CONTINUUM MECHANICS

ENAS 302

Lecture : 2 **Year : III**
Tutorial : 1 **Part : I**
Practical : 1.5

Course Objectives:
The objective of this course is to provide fundamental knowledge in solid mechanics, focusing on the concepts of general stress, strain, and Buckling of thin plates and their application in aircraft design.

1 Load on Structure and Response of Material (1 hour)

1.1 General load on structure and its effects
1.2 Elastic and non-elastic response of solids
1.3 Isotropy, anisotropy, continuity and homogeneity
1.4 Effect of temperature on elastic and plastic range of solids

2 Stress Tensor (4 hours)

2.1 Definition
2.2 Stress at a point
2.3 Stresses on structure due to general load
2.4 Stress notation and sign convention
2.5 Stresses acting on arbitrary planes
2.6 Transformation of stress and principal stress
2.7 Stress on deformable body
  2.7.1 Differential equation in rectangular co-ordinate system
  2.7.2 Differential equation in polar co-ordinate system
  2.7.3 Application of differential equation and its solution
2.8 Case study of applications in aerospace engineering

3 Deformation on Body and Strain Tensor (3 hours)

3.1 Definition of deformation on body and strain tensor
3.2 Strain at a point
3.3 Strain on structure due to general load
3.4 Strain notation and sign convention
3.5 Strain acting on arbitrary planes.
3.6 Transformation of strain and principal strain
3.7 Small displacement theory

3.8 Volumetric strain
3.9 Case study of applications in aerospace engineering

4 General Hooke's Law (2 hours)

4.1 Definition of general Hooke's law
4.2 Internal energy density, strain energy and complimentary strain energy density
4.3 Anisotropic and isotropic elasticity
4.4 Equation of thermo elasticity for isotropic materials

5 Statically Determinate and Indeterminate Structures (4 hours)

5.1 Introduction to energy method
5.2 Work done in deflection, reciprocity theorem
5.3 Strain energy for various types of loading
5.4 Castigliano's theorem
5.5 Use of a fictitious load, unit or dummy load method

6 Curved Beams (4 hours)

6.1 Definition of curved beam
6.2 Circumferential stress in curved beams
6.3 Radial stress in curved beams
6.4 Deflection of curved beams

7 Bending of Thin Plates (4 hours)

7.1 Pure bending of thin plates
7.2 Plates subjected to bending and twisting
7.3 Plates subjected to a distributed transverse load
7.4 Combined bending and in-plane loading of a thin rectangular plate
7.5 Bending of thin plates having small initial curvature
7.6 Energy method for the bending of thin plates

8 Torsion (4 hours)

8.1 Definition of torsion.
8.2 Torsion of non-circular solid section
8.3 Saint-Venant’s semi- inverse method
8.4 Torsion of a narrow rectangular cross section
8.5 Torsion of hollow thin wall section

9 Shear Centers for Thin Wall Beam Cross Section (2 hours)

9.1 Shear flow in thin wall beam cross section
9.2 Shear center definition and formulation for channel section

9.3 Composite beams
9.4 Application in aerospace design

10 Structural Instabilities of Thin Plates and Beams (2 hours)

10.1 Buckling of thin plate
10.2 Local instabilities

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. Application of generalized Hooke's law
5. Deflection and slope of statically determinate and indeterminate structures
6. Stresses and deflection in curved beam
7. Bending of thin plates
8. Torsion in non-circular, narrow rectangular and hollow thin wall cylinder
9. Shear centers for thin wall beam cross section
10. Buckling of and thin plates

Practical (22.5 hours)

1. To find the shear center of a given section and compare with the theoretical value
2. To compare measured deflections of various curved members with values calculated by exact and approximate methods
3. To investigate the effect of different notch depths on the energy absorbing characteristics of metal materials at room temperature using the Charpy impact method
4. To inspect the helicopter and identify the mechanical stability
5. To determine the torsional strength of solid shaft and compare them with theoretical value

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 2	5	10
3 and 4	5	10
5 and 6	8	16
7 and 8	8	16
9 and 10	4	8
Total	**30**	**60**

* There may be minor deviation in marks distribution.

References

1. Megson, T.H.G. (2007). Aircraft structures for engineering students. Elsevier.
2. Boresi, A.P., Schmidt, R.J. (2009). Advanced mechanics of materials. John Wiley & Sons.
3. Ugural, A.C., Fenster, S.K. (2003). Advanced strength and applied elasticity. Pearson Education.
4. Popov, E.P. (1998). Engineering mechanics of solids (Latest Edition). Pearson.
5. Hibbeler, R.C. (2010). Mechanics of materials. Prentice Hall.
6. Beer, F.P., Johnston, E.R., DeWolf, J.T., Mazurek, D. (2014). Mechanics of materials. McGraw-Hill.