25HMET401	ADVANCED MECHANICS OF MATERIALS	Category	L	T	P	R	Credit	Year of Introduction
		VAC	4	0	0	0	4	2025

Preamble: This course extends the classical Strength of Materials into advanced structural behaviour of engineering components. It focuses on stress transformation, advanced beam theory, torsion of non-circular sections, rotating members, energy principles, and thin-walled structures. Emphasis is placed on analytical techniques used in the design and evaluation of mechanical components subjected to complex loading conditions.

Prerequisite: 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 and strain states in elastic materials using tensor formulation, compatibility relations and constitutive equations.	K2 Understand
CO2	Apply energy principles and virtual work methods to determine strain energy and structural deflections in beams and frames.	K3 Apply
CO3	Apply principles of unsymmetrical bending, curved beams and shear centre to analyse stress distribution in structural members.	K3 Apply
CO4	Analyse torsional stresses in non-circular members and stress distribution in thick cylinders and rotating discs.	K4 Analyse

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	3	3
CO3	3	3	3	1	-	-	-	-	-	-	1	3	3
CO4	3	3	2	1	-	-	-	-	-	-	1	3	3
Avg	3	2.75	2	1	-	-	-	-	-	-	1	2.75	2.5

Mapping of Course Outcomes with Knowledge and Attitude Profile (WK)

CO	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 (12 hrs)

State of stress at a point – stress tensor in rectangular coordinates – Cauchy's equation – stress transformation – principal stresses and principal planes – octahedral stresses – hydrostatic and deviatoric components – equilibrium equations.

Displacement field – engineering strain – strain tensor under small deformation – strain-displacement relations – compatibility conditions – stress–strain relations for isotropic materials – generalized Hooke's law – boundary conditions – Saint Venant's principle.

Module 2 (14 hrs)

Strain energy of linear elastic deformation – strain energy density – strain energy in terms of load and geometry.

Principle of virtual work – complementary energy – work of virtual forces and displacements – principle of minimum potential energy – Maxwell's reciprocal theorem – Castigliano's theorems – deflection of beams and frames using energy methods.

Module 3 (14 hrs)

Bending of straight beams – principal axes – unsymmetrical bending – bending of curved beams (rectangular cross section) – stress distribution in curved beams.

Shear center – shear stress in thin-walled open sections – computation of shear center.

Module 4 (16 hrs)

Torsion of thin-walled circular rods – tubular rods of arbitrary cross sections – torsion of non-circular prismatic bars – Saint Venant method – Prandtl stress function (concept) – membrane analogy – thin rectangular sections – multiply connected sections.

Lame's problem (design perspective) – stresses in thick cylinders – radial displacement – stress

concentration (basic concept) – rotating disc (solid and with central hole) – permissible speed.

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. Rattan, S. S., *Strength of Materials*, 2nd Edition, Tata McGraw-Hill Education, 2011.
4. Saravanan, U., *Advanced Solid Mechanics*, NPTEL Course Material.
5. Lal, S. Anil, *Advanced Mechanics of Solids*, Siva Publications and Distributions, 2017.

Reference Books:

1. Gere, J. M., and Timoshenko, S. P., *Mechanics of Materials*, 2nd Edition, CBS Publishers, 2004.
2. Hibbeler, R. C., *Mechanics of Materials*, 9th Edition, Pearson, 2018.
3. Punmia, B. C., Jain, A., and Jain, A. K., *Mechanics of Materials*, Laxmi Publications Pvt. Ltd., 2001.
4. Timoshenko, S. P., and Goodier, J. N., *Theory of Elasticity*, 3rd Edition, Tata McGraw-Hill, 2010.
5. Hall, A., Holowenko, A., and Laughlin, H., *Schaum's Outline of Machine Design*, 1st Edition, 2007.

END SEMESTER EXAMINATION - MODEL QUESTION PAPER

Course Code	**25HMET401**
Course Name	**ADVANCED MECHANICS OF MATERIALS**
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 concept of stress tensor and state the physical significance of its normal and shear components.	3	1	L2
2	Distinguish between hydrostatic and deviatoric stress components with their significance in elastic material behaviour.	3	1	L2
3	Apply generalized Hooke's law to relate stress and strain components for an isotropic elastic material.	3	2	L3
4	Use Maxwell's reciprocal theorem to identify the relationship between deflections at two points of a beam.	3	2	L3
5	Apply the concept of principal axes to identify the condition for unsymmetrical bending in a straight beam.	3	3	L3
6	Determine the significance of shear centre in thin-walled open sections subjected to transverse loading.	3	3	L3
7	Analyze the difference between torsion of circular and non-circular prismatic bars.	3	4	L4
8	Analyze the stress variation in a thick cylinder subjected to internal pressure.	3	4	L4
Part B (Answer any one full question from each Module. Each carry 9 marks)				
Module I				
Qn No.	**Question**	**Marks**	**CO**	**BL**

9	Explain the state of stress at a point using stress tensor notation. Derive the stress transformation equations and discuss principal stresses and principal planes.	9	1	L2
OR				
10	Explain strain-displacement relations for small deformation theory and describe the compatibility condition for two-dimensional strain fields. Also discuss generalized Hooke's law for isotropic materials.	9	1	L2
Module II				
Qn No.	**Question**	**Marks**	**CO**	**BL**
11	Apply Castigliano's theorem to determine the deflection of a simply supported beam carrying a concentrated load. State the strain energy expression used and show the solution procedure clearly.	9	2	L3
OR				
12	Apply the principle of virtual work and complementary energy method to determine deflection of a beam or frame subjected to external loading.	9	2	L3
Module III				
Qn No.	**Question**	**Marks**	**CO**	**BL**
13	Apply the theory of unsymmetrical bending to determine the bending stress distribution in a beam section loaded away from a principal axis.	9	3	L3
OR				
14	Determine the shear centre of a thin-walled open section and explain its effect on twisting of structural members with a neat sketch.	9	3	L3
Module IV				
Qn No.	**Question**	**Marks**	**CO**	**BL**
15	Analyze torsion of non-circular prismatic bars using Saint Venant theory, Prandtl stress function and membrane analogy. Discuss a thin rectangular section.	9	4	L4
OR				
16	Analyze Lame's problem for a thick cylinder subjected to internal and external pressure. Derive the radial and hoop stress distribution and discuss the condition for maximum stress.	9	4	L4