INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

CIVIL ENGINEERING

COURSE DESCRIPTOR

Course Title	**STRENGTH OF MATERIALS – II**				
Course Code	ACE004				
Programme	B. Tech				
Semester	IV	CE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. Venu M, Professor				
Course Faculty	Mr. Suraj Baraik, Assistant Professor				

I. COURSE OVERVIEW:

Civil engineers are required to design structures like building, beams, dams, bridges, etc. The loads coming onto these structures, along with the self-weight, have to be safely transmitted to the ground. A structural engineer must be able to design a structure in such a way that none of its members fail during load transfer process. This foundational course in civil engineering is intended to introduce to concepts of stress and strain due to external loading on a structural member, and their calculations. For this, the concept and calculation of slopes and deflections of beams using various methods are covered in depth. Deflections by energy methods of propped cantilevers, fixed and continuous beams under various load combinations. Through this course content engineers can design the structures for safety and serviceability.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AME002	II	Engineering Mechanics	4
UG	ACE002	III	Strength of Materials -I	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Strength of Materials – II	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✘	Seminars	✘	Mini Project	✔	Videos
✔	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Assignments/ Exams
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Assignments/ Exams
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Assignments
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Open ended experiments

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO1	**Engineering Knowledge**: Graduates shall demonstrate sound knowledge in analysis, design, laboratory investigations and construction aspects of civil engineering infrastructure, along with good foundation in mathematics, basic sciences and technical communication.	2	Lectures, Assignments
PSO2	**Broadness and Diversity**: Graduates will have a broad understanding of economic, environmental, societal, health and safety factors involved in infrastructural development, and shall demonstrate ability to function within multidisciplinary teams with competence in modern tool usage.	-	-
PSO3	**Self-Learning and Service**: Graduates will be motivated for continuous self-learning in engineering practice and/or pursue research in advanced areas of civil engineering in order to offer engineering services to the society, ethically and responsibly.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Apply the concepts of strain energy and virtual work to calculate deflections in beams.
II	Discuss about springs and their various types of combination connections.
III	Outline of columns and struts with different end conditions and awareness about laterally loaded struts.
IV	Understand direct and bending stresses in concrete structures like retaining wall, chimney and dams.

IX. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
ACE004.01	CLO 1	Calculate the slope and deflection for cantilever and simply supported beams under various loads.	PO 1, PO 4	2
ACE004.02	CLO 2	Understand the different methods for deflection of beams with constant and variable moment of inertia.	PO 1	2
ACE004.03	CLO 3	Predict the differential equation for the elastic line of a beam.	PO 1	3
ACE004.04	CLO 4	Apply Mohr's theorems and moment area methods for simple cases including overhanging beams.	PO 2	2
ACE004.05	CLO 5	Understand the concept of conjugate beam method.	PO 1, PO 2	2
ACE004.06	CLO 6	Analyze the strain energy under gradual, sudden, impact and shock loadings simple applications.	PO 2	2
ACE004.07	CLO 7	Apply Strain energy in linear elastic system, expression of strain energy due to axial load, bending moment and shear force.	PO 3	2
ACE004.08	CLO 8	Understand the energy methods like work energy method, principal of virtual work, unit load method and Castigliano's theorem.	PO 1, PO 3	3
ACE004.09	CLO 9	Evaluate the deflections of simple beams and pin jointed trusses and concept extended to frames and indeterminate structures.	PO 3, PO 4	2
ACE004.10	CLO 10	Analyze structures using Maxwell's theorem of reciprocal deflections and betti's Law.	PO 3	2
ACE004.11	CLO 11	Understand the concept of thin seamless cylindrical shells.	PO 1	1
ACE004.12	CLO 12	Derive the formula for longitudinal and circumferential stresses, hoop, longitudinal and volumetrical strains.	PO 1	3
ACE004.13	CLO 13	Analyze Lames theory for thick cylinders.	PO 3, PO 4	1
ACE004.14	CLO 14	Derive the derivation of lames formulae and distribution of hoop and radial stresses across thickness.	PO 2, PO 4	3
ACE004.15	CLO 15	Evaluate thick cylinders and compound cylinders for necessary difference of radii under shrinkage and thick spherical shells.	PO 3	1
ACE004.16	CLO 16	Analyze propped cantilever and fixed beams using different methods.	PO 3, PO 4	2
ACE004.17	CLO 17	Derive the propped cantilever and fixed beams under various conditions.	PO 3, PO 4	2
ACE004.18	CLO 18	Calculate the deflection of propped cantilever and fixed beams.	PO 2, PO 3	2
ACE004.19	CLO 19	Understand the effect of rotation of a support.	PO 2, PO 3	1
ACE004.20	CLO 20	Explain clapeyron's theorem of three moments.	PO 2, PO 3	2
ACE004.21	CLO 21	Analyze continuous beams with constant and variable moments of inertia.	PO 2, PO 3	2

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
ACE004.22	CLO 22	Analyze the continuous beam with overhangs.	PO 3, PO 4	1
ACE004.23	CLO 23	Calculate the Effects of sinking of supports.	PO 3, PO 4	2

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X. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3			2									1		
CLO 2	2														
CLO 3	3														
CLO 4		2													
CLO 5	3	1													
CLO 6		2													
CLO 7			2												
CLO 8	3		3										2		
CLO 9			2	2									1		
CLO 10			2												
CLO 11	1												2		
CLO 12	3														
CLO 13			2	1											
CLO 14		3		3											
CLO 15			1										2		
CLO 16			1	3											
CLO 17			3	1											
CLO 18		3	2												
CLO 19		2	1										2		
CLO 20		2	3												
CLO 21		3	1										2		

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 22			2	1											
CLO 23			3	1									1		

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XI. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO3, PO4	SEE Exams	PO1, PO2, PO3, PO4	Assignments	PO1, PO2, PO3	Seminars	-
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XII. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XIII. SYLLABUS

Unit-I	DEFLECTIONS OF BEAMS
Bending into a circular arc, slope, deflection and radius of curvature, differential equation for the elastic line of a beam, double integration and Macaulay's methods, determination of slope and deflection for cantilever and simply supported beams subjected to various loads, Mohr's theorems, moment area method, application to simple cases including overhanging beams; Conjugate beam method, concept of conjugate beam method, difference between a real beam and a conjugate beam, deflections of determinate beams with constant and different moments of inertia.	
Unit-II	**DEFLECTIONS BY ENERGY METHODS**
Strain Energy: Resilience gradual, sudden, impact and shock loadings simple applications; Strain energy in linear elastic system, expression of strain energy due to axial load, bending moment and shear force; Energy Methods: Work energy method, principal of virtual work, unit load method, Castigliano's theorem; Deflections of simple beams and pin jointed trusses; Concept extended to frames and indeterminate structures; Maxwell's theorem of reciprocal deflections; Betti's Law.	
Unit-III	**STRESSES IN CYLINDERS AND SPHERICAL SHELLS**
Thin seamless cylindrical shells, derivation of formula for longitudinal and circumferential stresses, hoop, longitudinal and volumetrical strains, changes in diameter and volume of thin cylinders, thin spherical shells. Lames theory for thick cylinders, derivation of lames formulae, distribution of hoop and radial stresses across thickness, design of thick cylinders, compound cylinders, necessary difference of radii for shrinkage, thick spherical shells.	
Unit-IV	**INDETERMINATE BEAMS: PROPPED CANTILEVER AND FIXED BEAMS**
Analysis of propped cantilever and fixed beams using the method of consistent deformation, including the beams with varying moments of inertia, subjected to uniformly distributed load, central point load, eccentric point load, number of point loads, uniformly varying load, couple and combination of loads, shear force and bending moment diagrams for propped cantilever and fixed beams, deflection of propped cantilever and fixed beams; Effect of rotation of a support.	

Unit-V	INDETERMINATE BEAMS: CONTINUOUS BEAMS
Continuous beams, Clapeyron's theorem of three moments, analysis of continuous beams with constant and variable moments of inertia with one or both ends fixed, continuous beams with overhang; Effects of sinking of supports.	
Text Books:	
1. R. K. Bansal, "A Textbook of Strength of Materials", Laxmi Publications (P) Ltd., New Delhi, 2nd Edition, 2007. 2. F. Beer, E. R. Johnston, J. DeWolf , "Mechanics of Materials", Tata McGraw-Hill Publishing Company Ltd., New Delhi, India, 1st Edition, 2008. 3. S. S. Bhavikatti, "Strength of Materials", Vikas Publishing House Pvt. Ltd., New Delhi, 5th Edition, 2013.	
Reference Books:	
1. B. C. Punmia, Ashok K Jain and Arun K Jain, "Mechanics of Materials", Laxmi Publications Pvt. Ltd., New Delhi, 12th Edition, 2007. 2. R. Subramanian, "Strength of Materials", Oxford University Press, 2nd Edition, 2010. 3. D. S. Prakash Rao, "Strength of Materials A Practical Approach Vol.1", Universities Press (India) Pvt. Ltd., India, 3rd Edition, 2007. 4. J. M. Gere, S.P. Timoshenko, "Mechanics of Materials, SI units edition", CL Engineering, USA, 5th Edition, 2000. 5. E. G. Popov, "Engineering Mechanics of Solids", Pearson Education, India, 21st Edition, 2015.	

XIV. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-2	Calculate the slope and deflection for cantilever and simply supported beams under various loads.	CLO 1	T1: 12.1-12.2 R2: 7.2-7.3
3-4	Predict the differential equation for the elastic line of a beam.	CLO 2	T1: 12.3-12.5 R2: 7.4
5-6	Understand the different methods for deflection of beams with constant and variable moment of inertia.	CLO 2	T1: 12.6-12.7 R2:7.5
7-8	Apply Mohr's theorems and moment area methods for simple cases including overhanging beams.	CLO 3	T1: 12.8-12.11 R2:7.8
9-10	Understand the concept of conjugate beam method.	CLO 4	T1:14.1-14.6 R2:7.9
11-12	Understand the different methods for deflection of beams with constant and variable moment of inertia.	CLO 5	T1: 14.6-14.10 R2:7.7, 7.10
13-14	Analyze the strain energy under gradual, sudden, impact and shock loadings simple applications.	CLO 6	T1: 4.1-4.4 R1:12.1, 12.2
15-16	Apply Strain energy in linear elastic system, expression of strain energy due to axial load, bending moment and shear force.	CLO 7	T1: 4.6-4.7 R1:12.3
17-19	Understand the work energy method, principal of virtual work, unit load method and castigliano's theorem.	CLO 8	T2 :7.13-16 R1: 12.3
20-22	Evaluate the deflections of simple beams and pin jointed trusses and concept extended to frames.	CLO 9	T2:7.17-19 R1: 12.6
23-25	Analyze structures using maxwell's theorem of reciprocal deflections and betti's Law.	CLO 10	T2: 7.20 R1: 7.3, 7.4
26	Understand the concept of thin seamless cylindrical shells.	CLO 11	T1:17.1-17.3 R2:12.4
27-30	Derive the formula for longitudinal and circumferential stresses, hoop, longitudinal and volumetric strains.	CLO 12	T1: 17.4-17.7 R2:12.4

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
31-32	Analyze Lames theory for thick cylinders.	CLO 14	T1: 17.8 R2:12.5
33-34	Derive the derivation of lames formulae and distribution of hoop and radial stresses across thickness.	CLO 14	T1: 17.9 R2:12.5.1
35-38	Evaluate thick cylinders and compound cylinders for necessary difference of radii under shrinkage.	CLO 15	T1: 17.10-12 R2:12.5.3
39-44	Analyze propped cantilever and fixed beams using different methods.	CLO 14	T1:14.7, 15.1-3 R2:15.2
45-49	Derive the propped cantilever and fixed beams under various conditions.	CLO 16	T1:15.3-5 R2: 15.3
50-55	Calculate the deflection of propped cantilever and fixed beams. Understand the effect of rotation of a supports.	CLO 17	T1:15.6 –7 R2:15.5, 15.6
56	Explain the clapeyron‘s theorem of three moments.	CLO 19	T1:15.8 R1:8.1
57-58	Analyze continuous beams with constant and variable moments of inertia.	CLO 21	T1:15.8 R1:8.2, 8.3
59-60	Analyze continuous beams with overhangs and calculate the Effects of sinking of supports.	CLO 23	T1:15.8 R1:8.4, 8.5

XV. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	The internal behavior of the material with the externally applied loading.	Seminars/Guest Lectures/NPTEL	PO 4	PSO1
2	Analysis of stresses especially for cylindrical shells.	Seminars/Guest Lectures/NPTEL	PO 1	PSO 1
3	Real world applications in sinking of supports under various conditions.	Seminars/ Assignments	PO 4	PSO 1

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