

Exercise walk-through

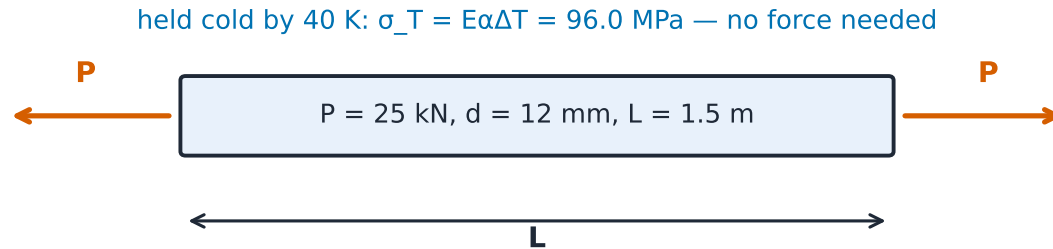
6.1

Axial loading

University Mechanical Engineering

Axial loading: stress, strain, held cold

the tie rod: one dimension, four traps



$$\sigma = P/A = 221.0 \text{ MPa} \cdot \delta = PL/AE = 1.658 \text{ mm} \cdot \epsilon = 0.001105$$

Tie rod $d = 12 \text{ mm}$, $P = 25 \text{ kN}$: $\sigma = P/A = 221.0 \text{ MPa}$, $\delta = PL/AE = 1.658 \text{ mm}$. Held cold by 40 K: $\sigma_T = E\alpha\Delta T = 96.0 \text{ MPa}$ with no force.

Exercises 2.1·2.2

2.1 A rod of $d = 20$ mm and $L = 2.0$ m carries $P = 40$ kN tension: the normal stress (one decimal, MPa) and the elongation (two decimals, mm). [4]

2.2 For that same rod and load, with Poisson's ratio $\nu = 0.30$ and $E = 200$ GPa: the axial strain (six decimals), the lateral strain (six decimals, magnitude) and the change in diameter (two decimals, micrometres, magnitude). [4]

Exercises 2.1-2.2

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2.1

- $A = \pi(0.010)^2 = 3.142 \times 10^{-4} \text{ m}^2$; $\sigma = 40 \times 10^3 / (3.142 \times 10^{-4}) = \mathbf{127.3}$ MPa.
- $\delta = PL/(AE) = 80\,000 / (6.283 \times 10^7) = \mathbf{1.27}$ mm.

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2.2

- $\varepsilon = \sigma/E = \mathbf{0.000637}$.
- $\varepsilon_{lat} = 0.30 \times 0.000637 = \mathbf{0.000191}$; $\Delta d = 20 \times 0.000191 = \mathbf{3.82}$ μm thinning.

Exercises 2.3·2.4

2.3 The same rod fitted between rigid walls and heated by 50 K ($E = 200$ GPa, $\alpha = 12 \times 10^{-6}/\text{K}$): the stress induced (one decimal, MPa). [3]

2.4 One sentence each: why does a free rod heated by 50 K carry no stress, and why does the wall-mounted one carry stress with no applied force? [3]

Exercises 2.3-2.4

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2.3

- $\sigma_T = E\alpha\Delta T = 200 \times 10^9 \times 12 \times 10^{-6} \times 50 = \mathbf{120.0}$ MPa compression.

2.4 One sentence each: why does a free rod heated by 50 K carry no stress, and why does the wall-mounted one carry stress with no applied force? [3]

2.4

- Free expansion just lengthens the rod - no internal force, so no stress.
- Held ends block the expansion; the constraint supplies the reaction force, and force over area is stress.