INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**MECHANICS OF SOLIDS**				
Course Code	AME004				
Programme	B. Tech				
Semester	III	ME			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. K. Viswanath Allamraju, Professor,				
Course Faculty	Dr. K. Viswanath Allamraju, Professor Mr. A. Somaiah, Assistant Professor.				

I. COURSE OVERVIEW:

Mechanics of Solids is the physical science that deals with the reaction of a body to movement and deformation due to mechanical, thermal, or other loads. The basis of virtually all mechanical design lies in how the material reacts to outside forces. Mechanics is the core of engineering analysis and is one of the oldest of the physical sciences. An in-depth understanding of material properties as well as how certain materials react to outside stimulus is paramount to an engineering education.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AME002	II	Engineering Mechanics	4
UG	AME001	I	Engineering Drawing	4

III. MARKSDISTRIBUTION

Subject	SEE Examination	CIA Examination	Total Marks
Mechanics of Solids	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.

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, with 25 marks for Continuous Internal Examination (CIE) and 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):
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 20 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, micro projects, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Level	Proficiency assessed by
PO1	Engineering Knowledge: Capability to apply the knowledge of mathematics, science and engineering in the field of mechanical engineering.	3	Presentation on real-world problems
PO2	Problem Analysis: An ability to analyze complex engineering problems to arrive at relevant conclusion using knowledge of mathematics, science and engineering.	3	Seminar
PO3	Design/ development of solutions: Competence to design a system, component or process to meet societal needs within realistic constraints.	3	Seminar
PO4	Conduct investigations of complex problems: To design and conduct research oriented experiments as well as to analyze and implement data using research methodologies.	3	Term Paper

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Level	Proficiency assessed by
PSO1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	3	Lecture, Assignments.
PSO2	**Problem solving skills**: An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	3	Projects
PSO3	**Successful career and Entrepreneurship**: To build the nation, by imparting technological inputs and managerial skills to become technocrats.	3	Projects

3= High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	To solve real field problems through evaluating the relationship between stress and strain.
II	To understand the shear force and bending moment diagrams of symmetrical beams.
III	To determine bending and shear stresses developed in beams of various sections
IV	To understand various theories of failure, mohr's circle of stresses, principle stresses and strains.
V	To understand and apply the concept of stress and strain to analyze and design structural members and machine parts under axial load, shear load, bending moment and torsion.

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
CAME004.01	CLO1	Demonstrate the statically determinate and indeterminate problems. Use algebraic equations to determine the effect of stress	PO 1	3

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
		and strain in the bars which are made up of various materials.		
CAME004.02	CLO2	Understand extension and reduction of length of different bars. Explain the various stresses and strains and their relations, also comprehend the importance of elastic moduli.	PO 1, PO 3	3
CAME004.03	CLO3	Explore the shear force diagrams under various loads. Explain the importance of beams in the real field by understanding the types of loads.	PO 1, PO 3	3
CAME004.04	CLO4	Comprehend bending moment and its variation at various loads. Explain the bending moment diagram and its importance, understanding the supports and beams.	PO 1, PO 2, PO 4	2
CAME004.05	CLO5	Determine the resistance and deformation in members which are subjected to axial, flexural and torsional loads.	PO 1, PO 3	2
CAME004.06	CLO6	Evaluate the principal stresses, strains and apply the concept of failure theories for design of shafts and other designed products.	PO 1, PO 2, PO 4	2
CAME004.07	CLO7	Able to calculate the shear stresses developed in various sections of beams.	PO 1, PO 2, PO 3	1
CAME004.08	CLO8	Capable of understand the loads which occur in crash analysis.	PO 1, PO 2, PO 3	1
CAME004.09	CLO9	Understand the effect of gradual loads on the various materials.	PO 1, PO 2	2
CAME004.10	CLO10	Understand torsion equation	PO 1, PO 3	2
CAME004.11	CLO11	Able to calculate the flexural developed in various sections of beams of real field problems.	PO 1, PO 3	3
CAME004.12	CLO12	Find principle stresses and strains and to apply theories of failure in the design of various mechanical parts.	PO 1, PO 2	3
CAME004.13	CLO13	Determine stresses developed in a shaft and design of a shaft.	PO 1, PO 3	3
CAME004.14	CLO14	Derive the expression for Longitudinal stress	PO 1, PO 2	2
CAME004.15	CLO15	Derive the expression for volumetric strain	PO 1, PO 3, PO 4	2
CAME004.16	CLO16	Find the volumetric strain of a thin spherical shell	PO 1, PO 2	2
CAME004.17	CLO17	Derive the expression for Hoop stress	PO 1, PO 2	3
CAME004.18	CLO18	Understand the real field problems of various pressure vessels which are made up of different materials.	PO 1, PO 2	2
CAME004.19	CLO19	Able to design the thin vessels which are subjected to different stresses.	PO 1, PO 3, PO 4	1
CAME004.20	CLO20	Explore the use of modern engineering tools, software and equipment to prepare for competitive exams, higher studies etc	PO 1, PO 2	1

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												1	2	
CLO 2	3		3										1		
CLO 3	3		3										1	2	
CLO 4	2	2		2									1	2	
CLO 5	2		2										1	2	
CLO 6	2	2		2										2	
CLO 7	1	1	1										1		
CLO 8	1	1	1											2	
CLO 9	2	2												2	
CLO 10	2		2										1		
CLO 11	3		3											2	
CLO 12	3	3											1		
CLO 13	3		3										1	2	
CLO 14	2	2											1		
CLO 15	2		2	2									1	2	
CLO 16	2	2											1		
CLO 17	3	3											1		
CLO 18	2	2											1	2	
CLO 19	1		1	1										2	
CLO 20	1	1												2	

XI. ASSESSMENT METHODOLOGIES – DIRECT

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

XII. ASSESSMENT METHODOLOGIES–INDIRECT

√	Assessment of course Outcomes (by feedback, once)	√	Student feedback on faculty (twice)
✘	Assessment of mini projects by experts		

XIII. SYLLABUS:

Unit-I	**SIMPLE STRESSES AND STRAINS**
Elasticity and plasticity – Types of stresses & strains–Hooke's law– stress – strain diagram for m – Working stress – Factor of safety – Lateral strain, Poisson's ratio & volumetric strain – Elastic & the relationship between them – Bars of varying section – composite bars – Temperature s Strain energy – Resilience – Gradual, sudden, impact and shock loadings.	
Unit-II	**SHEAR FORCE AND BENDING MOMENT DIAGRAMS**
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, u.d.l., uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.	
Unit-III	**FLEXURAL STRESSES, SHEAR STRESSES**
Theory of simple bending – Assumptions – Derivation of bending equation: M/I = f/y = E/R Neutral axis– Determination 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 beams sections like rectangular, circular, triangular, I, T angle sections.Steering gears: Conditions for correct steering, Davis Steering gear, Ackerman's steering gear, Hooke's joint: Single and double Hooke's joint, velocity ratio, application, problems.	
Unit-IV	**PRINCIPAL STRESSES AND STRAINS, THEORIES OF FAILURE**
Introduction – 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 (Von Mises Theory)..	
Unit-V	**DESIGN OF CIRCULAR SHAFTS AND STRESSES IN PRESSURE VESSELS**
Theory of pure torsion – Derivation of Torsion equations : T/J = q/r = Nθ/L – Assumptions made in the theory of pure torsion – Torsional moment of resistance – Polar section modulus – Power transmitted by shafts – Combined bending and torsion and end thrust – Design of shafts according to theories of failure. Thin Cylinders: Thin seamless cylindrical shells – Derivation of formula for longitudinal and circumferential stresses– hoop, longitudinal and Volumetric strains – changes in dia, and volume of thin cylinders– Thin spherical shells..	
Text Books:	
1. S. S Ratan, —Strength of Materials‖, Tata McGraw-Hill, 2nd Edition, 2011. 2. W.A. Nash, —Strength of Materials‖, Tata McGraw-Hill, 4th Edition, 2007.	

Reference Books:
1. Jindal, ―Strength of Materials‖, Pearson Education, 1st Edition, 2012. 2. S. Ramamrutam, R. Narayan, ―Strength of Materials‖, Dhanpat Rai Publishing Company, 18th Edition, 2014. 3. R. K. Rajput, ―Strength of Materials‖, S.Chand & Co New Delhi, 4th Edition, 2007.

XIV. COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No	Topic/s to be covered	Course Learning Outcomes (CLOs)	Reference
1	Elasticity and plasticity	CLO1	T1-1.1 , R1- 1.31.4 ,R2.1.7
3-4	Types of stresses & strains– Hooke's law	CLO1	T1- 1.2, R1-1.8,
5-6	stress – strain diagram for mild steel – Working stress – Factor of safety	CLO1	T1- 1.15, R1- 1.16
7-8	Lateral strain, Poisson's ratio & volumetric strain	CLO2	T1- 1.6
9-10	Elastic moduli & the relationship between them	CLO2	T1- 2.2, R2-2.6
11	Bars of varying section -composite bars – Temperature stresses.	CLO2	T1-2.6, R3-2.10
12	Strain energy – Resilience – Gradual, sudden, impact and shock loadings.	CLO3	T1-3.2, R2-3.3,
13-14	Shear Force and Bending Moment: Definition of beam – Types of beams – Concept of shear force and bending moment	CLO3	T1-3.5
15-16	S.F and B.M diagrams, point loads, u.d.l., uniformly varying loads and combination of these loads for cantilever	CLO4	T1-2.13, 2.14,R1- 2.16
17-18	simply supported beams subjected to point loads, u.d.l., uniformly varying loads and combination of these loads	CLO4	T1-2.15, R1-2.15
23-24	Overhanging subjected to point loads, u.d.l., uniformly varying loads and combination of these loads	CLO4	T1-3.9, R1-3.9
25-27	Theory of simple bending – Assumptions – Derivation of bending equation: M/I = f/y = E/R	CLO5	T1-6.1, R2-6.3
27-28	Neutral axis – Determination bending stresses	CLO6	T1-6.2, R2- 6.3
29-30	Section modulus of rectangular and circular sections (Solid and Hollow), I, T, Angle and Channel sections	CLO6	T1-6.5, 6.6
33-34	Design of simple beam sections.	CLO7	T1-6.7, 6.8
37-38	Shear Stresses: Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I, T angle sections.	CLO8	T1-7.1
39-40	Principal Stresses and Strains: Introduction – Stresses on a loading	CLO18	T1- 7.2, R1-7.3

Lecture No	Topic/s to be covered	Course Learning Outcomes (CLOs)	Reference
41-42	Two perpendicular normal stresses accompanied by a state of simple shear Mohr's circle of stresses – Principal stresses and strains – Analytical and graphical solutions.	CLO8	T1- 7.9,R1-7.9
43-44	Theories of Failure: Introduction – Various theories of failure - Maximum Principal Stress Theory, Maximum Principal Strain Theory, Strain Energy and Shear Strain Energy Theory (Von Mises Theory).	CLO8	T1-7.9, R1-7.10
45-46	Torsion of Circular Shafts: Theory of pure torsion – Derivation of Torsion equations : $T/J = q/r = N\theta/L$ – Assumptions made in the theory of pure torsion	CLO9	T1- 7.11,R2-7.12
47-48	Torsional moment of resistance –Polar section modulus	CL010	T1- 10.1, R1-10.2
49-50	Power transmitted by shafts – Combined bending and torsion and end thrust	CLO11	T1-10.4,R1- 10.5
51	Design of shafts according t	CLO12	T1-10.6, 10.7and 10.8
52-53	Hoop, longitudinal and Volumetric strains – changes in dia, and volume of thin cylinders– Thin	CLO13	T1- 10.14 and 10.15
54-55	Longitudinal stress	CLO14	T1-10.11
56-57	Volumetric strain	CLO15	T1-10.16
58-59	Thin spherical shell introduction	CLO16	T1-10.20, R4-10.22
60-61	Hoop stress of spherical shell	CLO17	T1- 11.1, R2-11.2
62-63	Problems on spherical shell	CLO19	T1- 11.6, R2-11.7
64-65	Revision of fifth unit	CLO20	T1-11.12,R3-11.12

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

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Equilibrium equation applications,Cetroid and centeer of gravity	Seminars	PO 1, PO 4	PSO 1
2	Moment of inertia concepts to solve for arbitrary geometries	Seminars / NPTEL	PO 4, PO3	PSO 1
3	Encourage students to design beams by writing MATLAB code to solve problems.	NPTEL	PO 2	PSO 1

Prepared by:

Dr. K. Viswanath Allamraju, Professor
Mr. A. Somaiah, Assistant Professor

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