INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

CIVILENGINEERING

COURSE DESCRIPTOR

Course Title	**STRENGTH OF MATERIALS – I**				
Course Code	ACE001				
Program	B.Tech				
Semester	III	CE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Dr. M. Venu, Professor.				
Course Faculty	Dr. M. Venu, Professor. Ms.J.Cici Jennifer Raj, Assistant Professor.				

I. COURSE OVERVIEW:

The 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 calculations of (a) shear force diagrams and bending moment diagram for different type of beams, (b) bending and shear stresses in beams, (c) slope and deflection of beams using various methods are covered in depth. Besides, the important calculations of principal stresses and principal strains and the consequent theory of failures for prediction of the strength of the materials are also discussed. Eventually, through this course content engineers can design the structures for safety and serviceability.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AHS002	I	Linear Algebra and OrdinaryDifferential Equations
UG	AME002	II	Engineering Mechanics

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
STRENGTH OF MATERIALS - 1	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 fiveunits 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
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Assignments/ Exams
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	3	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	3	Assignments /Mini Projects
PO 4	**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	3	Open ended experiments
PO 7	**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	Seminars

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**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	Open ended experiments
PSO 2	**Broadness and Diversity:** Graduates will have a broad understanding of economical, environmental, societal, health and safety factors involved in infrastructural development, and shalldemonstrate ability to function within multidisciplinary teams with competence in modern tool usage.	1	Seminar
PSO 3	**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 offerengineering services to the society, ethically and responsibly.	1	Seminar

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Relate mechanical properties of a material with its behavior under various load types
II	Apply the concepts of mechanics to find the stresses at a point in a material of a structural member
III	Analyze a loaded structural member for deflections and failure strength.
IV	Evaluate the stresses and strains in materials and deflections in beam members.

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
ACE001.01	CLO 1	Calculate the stress and strain developed in any structural member due to applied external load.	PO 1 PO2	3
ACE001.02	CLO 2	Calculate the normal and tangential stresses on an inclined section a bar of under uni-axial,biaxial, pure shear and plain stress conditions.	PO 1 PO 4	2
ACE001.03	CLO 3	Predict the strain energy and their applications like sudden load, uniform load and impact load.	PO 3	1
ACE001.04	CLO 4	Evaluate the principal stress and principal strain at a point of a stressed member and draw theMohr's circle of stresses.	PO 1 PO 7	2
ACE001.05	CLO 5	Understand failure of a material using various theories of failure, and their relative applications.	PO 3	1
ACE001.06	CLO 6	Differentiate the types of beam and the various loading and support condition upon them.	PO 1 PO 2	3
ACE001.07	CLO 7	Apply the formulae for beams under different loading condition.	PO 1 PO 2,	2
ACE001.08	CLO 8	Draw shear force diagram and bending moment diagram for different type of beams.	PO 3	1
ACE001.09	CLO 9	Derive the pure bending equation, and on its basis explain the existence of normal stresses.	PO 7	1
ACE001.10	CLO 10	Analyze the pure bending equation and on its basis.	PO1	1
ACE001.11	CLO 11	Explain the existence of shear stresses in the different layers of the beam.	PO1	1
ACE001.12	CLO 12	Evaluate the section modulus for various beam cross-sections.	PO1	1
ACE001.13	CLO 13	Explain the importance of section modulus for various beam cross-sections.	PO7	2
ACE001.14	CLO 14	Derive the torsion equations and pure torsion.	PO1	1
ACE001.15	CLO 15	Explain the design procedures of shafts and their theories of failure applications.	PO2	1
ACE001.16	CLO 16	Understand the types of springs and explain their different conditions.	PO1	1
ACE001.17	CLO 17	Analyze the close and open coiled helical springs under various conditions.	PO1	1
ACE001.18	CLO 18	Differentiate the types of column under the various end conditions.	PO2	1
ACE001.19	CLO 19	Analyze the columns under the various formulas like Euler's formulae, Rankine'sandGordon formula.	PO1	2
ACE001.20	CLO 20	Calculate the columns under the various formulas like empirical formulae, straight line formula andperry's formula.	PO1	3
ACE001.21	CLO 21	Understand the laterally loaded struts under concentrated and uniformly distributed loads.	PO2	3
ACE001.22	CLO 22	Calculate the laterally loaded struts under various loading conditions.	PO1	3

3 = High; 2 = Medium; 1 = Low

X. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC 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	3											3	3	2
CLO 2	3			2									3	2	
CLO 3			2											2	1
CLO 4	3						2							3	
CLO 5			1										3		
CLO 6	3	3													
CLO 7	3	2		2											
CLO 8			2												
CLO 9							2						2		2
CLO 10	2													1	
CLO 11	1														
CLO 12	2												1		
CLO 13															1
CLO 14	1												1		
CLO 15		2													
CLO 16	2														
CLO 17	1														
CLO 18		2													
CLO 19	2														
CLO 20	3														
CLO 21		2		2											
CLO 22	3		2												

3 = High; 2 = Medium; 1 = Low

XI. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1,PO2, PO3, PO4, PO 7	SEE Exams	PO 1,PO2 PO3, PO4,PO 7	Assignments	PO 2	Seminars	PO1, PO 2
Laboratory Practices	PO 1	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	**STRESSES AND STRAINS (SIMPLE AND PRINCIPAL)**
Introduction:Concept of stress and strain, elasticity and plasticity, Hooke‘s law, stress-strain diagram for mild steel, Poisson‘s ratio, volumetric strain, elastic module and the relationship between them bars of varying section, composite bars, temperature stresses; Strain energy, modulus of resilience, modulus of toughness; stresses on an inclined section of a bar under axial loading; compound stresses; Normal and tangential stresses on an inclined plane for biaxial stresses; Two perpendicular normal stresses accompanied by a state of simple shear; Mohr‘s circle of stresses; Principal stresses and strains; Analytical and graphical solutions. Theories of Failure: Introduction, various theories of failure, maximum principal stress theory, maximum principal strain theory, strain energy and shear strain energy theory.	
Unit-II	**SHEAR FORCE AND BENDING MOMENT**
Shear force and Bending moment: Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contraflexure – Relation between S.F., B.M and rate of loading at a section of a beam.	
Unit-III	**FLEXURAL AND SHEAR STRESSES IN BEAMS**
Flexural Stresses: Theory of simple bending – Assumptions – Derivation of bending equation: M/I = f/y = E/R- Neutral axis – Determination of bending stresses – Section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections – Design of simple beam sections. Shear Stresses: Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	
Unit-IV	**TORSION OF CIRCULAR SHAFTS**
Torsion of Circular Shafts: Theory of pure torsion- derivation of torsion equations: - assumptions made in the theory of pure torsion - torsional moment of resistance - polar section modulus - power transmitted by shaft - combined bending and torsion and end thrust - design of shafts according to theories of failure. Introduction to springs- types of springs - deflection of close and open coiled helical springs under axial pull and axial couple - springs in series and parallel - carriage or leaf springs.	
Unit-V	**COLUMNS AND STRUCTS (BUCKLING)**
Columns and Struts: Types of columns, short, medium and long columns, axially loaded compression members, crushing load, Euler‘s theorem for long columns, assumptions, derivation of Euler‘s critical load formulae for various end conditions. Equivalent length of a column, slenderness ratio, Euler‘s critical stress, limitations of Euler‘s theory, Rankine‘s and Gordon formula, long columns subjected to eccentric loading, secant formula, empirical formulae, straight line formula and Prof. Perry‘s formula. Laterally loaded struts, subjected to uniformly distributed and concentrated loads, maximum bending moment and stress due to transverse and lateral loading.	

Text Books:
1 F. Beer, E. R. Johnston, J. De Wolf, "Mechanics of Materials", Tata McGraw-Hill Publishing Company Limited, New Delhi, Indian 1st Edition, 2008. 2 B. C. Punmia, Ashok Kumar Jain, Arun Kumar Jain, "Mechanics of Materials", Laxmi Publications Private Limited, New Delhi, 4th Edition, 2007. 3 R. K. Rajput, "Strength of Materials: Mechanics of Solids", S. Chand & Co Limited, New Delhi, 3rd Edition, 2007.
Reference Books:
1.J. M. Gere, S.P. Timoshenko, "Mechanics of Materials", CL Engineering, USA, 5thEdition,2000. 2 .E. G. Popov, "Engineering Mechanics of Solids", Pearson Education, India, 2ndEdition,2015.

XIV.COURSE PLAN:

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

Lecture No	Topic/s to be covered	CLOs	Reference
1-2	Elasticity and plasticity – Typesofstresses and strains – Hooke'law	CLO 1	T1: 1.1-3, 2.1-5
3-4	Stress – strain diagram for mild steel– Working stress – Factor of safety	CLO 2	T1: 2.4
5-6	Bars of varying section	CLO 2	T1: 2.6-14
7-8	Composite bars – Temperature stresses	CLO 3	T1: 2.15-20
9-10	Lateral strain, Poisson's ratio and volumetric strain – Elasticmoduliand the relationship betweenthem	CLO 3	T1: 3.1-.3
11-12	Strain Energy, Resilience – Gradual, sudden, impact and shock loadings –simple applications	CLO 3	T1: 3.5-14
13-14	Principal stresses and strains; Analytical and graphical solutions. Theories of Failure: Introduction, various theories of failure, maximum principal stress theory, maximum principal strain theory, strain energy and shear strainenergy theory	CLO 4, CLO 5	T1: 6.1-5
15-16	Definition of beam – Types of beams– Concept of shear force and bending moment	CLO 6	T1: 9.1-5
17-19	S.F and B.M diagrams for cantilever, subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these load– Point of contra flexure	CLO 7	T1: 9.6-7
20-22	S.F and B.M diagrams simply supported subjected to point loads, uniformly distributed load, uniformly varying loads and combination ofthese loads – Point of contra flexure	CLO 7	T1: 9.6-7
23-25	S.F and B.M diagrams for overhanging beams subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Pointof contra flexure	CLO 7	T1: 9.6-7
26	Relation between S.F., B.M and rate of loading at a section of a beam	CLO 8	T1:9.6-11
27-28	Theory of simple bending – Assumptions – Derivation of bending equation: M/I= f/y = E/R	CLO 9	T1: 10.1-5
29-30	Neutral axis – Determination of bending stresses	CLO 11	T1: 10.5-7
31-32	Section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections	CLO 12	T1: 10.7
33-34	Design of simple beam sections	CL0 13	T1: 10.7
35-39	Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections	CL0 13	T1: 11.1-7

Lecture No	Topic/s to be covered	CLOs	Reference
40-42	Introduction, Explain theory of pure torsion and assumptions made in pure torsion	CLO 14	T4: 2.1 -2.2
42-45	Define torsional moment of resistance and polar section modulus. Derive power transmitted by shafts and its efficiency	CLO 14	T4: 2.3 -2.6
46-47	Derive expression for strain energy stored in a body due to torsion	CLO 14	T4: 2.7 - 2.9
48-49	Strength of shaft for varyingsections, composite shafts and problems	CLO 15	T4: 3.1 -3.6
50-52	Introduction, types of springs. Derive expressions for stiffness and efficiency for springs connected in series and parallel and problems	CLO 16	T4: 3.8 - 3.10
53-54	Derive the expressions for maximum shear stress induced in wire, expression for deflection of spring, expression for stiffness of springs	CLO 16	T4: 4.1 - 4.6
55-56	Brief explanation on leaf springs	CLO 17	T4: 4.6
57-58	Columns & struts: Introduction, explain types of columns- long, medium and short. Brief explanation on axially compression members. Define crushing load	CLO 18, CLO 19, CLO 20,	T4: 6.1 - 6.3
59-60	Explain Euler's theorem for long columns - assumptions, limitations, derivation of Euler's critical load for	CLO 21, CLO 22, CLO 23	T4: 7.1 - 7.6

XIV. 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 appliedloading including thermal loads.	Seminars /Guest Lectures /NPTEL	PO 1, PO 4	PSO 1, PSO 2
2	Analysis of structure especially for building moments and shear force and decision makingofanalysis.	Seminars /Guest Lectures /NPTEL	PO 1	PSO 1, PSO 2
3	Torsional effects in the structure and failure criteria of the compressionmembers.	Seminars/ Assignments	PO 1, PO 4	PSO 3

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