INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

CIVIL ENGINEERING

COURSE DESCRIPTOR

Course Title	**STRENGTH OF MATERIALS**				
Course Code	ACEB07				
Programme	B.Tech				
Semester	IV	CE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	2	1
Chief Coordinator	Mr. G Venkateswarlu, Assistant Professor, MECH				
Course Faculty	Mr. G.Venkateswarlu, Assistant Professor, MECH				

I. COURSEOVERVIEW:

The primary objective of Strength of Materials is concerned with establishing an understanding of the behavior of structure basic structural components such as beams, columns, frames, plates and shells, when subjected to different loads or other actions which have the effect of changing the state of stress and deformation of the structure.

II. COURSEPRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEB03	III	Engineering Mechanics	4

III. MARKSDISTRIBUTION:

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

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V. EVALUATIONMETHODOLOGY:

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 modules and each module carries equal weight age in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in aquestion.

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 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**			**Total Marks**
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	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 20 marks of 2 hours duration consisting of five descriptive type questions out of which four 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 – Online Examination:

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). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quizzes for everycourse.

Alternative Assessment Tool (AAT):

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the class room into effective learning centre. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in engineering) five minutes video and MOOCs etc.

VI. HOW PROGRAM OUTCOMES AREASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Seminars
PO 2	**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	3	Quiz
PO 3	**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
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.	1	Videos
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in thebroadest context of technological change	3	Assignments

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES AREASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional skills:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	3	LCD/PPT
PSO2	**Problem-solving Skills:** Imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problemsof components to complete the challenge of airworthiness for flight vehicles.	2	Assignments
PSO 3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	3	Assignments

3 = High; 2 = Medium; 1 = Low

VIII. COURSEOBJECTIVES:

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

IX. COURSE OUTCOMES(COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand the basics of material properties, stress and strain.	CLO 1	Calculate the stress strain relations in conjunction with elasticity and material properties
		CLO 2	Describe the resistance and deformation in members which are subjected to axial, flexural and torsion loads.
		CLO 3	Discuss thermal explanations in solid bars and induced thermal stresses
CO 2	Apply knowledge of various kinds of beams for engineering applications.	CLO 4	Solve for bending and shear parameters of beams under loading conditions
		CLO 5	Explain for deflections of beams under loading with various approaches.
		CLO 6	Determine the deflections of different beams under different loading conditions.
CO 3	Gain the knowledge to identify, formulate, and solve engineering &real life problems.	CLO 7	Compute the bending stresses developed in various sections of beams of real field problems.
		CLO 8	Apply the bending equation on various sections
		CLO 9	Determine the shear stresses developed in various sections of beams
CO 4	Design and conduct experiments, as well as to analyze and interpret data	CLO 10	Calculate the stability of structural elements and determine buckling loads.
		CLO 11	Discuss critical buckling load for column with various loading and end conditions
		CLO 12	Apply theories and to predict the performance of bars under axial loading including buckling.
		CLO 13	Understand the theory of beam column & determine buckling loads on it.
CO 5	Understand to design a component to meet desired needs within realistic constraints of safety.	CLO 14	Solve the principal stress problems by graphical methods.
		CLO 15	Explain the stress transformation and concept of principle plane and principle stresses
		CLO 16	Evaluate principal stresses, strains and apply the concept of failure theories for design
		CLO 17	Acquire knowledge to solve real time problems in Aircraft structure subjected loading conditions

X. 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
ACEB07.01	CLO 1	Calculate the stress strain relations in conjunction with elasticity and material properties	PO1	3
ACEB07.02	CLO 2	Describe the resistance and deformation in members which are subjected to axial, flexural and torsion loads.	PO1	2
ACEB07.03	CLO 3	Discuss thermal explanations in solid bars and induced thermal stresses	PO2	3
ACEB07.04	CLO 4	Solve for bending and shear parameters of beams under loading conditions	PO2	3
ACEB07.05	CLO 5	Explain for deflections of beams under loading with various approaches.	PO1	2
ACEB07.06	CLO 6	Determine the deflections of different beams under different loading conditions.	PO12	1
ACEB07.07	CLO 7	Compute the bending stresses developed in various sections of beams of real field problems.	PO3	2
ACEB07.08	CLO 8	Apply the bending equation on various sections	PO2	2
ACEB07.09	CLO 9	Determine the shear stresses developed in various sections of beams	PO4	1
ACEB07.10	CLO 10	Calculate the stability of structural elements and determine buckling loads.	PO4	3
ACEB07.11	CLO 11	Discuss critical buckling load for column with various loading and end conditions	PO1	3
ACEB07.12	CLO 12	Apply theories and to predict the performance of bars under axial loading including buckling.	PO3	2
ACEB07.13	CLO 13	Understand the theory of beam column & determine buckling loads on it.	PO1	1
ACEB07.14	CLO 14	Solve the principal stress problems by graphical methods.	PO4	3
ACEB07.15	CLO 15	Explain the stress transformation and concept of principle plane and principle stresses	PO1	1
ACEB07.16	CLO 16	Evaluate principal stresses, strains and apply the concept of failure theories for design	PO1	2
ACEB07.17	CLO 17	Acquire knowledge to solve real time problems in Aircraft structure subjected loading conditions	PO12	2

3 = High; 2 = Medium; 1 = Low

XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)					Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 12	PSO1	PSO2	PSO3
CO 1	3	3				2	1	
CO 2	2	3				1	2	
CO 3	2	3			1	2	1	
CO 4	2	2		1	1	2	2	2
CO 5	2		**3**	**3**	**2**	2		3

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFICOUTCOMES:

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	
CLO 2	2														1
CLO 3		3												2	
CLO 4		3												3	
CLO 5	2												1		
CLO 6												1		2	
CLO 7			2												1
CLO 8		2											1		
CLO 9				1										2	
CLO 10				3										2	
CLO 11	3												2		
CLO 12			2												2
CLO 13	1												2		
CLO 14				3										2	
CLO 15	1												1		
CLO 16	2														3
CLO 17												2	2		

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XIII. ASSESSMENTMETHODOLOGIES–DIRECT

CIE Exams	PO 1, PO2, PO3, PO4,PO12,PSO1, PSO2,PSO3	SEE Exams	PO 1, PO2, PO3, PO4,PO12, PSO1, PSO2,PSO3	Assignments	PO 3, PO 12, PSO2, PSO3	Seminars	PO 1
Laboratory Practices	PO4	Student Viva	PO12	Mini Project	-	Certification	-
Term Paper	-						

XIV. ASSESSMENTMETHODOLOGIES-INDIRECT

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

XV. SYLLABUS

IV Semester: CE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
ACEB07	Core	3	1	-	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

OBJECTIVES:

The course should enable the students to:

I. Describe the concepts and principles, understand the theory of elasticity including strain/displacement and Hooke's law relationships; and perform calculations, relative to the strength and stability ofstructures and mechanicalcomponents;

II. Define the characteristics and calculate the magnitude of combined stresses in individual members and complete structures; analyze solid mechanics problems using classical methods and energymethods;

III. Analyze various situations involving structural members subjected to combined stresses by application of Mohr's circle of stress; locate the shear center of thin wall beams;and

IV. Calculate the deflection at any point on a beam subjected to a combination of loads; solve for stresses and deflections of beams under unsymmetrical loading; apply various failure criteria for general stress states at points; solve torsion problems in bars and thin walledmembers;

MODULE –I	STRESSES AND STRAINS	Classes: 12

Concept of stress and strain, St. Venant"s principle, stress and strain diagram, Elasticity and plasticity, types ofstresses and strains, Hooke's law stress – strain diagram for mild steel working stress, factor of safety, Lateralstrain, Poisson's ratio and volumetric strain – Elastic moduli and the relationship between them; Bars ofvarying section, composite bars, temperature stresses. Strain Energy – Resilience, Gradual, sudden, impact andshock loadings, simple applications, two-dimensional system, stress at a point on a plane, principal stresses andprincipal planes, Mohr circle of stress, ellipse of stress and their applications. Two-dimensional stress-strainsystem, principal strains and principal axis of strain, circle of strain and ellipse of strain. Relationship betweenelastic constants.

MODULE –II	BENDING MOMENT AND SHEAR FORCE DIAGRAMS	Classes : 08

Bending Moment (BM) and Shear Force (SF) diagrams. BM and SF diagrams for cantilevers simply supported with or without overhangs. Calculation of maximum BM and SF and the point of contra flexure under concentrated loads, uniformly distributed loads over the whole span or part of span, combination of concentrated loads (two or three) and uniformly distributed loads, uniformly varying loads, application of moments. Relationship between moment, slope and deflection, Moment area method, Macaulay's method. Useof these methods to calculate slope and deflection for determinant beams.

MODULE –III	DEFLECTIONS IN BEAMS, TORSION	Classes: 08

Derivation of bending equation, Neutral axis, determination of bending stresses, section modulus ofrectangular and circular sections (Solid and Hollow), I, T, Angle and Channel sections, Design of simple beamsections.

Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.

MODULE –IV	TORSION	Classes: 08
Derivation of torsion equation and its assumptions. Applications of the equation of the hollow and solid circular shafts, torsional rigidity, Combined torsion and bending of circular shafts, principal stress and maximum shear stresses under combined loading of bending and torsion. Analysis of close-coiled-helicalsprings.		
MODULE –V	**THIN CYLINDERS AND SPHERES**	**Classes: 09**
Derivation of formulae and calculations of hoop stress, longitudinal stress in a cylinder, and sphere subjectedto internal pressures.		

Text Books:

1. Timoshenko, S. and Young, D. H., "Elements of Strength of Materials", DVNC, New York, USA.
2. Kazmi, S. M. A., "Solid Mechanics" TMH, Delhi, India.
3. Hibbeler, R. C. Mechanics of Materials. 6th ed. East Rutherford, NJ: Pearson Prentice Hall, 2004.
4. Crandall, S. H., N. C. Dahl, and T. J. Lardner. An Introduction to the Mechanics of Solids. 2nd ed. NewYork, NY: McGraw Hill, 1979.

Reference Books:

1. Mechanics of Materials - Ferdinand P. Beer, E. Russel Jhonston Jr., John T. DEwolf– TMH2002.
2. Strength of Materials by R. Subramanian, Oxford University Press, New Delhi.

Web References:

1. http://www.nptelvideos.in/2012/11/strength-of-materials- prof.html
2. http://ocw.mit.edu/courses/civil-and-environmental-engineering/1-050-solid-mechanics-fall-2004/lecture-notes/
3. https://www.youtube.com/watch?v=coRgpxG2pyY&list=PLLbvVfERDon3oDfCYxkwRct1Q6YeOzi9g

E-Text Books:

1. http://www.freeengineeringbooks.com/Civil/Strength-of-Material-Books.php
2. http://royalmechanicalbuzz.blogspot.in/2015/04/strength-of-materials-book-by-r-k-bansal.html
3. https://books.google.co.in/books?id=I8gg0Q4OQ4C&printsec=frontcover&dq=STRENGTH+OF+MATERIALS&hl=en&sa=X&ved=0ahUKEwjpveCD44HgAhWBad4KHacUAgYQ6AEIMDAB#v=onepage&q=STRENGTH%20OF%20MATERIALS&f=false

XVI. COURSEPLAN:

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

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-3	Mechanical properties of engineering materials, Hooke's law, derivation of relation between three elastic constants	CLO 1	T1:1.1-1.6
4	Derivation of Bars of varying cross-section, explaining the concept factor of safety applied to various problems	CLO 1	T1:1.10
5	Explanation of Concept of thermal stresses, problems on thermal stresses	CLO 2	T1:1.14
6	Derivation of Torsion in shafts. Different Problems on torsion of shafts	CLO 2	T1:1.14
7	Explanation of strain energy concept for different structures and derivation of strain energy equation.	CLO 2	T1:4.1-4.6

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
8-9	Problems on design of bars, problems on three elastic constants	CLO 3	T1:1.17
10	Explaining different type of beams under various loads and also the concept of shear force and bending moment.	CLO 3	T1:6.1-6.5 R1:4.1-4.10
11	Problems on shear force and bending moment diagram of cantilever beams subjected to point load, udl, uvl.	CLO 4	T1:6.6-6.9 R1:5.1-5.6
12	Problems on shear force and bending moment diagram of SSB beams subjected to point load, udl, uvl.	CLO 4	T1:6.10-6.12
13	Problems on shear force and bending moment diagram of SSB beams subjected to point load, udl, uvl.	CLO 5	T1:6.10-6.12
14	Problems on shear force and bending moment diagram of overhanging beams subjected to point load, udl, uvl.	CLO 5	T1:7.1-7.3
15-16	Assumptions of pure bending, derivation of deflection of beams. Problems on deflection on beams by double integration method.	CLO 6	T1:7.1-7.3 R1:8.2-8.9
17-18	Problems on double integration method for various beams like cantilever, simply supported beam under various loading conditions.	CLO 6	T1:12.1-12.3
19	Problems on moment area method for various beams like cantilever, simply supported beam under various loading conditions.	CLO 7	T1:13.1-13.5
20-22	Concept of principal of superposition and application on various problems.	CLO 8	T1:7.4-7.5
23-24	Explanation of pure bending and derivation of equation of bending stresses	CLO 8	T1:7.4-7.5 R3:8.5-8.10
24-26	Concept of shear stresses and its variation on beams of symmetric sections.	CLO 8	T1:8.1-8.3
27	Shear stresses variations on unsymmetrical sections.	CLO 9	T1:8.1-8.3
28-30	Problems on shear stresses and for symmetrical and unsymmetrical sections	CLO 9	T1:8.1-8.3
30	Derivation of beam of uniform strength and problems on it.	CLO 9	T1:7.1-7.3
31-32	Concept of flexural stress and derivation of bending equation.	CLO 9	T1:19.1-19.3
33-35	Calculation of bending stresses for different cross sections.	CLO 10	T1:19.1-19.3
36	Explaining about different types of columns and their applications	CLO 11	T1:19.3
37-39	Assumptions for Euler's formula of instability of columns	CLO 11	T1:19.3
40-41	Derivation of Euler's formula for buckling of column	CLO 12	T1:19.4-19.6
42-44	Problems on Euler's formula of buckling for long and intermediate columns.	CLO 12	T1:19.6-19.9 R2:9.1-9.10
45-47	Explanation of short columns and their applications.	CLO 13	T1:19.11 R2: 10.1-10.5
48-50	Derivation of Rankine's short column formula for short column crushing load.	CLO 13	T1:19.11 R3: 5.5-5.12
50	Derivation of Jonson's short column formula for short column crushing load.	CLO 14	T1:19.13-19.15
51-52	Concept of analysis of beam-column and its applications. Problems on beam columns.	CLO 14	T1:19.8
53-54	Explaining the stresses acting on a 3dimensional elastic body and deriving the stress equations.	CLO 15	T3:1.1-1.6
55	Derivation of compatibility equations for 3dimensional elastic body	CLO 15	T3:1.10-1.12
56	Problems on equilibrium and compatibility equations	CLO 16	T3:1.16
57-58	Concept of Airy's stress function for 3Dimensional elastic body and application on problems	CLO 16	T3:2.1-2.2
59	Explanation of plane stresses and plane strains by analytical methods and graphical methods	CLO 17	T3:1.14
60	Problems on principal stresses and strains using various methods.	CLO 17	T3:1.16

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSIONREQUIREMENTS:

S. No	Description	Proposedactions	Relevance withPOs	Relevance with PSO's
1	Shear force and Bending moment for inclined loading conditions on various beams.	Guest Lecture/Seminar	PO1,PO2,PO4	PSO 2
2	Deflection of beams by using conjugate beam method.	Seminars	PO 5	PSO 2, PSO 3
3	Concept of combined bending and torsion on shafts.	Seminars	PO 3	PSO 1, PSO 3

Prepared by: **HOD, CE**

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