

**Department of Mechanical Engineering**  
**ME315– Stress Analysis**  
(Required)

**Catalog Description: ME 315 (3-0-3)**

Problems related to mechanical design. Topics include two-dimensional elasticity, transformation of stress and strain, plane stress problems, axisymmetric members, buckling criteria and failure theories.

**Prerequisites:** ME 215 – Engineering Materials and Processes  
Mech 237 – Strength of Materials  
Math 222 – Differential Equations

**Textbook(s) Materials Required:**

1. A. Ugural and S. Fenster, Advanced Strength and Applied Elasticity, 4<sup>th</sup> Ed., Prentice Hall, 2003

**Reference(s) (Not Required):**

1. Power-point lectures notes e-mailed to students

**Course Supervisor: Dr. A. Rosato**

**Pre-requisite by topic:**

1. Calculus
2. Ordinary differential equations
3. Statics
4. Engineering mechanics / Strength of materials
5. Properties of engineering materials

**Course Objectives <sup>1</sup>:**

1. To develop the student's understanding of the foundations of stress and strain (A, B, C)
2. To develop the student's understanding of the displacement field, Hooke's constitutive law, strain-displacement relations, and the equilibrium and compatibility equations (A, B, C)
3. To develop student's skills in analyzing stress problems through the application of the basic laws and equations (A, B, C, E)
4. To provide the student with knowledge and proper use of failure theories to a variety of loading situations (A, B, C, D, E)
5. To provide the student with knowledge of axisymmetric problems and important applications (A,B,C,D,E)
6. To provide the student the ability to analyze indeterminate structures (A, B, C, D) using Castigliano's theorems (A, B, C, E)

**Topics <sup>2</sup>:**

1. Introduction, stress tensor; Equilibrium, transformation of stresses, principal stresses (3hrs)
2. Mohr's circle for stress, Three-dimensional stresses (3hrs)
3. Normal and shearing strains, strain tensor, compatibility, Transformation of strains (3hrs)

4. Stress-strain relations (1.5hrs)
5. Strain energy, St. Venant's principle (1.5hrs)
6. Plane stress, plane strain, Airy stress function (6hrs)
7. Stress and strain in polar coordinates, Stress concentration (3hrs)
8. Axisymmetrically loaded members, Shrink fit, composite cylinders, rotating disks (3hrs)
9. Theories of Failure (3 hrs)
10. Energy methods, Castigliano's Theorem, Virtual Work (3 hrs)
11. Elastic Stability of Columns (3 hrs)

**Evaluation Method:**

1. In-class Exams
2. Participation in class
3. Final Exam

**Schedule:** Lecture Recitation: 3 hours, per week

**Professional Component:** Engineering Science

**Program Objectives Addressed:** A, B, C, D, E

**Course Outcomes :**

**Objective 1**

- 1.1 Students will demonstrate an understanding of the stress tensor. (1,2,3) (a,c,e,h,k)
- 1.2 Students will demonstrate an understanding of the stress (strain) tensor transformation equations and their relationship to Mohr's circle. (1,2,3) (a,c,e,h,k)
- 1.3 Students will demonstrate an understanding that symmetry of the stress tensor is a consequence of conservation of angular momentum. (1,2,3) (a,e,k)
- 1.4 Students will learn how to obtain the Cartesian and cylindrical forms of the strain-displacement relations. (a,c,e,h,k) (1,2,3)

**Objective 2**

- 2.1 Students will demonstrate an understanding of the stress (strain) tensor transformation equations and their relationship to Mohr's circle. (1,2,3) (a,e,h,k)
- 2.2 Students will demonstrate an ability to develop the Mohr's circle for different loading conditions and to compute principal values and directions from the circle. (1,2,3) (a,e,h,k)
- 2.3 Students will demonstrate an ability to compute principal values and directions by solving the appropriate eigenvalue problem. (1,2,3) (a,e,h,k)

**Objective 3**

- 3.1 Students will demonstrate an understanding of the compatibility equations by solving problems. (1,2,3) (a,e,h,k)

**Objective 4**

- 4.1 Students will demonstrate an understanding of plane stress /plane strain problems.(1,2,3) (a,e,h,k)
- 4.2 Students will demonstrate an understanding of the Airy stress function (1,2,3) (a,e,h,k)
- 4.3 Students will demonstrate an understanding of Airy's stress functions for axisymmetric bodies.(1,2,3) (a,e,h,k)
- 4.4 Students will solve problems for thick-walled cylinders, a plate with a circular hole, shrink-fits and rotating disks. (1,2,3) (a,c,e,h,k)

### **Objective 5**

5.1 Students will demonstrate an understanding of strain energy. (1,2,3) (a,e,h,k)

5.2 Students will demonstrate an understanding of the failure theories. (1,2,3) (a,c,e,h,k)

5.3 Students will apply failure theories to various problems (1,2,3) (a,c,e,h,k)

### **Objective 6**

6.1 Students will demonstrate an understanding of deformation work, Betti's reciprocity theorem and Castigliano's theorem. (1,2,3) (a,e,h,k)

6.2 Students will apply Castigliano's theory to statically indeterminate problems. (1,2,3) (a,c,e,h,k)

6.3 Students will demonstrate an understanding of elastic stability related to column buckling. (1,2,3) (a,c,e,h,k)

**Prepared by: A. Rosato**

**Date: September 25, 2006**

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<sup>1</sup>

Capital Letters in parenthesis refer to the Program Objectives of the Mechanical Engineering

Department. Listed in Sec 2 d Tables B-2-9, B-2-12. Table B-2-8 links Program Objectives with the ABET a-k Criterion.

<sup>2</sup>

Topic numbers in parenthesis refer to lecture hours. (three hours is equivalent to 1 week)

<sup>3</sup>

Outcome numbers in parenthesis refer to evaluation methods used to assess the student performance. Lower case letters in parenthesis refer to ABET a-k outcomes.