Mechanics of Materials

Lecture 1 - Equilibrium

Dr. Nicholas Smith

Wichita State University, Department of Aerospace Engineering

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schedule

- 18 Aug - Introduction, Equilibrium
- 20 Aug - Stress
- 25 Aug - Strain, Homework 1 Due
- 27 Aug - Mechanical Properties

outline

- introduction
- syllabus
- mechanics
- equilibrium

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

research

Figure 2: picture of lamborghini symbol made from compression molded chopped carbon fiber

research

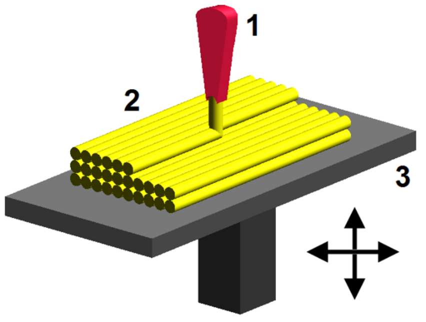


Figure 3: picture illustrating the fused deposition modeling 3D printing process, where plastic filament is melted and deposited next to other filament, and fuses together

introductions

- Name
- One interesting thing to remember you by

course textbook

- R.C. Hibbeler - Mechanics of Materials
- This semester I am changing how I do homework, and MasteringEngineering will NOT be used

office hours

- I will e-mail everyone in the course a Doodle link we can use to find the optimal office hours
- Let me know if you do not receive the e-mail, you may need to update your information in Blackboard
- If the regular office hours do not work for your schedule, send me an e-mail and we can work out a time to meet

tentative course outline

- Section 1 - stress, strain, mechanical properties
  - Ch 1 - Stress (18 Aug)
  - Ch 2 - Strain (20 Aug)
  - Ch 3 - Mechanical Properties (25 Aug)
  - Project 1 (29 Aug)
  - Exam 1 (1 Sep)

tentative course outline

- Section 2 - loading
  - Ch 4 - Axial Load (8 Sep)
  - Ch 5 - Torsion (15 Sep)
  - Ch 6 - Bending (22 Sep)
  - Ch 7 - Transverse Shear (29 Sep)
  - Project 2 (2 Oct)
  - Exam 2 (5 Oct)

tentative course outline

- Section 3 - beams, shafts, combined loading
  - Ch 8 - Combined Loading (13 Oct)
  - Ch 9 - Stress Transformation (20 Oct)
  - Ch 10 - Strain Transformation (27 Oct)
  - Ch 12 - Deflection of Beams and Shafts (3 Nov)
  - Project 3 (13 Nov)
  - Exam 3 (16 Nov)

tentative course outline

- Section 4 - buckling, stress concentration
  - Ch 4.7, 5.8, 6.9 - Stress concentration (1 Dec)
  - Ch 13 - Buckling (3 Dec)
  - Final Exam (comprehensive) (7 Dec)

grades

- Grade breakdown
    - Homework 5%
    - Exam 1 10%
    - Exam 2 10%
    - Exam 3 10%
    - Final Exam 20%
    - Project 1 15%
    - Project 2 15%
    - Project 3 15%

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

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

rigid-body mechanics

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

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

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

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

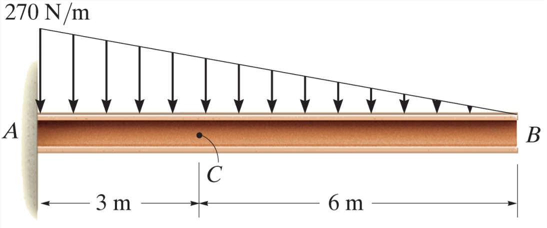
planar problems

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

summary

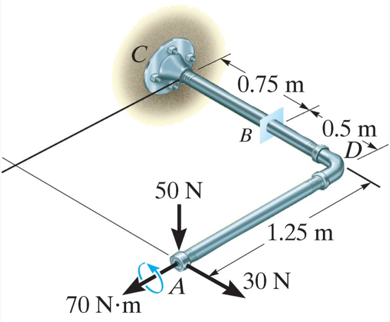
- Support reactions
- Free body diagram
- Equations of equilibrium

example 1.1



Find the internal forces at point C.

example 1.4

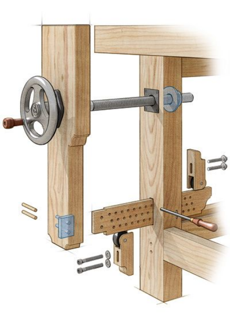


Find the internal forces at point D.

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