AE333

Mechanics of Materials

Lecture 8 - Axial Load

Dr. Nicholas Smith
Wichita State University, Department of Aerospace Engineering

February 13, 2019

schedule

- 13 Feb - Axial Load
- 15 Feb - Torsion
- 18 Feb - Torsion, HW3 Due
- 20 Feb - Bending

outline

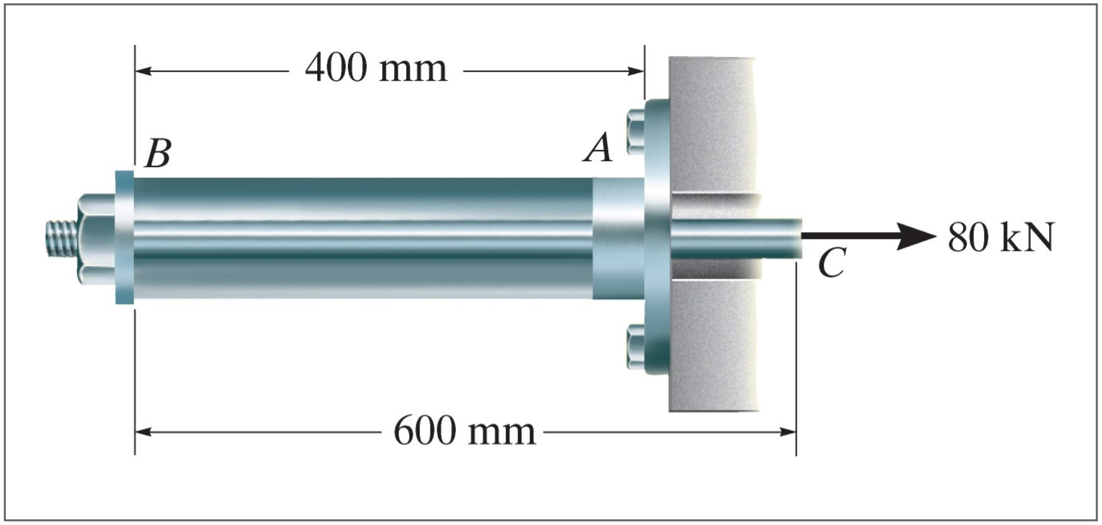
- review
- superposition
- statically indeterminate
- force method
- thermal stress

review

review

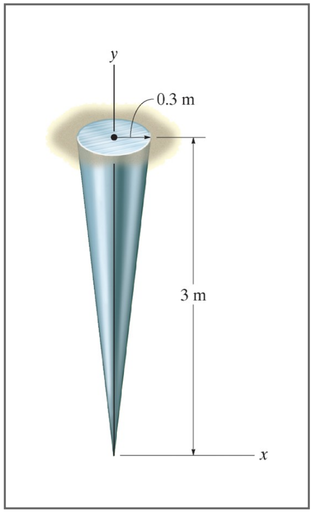
- What is Saint Venant's Principle?
- How do we find axial deformation, in general?

example 4.2



A steel rod with a 10mm diameter is attached to a rigid collar passing through an aluminum tube with cross-sectional area of 400 mm². Find the displacement at C if $E_{st} = 200$ GPa and $E_{al} = 70$ GPa.

example 4.4



The cone shown has a specific weight of $\gamma = 6\ \text{kN/m}^3$ and $E = 9$ GPa. Determine how far the end is displaced due to gravity.

superposition

superposition

- Some problems are too complicated to solve all at once
- Instead, we break them up into two simpler problems
- Each "sub-problem" must still satisfy equilibrium
- Problem must be linear and the deformation should be small enough that it does not cause moment-equilibrium isssues

statically indeterminate

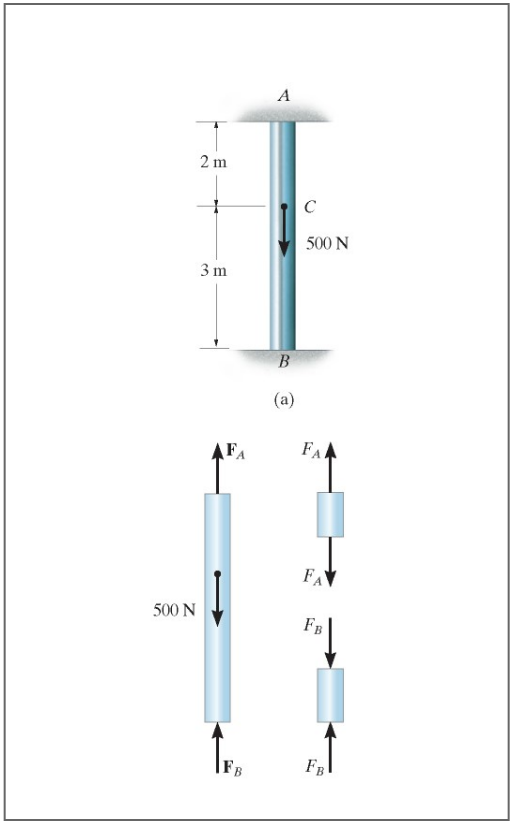
statically indeterminate

- There are many problems that are at least slightly over-constrained
- While this is common engineering practice, it creates too many variables for statics analysis
- These problems are called "statically indeterminate"

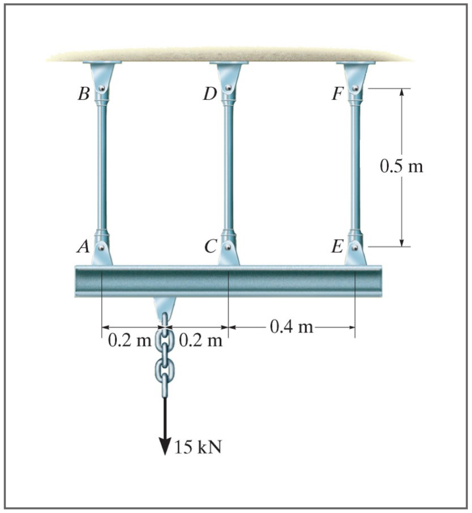
statically indeterminate

- One extra equation we can use is called "compatibility" or the "kinematic condition"
- We know that at the displacement must be equal on both sides of any arbitrary section we make in a member
- We can separate a member into two parts, then use compatibility to relate the two unknown forces

statically indeterminate



example 4.7



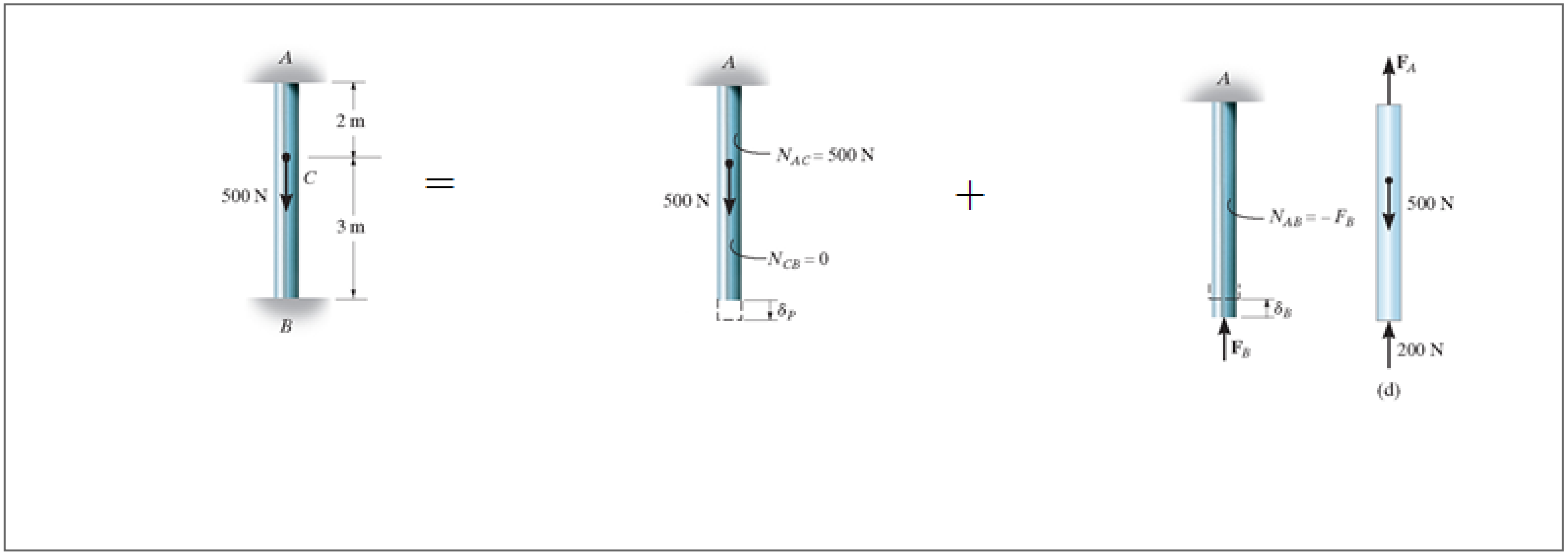
Assuming the bottom bar is rigid, find the force developed in each bar. AB and EF have cross-sectional areas of 50 mm^2 while CD has a cross-sectional area of 30 mm^2.

force method

force method

- One way to solve statically indeterminate problems is using the principle of superposition
- We choose one redundant support and remove it
- We then add it back as a force separately (without the other forces in the problem)

force method



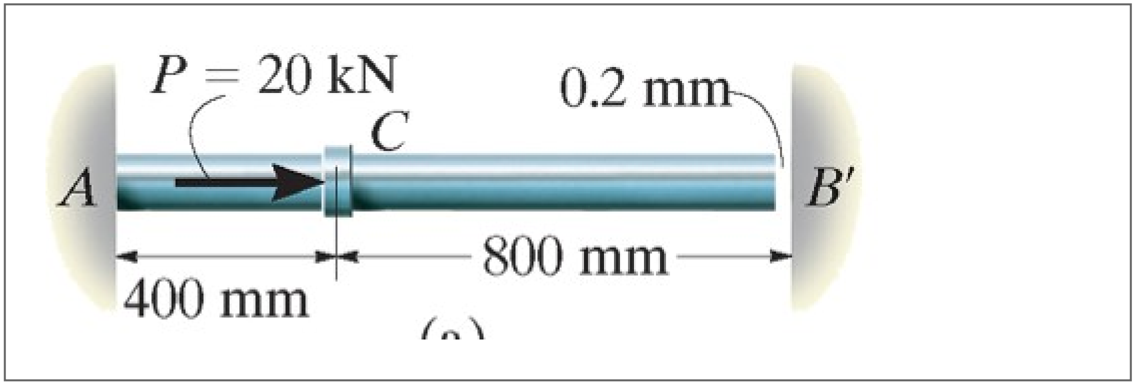
force method

- We connect the two problems by requiring that the displacement in both frames adds to 0 to meet the support requirements
- This is referred to as the equation of compatibility

procedure

- Choose one support as redundant, write the equation of compatibility
- Express the external load and redundant displacements in terms of load-displacement relationship
- Draw free body diagrams and use the equations of equilibrium to solve

example 4.9



The steel rod shown has a diamater of 10 mm. Determine the reactions at A and B'.

thermal stress

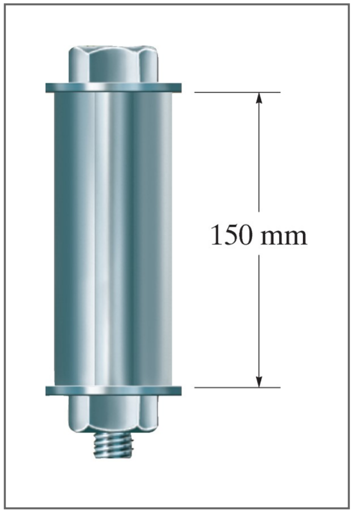
thermal stress

- A change in temperature cases a material to either expand or contract
- For most materials this is linear and can be described using the coefficient of linear expansion
  $\delta_T = \alpha \Delta T L$

thermal stress

- When a body is free to expand, the deformation can be readily calculated using
- If it is not free to expand, however, thermal stresses develop
- We can use the force method described previously to find the thermal stresses developed

example 4.12



An aluminum tube with cross-section of 600 mm^2 is used as a sleeve for a steel bolt with cross-sectional area of 400 mm^2. When T=15 degrees Celsius there is negligible force and a snug fit, find the force in the bolt and sleeve when T=80 degrees Celsius.