MENG S280: Strength and Deformation of Machine Elements

Credits and contact hours: 1.0 credits, 6.75 hours/week

Ron Adrezin, Ph.D., P.E., Ronald.Adrezin@yale.edu

This is a summer course, so each class session represents 1.5 weeks of classes during a traditional semester. Expect 6 to 8 hours of coursework outside of each class session. Pre-reading of the text is required, and homework will be assigned each class and due at the start of the subsequent class. If you have the time to dedicate, this class may be for you.

Course description: Elements of statics; mechanical behavior of materials; equilibrium equations, strains and displacements, and stress-strain relations. Elementary applications to trusses, bending of beams, pressure vessels, and torsion of bars.

Goals: The main goal of this course is to learn how to analyze whether structures can support different types of loads without failure. Applications include the analysis and design of structures such as buildings, vehicles, engines, machinery, robots, and biomedical devices. This course is recommended to be taken early in the series of core Mechanical Engineering courses (usually sophomore year) since the concepts of stress and strain form the foundation of fluid and solid mechanics. The concepts presented in this course and the strategies to solve problems in this course should prove invaluable for future design projects. We will build up to this goal throughout the semester by achieving the following objectives:

- Develop a problem-solving strategy to present your professional work in a neat, thorough, and logical manner.
- Draw FBD's of 2D/3D particles and solve for unknowns using equilibrium equations.
- Find the moment of a force in 2D and 3D using vector product
- Determine external support reactions and internal forces in any structure
- Understand and determine the centroid (first moment) and second moment of area
- Apply the laws of equilibrium to solve for the shear and moment diagrams using FBD' with equilibrium equations and graphical approaches.
- Recognize the qualitative features of the stresses, strains, material properties and area properties associated with axial loading, bending, shear, and torsion.
- Distinguish between normal and shear stresses as well as shear strains.
- Solve for stresses in a structural component due to axial, shear, bending, torsion, and thermal acting individually or in combination.
- Solve for deformation of a structural component due to axial load, bending, torsion, and thermal loads acting individually or in combination.
- Calculate principal stresses and maximum in-plane shear stress.
- Calculate beam deflections.
- Analyze columns for compression and buckling failure.

Prerequisites: PHYS 180 or 200 and MATH 115. This course builds heavily on the concepts of Newtonian mechanics and makes limited use of various mathematical techniques including dot products, cross products, multi-variable integrals, and differential equations. If you have not taken these courses yet, contact the instructor and we may be able to help.

Textbook Required: "Statics and Mechanics of Materials", 3rd edition, by Beer, Johnston, DeWolf, and Mazurek. McGraw-Hill Education, Copyright 2021.You will need this book for the course readings, example problems, homework problems, and reference for future engineering work beyond this course. You can purchase a digital or hard copy. This text will be highly useful in your collection, so I recommend purchasing rather than renting.

Attendance Policy: Attendance in mandatory for all summer courses.

Grading:

Homework – 9 total	55%
Quizzes – 5 to 7 total	35%
In Class Activities – 2 total	10%

Academic Integrity: Any form of cheating (including but not limited to copying solutions, submitting someone else's work as your own, and plagiarism) attempting to manipulate the grading process, or falsifying information to be excused from an assignment — is a waste of your opportunity to learn, and a waste of educational resources. It will result in failure of the assignment, a penalty to your conduct grade, or the entire course, depending on the severity of the situation.

Tentative Schedule (Subject to Change)

Class session	Topic	In-Class	Due
1	Chapter 1: Intro and overall system of units and problem solving approach Chapter 2: 2D particle Equil		
2	Chapter 3: 3D particle Equil, Moments due to forces: 2D, 3D, and couples. Used vector products.	In Class Activity 1	HW Set 1 (on Ch 2)
3	Chapter 4:2D rigid body equilibrium; 3D rigid Body Equil; and Introduced Friction forces.	In Class Activity 2	HW Set 2 (on Ch 3)
4	Chapter 6: Trusses (particle and section), Frames, and Machines	Quiz 1 (on Ch 2)	HW Set 3 (on Ch 4)
5	Chapter 12: Distributed forces, Internal forces in beams, drawing V/M diagrams	Quiz 2 (on Ch 3)	HW Set 4 (on Ch 6)
6	Chapter 5: Centroids – integration and composite cross-sections Chapter 7: Moment of Inertia – integration and composite sections	Quiz 3 (on Ch 4)	HW Set 5 (on Ch 12)
7	Chapter 8: Engineering Axial	Quiz 4 (on Ch 6)	HW Set 6 (on Ch 5, 7)

	Stresses Chapter 9: Strains, stress-strain relationship, material properties, Temperature changes, axially indeterminate members, St.-Venant, and stress concentrations.		
8	Chapter 10: Torsion Chapter 11: Pure Bending	Quiz 5 (on Ch 12)	HW Set 7 (on Ch 8, 9)
9	Chapter 13: Shear stresses in beams	Quiz 6 (on Ch 5 and 7)	HW Set 8 (on Ch 10, 11)
10	Chapter 14: Transformation of Stresses and Mohr Circle Chapter 15: Beam Deflection	Quiz 7 (on Ch 8 and 9)	HW Set 9 (on Ch 13)