including effective communication and technical reporting. Students are required to document their learning in a comprehensive report, evaluated at the start of the third semester, and submit a certificate of completion from the hosting organization.

Course Outcomes:

After successful completion of the course, students will be able to,

- Identify appropriate training areas in structural engineering that align with professional and academic goals.
- Describe the work culture, processes, and technological advancements observed during the internship.
- Prepare a detailed on-site training report documenting the tasks, learning outcomes, and project contributions.

Open Elective

Sr. No.	Course Code	Course
1.	MOE2012	Artificial Intelligence - Machine Learning
2.	MOE2022	Creative Thinking: Techniques and Tools
3.	MOE2032	MOOC Course
4.	MOE2041	Energy Audit and Management
5.	MOE2062	Augmented Reality and Virtual Reality
6.	MOE2072	Industrial Instrumentation
7.	MOE2082	Advanced Mechatronics systems
8.	MOE2091	Disaster Management

Note for Open Elective

An Open Elective course is included in the curriculum of S. Y. M. Tech (Semester-III), under which students need to learn either MOOC course or courses offered by department.

Guidelines for MOOC course under Open Elective

1. If students opt for MOOC course as an Open Elective, he/she should select this course from NPTEL platform only.
2. As three credits are allotted to open elective, selected MOOC course must be of minimum 8 weeks or 48 hours.
3. Students need to solve assignments given by platform and also, give the final certification exam at allotted NPTEL exam center.
4. Student must secure certification of NPTEL platform within program duration, otherwise he/she will not beeligible for final evaluation.
5. If student fails in NPTEL certification course, he or she should reregister for the course in the next semester.

Guidelines for other courses mentioned under Open Elective:

1. Student can opt for courses mentioned in the curriculum.
2. While selecting the course, students must take care that selected course from the list is not learned in UG or PG first year curriculum.
3. Lectures of these courses will be conducted by concerned department faculty by online mode.
4. Evaluation of these courses will be as mentioned in the curriculum.

Open Elective

Class: **S. Y. M. Tech.**	Semester- **III**
Course Code: **MOE 2012**	Course Name: **Artificial Intelligence - Machine Learning**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
Machine learning is a part of Artificial Intelligence. It uses interdisciplinary techniques such as statistics, linear algebra, optimization, and computer science to create automated systems that can sift through large volumes of data at high speed to make predictions or decisions without human intervention. Machine learning as a field is now incredibly pervasive, with applications spanning from business intelligence to homeland security, from analyzing biochemical interactions to structural monitoring of aging bridges, and from emissions to astrophysics, etc. This class will familiariz students with a broad cross-section of models and algorithms for machine learning and prepare students for research or industry application of machine learning techniques.

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

1. Describe central machine learning methods and techniques and how they relate to artificial intelligence.
2. Differentiate between supervised and unsupervised learning techniques.
3. Apply the ML algorithms to a real-world problem.
4. Optimize the models learned and report on the expected accuracy that can be achieved by applying the models.
5. Evaluate a given problem and apply appropriate machine learning technique.

Prerequisite: Statistics, linear algebra, optimization techniques, programming language

Course Content

Unit No	Description	Hrs.
01	**Introduction to Artificial Intelligence and Machine learning:** Introduction: What Is AI and ML? Examples of AI and ML, Applications, Supervised Learning, Un-Supervised Learning and Reinforcement Learning, Important Elements of Machine Learning- Data formats, Learnability, Statistical learning approaches, Elements of information theory.	06
02	**Feature Selection:** Scikit- Learn Dataset, creating training and test sets, managing categorical data, Managing missing features, Data scaling and normalization, Feature selection and Filtering, Principle Component Analysis(PCA)- non-negative matrix factorization, Sparse PCA, Kernel PCA. Atom Extraction and Dictionary Learning.	06

03	**Regression:** Linear regression- Linear models, A bi-dimensional example, Linear Regression and higher dimensionality, Polynomial regression, Logistic regression-Linear classification, Logistic regression, Implementation and Optimizations, Stochastic gradient descendent algorithms.	06
04	**Naïve Bayes and Support Vector Machine:** Bayes Theorom, Naïve Bayes Classifiers, Naïve Bayes in Scikit- learn- Bernoulli Naïve Bayes, Multinomial Naïve Bayes, and Gaussian Naïve Bayes. **Support Vector Machine(SVM):** Linear Support Vector Machines, Scikit- learn implementation, Linear Classification, Kernel based classification, Non- linear Examples. Controlled Support Vector Machines, Support Vector Regression.	06
05	**Decision Trees and Ensemble Learning:** Decision Trees- Impurity measures, Feature Importance. Decision Tree Classification with Scikit learn, Ensemble Learning-Random Forest, AdaBoost, Gradient Tree Boosting, Voting Classifier. Clustering Fundamentals- Basics, K-means: Finding optimal number of clusters, DBSCAN, Spectral Clustering. Evaluation methods based on Ground Truth- Homogeneity, Completeness, Adjusted Rand Index.	04
06	**Clustering Techniques:** Hierarchical Clustering, Expectation maximization clustering, Agglomerative Clustering Dendrograms, Agglomerative clustering in Scikit- learn, Connectivity Constraints. Introduction to Recommendation Systems- Naïve User based systems, Content based Systems, Model free collaborative filtering-singular value decomposition, alternating least squares.	08

References –

Text Books:

- Giuseppe Bonaccorso, "Machine Learning Algorithms", Packt Publishing Limited.
- Josh Patterson, Adam Gibson, "Deep Learning: A Practitioners Approach", O REILLY, SPD.

Reference Books:

- Ethem Alpaydin, "Introduction to Machine Learning", PHI.
- Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press.

Open Elective

Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **MOE 2022**	Course Name: **Creative Thinking: Techniques &Tools**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
In today's ever-growing and changing world, being able to think creatively and innovatively are essential skills. It can sometimes be challenging to step back and reflect in an environment which is fast paced or when students required to assimilate large amounts of information. Making sense of or communicating new ideas in an innovative and engaging way, approaching problems from fresh angles, and producing novel solutions are all traits which are highly sought after by employers. This course will equip with a 'tool-box', introducing to a selection of behaviors and techniques that will augmer innate creativity. Some of the tools are suited to use on own and others work well for a group, enabling you to leverage the power of several minds. People can pick and choose which of these tools or techniques suit needs and interests, focusing on some or all of the selected approaches and in the order that fits best.

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

1. Comprehend importance in tackling global challenges as well as in everyday problem-solving scenarios.
2. Apply different brainstorming techniques in group activities.
3. Be proficient in the application of the 6 thinking hats tool in different life scenarios.
4. Develop a systematic approach to idea generation through the use of morphological analysis.
5. Innovate on an existing product, service or situation applying the SCAMPER method.
6. Get confident with the theory of inventive problem solving, called TRIZ.

Prerequisite: There are no prerequisites to this course.

Course Content		
Unit No	**Description**	**Hrs**
01	Introduction to the Principles of Creativity: Basic principles of creativity and highlight its importance in tackling global challenges. Creativity is explored and applied at two different levels, lower and higher-level creativity.	**06**

02	**Creativity Tools:** Augment our creativity using different methods of Brainstorming, a creativity approach that aids the generation of ideas in solving a stated problem. Particularly focus on the application of brainstorming tools in group activities, with the aim of enabling to understand, evaluate and apply different types of brainstorming techniques in own context.	06
03	**Six Thinking Hats:** Principles as well as application of the 6 Hats thinking tool both at an individual level and in a group, under various professional and personal situations, allowing students to develop competency and accelerate proficiency on the use of technique.	06
04	**Clarifying the Problem:** Organizing a process, turning problems into opportunities, facts, feelings & hunches, problem as question.	06
05	**Generating Ideas:** Brainstorming, scamper, forced connections, portable think tank, case studies on generating ideas.	06
06	**Developing Ideas & Planning for action:** Organizing ideas, ideas to solutions, implementing solutions, case studies of development of ideas and plan of action.	06

References -

Text Books:

- Michael Michalko, Thinkertoys, "A Handbook of Creative-Thinking Techniques", Ten Speed Press.
- Michael Michalko, Cracking Creativity, "The Secrets of Creative Genius", Ten Speed Press.
- Edward de Bono, Penguin, Lateral Thinking: A Textbook of Creativity.
- Edward de Bono, Penguin, Six Thinking Hats.

Reference Books:

- New World Library, Creative Thinkering: Putting Your Imagination to Work.
- Chris Griffiths, Kogan Page, The Creative Thinking Handbook: Your Step by Step Guide to Problem Solving in Business.

Open Elective

Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **MOE 2032**	Course Name: **MOOC Course**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:

Student can opt for online certification course and produce certificate.

The students who are doing course on MOOC/NPTEL Course /Courses suggested by DPGC should select the course in consultation with supervisor and submit the details to Head of Program. The course should be minimum 30 hours duration and should have certification facility. Student should complete course and get certificate. The certificate copy should be submitted to head of program with supervisor signature.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Identify the real applications and practices of courses studied, at industry level
2. Recognize various modelling, analysis and validation techniques adopted at industries.
3. Demonstrate the issues at design, manufacturing and assembly levels.
4. Summarize and present technical data in report format.

Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **MOE 2041**	Course Name: **Energy Audit and Management**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
This course provides basic understanding of energy audit and management. Essential theoretical and practical knowledge about the concept of energy conservation, energy management, and different approaches of energy conservation in industries, economic aspects of energy conservation project and energy audit and measuring instruments in commercial and industrial sector will be achieved through this course.

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

1. Identify the important of Energy Scenario.
2. Use energy audit knowledge to carry out energy audit of a given firm.
3. Examine different rolls in energy action planning
4. Apply project finance and management skills to carry out energy audit
5. Plan for energy monitoring and targeting.

Prerequisite: Electric Machines, Thermal Systems and Finance system

Course Content

Unit No	Description	Hrs.
01	**Unit Name: Energy Scenario** Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment, Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features.	06
02	**Unit Name: Energy Management and Audit** Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments	06
03	**Unit Name: Energy Action Planning** Key elements, Force field analysis, Energy policy purpose, perspective, Contents, Formulation, Ratification, Organizing –location of energy management, Top management support, Managerial function, Roles and responsibilities of energy manager, Accountability. Motivating-motivation of employees: Information system-	06

	designing barriers, Strategies; Marketing and communicating-training and planning.	
04	**Unit Name: Financial Management** Investment-need, Appraisal and criteria, Financial analysis techniques-Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis; Financing options, Energy performance contracts and role of ESCOs	**06**
05	**Unit Name: Project Management** Definition and scope of project, Technical design, Financing, Contracting, Implementation and performance monitoring. Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement & Verification	**06**
06	**Unit Name: Energy Monitoring And Targeting** Defining monitoring & targeting, Elements of monitoring & targeting, Data and information-analysis, Techniques -energy consumption, Production, Cumulative sum of differences (CUSUM).	**06**

References -

Text Books:

- Amit Kumar Tyagi, "Handbook on Energy Audits and Management", TERI Publication
- Wayne C. Turner, "Energy Management Handbook", Wiley Inter Science Publication

Reference Books:

- P. O. Callaghan, "Energy Management", McGraw - Hill Book Company
- Bureau of Energy Efficiency Study material for Energy Managers and Auditors Examination: Paper I

Open Elective

Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **MOE2062**	Course Name: **Augmented Reality and Virtual Reality**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
This course presents an introduction to virtual and augmented reality technologies, with an emphasis on designing and developing interactive virtual and augmented reality experiences. The course will cover the history of the area, fundamental theory, and interaction techniques. Students are provided with hands-on experience developing applications for modern virtual and augmented reality systems. In the course, students will also explore libraries and tools for creating AR/VR experiences such as Vuforia and UNITY.

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

1. Define the basic concepts of Virtual and Augmented Reality
2. Identify the differences in AR/VR concepts and technologies
3. Describe the fundamental concepts relating to Virtual Reality such as presence,immersion, and engagement
4. Evaluate usability of AR/VR applications and critique their use of AR/VR capabilities
5. Design and prototype effective AR/VR applications using UNITY platform for various application.

Prerequisites: Programming and Data Structures

Course Content

Unit No	Description	Hrs.
01	**Introduction to Augmented Reality:** Definition and Scope, Brief History of Augmented Reality, Displays (Multimodal Displays, Spatial Display Model, and Visual Displays), Strong vs Weak, AR Applications AR Challenges in AR.	06
02	**Introduction to Virtual Reality:** Definition and Scope, Types of VR Characteristics, Basic VR environments, Limitations of VR environments, Immersion Vs Presence.	06
03	**Interaction design for AR/VR environments:** Interaction design process Identifying user needs, AR/VR design considerations Typical AR/VR Interface Metaphors, User experience (UX) guidelines for AR/VR, UX challenges for AR/VR, Prototyping for AR/VR, Evaluation of the developed AR/VR prototype.	06

04	**Introduction to UNITY:** Unity Overview: Windows, Interface, Navigation, Terminology, Game Objects, Hierarchy, Parenting Objects, Asset Store, Importing Plug-ins, Creating a Terrain, Materials, Colors, Transparency, Introduction to Mono behaviours: Awake, Start, Update.	**06**
05	**Introduction to Vuforia and Physics in UNITY:** Vuforia Overview: Interface, Navigation, Terminology, Image Targeting, Custom Images, Overview of Physics in Unity, Introduction to Scripting: Terminology, Creating Objects, Accessing Components, Debugging, Lists, Loops.	**06**
06	**Expanding on Scripting and Interaction:** Creating Trigger Events, Manipulating Components in Scripts, Programming Interactions between Objects and Tracked Images in AR, designing a simple User Interface in AR, Introduction to colliders and their use: On Collision Enter, On Collision Exit. On Collision Stay, On Trigger vs On Collision, Rigid bodies and how Colliders report to them.	**06**

References:

Text Books:

- Vince, "Virtual Reality Systems", Pearson Education.
- Grigore Burdea, Philippe Coiffet,"Virtual Reality Technology", Wiley.
- Schmalstieg, D., & Hollerer, T. "Augmented reality: principles and practice", Addison-Wesley Professional.

Reference Books:

- Azuma, R.T. A survey of augmented reality. Presence: Teleoperators & Virtual Environments.
- Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. Recent advances in augmented reality. IEEE computer graphics and applications.
- Bhagat, K. K., Liou, W.-K., & Chang, C.-Y.A cost-effective interactive 3D virtual reality system applied to military live firing training. Virtual Reality,.
- Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., & Ivkovic, M. Augmented reality technologies, systems and applications. Multimedia tools and applications.
- Raisamo, R., Rakkolainen, I., Majaranta, P., Salminen, K., Rantala, J., & Farooq, A. Human augmentation: Past, present and future. International journal of human- computer studies.
- Schuemie, M. J., Van Der Straaten, P., Krijn, M., & Van Der Mast, C. A. Research on presence in virtual reality: A survey. Cyber Psychology & Behavior.

Open Elective

Class: **S. Y. M. Tech**	Semester: **III**
Course Code: **MOE 2072**	Course Name: **Industrial Instrumentation**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
This course is an overview of the principles, concepts, and applications of process transmitters found in an industrial plant. Continuous measurement and control of all the parameters will be emphasized. Also practical installation and calibration procedures of various types of sensors and transducers will be covered. Open and closed loop control systems will also be discussed, including such concepts as on/off control, set point, overshoot, undershoot, gain, feedback, PID loops, and reverse/direct acting systems.

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

1. Elaborate working principal of different transducers.
2. Select suitable transducer/sensor for specific application.
3. Justify the use of specific measurement technique for specific task.
4. Evaluate the Calibration and Interfacing of the transducers.

Prerequisite: Sensor and measurement

Course Content

Unit No	Description	Hrs
01	**Metrology:** Measurement of length – Gauge blocks – Plainness – Area using Simpson's rule, Plain meter – Diameter – Roughness – Angle using Bevel protractor, sine bars and Clinometer – Mechanical, Electrical, Optical and Pneumatic Comparators. Optical Methods for length and distance measurements using Optical flats and Michelson Interferometer.	06
02	**Velocity and Acceleration Measurement:** Relative velocity – Translational and Rotational velocity measurements – Revolution counters and Timers – Magnetic and Photoelectric pulse counting stroboscopic methods. Accelerometers-different types, Gyroscopes-applications.	06
03	**Force and Pressure Measurement:** Force measurement – Different methods – Gyroscopic Force Measurement – Vibrating wire Force transducer. Basics of Pressure measurement –Manometer types – Force-Balance and Vibrating Cylinder Transducers – High and Low Pressure measurement – McLeod Gauge, Knudsen Gauge, Momentum Transfer Gauge, Thermal Conductivity Gauge, Ionization Gauge,	06

	Dual Gauge Techniques, Deadweight Gauges, Hydrostatic Pressure Measurement.	
04	**Flow Measurement and Level Measurement:** Flow Meters- Head type, Area type (Rota meter), electromagnetic type, Positive displacement type, mass flow meter, ultrasonic type, vertex shedding type, Hotwire anemometer type, Laser Doppler Velocity-meter. Basic Level measurements – Direct, Indirect, Pressure, Buoyancy, Weight, Capacitive Probe methods.	06
05	**Density, Viscosity and Other Measurements:** Density measurements – Strain Gauge load cell method – Buoyancy method – Air pressure balance method – Gamma ray method – Vibrating probe method. Units of Viscosity, specific gravity scales used in Petroleum Industries, Different Methods of measuring consistency and Viscosity –Two float viscorator –Industrial consistency meter. Sound-Level Meters, Microphones, Humidity Measurement.	06
06	**Calibration and Interfacing:** Calibration using Master Sensors, Interfacing of Force, Pressure, Velocity, Acceleration, Flow, Density and Viscosity Sensors, Variable Frequency Drive. Open and closed loop control system with on/off control, setpoint, overshoot, undershoot, gain, feedback, PID loops, and reverse/direct acting systems.	06

References:

Text Books:

- Doeblin E.O., "Measurement Systems – Applications and Design", McGraw Hill International.
- Patranabis D, "Principles of Industrial Instrumentation", Tata McGraw Hill.

Reference Books:

- Considine D. M., "Process Instruments and Control Handbook", McGraw Hill International.
- Jain R.K., "Mechanical and Industrial Measurements", Khanna Publications.

RAJARAMBAPU INSTT. OF TECHNOLOGY RAJARAMNAGAR CIVIL ENGG. DEPT.

K.E.S. Rajarambapu Institute of Technology Rajaramnagar Autonomous 415 414

Class: **S. Y. M. Tech**	Semester: **III**
Course Code: **MOE2082**	Course Name: **Advanced Mechatronics Systems**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
The course will be helpful to provide overview of mechanical and electronic systems used in industrial atmosphere. This will be helpful for upcoming automation in industry. Mechatronics is a multidisciplinary field of science that includes a combination of Mechanical Engineering, Electronics, Computer Engineering, Telecommunications Engineering and Control Engineering. Mechatronics is a multi-disciplinary study dealing with the integration of mechanical devices, actuators, sensors, electronics, intelligent controllers and computers. Mechatronics generally involves

(i) implementing electronics control in a mechanical system
(ii) enhancing existing mechanical design with intelligent control and
(iii) replacing mechanical component with an electronic solution.

This course will cover all aspects related with mechatronics such as sensors and transducers, actuators and mechanisms, signal conditioning, microprocessors and microcontrollers, modeling & system response and design of mechatronics systems.

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

1. Explain Mechatronics System.
2. Analyze the Mechatronics Based System.
3. Model, simulate, and verify the mechatronics systems.
4. Identify Electrical, Hydraulic and Pneumatic Components.

Prerequisite: Research Methodology

Course Content

Unit No.	Description	Hrs
01	**Introduction:** What is Mechatronics, Integrated Design Issues in mechatronics, Mechatronics Design Process, Mechatronics Key elements, applications in mechatronics.	06
02	**Modelling and Analysis of Mechatronics Systems:** Block Diagram Modelling, Analogy approach, Impedance Diagrams, Electrical Systems, Mechanical systems and electromechanical systems. Mass-Spring-Oscillation and Damping system, Dynamic response of systems, Transfer function and frequency response. Labview, MATLAB, Scilab.	06
03	**Sensors and Actuators:** Performance terminology of sensors, Displacement, Position & Proximity Sensors, Displacement, Position sensors, Force, Fluid pressure, Liquid flow sensors,	06

	temperature, light sensor, Acceleration and Vibration measurement, Electrical and Mechanical Actuation Systems.	
04	**Signal Conditioning:** Introduction to signal processing, Op-Amp as signal conditioner, Analogue to Digital Converter, Digital to Analogue Converter, Signal processing devices, relays, contactors and timers. Microcontrollers, PID controllers and PLCs.	**06**
05	**Hydraulic system and Pneumatic system:** Flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, and pumps, Pneumatic system components and graphic representations, Advantages and limitations of pneumatic systems.	**06**
06	**Case Study:** List of various mechatronics systems, Case study of pick and place mechanism of robotic arm using pneumatic power, Hydraulic circuit for CNC Lathe machine, 3D Printer, Auto-control system for Green House Temperature and Auto-focusing in Digital Cameras.	**06**

References –

Text Books:

- Bradley, D. Dawson, N. C. Burd and A.J. Loader, "Mechatronics: Electronics in product and process", Chapman and Hall, London.
- Devadas Shetty, Richard A. Kolkm, "Mechatronics system design, PWS publishing company.
- David G. Alciatore, Michael B. Histand, "Introduction to mechatronics and measurement systems" Mc Graw Hill Education.

References Books:

- R. Merzouki, A. K. Samantaray, P. M. Pathak, "Intelligent Mechatronic Systems: Modeling, Control and Diagnosis", Ould Bouamama, Springer, London.
- Technical website: https://onlinecourses.nptel.ac.in/noc21_me27/course

Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **MOE 2091**	Course Name: **Disaster Management**

L	T	P	Credits
03	--	--	03

Course Description:
This course provides a holistic understanding of disaster management, covering both natural and manmade disasters. Students will delve into the meaning, nature, and various types of disasters, exploring their effects on individuals, communities, and the environment. The course encompasses a global perspective while focusing on the disaster profile of India, considering regional and seasonal variations

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

1. Outline disaster and disaster management cycle.
2. Summarize disaster preparedness and response activities for various types of disaster.
3. Apply various advanced techniques for disaster management.
4. Examine role of various agencies in disaster management.
5. Dissect the disaster management scenario in India.

Prerequisite: Environmental Science

Course Content

Unit No.	Description	Hrs.
01	**Natural Disaster:** Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic, eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion.	06
02	**Manmade Disasters:** Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents. Disasters -A Global View, Disaster Profile of India- Regional, and Seasonal.	06
03	**Disaster management cycle:** Introduction to Disaster Management Cycle: Mitigation, Preparedness, Response and Recovery. Disaster Mitigation, Hazard identification and vulnerability analysis, Mitigation strategies or measures.	06
04	**Disaster Preparedness, Response and Recovery:** Introduction to Disaster Preparedness, Disaster Risk Reduction (DRR), The Emergency Operation Plan (EOP).	06

	Introduction to Disaster Response, Aims of disaster response, Disaster Response Activities, Modern and traditional responses to disasters, Modern methods of disaster response, Disaster Recovery, The Recovery Plan, Disasters as opportunities for development initiatives.	
05	**Role of technology in Disaster management:** Geographic Information System (GIS) and Disaster Management. GIS applications. Global Positioning System (GPS) and Disaster Management, Applications of GPS to Disaster management. Remote Sensing and its significance in Disaster Management.	**06**
06	**Role of Multiple Stakeholders in Disaster management:** Role of NGO's, Community based organizations, media, Central, State, District and Local Administration, armed forces, Police and other organizations.	**06**

References:

Codes of Practice:

- National Disaster Management Authority (NDMA). National Disaster Management Plan 2019.
- National Disaster Management Authority (NDMA). National Disaster Management Act 2005.

Text Books:

- Coppola, D. P. "Introduction to International Disaster Management", Elsevier USA.
- Singh R. B., "Disaster Management", Rawat Publication.

Reference Books:

- Reiter L., "Earthquake Hazard Analysis: Issues and Insight", Colombia University Press.
- Mileti D. S. "Disaster by Design: A Reassessment of National Hazards in United States", The National Academic Press.

Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **CES 2036**	Course Name: **Dissertation Phase I**

L	T	P	Credits
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Course Description:

Dissertation Phase I and Synopsis Approval Presentation:

The student is required to do innovative and research oriented work as a dissertation relevant to structural engineering under the guidance of supervisor. The dissertation work shall include analytical formulation, experimentation or software-based project. Student can undertake an interdisciplinary type topic for dissertation with the prior permission of DPGC from concerned departments.

Synopsis:

Student need to carry out rigorous literature survey with consultation of his/her supervisor by referring minimum 25 papers published in reputed national/ international journal and conferences. Based on the literature review carried out student has to identify the gaps in the literature and formulate the research problem statement followed by objectives under the guidance of supervisor. Student has to prepare the synopsis of the identified research topic for dissertation deliver the presentation based on it before the Department Post Graduate Program Committee(DPGC). At the time of presentation student has to submit the literature review file.

After the synopsis presentation is over, the student has to modify the synopsis in standard format (provided by the department) incorporating the suggestions recommended by DPGC and submit the same in two spiral bound hard copies to the head of program.

The submitted synopsis reports are then scrutinized for changes done as per the suggestions /modifications given by DPGC and then final approval is provided. Once the synopsis is approved by DPGC no changes are allowed in it. However, under specific circumstances if it becomes necessary to incorporate the changes either in the title or objectives or methodology the student has to apply for special permission for such changes as per academic rules and regulations of the institute.

Course Outcomes:

After successful completion of the course, students will be able to,

- Identify relevant research problems in structural engineering through literature review
- Recognize the gap in the research and define a problem statement.
- Explain significance and applicability of problem statement.
- Formulate clear and concise objectives.
- Prepare and present synopsis report.

Class: **S. Y. M. Tech.**	Semester-**III**
Course Code: **CES2056**	Course Name: **Dissertation Phase– II**

L	T	P	Credits
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Course Description:

Dissertation Phase-II focuses on evaluating the student's progress through End Semester Examination (ESE) and In-Semester Evaluation (ISE). Students are required to present preliminary results from their research work conducted during the semester, accompanied by a report prepared in the prescribed format. The evaluation process involves the Departmental Postgraduate Committee (DPGC) and an external examiner.

The ISE is conducted by the DPGC, while the ESE involves both the DPGC and an external expert. Students must submit a soft-bound report at least one week before the scheduled presentation. If a student's performance is deemed unsatisfactory, a grace period of two weeks will be provided for improvement. After this period, re-evaluation will be conducted with a grade penalty.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Present preliminary research findings clearly and effectively
2. Analyze the progress of their research work in alignment with the prescribed objectives.
3. Apply feedback from the DPGC and external examiner to improve the quality of their research
4. Evaluate their own work critically to meet academic and professional standards within the given timeline

Class: **S. Y. M. Tech.**	Semester-**IV**
Course Code: **CES2026**	Course Name: **Dissertation Phase – III**

L	T	P	Credits
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Course Description:
In this phase, students present the progress of their dissertation work to the supervisor and the Departmental Postgraduate Committee (DPGC). By this stage, students are expected to have completed approximately 90% of their dissertation. The presentation aims to evaluate progress, gather constructive feedback, and ensure alignment with the approved synopsis. This In-Semester Evaluation (ISE) ensures the work aligns with academic and research standards

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

1. Analyze the issues related to the methods adopted for problem-solving.
2. Apply appropriate techniques to address the identified research problem.
3. Evaluate their findings by comparing them with established literature.

Class: **S. Y. M. Tech.**	Semester-**IV**
Course Code: **CES 2046**	Course Name: **Dissertation Phase – IV**

L	T	P	Credits
--	--	**24**	**12**

Course Description:

This phase marks the final presentation (viva voce) of the dissertation. Students are permitted to present only after submitting a duly completed and certified dissertation report. The presentation will be conducted in the presence of the supervisor, the Departmental Postgraduate Committee (DPGC), and an external examiner. The evaluation will ensure the dissertation aligns fully with the approved synopsis and assesses the quality of the work. The assessment will consider the depth of research, the effort invested, and the quality of papers published based on the dissertation work.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Defend their dissertation work during the viva voce, demonstrating depth of understanding and clarity in communication.
2. Evaluate the alignment of their work with the approved synopsis and the quality of their research contributions.
3. Justify their methodologies and results in comparison with existing literature.
4. Create high-quality publications based on their dissertation work

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