## Mechanics of Materials

Lecture 1 - Equilibrium

Dr. Nicholas Smith

Wichita State University, Department of Aerospace Engineering

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## schedule

- 16 Aug - Introduction, Equilibrium
- 18 Aug - Stress
- 23 Aug - Strain, Homework 1 Due
- 25 Aug - Mechanical Properties

- introduction
- syllabus
- mechanics
- equilibrium

## introduction

## about me

## education

- B.S. in Mechanical Engineering from Brigham Young University
  - Worked with ATK to develop tab-less gripping system for tensile testing composite tow specimens
  - Needed to align the specimen, as well as grip it without causing a stress concentration

## education

- M.S. and Ph.D. from School of Aeronautics and
  Astronautics at Purdue University
  - Worked with Boeing to simulate mold flows
  - First ever mold simulation with anisotropic viscosity

## research



**Figure 1:** picture of chopped carbon fiber prepreg

**Figure 2:** picture of lamborghini symbol made from compression molded chopped carbon fiber
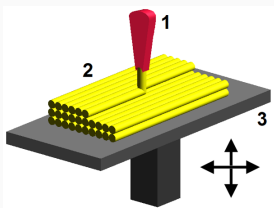
**Figure 3:** picture illustrating the fused deposition modeling 3D printing process, where plastic filament is melted and deposited next to other filament, and fuses together

- Composites are being used in 3D printing now
- Printing patterns are optimized for isotropic materials
- Sometimes composites hurt more than they help when not utilized properly

- Name
- One interesting thing to remember you by

**syllabus and schedule**

## course textbook

- R.C. Hibbeler - Mechanics of Materials
- I have changed how I do homework, and MasteringEngineering will NOT be used

## office hours

- We need to be careful about social distancing (avoid congregating in the main AE office)
- I will send out a Doodle to schedule
- Office appointments can also be scheduled via e-mail

## tentative course outline

- Section 1 - stress, strain, mechanical properties
- Ch 1 - Stress (16 Aug)
- Ch 2 - Strain (18 Aug)
- Ch 3 - Mechanical Properties (23 Aug)
- Exam 1 (1 Sep)
- Project 1 (3 Sep)

## tentative course outline

- Section 2 - loading
- Ch 4 - Axial Load (8 Sep)
- Ch 5 - Torsion (13 Sep)
- Ch 6 - Bending (20 Sep)
- Ch 7 - Transverse Shear (27 Sep)
- Exam 2 (6 Oct)
- Project 2 (8 Oct)

## tentative course outline

- Section 3 - beams, shafts, combined loading
- Ch 8 - Combined Loading (13 Oct)
- Ch 9 - Stress Transformation (18 Oct)
- Ch 10 - Strain Transformation (20 Oct)
- Ch 12 - Deflection of Beams and Shafts (1 Nov)
- Exam 3 (10 Nov)
- Project 3 (12 Nov)

## tentative course outline

- Section 4 - buckling, stress concentration
- Ch 4.7, 5.8, 6.9 - Stress concentration (8 Nov)
- Ch 13 - Buckling (15 Nov)
- Final Exam (comprehensive) (6 Dec, 11:00 - 12:50)

## grades

- Grade breakdown
- Homework 5%
- Exam 1 15%
- Exam 2 15%
- Exam 3 15%
- Final Exam 20%

- Project 1 10%
- Project 2 10%
- Project 3 10%

## grades

- Follow a traditional grading scale
- (80% B-, 83% B, 87% B+, etc.)

## curve

- I do NOT curve final grades
- Instead, each individual exam is curved on a best-fit linear scale
- This scale is somewhat subjective, best score is mapped to 100, I pick one other score to map that I feel is representative of a C or a B
- The end goal of this curve is to get a standard deviation close to 10% and a class average representative of the performance on the exam, usually between a C and a B

## class expectations

- Consider the cost (to you or others) of your being in class
- I ask that you refrain from distracting behaviors during class
- When you have something more important than class to take care of, please take care of it outside of class
- Chegg

## homework

- In general, homework assignments will be due every Friday by midnight
- Homework will be submitted online via Blackboard, half the homework credit will be granted for completion.
- Late homework will not be accepted

## self-grade

- Your homework will be self-graded, your self-grading will generally be due the week after the original assignment
- Homework solutions will be posted to Blackboard, and the remaining half of the homework credit will be assigned after you complete (and submit) your self-grade.
- You do not lose credit for incorrect answers, but your self-grade should explain the differences between your answer and the correct solution.
- Some problems will be somewhat open-ended and there may not be a "correct" answer, so consider that when looking at what is different between your solution and mine

# mechanics

## mechanics

- Generally subdivided into three branches
- Rigid-body mechanics
- Deformable-body mechanics
- Fluid mechanics

- Statics - bodies in equilibrium (rest or constant velocity)
- Dynamics - bodies under accelerated motion ($F = ma$)

# equilibrium of a deformable body

## loads

- Surface loads act on the surface of a body, can be either concentrated forces or distributed loads
- Body forces are developed inside a body, some examples are gravity or electromagnetic fields

## support reactions

- In general, if a support prevents translation in a given direction, then a reaction force must be developed in that direction
- Similarly, if a support prevents rotation about an axis, then a couple moment must be developed about that axis

## equilibrium

- For a body to be in equilibrium the balance of forces and the balance of moments must both be zero

$$\sum F_i = 0$$

$$\sum M_i = 0$$

- For 2D problems, this reduces to

$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M_O = 0$$

## internal resultant loadings

- We use statics to find resultant loadings acting within a body
- This is done using the method of sections

## internal resultant loadings

- Normal Force, N - acts perpendicular to an area
- Shear Force, V - lies in the plane of an area, causes two segments to slide over one another
- Torsional Moment, T - tendency to twist about an axis perpendicular to an area
- Bending Moment, M - tendency to bend the body about an axis lying within the plane of the area
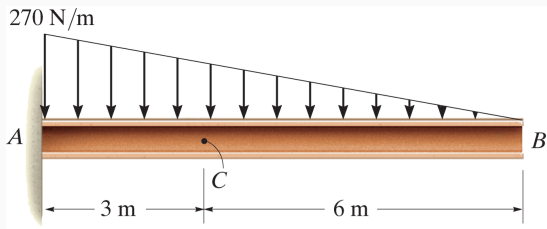
## planar problems

- In planar problems, where all forces lie in the same plane, we only have
- Normal Force
- Shear Force
- Bending Moment

- Support reactions
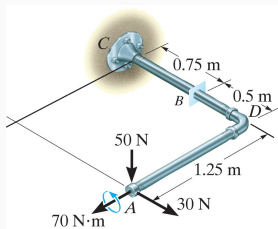- Free body diagram
- Equations of equilibrium

**examples**

## example 1.1



270 N/m

A                                                                    B

|← 3 m →|←      6 m      →|

C

Find the internal forces at point C.

## example 1.4



C
0.75 m
B
0.5 m
D
50 N
1.25 m
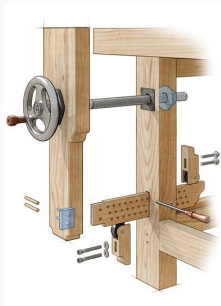A      30 N
70 N·m

Find the internal forces at point D.

## example

Compare three cases for a traditional leg vise for use on
Dr. Smith's workbench - No bottom support - Standard
pin-board - St. Peter's Cross - NOTE: Assume the force applied
at the vise is the same in all cases (around 2000 lb if you want
a number), that the leg vise is 3 ft. tall and the screw is 1 ft.
down from the top.

## traditional pin-board

# St. Peter's Cross