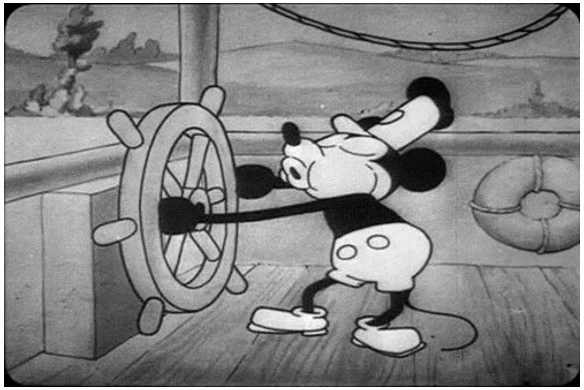
WORCESTER POLYTECHNIC INSTITUTE
MECHANICAL ENGINEERING DEPARTMENT

STRESS ANALYSIS
ES-2502, D'2020

We will get started soon...



16 April 2020

WORCESTER POLYTECHNIC INSTITUTE
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STRESS ANALYSIS
ES-2502, D'2020

We will get started soon...

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

16 April 2020

General information

Instructor: Cosme Furlong
HL-152
(774) 239-6971 – Texting Works
Email: cfurlong @ wpi.edu
http://www.wpi.edu/~cfurlong/es2502.html

Teaching Assistant: Zachary Zolotarevsky
Email: zjzolotarevsky @ wpi.edu

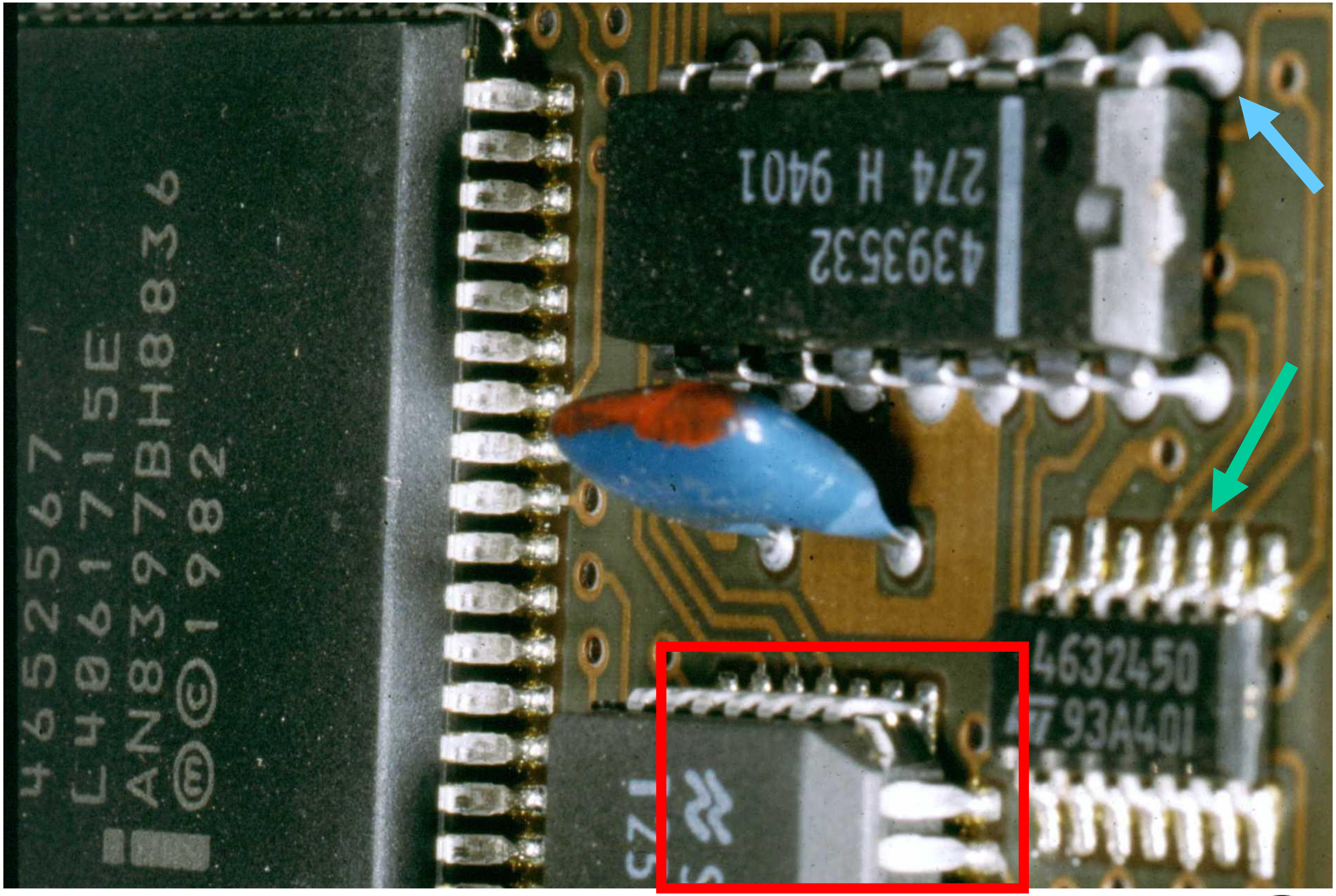
Thermal stresses: example

Components are design to account for thermal expansions

Expansion joints

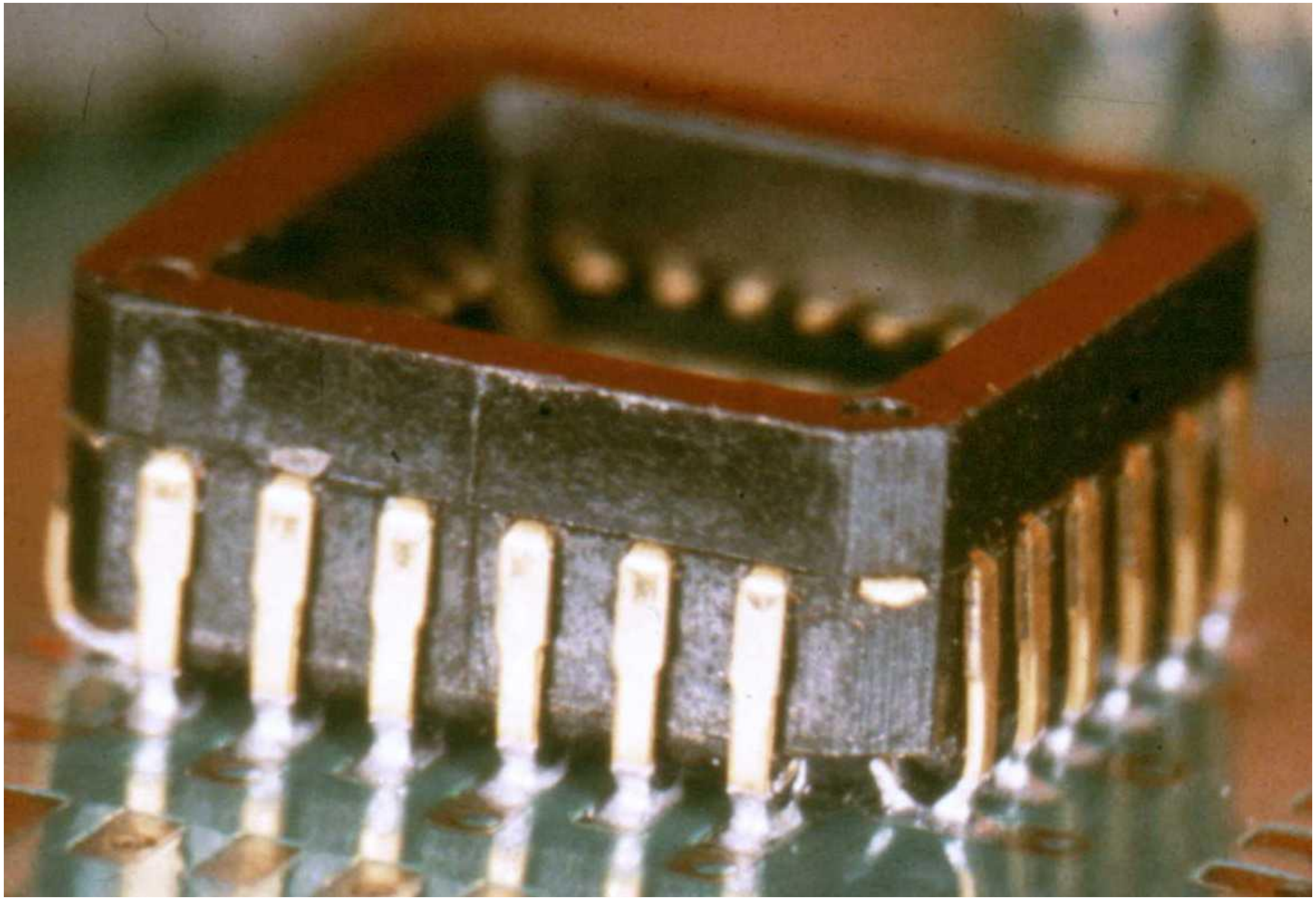
Thermal stresses: example

In electronic components



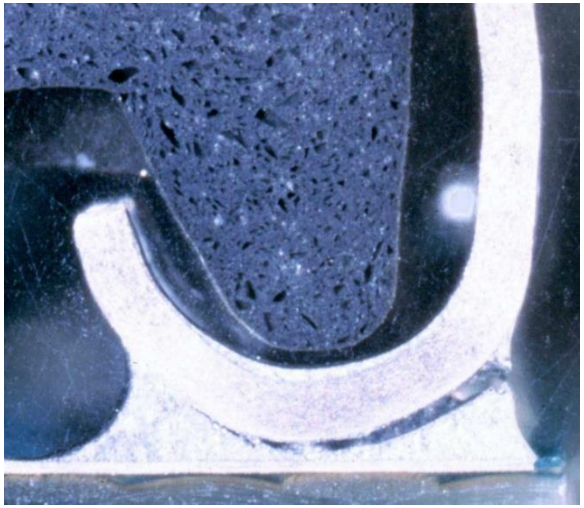
Thermal stresses: example

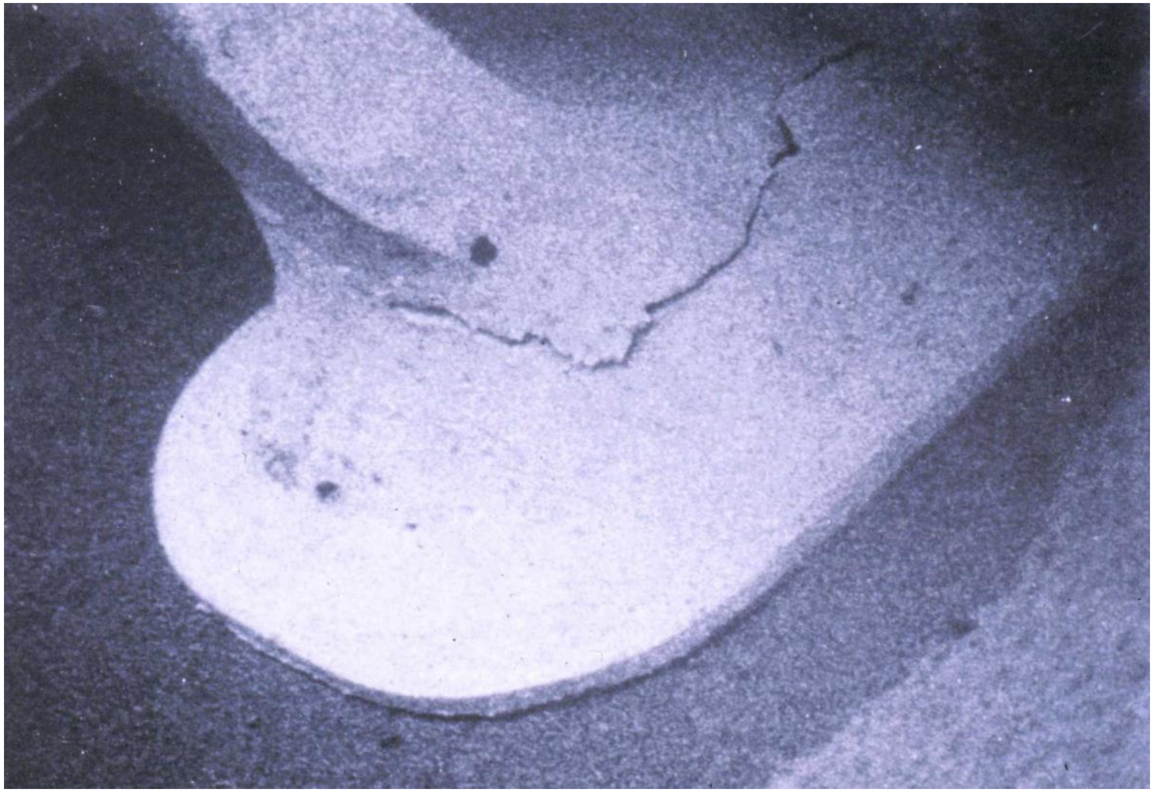
In electronic components: J-lead attachment



Thermal stresses: example

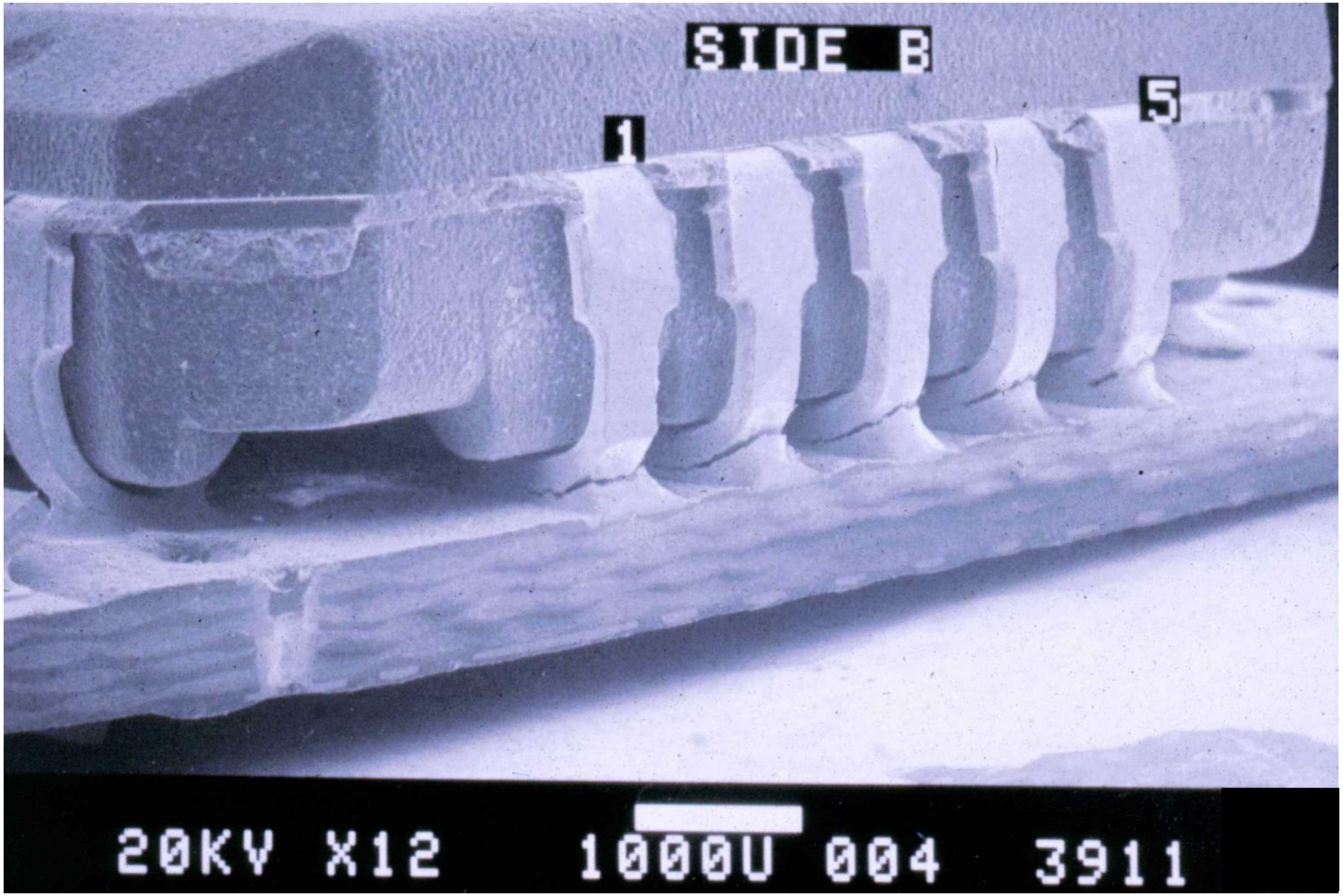
In electronic components: J-lead attachment





Thermal stresses: example

In electronic components: J-lead attachment

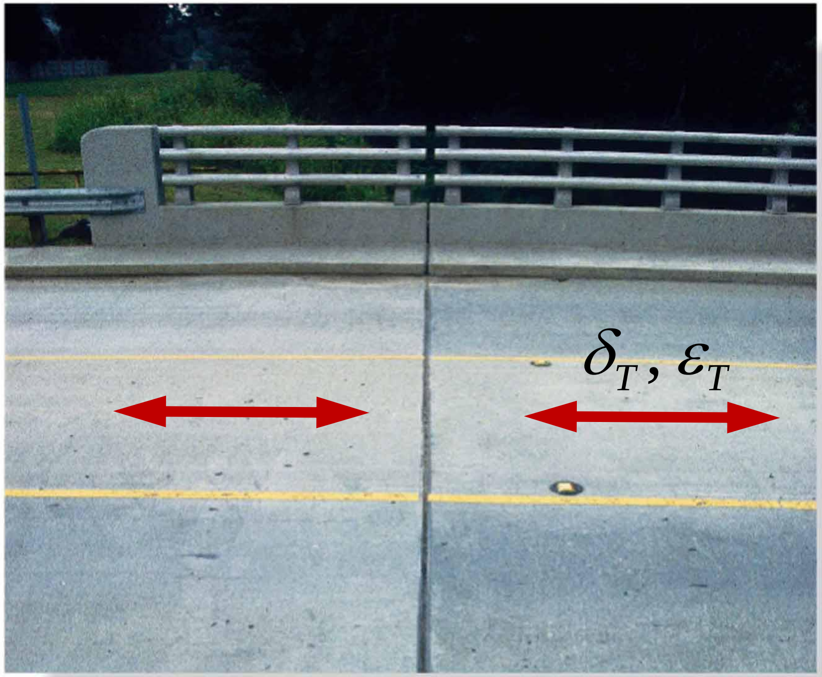


Thermal stresses: uniaxial effects shown here (3D case later)

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

(Thermal strains) (Thermal deformations)

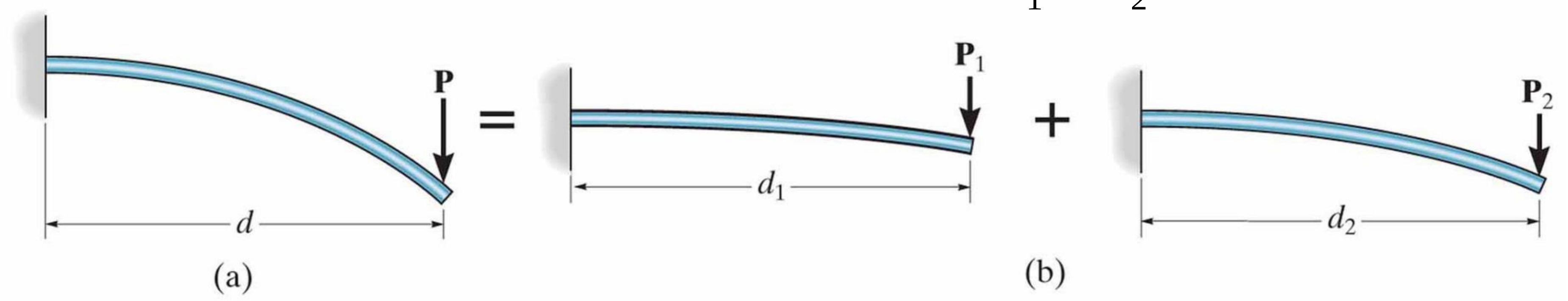
α = linear coefficient of thermal expansion, $1/^{o}C$, $1/^{o}F$
ΔT = temperature differential
L = original length of component



Principle of superposition

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

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



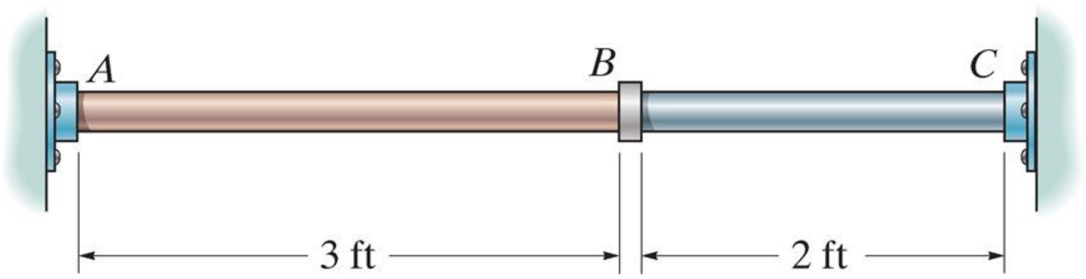
Can only be applied for:

(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 $1.75\ in^2$.

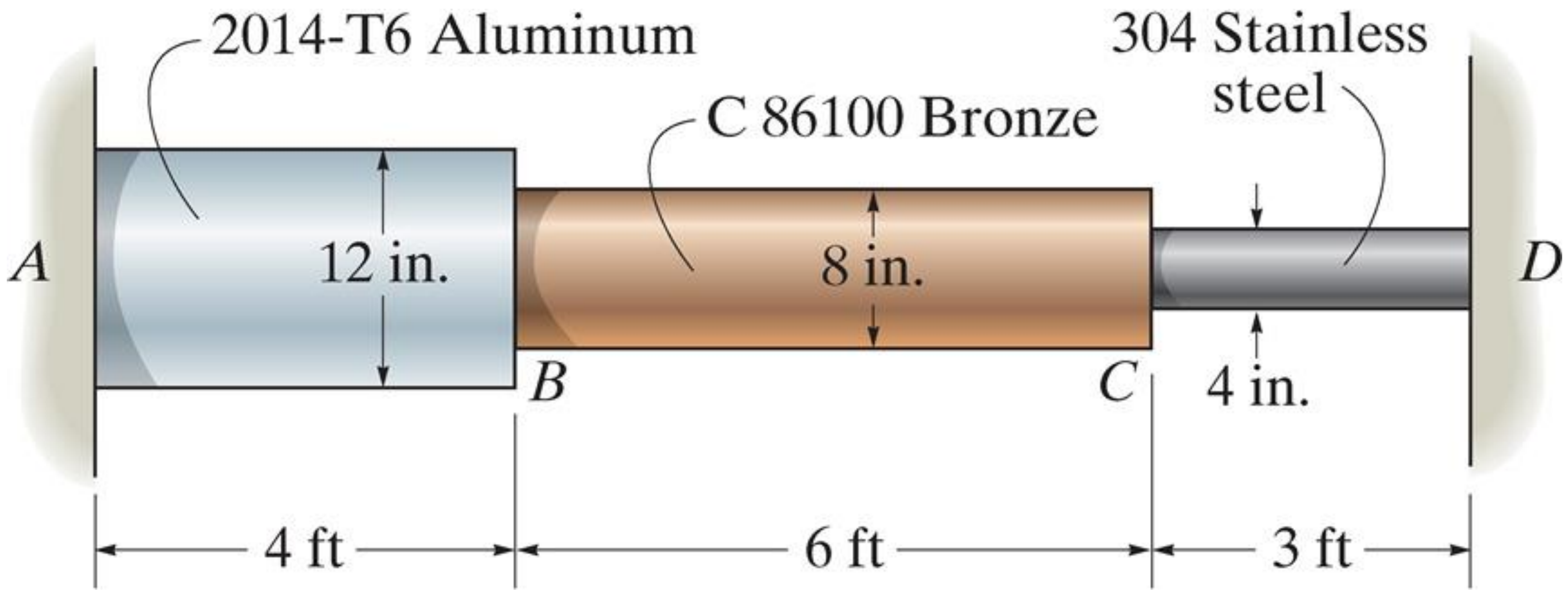


Approach:

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

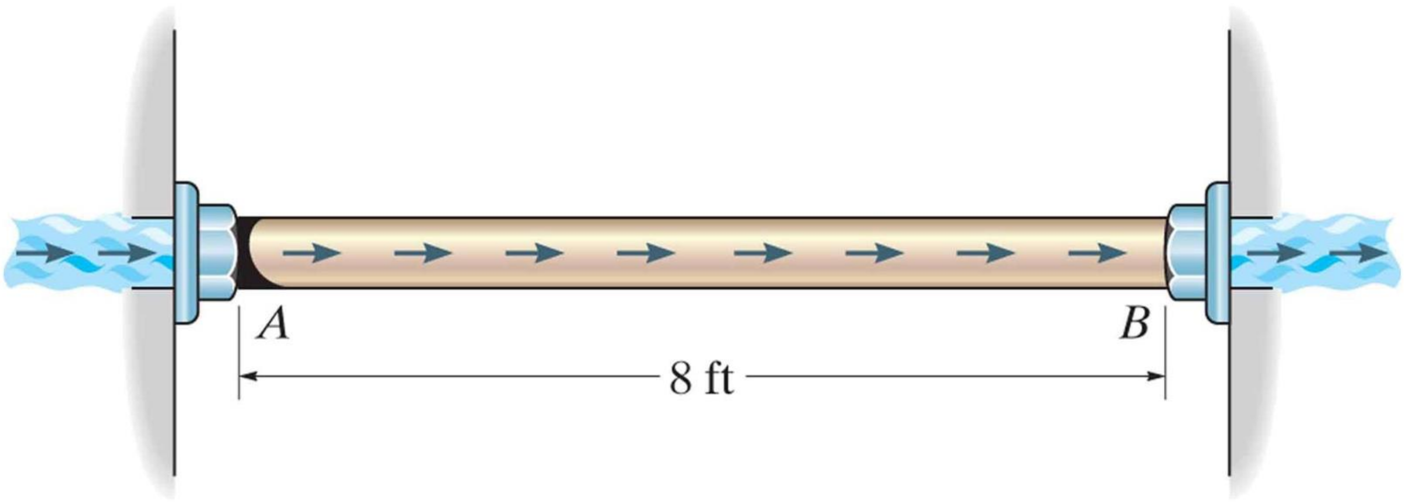
Axial load: example B

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



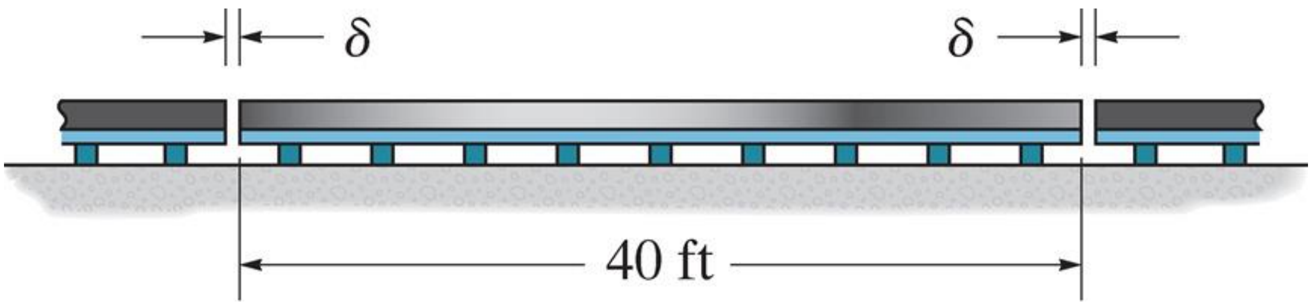
Axial load: example C

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 $T_A = 200\ ^oF$ at A to $T_B = 60\ ^oF$ at B, determine the axial force it exerts on the walls. The pipe was fitted between the walls when $T = 60\ ^oF$.



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 δ so that the rails just touch one another when the temperature is increased from T_1 = -20°F to T_2 = 90°F. Using this gap, what would be the axial force in the rails if the temperature rises to T_3 = 110°F? The cross-sectional area of each rail is 5.10 in^2.

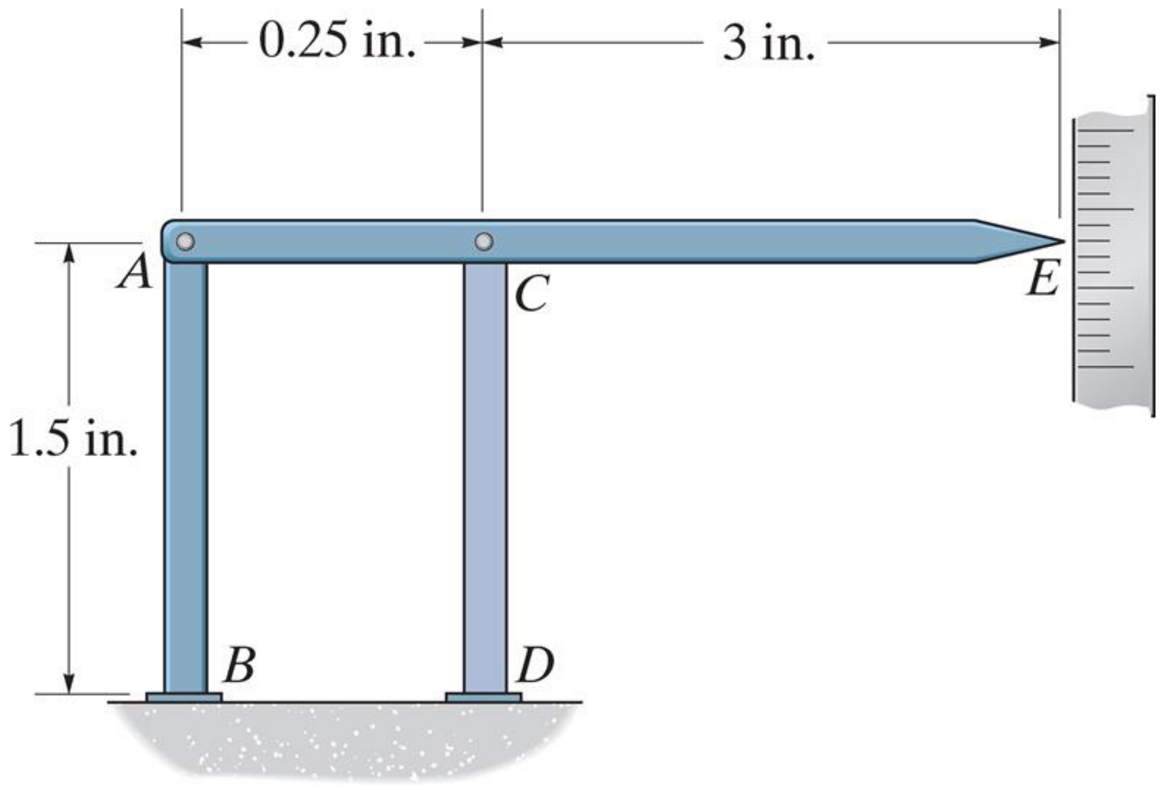


Approach:

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