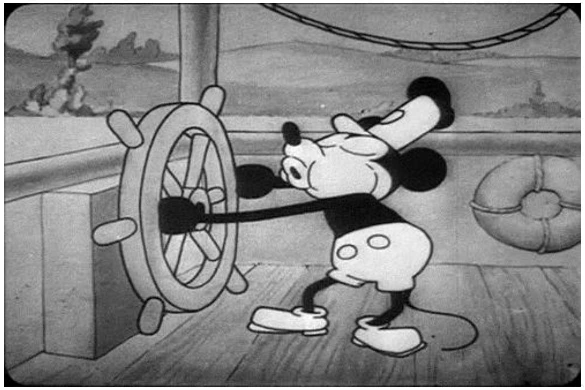
WORCESTER POLYTECHNIC INSTITUTE
MECHANICAL ENGINEERING DEPARTMENT

STRESS ANALYSIS
ES-2502, B'2025

We will get started soon...



10 November 2025

WORCESTER POLYTECHNIC INSTITUTE
MECHANICAL ENGINEERING DEPARTMENT

STRESS ANALYSIS
ES-2502, B'2025

Lecture 12:
Unit 6: tension/compression of slender longitudinal bars:
statically indeterminate & thermal stresses

10 November 2025

General information

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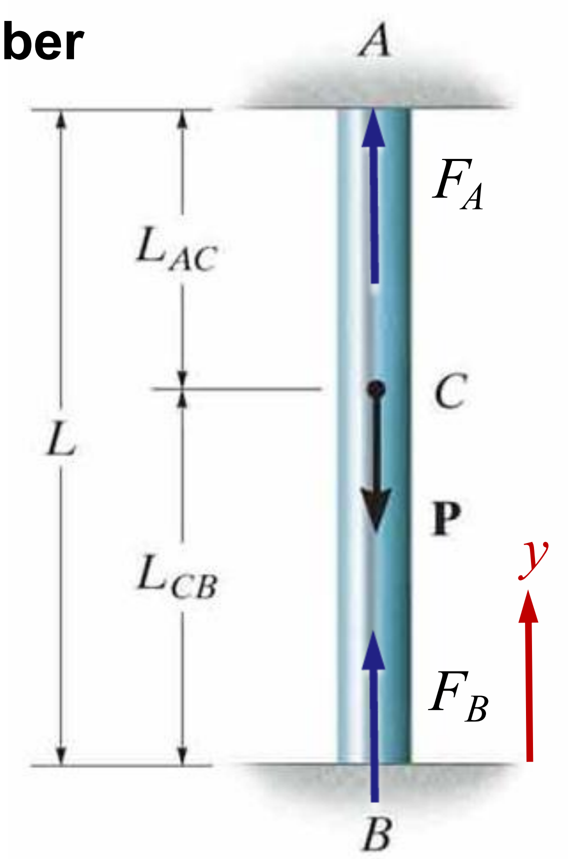
Statically indeterminate axially loaded member

Axially loaded member



In this case, only one equilibrium equation:

$$+\uparrow \quad \sum F_y = 0\,;$$

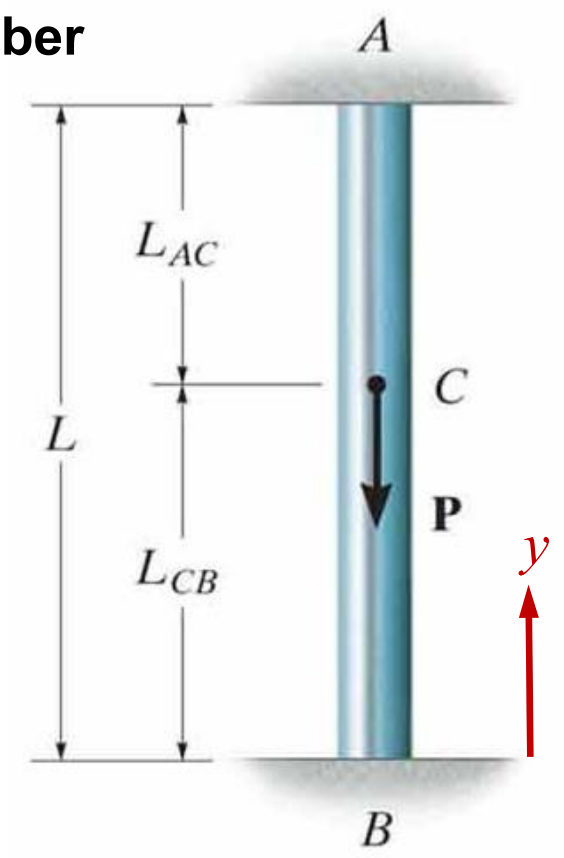
$$F_B + F_A - P = 0 \qquad (1)$$

→ Statically indeterminate problem

Need additional equations!!

Statically indeterminate axially loaded member

Axially loaded member



Additional equations are obtained by applying:

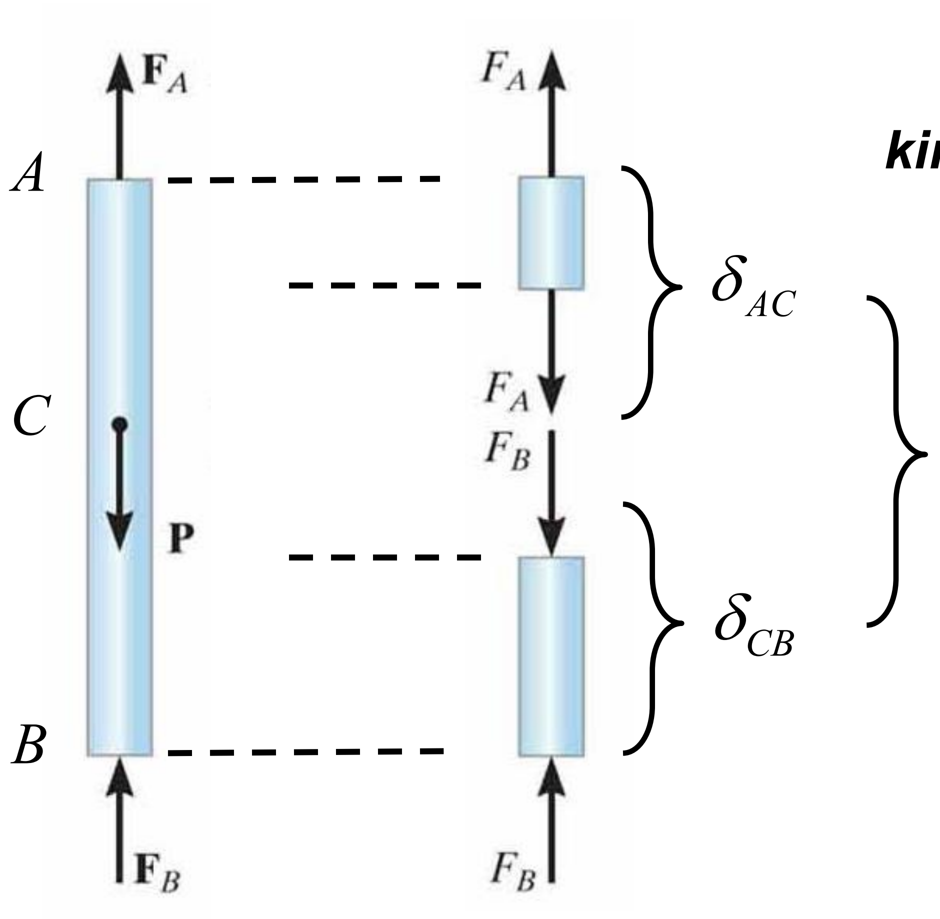
Compatibility or kinematic equations

↑

Load-displacement equations

$$\delta_{A/B} = 0$$

Statically indeterminate axially loaded member

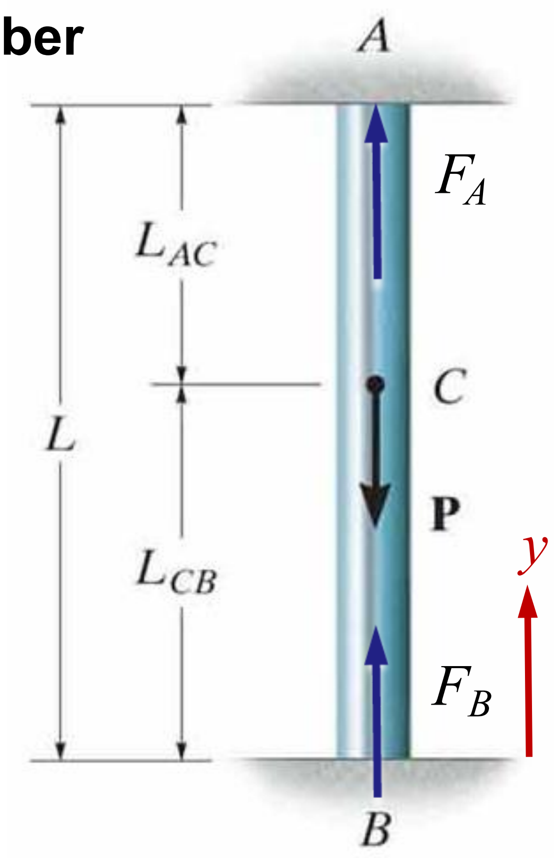


***Compatibility or kinematic equations*:**

$$\frac{F_A\,L_{AC}}{A\,E} - \frac{F_B\,L_{CB}}{A\,E} = 0 \qquad (2)$$

Statically indeterminate axially loaded member

Axially loaded member



Forces ***are obtained by solving system of equations*:**

Equilibrium

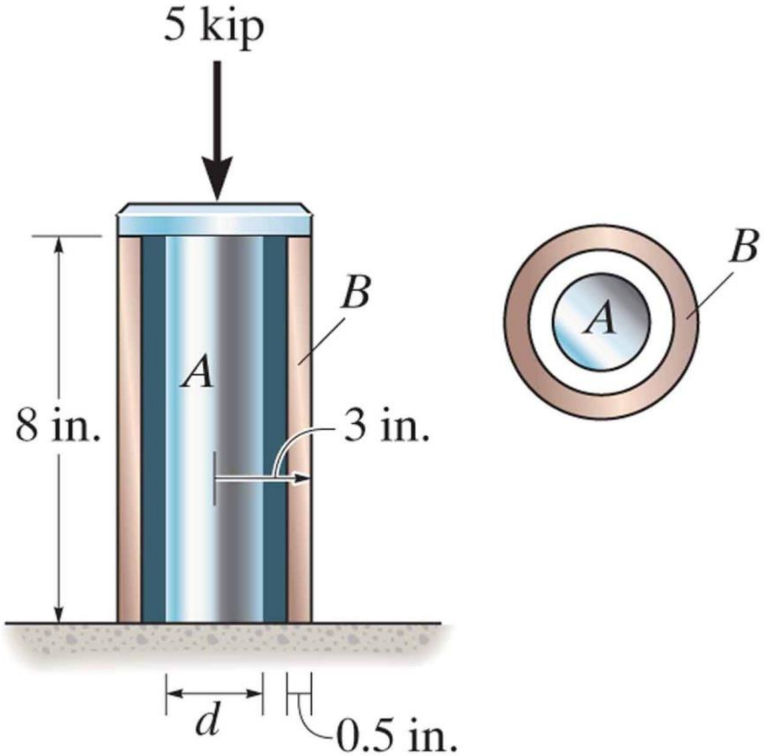
$$F_B + F_A - P = 0 \quad (1)$$

$$\frac{F_A\, L_{AC}}{A\, E} - \frac{F_B\, L_{CB}}{A\, E} = 0 \quad (2)$$

Compatibility

Axial load: example F

The 304 stainless steel post A has a diameter of $d = 2$ in and is surrounded by a red brass C83400 tube B. Both rest on the rigid surface. If a force of 5 kip is applied to the rigid cap, determine the average normal stresses developed in the post and the tube.

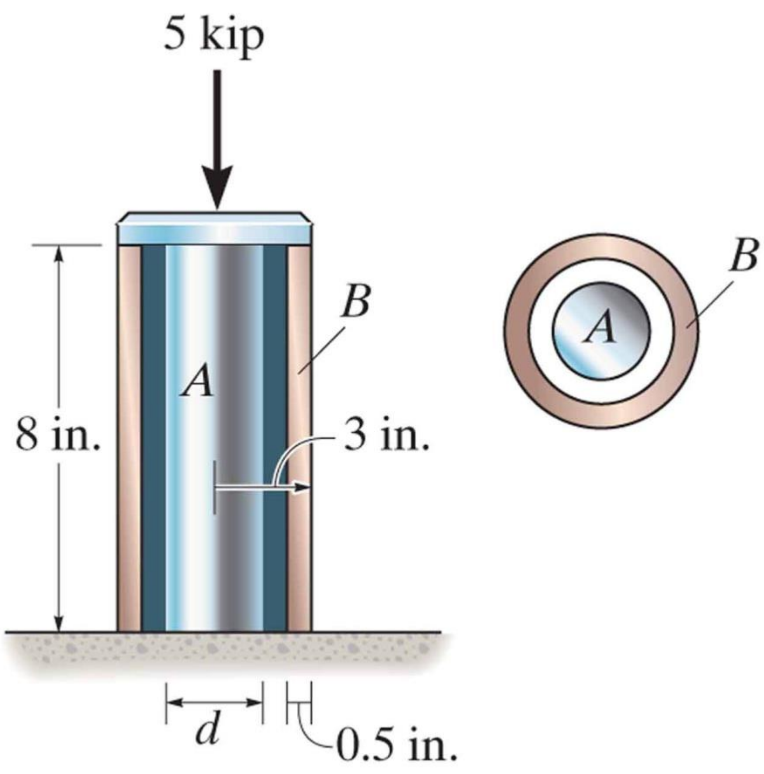


Approach:

1) Apply equilibrium equations
2) Apply compatibility equations
3) Solve for stresses

Axial load: example G

The 304 stainless steel post A is surrounded by a red brass C83400 tube B. Both rest on the rigid surface. If a force of $5\ \mathrm{kip}$ is applied to the rigid cap, determine the required diameter d of the steel post so that the load is shared equally between the post and tube.

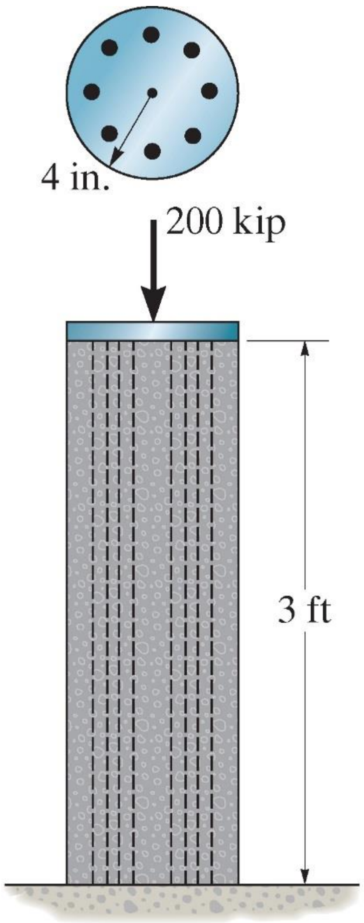


Approach:

1) Apply equilibrium equations
2) Apply compatibility equations
3) Solve for diameter

Axial load: example H

The column is constructed from high-strength concrete and eight A992 steel reinforced rods. If the column is subjected to an axial force of 200-kip, determine the average normal stress in the concrete and in each rod. Each rod has a diameter of 1-inch.



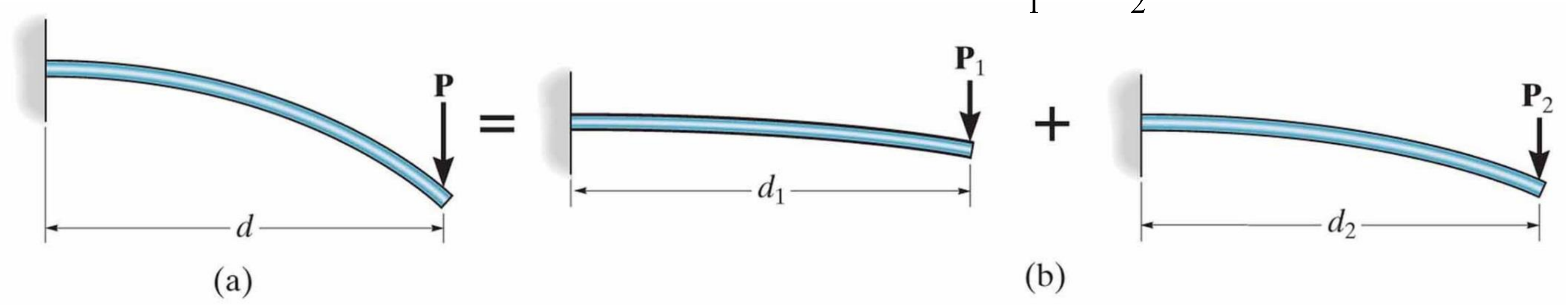
Approach:

1) Apply equilibrium equations
2) Apply compatibility equations
3) Solve for forces/ stresses

Principle of superposition

Applied when a component is subjected to complicated loading conditions → break a complex problem into series of simple problems

$$\mathbf{P} = \mathbf{P}_1 + \mathbf{P}_2$$



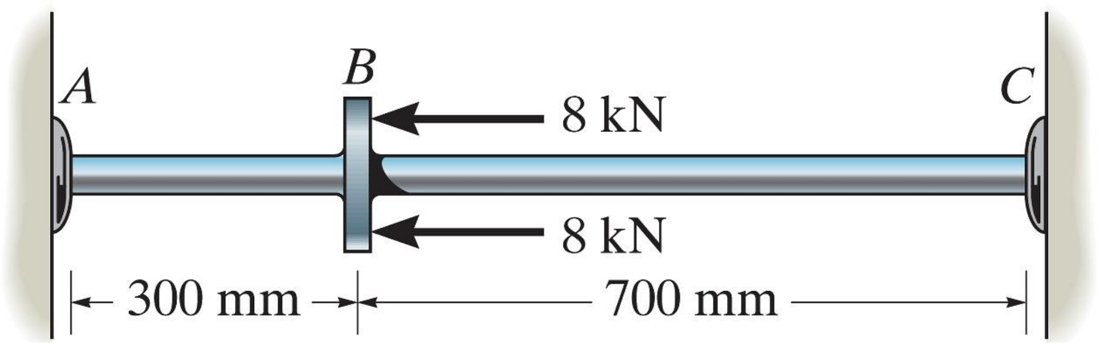
Can only be applied for:

(a) small deformations;

(b) deformations in the elastic (linear) range of the $\sigma-\varepsilon$ diagram

Axial load: example I

The A-36 steel pipe has an outer radius of 20 mm and an inner radius of 15 mm. If it fits snugly between the fixed walls before it is loaded, determine the reactions at the walls when it is subjected to the load shown.

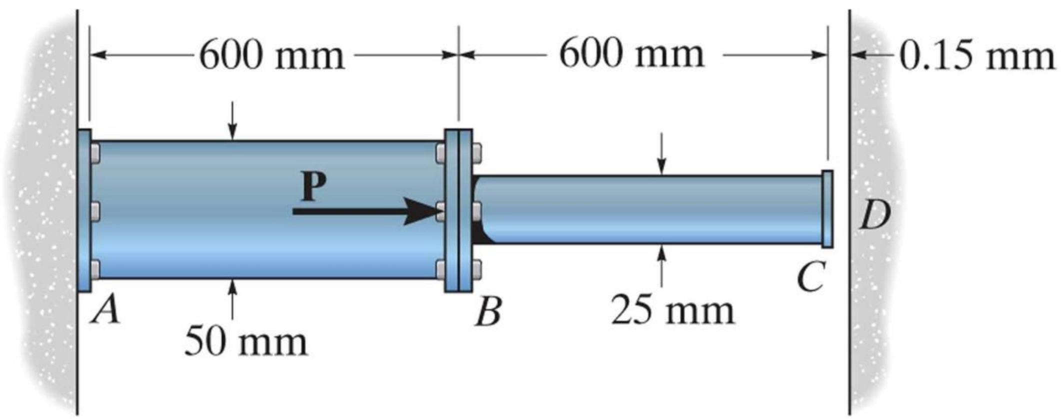


Approach:

1) Apply equilibrium equations
2) Apply compatibility equations
3) Solve for forces

Axial load: example J

If the gap between C and the rigid wall at D is initially $0.15\ \text{mm}$, determine the support reactions at A and D when the force $P = 200\ \text{kN}$ is applied. The assembly is made of solid A36 steel cylinders.

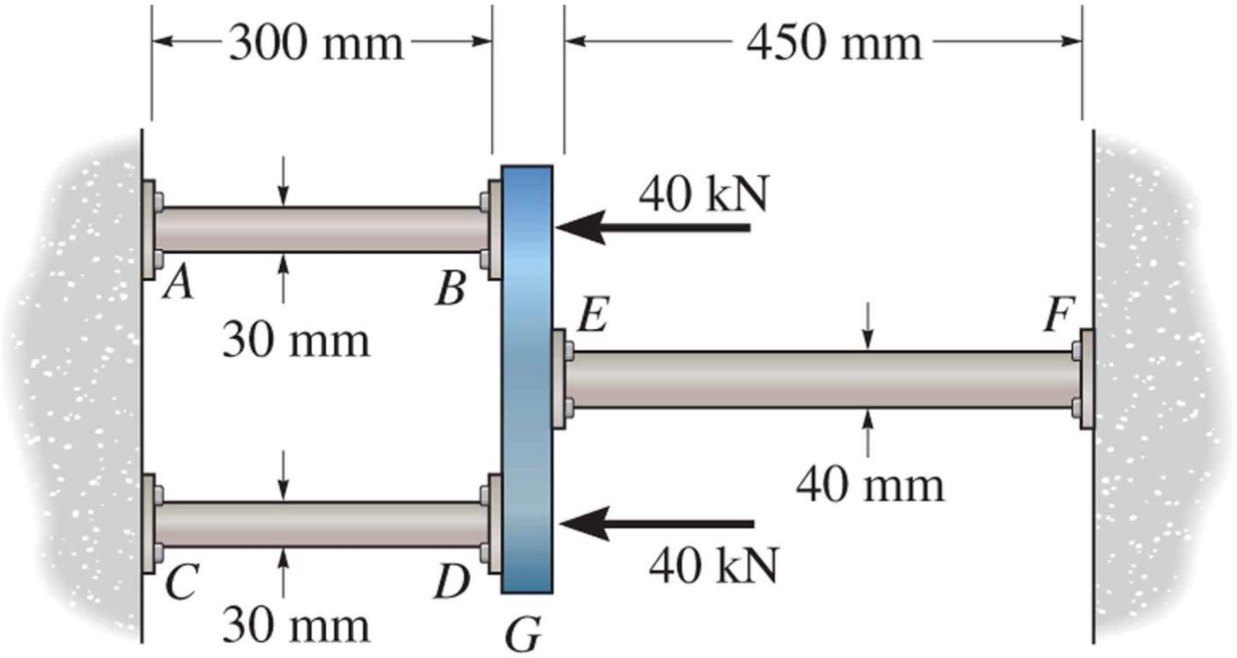


Approach:

1) Apply equilibrium equations
2) Apply compatibility equations
3) Solve for reactions

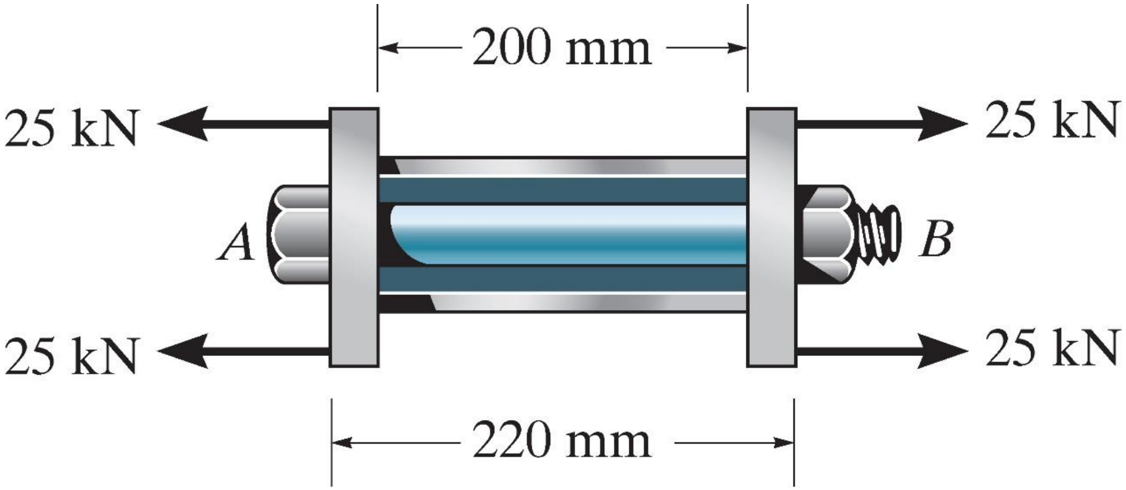
Axial load: example K

The assembly consists of two red brass C83400 copper alloy rods *AB* and *CD* of diameter *30 mm,* a stainless 304 steel alloy rod *EF* of diameter *40 mm,* and a rigid cap *G*. If the supports at *A, C* and *F* are rigid, determine the average normal stress developed in rods *AB, CD* and *EF.*



Axial load: example L

The bolt AB has a diameter of $20\ \mathrm{mm}$ and passes through a sleeve that has an inner dimeter of $40\ \mathrm{mm}$ and an outer diameter of $50\ \mathrm{mm}$. The bolt and sleeve are made of A-36 steel and are secured to the rigid brackets as shown. If the bolt length is $220\ \mathrm{mm}$ and the sleeve length is $200\ \mathrm{mm}$, determine the tension in the bolt when a force of $50\ \mathrm{kN}$ is applied to the brackets.



Approach:

1) Apply equilibrium equations
2) Apply compatibility equations
3) Solve for forces

Reading assignment

- Chapters 3 and 4 of textbook
- Review notes and text: ES2001, ES2501

Homework assignment

- As indicated on webpage of our course