25UMET416	ADVANCED MECHANICS OF SOLIDS	Category	L	T	P	R	Credit	Year of Introduction
		PEC	3	0	0	0	3/5	2025

Preamble: This course provides an advanced treatment of stress analysis and elasticity theory beyond the basic Strength of Materials. It introduces the formulation of stress and strain tensors, compatibility and equilibrium equations, constitutive relations for isotropic solids, and two-dimensional elasticity problems using Airy's stress function.

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Pre-requisite: 25UMET301 Strength of Materials

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

CO	Course Outcomes	Knowledge Level
CO1	Explain stress–strain tensors, stress transformation, equilibrium equations, and compatibility conditions in elastic solids.	**K2 Understand**
CO2	Apply constitutive relations and Airy's stress function to solve two-dimensional elasticity problems.	**K3 Apply**
CO3	Determine stress distribution in thick cylinders, rotating discs, curved beams, and unsymmetrical bending problems.	**K3 Apply**
CO4	Apply energy principles and torsion theory to determine deformation and stress in structural members.	**K3 Apply**

Mapping of course outcomes with program outcomes and program specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	2	-	-	-	-	-	-	-	1	2	2
CO3	3	3	3	1	-	-	-	-	-	-	1	3	3
CO4	3	3	2	1	-	-	-	-	-	-	1	3	3
Avg	3	2.75	2	1	-	-	-	-	-	-	1	2.5	2.25

Mapping of course outcomes with Knowledge and Attitude Profile (WK)

	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CO1	*	*	*	*	*	–	–	–	–
CO2	*	*	*	*	*	–	–	–	–
CO3	*	*	*	*	*	–	–	–	–
CO4	*	*	*	*	*	–	–	–	–

WKs Mapped with the course

WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
*	*	*	*	*	*	–	–	–

Mark Distribution:

Total Marks	CIE Marks	ESE Marks	ESE Duration
100	**40**	**60**	**2.5 hrs**

Continuous Internal Evaluation Pattern:

Attendance : 5 marks
Continuous Assessment Test : 20 marks
Continuous Assessment Assignment : 15 marks

SYLLABUS

Module 1 (10 hrs)

Stress at a point – stress tensor – stress components in rectangular and polar coordinate systems – Cauchy's equations of equilibrium (2D form) – stress transformation equations – principal stresses and principal planes (principal stress equation) – hydrostatic and deviatoric stress components – octahedral shear stress (expression) – equations of equilibrium.

Displacement field – engineering strain – strain tensor (basic formulation) – strain–displacement relations for small strain theory (2D form) – compatibility conditions (2D compatibility equation).

Module 2 (10 hrs)

Generalized Hooke's law – stress–strain relations for linear elastic isotropic solids (3D form and reduction to plane stress and plane strain) – relations among elastic constants (E, G, K, ν) – boundary conditions – St. Venant's principle – uniqueness theorem.

Two-dimensional elasticity – plane stress and plane strain problems – stress compatibility equation – Airy's stress function (governing biharmonic equation) – polynomial method of solution – bending of cantilever with end load (stress distribution).

Module 3 (10 hrs)

Equations in polar coordinates (2D) – equilibrium equations – strain–displacement relations – Airy's stress function in polar form (governing equation).

Applications: Lame's problem for thick cylinder (stress distribution equations) – stress concentration in a plate with circular hole (stress distribution only) – axisymmetric problems (governing equations) – thick cylinders under pressure – rotating discs (stress distribution for solid disc).

Unsymmetrical bending of straight beams (sections with one axis of symmetry) – bending stress equation for unsymmetrical sections – curved beams (rectangular cross section; stress equation)

Module 4 (12 hrs)

Strain energy of deformation – strain energy expressions for axial load, bending moment and torsion – Maxwell's reciprocal theorem – Castigliano's first and second theorems – principle of virtual work – minimum potential energy theorem.

Torsion of circular shafts (torsion equation) – Saint Venant theory – Prandtl stress function (governing equation) – membrane analogy – torsion of thin-walled tubes and thin rectangular sections.

Text Books:

1. Sreenath, L. S. *Advanced mechanics of solids*. McGraw Hill Education, 2008
2. Kazimi, S. M. A. *Solid mechanics*. McGraw Hill Education, 2008.
3. Jose, S. *Advanced mechanics of materials*. Pentagon Educational Services, 2013
4. Govindaraju, L., & Sitharaman, T. G. *Applied elasticity for engineers*. NPTEL
5. Saravanan, U. *Advanced solid mechanics*. NPTEL.
6. Lal, S. A., *Advanced mechanics of solids*. Siva Publications and Distributions, 2017

Reference Books:

1. Timoshenko, S. P., & Goodier, J. N., *Theory of elasticity*. McGraw Hill, 1970.
2. Atkin, R. J., & Fox, N., *An introduction to the theory of elasticity*. Longman, 1980.
3. Den Hartog, J. P., *Advanced strength of materials.* McGraw Hill, 1987.
4. Wang, C. K., *Applied elasticity*. McGraw Hill, 1983.
5. Bower, A. F., *Applied mechanics of solids*. CRC Press, 2009.

END SEMESTER EXAMINATION - MODEL QUESTION PAPER

Course Code	**25UMET416**
Course Name	**ADVANCED MECHANICS OF SOLIDS**
Max. Marks: 60	**Duration: 2.5 Hours**

Part A

(Answer all questions. Each question carries 3 marks)

Qn No.	Question	Marks	CO	BL
1	Explain the physical significance of hydrostatic and deviatoric stress components in a three-dimensional stress state.	3	1	L2
2	Explain the need for strain compatibility conditions in two-dimensional elasticity problems.	3	1	L2

Qn No.	Question	Marks	CO	BL
3	Use generalized Hooke's law to write the stress-strain relations for an isotropic material under plane stress condition.	3	2	L3
4	Use Airy's stress function concept to identify whether a given polynomial stress function satisfies the biharmonic requirement.	3	2	L3
5	Determine the nature of radial and hoop stress variation in a thick cylinder subjected to internal pressure.	3	3	L3
6	Use the concept of unsymmetrical bending to identify the position of the neutral axis for a beam section with one axis of symmetry.	3	3	L3
7	Apply Castigliano's theorem to determine the deflection expression for a member subjected to axial loading.	3	4	L3
8	Use the torsion equation to determine the shear stress variation across a circular shaft.	3	4	L3

Part B

(Answer any one full question from each Module. Each carries 9 marks)

Qn No.	Question	Marks	CO	BL
	Module I			
9	Explain stress tensor, stress transformation equations, principal stresses, principal planes, and Cauchy's equilibrium equations for a two-dimensional elastic solid.	9	1	L2
	OR			
10	Explain strain tensor, strain-displacement relations, compatibility conditions, hydrostatic stress, deviatoric stress, and octahedral shear stress.	9	1	L2
	Module II			
11	Apply constitutive relations for linear elastic isotropic solids to reduce the three-dimensional stress-strain equations into plane stress and plane strain forms. Also indicate the role of boundary conditions in solving elasticity problems.	9	2	L3
	OR			
12	Use Airy's stress function method to solve a two-dimensional elasticity problem. Verify the suitability of a polynomial stress function and determine the corresponding stress components.	9	2	L3
	Module III			
13.a	Determine the radial and hoop stress distributions in a thick cylinder subjected to internal and external pressure using Lame's theory.	5	3	L3
13.b	Determine the stress distribution in a rotating solid disc and identify the location of maximum stress.	4	3	L3
	OR			
14.a	Use the polar-coordinate elasticity equations to determine stress variation around a circular hole in a plate subjected to uniaxial tension.	5	3	L3

Qn No.	Question	Marks	CO	BL
14.b	Determine the bending stress in an unsymmetrical beam section and locate the neutral axis for a given loading condition.	4	3	L3
Module IV				
15.a	Apply Castigliano's theorem to determine the deflection of a structural member subjected to axial or bending load.	5	4	L3
15.b	Use the torsion equation to determine shear stress and angle of twist in a circular shaft.	4	4	L3
OR				
16.a	Apply the principle of virtual work or minimum potential energy to determine deformation in a structural member.	5	4	L3
16.b	Use Prandtl stress function or membrane analogy to determine torsional behaviour of thin-walled tubes and thin rectangular sections.	4	4	L3