

MECHANICS OF SOLIDS

ENME 251

Lecture : 3
Tutorial : 1
Practical : 3/2

Year : II
Part : II

Course Objectives:

The objective of this course is to provide fundamental principles and skills of solid mechanics and enable students to apply theoretical knowledge to practical problems through design exercises. After the completion of this course, the students will be familiar with the methods and tools to analyze different engineering problems.

- 1 Introduction (2 hours)**
 - 1.1 Rigid body and deformable body
 - 1.2 Types of loads on structure
 - 1.3 Concept of elasticity
 - 1.4 Elastic and non-elastic behaviour of solids
 - 1.5 Elastic coefficients and their relations

- 2 Three-Dimensional Stress (6 hours)**
 - 2.1 Stress Tensor: Definition, notation and sign convention
 - 2.2 State of stress at a point
 - 2.3 Stress acting on an arbitrarily oriented plane
 - 2.4 Stress transformation
 - 2.5 Principal stress, principal plane, octahedral stress
 - 2.6 Differential equations of motion of a deformable body
 - 2.7 Von Mises stress

- 3 Analysis of Deformation (6 hours)**
 - 3.1 Strain at a point
 - 3.2 Small displacement theory and compatibility relations
 - 3.3 Strain Tensor
 - 3.4 Normal and shear strain, plane strain
 - 3.5 Strain acting on arbitrarily oriented plane
 - 3.6 Strain transformation and principal strain
 - 3.7 Volumetric strain

- 4 Strain Energy and Applications of Energy Method (7 hours)**
 - 4.1 Definition
 - 4.2 Strain energy density

- 4.3 Isotropic and anisotropic elasticity
- 4.4 Strain energy in tension, shear, bending and torsion
- 4.5 Castigliano's theorem
- 4.6 Dummy load method

5 Curved Beam (4 hours)

- 5.1 Definition
- 5.2 Assumptions in stress distribution
- 5.3 Circumferential, radial, and axial stresses
- 5.4 Deflection of curved beam
- 5.5 Statically indeterminate closed ring

6 Unsymmetrical Bending and Shear Center (8 hours)

- 6.1 Definition
- 6.2 Bending stress due to unsymmetrical bending
- 6.3 Deflections due to unsymmetrical bending
- 6.4 Shear flow in thin wall beam cross section
- 6.5 Shear center for channel section
- 6.6 Composite beams

7 Thin and Thick Wall Cylinder (5 hours)

- 7.1 Stress and strain in thin cylindrical shell
- 7.2 Open and closed end thick cylinder
- 7.3 Circumferential, radial and longitudinal stress
- 7.4 Linear and volumetric strain
- 7.5 Composite thick cylinders

8 Torsion (5 hours)

- 8.1 Torsion in triangular, rectangular, and elliptical sections
- 8.2 Torsion in narrow rectangular cross section
- 8.3 Torsion of hollow thin wall section

9 Contact Stresses (2 hours)

- 9.1 Point and line contact
- 9.2 Expressions for principal stresses

Tutorial (15 hours)

- 1. Elastic behavior of solid and material property
- 2. Stress components, stress tensor and principal stress
- 3. Strain, principal strain and compatibility relations
- 4. Deflection and slope of statically determinate and indeterminate structures
- 5. Stresses and deflection in curved beam, closed ring
- 6. Bending stress due to unsymmetrical loading, shear center

7. Stresses in thin and thick wall cylinder, composite thick cylinder
8. Torsion in non-circular, narrow rectangular and hollow thin wall cylinder

Practical

(22.5 hours)

1. Non-linear behaviour of rubber in tension
2. Creep test and relaxation test on viscoelastic specimen
3. Torsion test, torsion test of rectangular and triangular section rods, torsion test of circular, square and rectangular closed thin wall tubes
4. Deflections and stresses in curved beams
5. Stress and strain in thick wall cylinders
6. Determination of shear center for a beam with a channel cross section
7. Effects of suddenly applied dynamic loads, tension member subjected to dynamic load, Sudden transverse loading of a beam

Final Exam

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

Chapters	Hours	Marks distribution*
1 and 9	4	4
2	6	8
3	6	8
4	7	8
5	4	6
6	8	12
7	5	8
8	5	6
Total	45	60

* There may be minor deviation in marks distribution.

References

1. Boresi, A. P., Schmidt, R. J. (2009). Advanced mechanics of material (6th ed.). John Wiley & Sons.
2. Popov, E. P. (1998). Engineering mechanics of solids (2nd ed.). Pearson.
3. Ugural, A. C., Fenster, S. K. (2003). Advanced strength and applied elasticity. Pearson education.
4. Srinath, L. S. (1980). Advanced mechanics of solids (3rd ed.). Tata McGraw-Hill Publishing co. ltd.
5. Hibbeler. R. C, (2010) "Mechanics of Materials (8th ed.). Prentice Hall Inc.
6. Beer, F., Johnston, E., DeWolf, J., Mazurek, D. (2014). Mechanics of materials, 7th Edition. McGraw-Hill Publishing co. ltd.