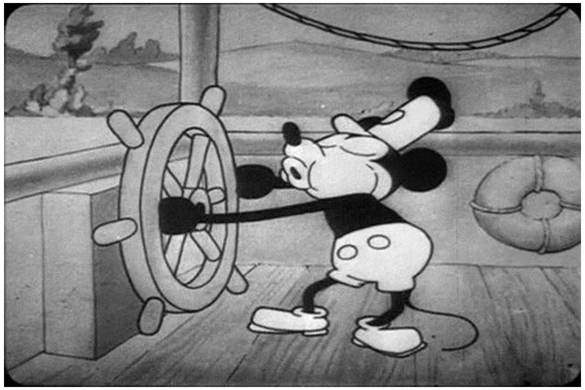
# WORCESTER POLYTECHNIC INSTITUTE
# MECHANICAL ENGINEERING DEPARTMENT

## STRESS ANALYSIS
## ES-2502, B'2025

**We will get started soon...**



**11 November 2025**

# WORCESTER POLYTECHNIC INSTITUTE
# MECHANICAL ENGINEERING DEPARTMENT

## STRESS ANALYSIS
## ES-2502, B'2025

## Lecture 13:
## Unit 6: tension/compression of slender longitudinal bars:
## *statically indeterminate & thermal stresses*

## 11 November 2025

# General information

Instructor: Cosme Furlong
HL-152
(508) 831-5126
Email: cfurlong @ wpi.edu
http://www.wpi.edu/~cfurlong/es2502.html

Graduate Assistants:

→ Hamed Ghavami (TA)
Email: sghavami @ wpi.edu

→ Jay Patil (GA)
Email: jpatil1 @ wpi.edu

→ Mikayla Almeida (GA)
mpalmeida @ wpi.edu

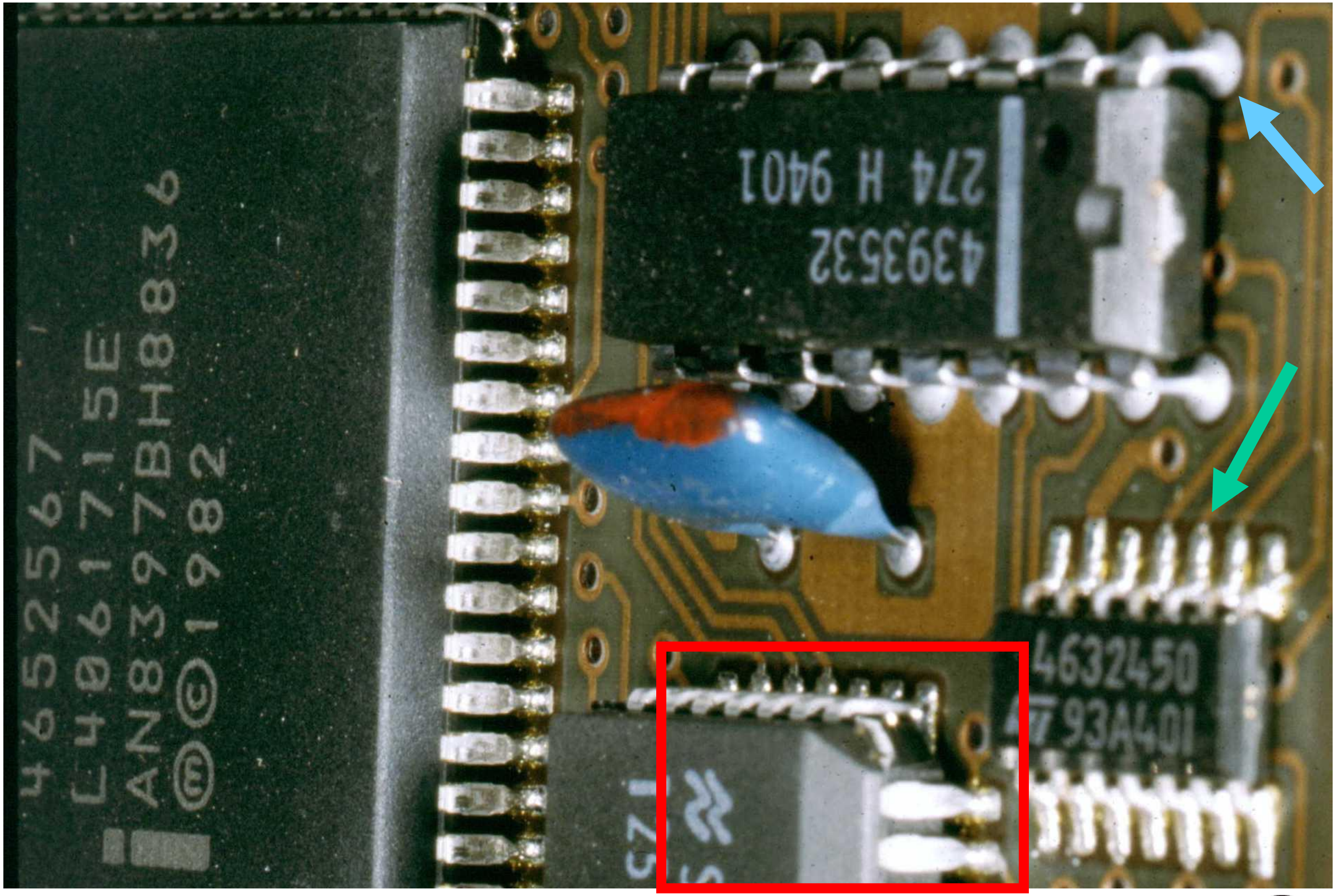
# Thermal stresses: example

Components are design to account for thermal expansions

Expansion joints

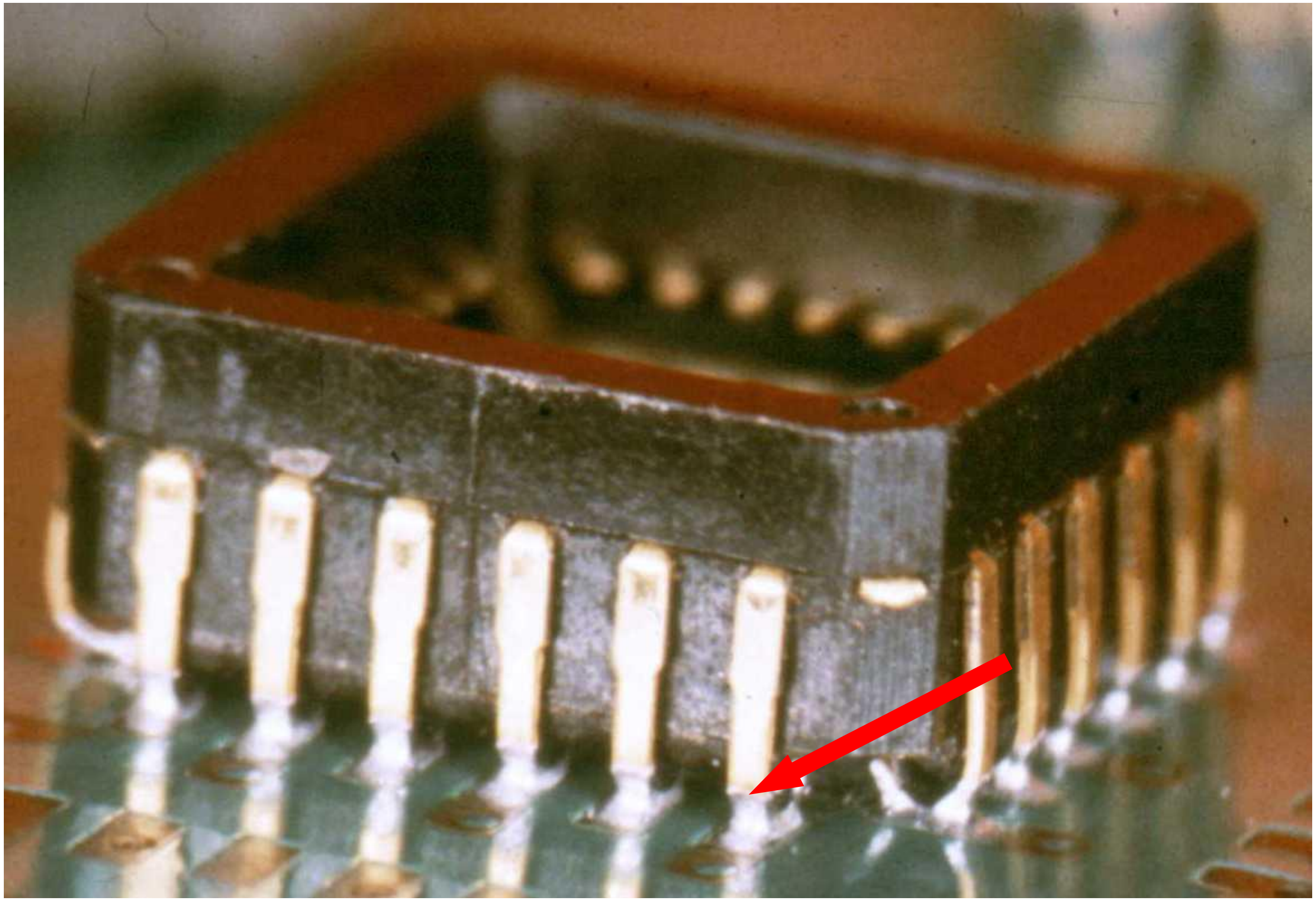
# Thermal stresses: example

In electronic components



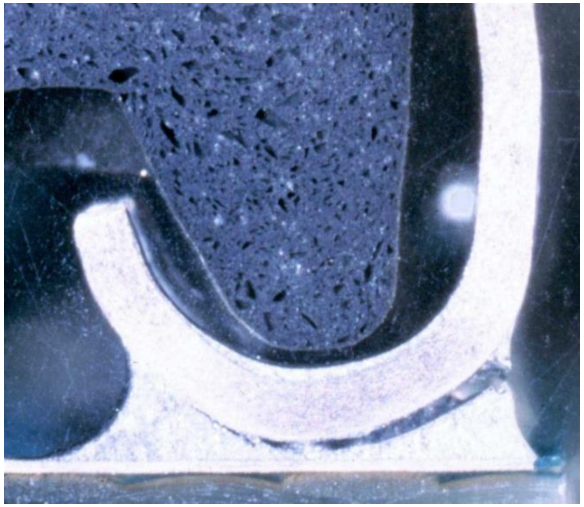
# Thermal stresses: example

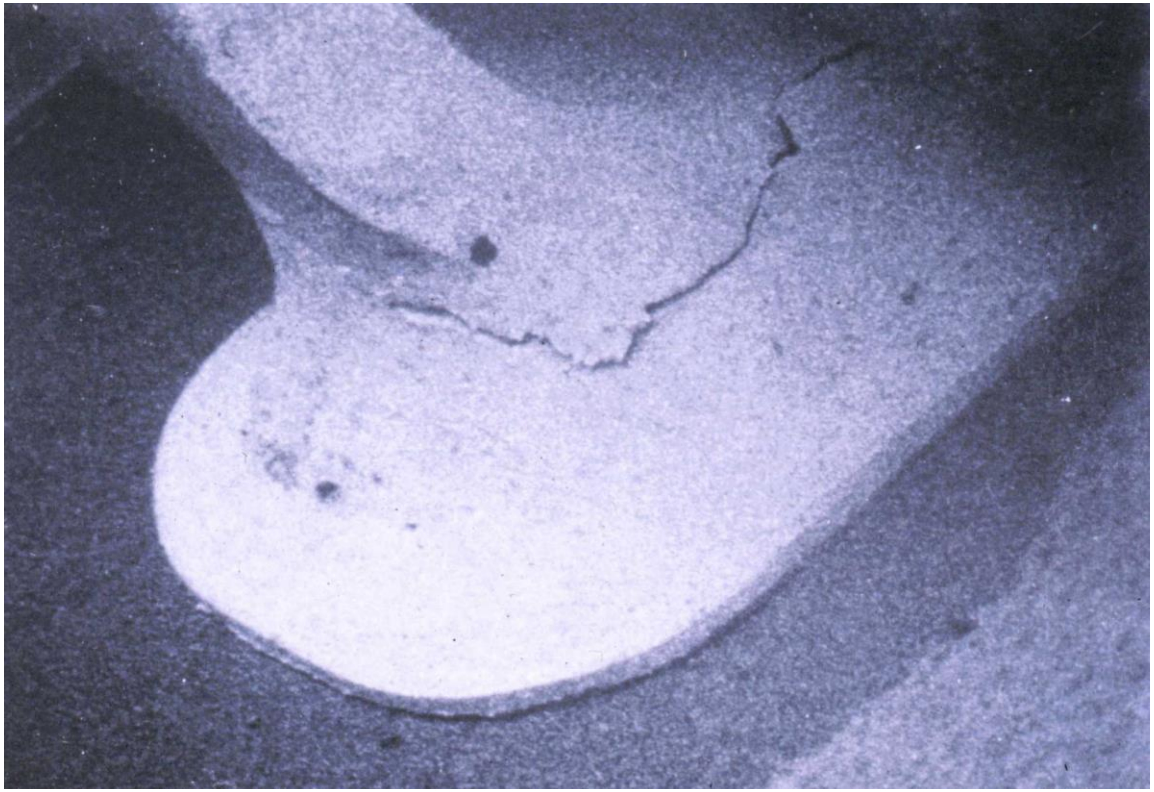
In electronic components: J-lead attachment



# Thermal stresses: example

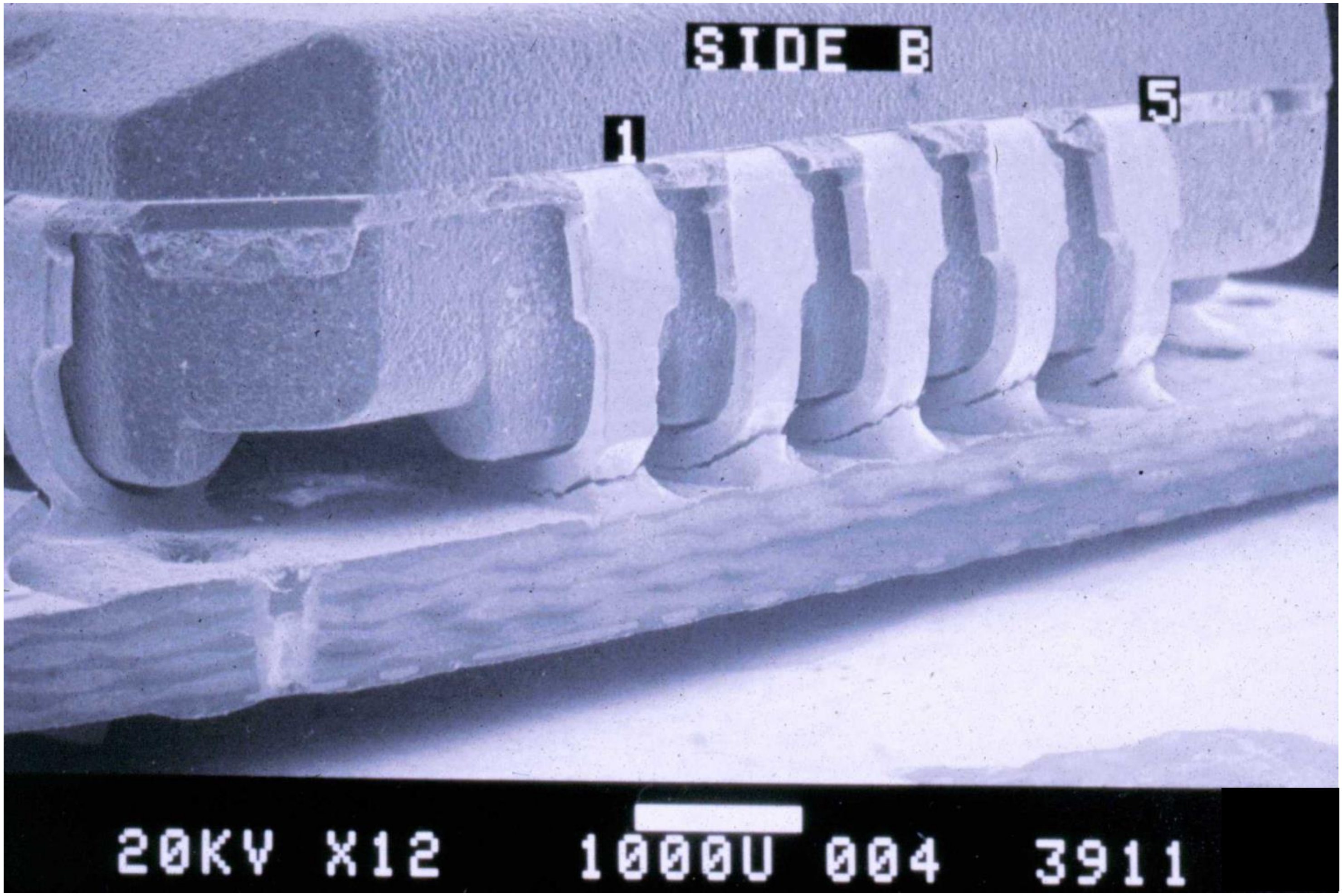
In electronic components: J-lead attachment





# Thermal stresses: example

In electronic components: J-lead attachment

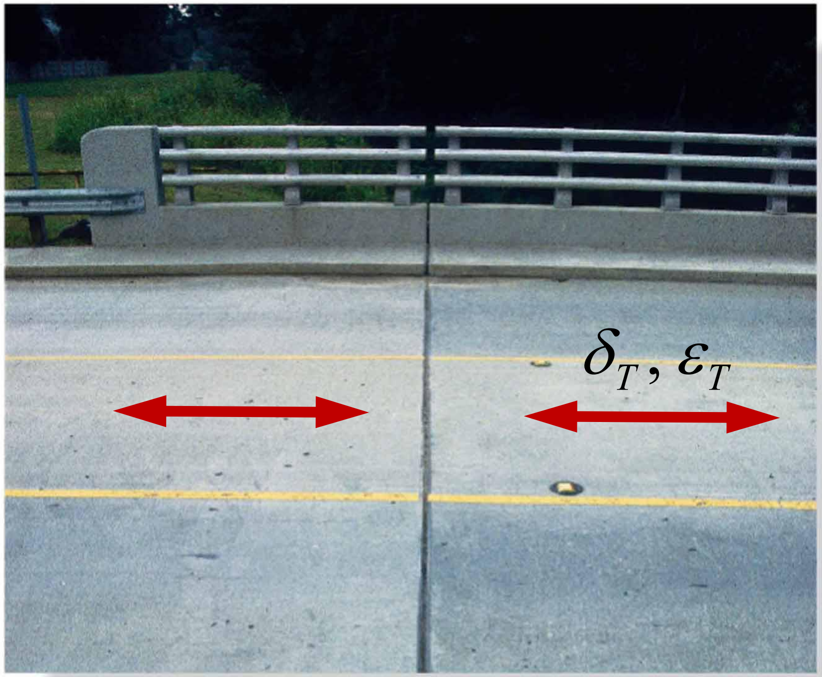


# Thermal stresses: uniaxial effects shown here (3D case later)

$$\varepsilon_T = \alpha\,\Delta T \quad \longrightarrow \quad \delta_T = \varepsilon_T\,L = \alpha\,\Delta T \cdot L$$

(Thermal strains) → (Thermal deformations)

$\alpha$ = linear coefficient of thermal expansion, 1/ºC, 1/ºF
$\Delta T$ = temperature differential
$L$ = original length of component

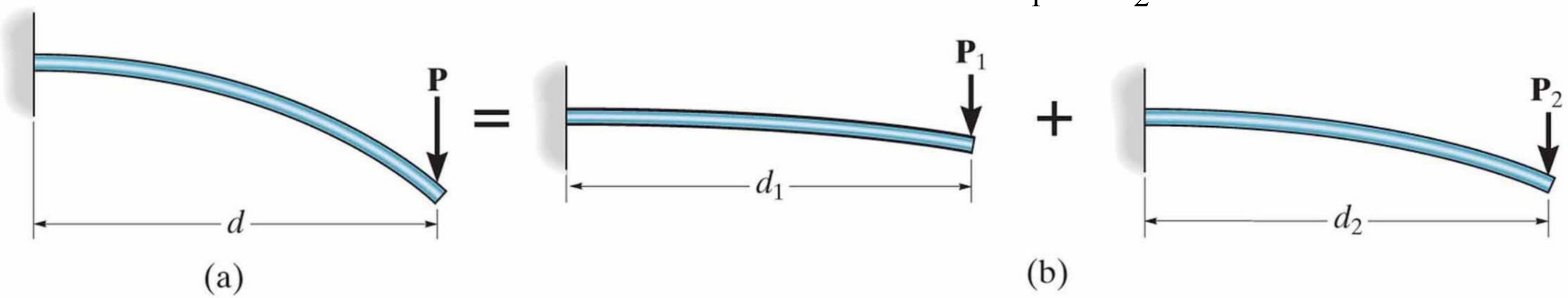


# Principle of superposition

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

Can include mechanical + thermal + other loads

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



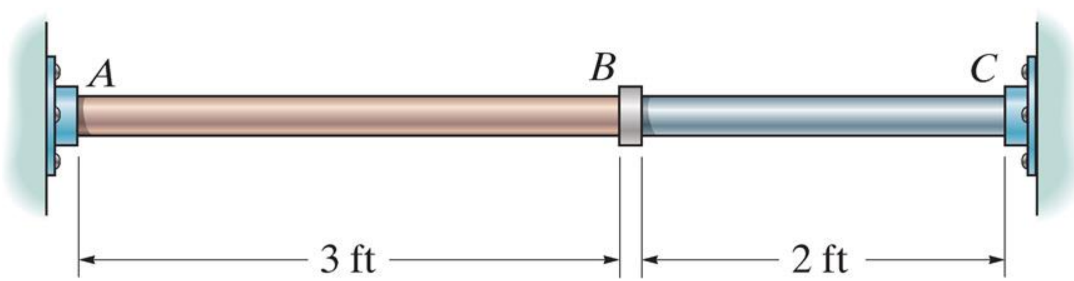

**Can only be applied for:**

(a) small deformations;

(b) deformations in the elastic (linear) range of the σ–ε diagram

# Axial load: example A

The C83400-red-brass rod $AB$ and 2014-T6-aluminum rod $BC$ are joined at the collar $B$ and fixed connected at their ends. If there is no load in the members when $T_1 = 50^{o}F$, determine the average normal stress in each member when $T_2 = 120^{o}F$. Also, how far will the collar be displaced? The cross-sectional area of each member is $1.75 \text{ in}^2$.

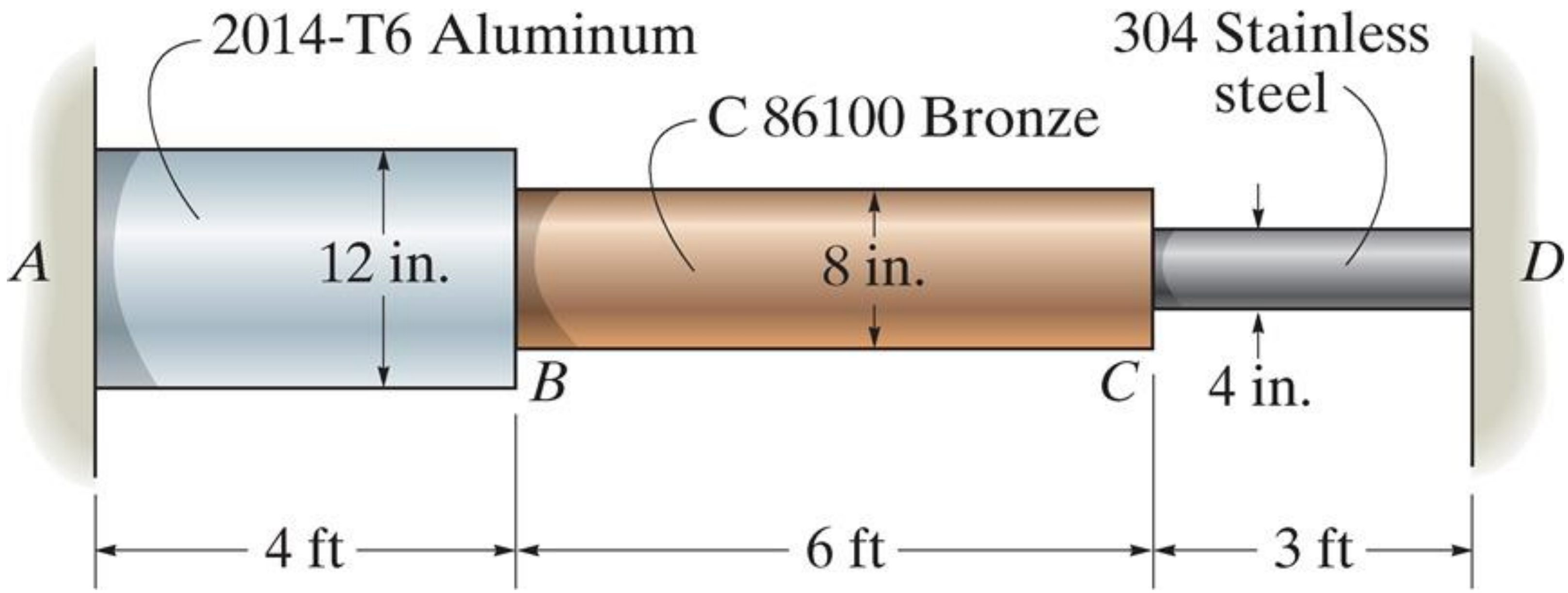



**Approach:**

1) Compute thermal deformations
2) Apply compatibility equations & superposition
3) Compute forces/ stresses/ displacement

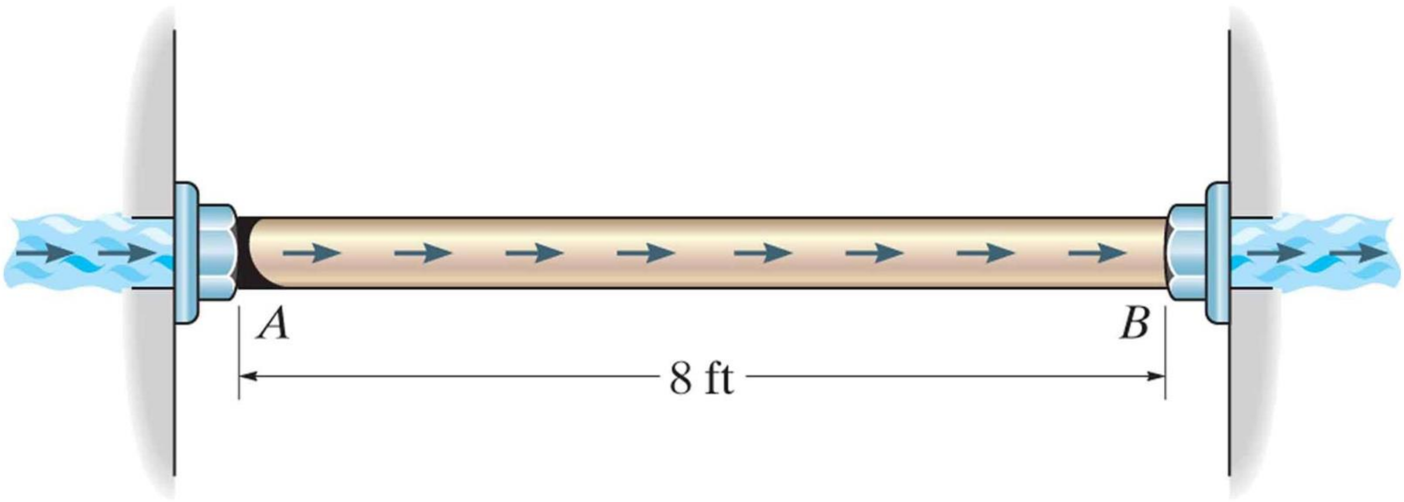
# Axial load: example B

The assembly has the diameters and materials indicated. If it fits securely between its fixed supports when the temperature is $T_1 = 70^{o}F$, determine the average normal stress in each material when the temperature reaches $T_2 = 110^{o}F$.



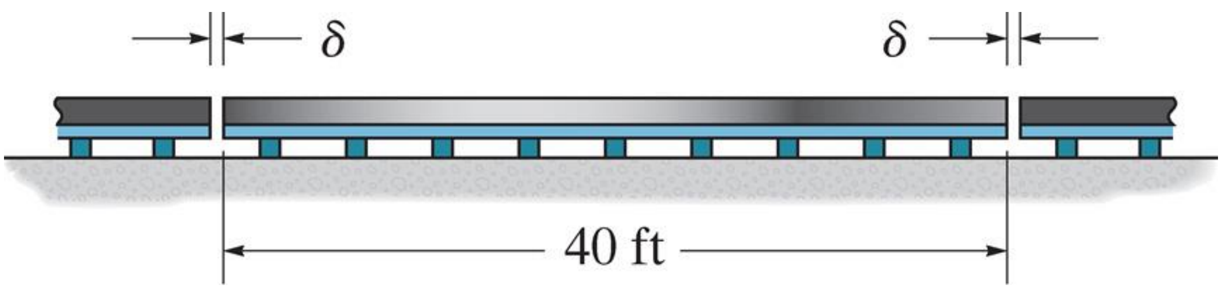
# Axial load: example C

The bronze C86100 pipe has an inner radius of 0.5 in. and a wall thickness of 0.2 in. If the gas flowing through it changes the temperature of the pipe uniformly from $T_A = 200$ °F at $A$ to $T_B = 60$ °F at $B$, determine the axial force it exerts on the walls. The pipe was fitted between the walls when $T = 60$ °F.



# Axial load: example D

The 40-ft-long A-36 steel rails on a train track are laid with a small gap between them to allow for thermal expansion. Determine the required gap $\delta$ so that the rails just touch one another when the temperature is increased from $T_1 = -20^oF$ to $T_2 = 90^oF$. Using this gap, what would be the axial force in the rails if the temperature rises to $T_3 = 110^oF$? The cross-sectional area of each rail is $5.10\ in^2$.

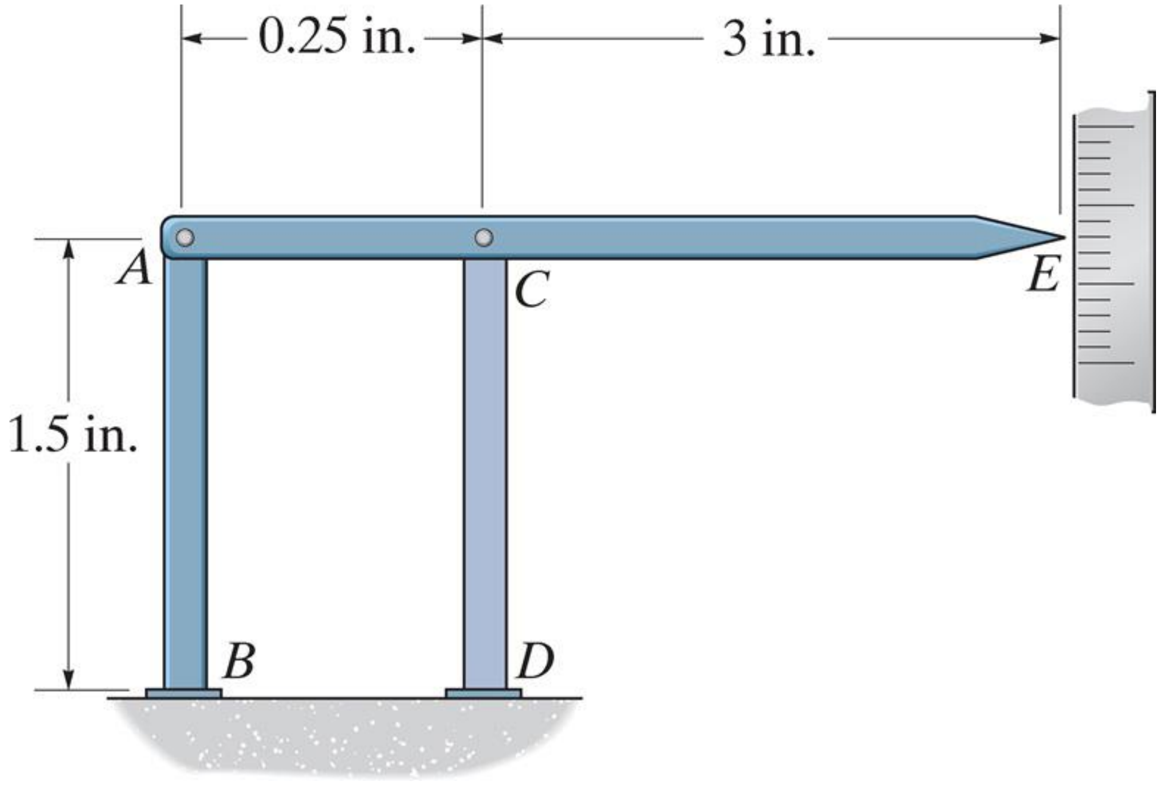



**Approach:**

1) Compute thermal deformations
2) Apply compatibility equations & superposition
3) Compute gap/ forces

# Axial load: example E

The device is used to measure a change in temperature. Bars *AB* and *CD* are made of A-36 steel and 2014-T6 aluminum alloy, respectively. When the temperature is at 75°F, *ACE* is in the horizontal position. Determine the vertical displacement of the pointer at *E* when the temperature rises to 150°F.



# Reading assignment

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

# Homework assignment

- As indicated on webpage of our course