MECHANICS OF MATERIALS

ENAM 201

Lecture : 3 **Year : II**
Tutorial : 2 **Part : I**
Practical : 1.5

Course Objectives:
The objective of this course is to develop a comprehensive understanding of stress and strain analysis in bars, compound bars, beams, shafts, cylinders, and spheres, including the concepts of principal stresses and buckling. Additionally, students will learn to design various structural and automotive components based on these principles.

1 Introduction (3 hours)

1.1 Classification of loads
1.2 Concept and types of stresses and strains, bearing stress in connection
1.3 Ultimate stress, allowable load, allowable stress, factor of safety
1.4 Elasticity and Hooke's law, Poisson's ratio, elastic constants (Young's modulus, shear modulus and bulk modulus) and their relationship
1.5 Stress strain diagram for ductile and brittle materials, true stress and true strain
1.6 Multiaxial loading: Generalized Hooke's law

2 Stress and Strain: Axial Loading (5 hours)

2.1 Tension, compression and shear
2.2 Stress on an oblique plane under axial loading
2.3 Axial deformation on a bar of constant section and varying section under uniform load, uniformly varying load, self-weight
2.4 Thermal stress and strain
2.5 Statically determinate and indeterminate problems
2.6 Stress and strain distribution under axial loading: Saint-Venant's principle
2.7 Stress concentrations, plastic deformation, residual stress

3 Torsion (6 hours)

3.1 Theory of pure torsion and its assumptions
3.2 Torsion moment diagram and torsional stress and twist angle variation
3.3 Torsion of hollow and circular shaft
3.3.1 Comparison between hollow and solid shaft by strength and weight
3.3.2 Shafts in series and parallel
3.3.3 Statically indeterminate problems

3.3.4 Composite shafts
3.3.5 Torsion of noncircular (Square and rectangular) solid members and thin-walled tubular members

4 Bending Stresses in Beams (6 hours)

4.1 Theory of pure bending and its assumptions
4.2 Bending stresses in symmetrical sections and unsymmetrical sections
4.3 Beams with composite sections
4.4 Assumptions in stress distribution in curved beams
4.5 Stresses in a curved beam, circular ring and chain link
4.6 Stress concentration and plastic deformation

5 Unsymmetrical Bending and Shear Centre (6 hours)

5.1 Stress in unsymmetrical bending
5.2 Deflection of beams in unsymmetrical bending
5.3 Eccentric tension and compression
5.4 Shear centre
5.5 Determination of shear centre for C, I and L sections

6 Shear Stresses in Beams (3 hours)

6.1 Shear stress in a beam cross section
6.2 Relationship between shear force and shear stress in a beam
6.3 Distribution of shear stress in common beam sections (Rectangular, circular, triangular, I and T type)

7 Principal Stresses and Strains (6 hours)

7.1 Normal and tangential components of stress
7.2 Principal planes, principal stresses and maximum shearing stress
7.3 Analytical and graphical method (Mohr's circle for plane stress) for determining stresses on principal planes and oblique section

8 Deflection of Beams (6 hours)

8.1 Deformation of a beam under transverse loading
8.2 General differential equation of the elastic curve
8.3 Slope and deflection of loaded members
8.4 Double integration method
8.5 Moment area method

9 Columns and struts (3 hours)

9.1 Column and strut, slenderness ratio, buckling factor and buckling load
9.2 Classification of columns

9.3 End conditions and effective length of a column
9.4 Euler's theory of long columns: Assumptions, derivations and limitations
9.5 Design of column under central loading

10 Thin Cylinders, Shells and Thick Cylinders (3 hours)

10.1 Stresses and strains in thin cylindrical and spherical shell due to internal pressure
10.2 Circumferential, radial and longitudinal stresses and strains in thin and thick cylinders

Tutorial (30 hours)

1. Problems related to calculation of normal stress, shear stress and strain for various elements of the mechanism, rods, bolts. Elasticity and Hooke's law, Poisson's ratio, elastic constants and their relationship
2. Problems related to stress and strain developed due to Axial loading on oblique plane, axial deformation on a bar under different loads, thermal stress, statically determinate and indeterminate problems
3. Problems related to torsion for hollow and circular shafts, statically indeterminate shaft, noncircular solid members, composite shafts
4. Problems related to bending stresses in beams for symmetrical sections, unsymmetrical sections and composite sections; Stresses in a curved beam, circular ring and chain link
5. Problems related to unsymmetrical bending; shear center for C, I and L sections
6. Problems related to shear stresses in beams
7. Problems related to principal planes, principal stresses and maximum shearing stress; Analytical and graphical method (Mohr's circle)
8. Problems related to deflection of beams under transverse loading, calculation of slope and deflection using double integration method and moment area method
9. Problems related to columns and struts
10. Problems related to thin cylinders, shells and thick cylinders

Practical (22.5 hours)

1. To determine beam reactions for simply supported beams and cantilever beams
2. To study torsional behavior and determine shear modulus of ductile and brittle materials for circular and non-circular cross section
3. To study buckling effect in different end conditions of column
4. To determine stresses and strains in thin wall and thick wall cylinder

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	3	4
2	3	4
3	6	8
4	6	8
5	6	8
6	3	4
7	6	8
8	6	8
9	3	4
10	3	4
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Beer, F.P., Johnson, E.R. (2020). Mechanics of materials. McGraw Hill.
2. Boresi, A.P., Schmidt, R.J., Sidebottom, O.M. (2019). Advanced mechanics of materials. John Wiley & Sons Inc.
3. Rajput, R.K. (2015). Strength of materials. S. Chand & Co. Ltd.
4. Bansal, R.K. (2018). Strength of materials. McGraw Hill.
5. Popov, E.P. (1998). Engineering mechanics of solids. Prentice Hall Inc.
6. Motra, G.B. (2021). A textbook of strength of materials. Heritage Publishers & Distributors Pvt. Ltd.