INTERMEDIATE MECHANICS OF DEFORMABLE BODIES
(58:150/51:151/53:140)

Fall 2003

Instructor: Sharif Rahman, 2140 SC, 335-5679, rahman@engineering.uiowa.edu

Lecture: WF, 3:30 – 4:45 pm at 3315 SC

Office Hours: WF, 1:00 – 2:30 pm at 2140 SC + by appointment

Prerequisites: 57:019

Textbooks:

1. A. C. Ugural and S. K. Fenster, Advanced Strength and Applied Elasticity, 4th Edition, Prentice Hall PTR, Upper Saddle River, New Jersey, 2003. (Available at IMU Bookstore, 335-3179.)
2. S. Rahman, Lecture Notes, 2003. (Available at IMU Bookstore.)

References:

1. A. P. Boresi and K. P. Chong, Elasticity in Engineering Mechanics, 2nd Edition, John Wiley, 2000.
2. S. P. Timoshenko and J. N. Goodier, Theory of Elasticity, 3rd Edition, Mc-Graw Hill, 1970.
3. I. S. Sokolnikoff, Mathematical Theory of Elasticity, 2nd Edition, Mc-Graw Hill, 1956.
4. M. Hetenyi, Beams on Elastic Foundations, The University of Michigan Press, London, 1946.
5. H. L. Langhaar, Energy Methods in Applied Mechanics, John Wiley, 1962.

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TA Office Hours: T,Thu; 10:30 am – 12:00 noon at G130 SC

Course Goals: This course provides students with the opportunity to develop an understanding of the basic scientific principles, techniques, and procedures used to derive the critical load-stress and load-deformation relationships that govern the behavior of deformable bodies in equilibrium, and to apply this basic knowledge in the solution of typical engineering problems arising in the mechanical design and analysis of deformable systems.

Course Outline (30 Meetings)

1. Stress Analysis (4 lectures)

- Introduction, historical perspectives, fundamental assumption of continuity
- Definition of stress
- Components of stress (stress tensor)
- Variation of stress within a body
- Two-dimensional stress at a point
- Principal stresses and Maximum shear stress in 2D
- Mohr's circle for 2D stress
- Three-dimensional stress at a point
- Principal stress in 3D
- Normal and shear stress in oblique plane
- Octahedral stresses
- Mohr's circle for 3D stress
- Boundary conditions

2. Strain Analysis and Constitutive Equations (4 lectures)

- Introduction, displacements in a body
- Deformation
- Strain
- Compatibility equation
- State of strain at a point, transformation of strain, Mohr's circle for strain
- principal strain, maximum shear strain, octahedral strain
- Strain measurements
- Engineering materials
- Hooke's law and Generalized Hooke's law
- Strain energy
- Strain energy in common structural components, strain energy components
- Saint-Venant's principle

3. 2D Problems in Elasticity (3 lectures)

- Introduction, fundamental principles in theory of elasticity
- Plane stress and plane strain
- Stress function
- Solution of elasticity problems
- Basic relations in polar coordinates
- Stresses due to concentrated loads
- Stress concentration
- Thermal stresses
- Contact stresses

4. Material Failure Criteria (2 lectures)

- Introduction
- Yielding failure, fracture failure
- Yield criteria for pressure-independent material
- Maximum shear stress theory
- Maximum distortion energy theory
- Octahedral shear stress theory
- Comparison of yielding theories
- Maximum principal stress theory
- Yield criteria for pressure-dependent material
- Coulomb-Mohr theory
- Drucker-Prager theory
- Failure criteria for metal fatigue
- Fatigue life under combined loads
- Impact and dynamic loads
- Dynamic and thermal effects

5. Bending of Beams (5 lectures)

- Introduction
- Pure bending of beams of symmetrical cross-section
- Pure bending of beams of asymmetrical cross-section
- Bending of cantilever of narrow section
- Bending of simply supported narrow beam
- Elementary theory of bending
- Bending and shear stresses
- Effect of transverse normal stress
- Statically indeterminate systems
- Energy method for deflections
- Exact solution
- Winkler's theory

6. Torsion of Bars (2 lectures)

- Introduction
- Elementary theory of torsion of circular bars
- General solution of torsion problem
- Prandtl's membrane analogy
- Torsion of thin-walled members of open cross-section
- Torsion of multiply connected thin-walled sections
- Fluid flow analogy
- Torsion of restrained thin-walled members of open cross-section

7. Axisymmetric Problems (2 lectures)

- Introduction
- Thick-walled cylinders
- Maximum tangential stress
- Application of failure theories
- Compound cylinders
- Rotating disks of constant thickness
- Rotating disks of variable thickness
- Rotating disks of uniform stress
- Thermal stresses in thin disks

8. Beams on Elastic Foundation (2 lectures)

- Introduction
- Infinite beams
- Semi-infinite beams
- Finite beams
- Beams supported by equally spaced elastic elements
- Simplified solutions for relatively stiff beams
- Applications

9. Energy Methods (2 lectures)

- Introduction
- Work done in deformation
- Reciprocity theorem
- Castigliano's theorem
- Unit or dummy load method
- Crotti-Engesser Theorem
- Statically Indeterminate Systems
- Principle of virtual work
- Trigonometric series
- Rayleigh-Ritz method

+ **[1 Midterm Examination]**
+ **[2 Review Sessions]**
+ **[1 Class Discussion]**