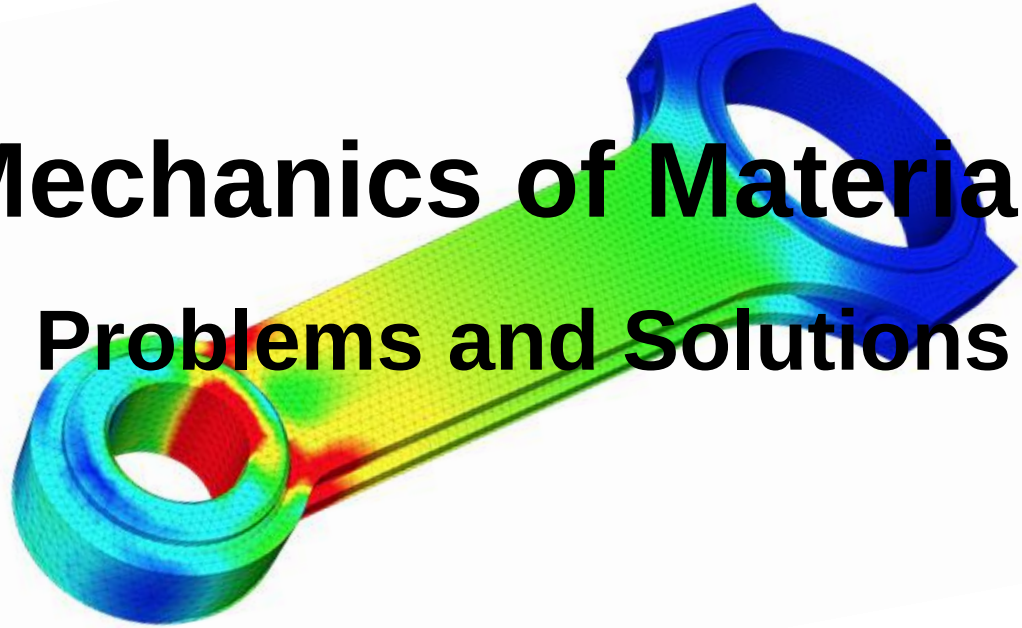
Mechanics of Materials

Problems and Solutions



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Module – 1 Mechanics of Materials

- Uniaxial Stress – Strain

  tensile stress & strain, shear stress & strain, uniaxial deformation, material modulus

- Thermal Deformation

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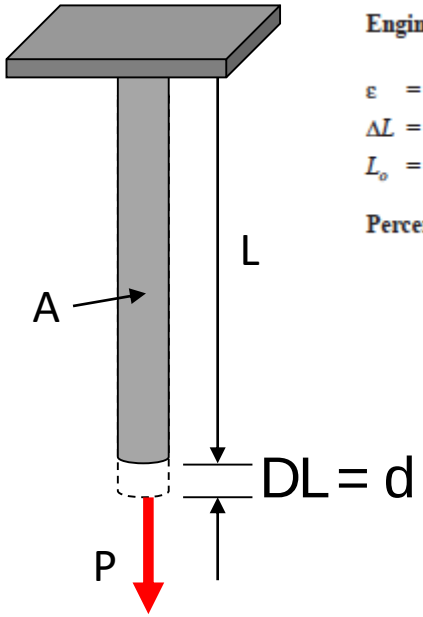
Uniaxial Stress & Strain



Engineering Strain

$\varepsilon = \Delta L / L_o$, where

ε = engineering strain (units per unit)

ΔL = change in length (units) of member

L_o = original length (units) of member

Percent Elongation

$$\% \text{ Elongation} = \left(\frac{\Delta L}{L_o}\right) \times 100$$

Longitudinal Stress

$\sigma = P/A$, where

σ = stress on the cross section

P = loading

A = cross-sectional area

Longitudinal Deformation

$\varepsilon = \delta / L$, where

δ = elastic longitudinal deformation

L = length of member

$$E = \sigma/\varepsilon = \frac{P/A}{\delta/L}$$

$$\delta = \frac{PL}{AE}$$

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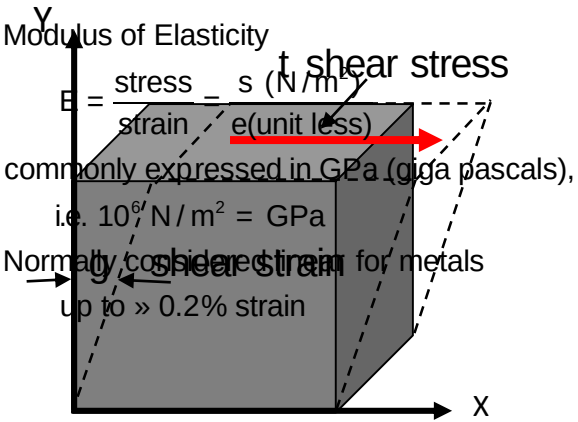
Uniaxial Stress & Strain



Modulus of Elasticity

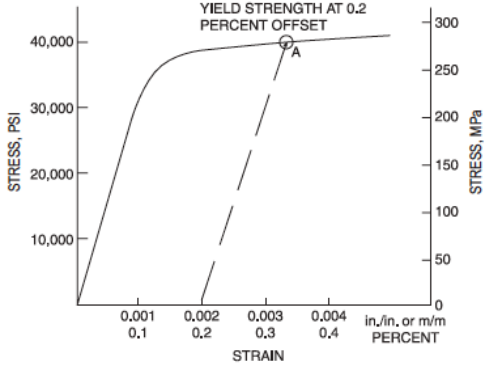
$$E = \frac{\text{stress}}{\text{strain}} = \frac{s\ (N/m^2)}{e\ (\text{unit less})}$$

commonly expressed in GPa (giga pascals),

i.e. $10^6\ N/m^2 = GPa$

Normally considered true for metals up to » 0.2% strain

Stress-Strain Curve for Mild Steel



The slope of the linear portion of the curve equals the modulus of elasticity.

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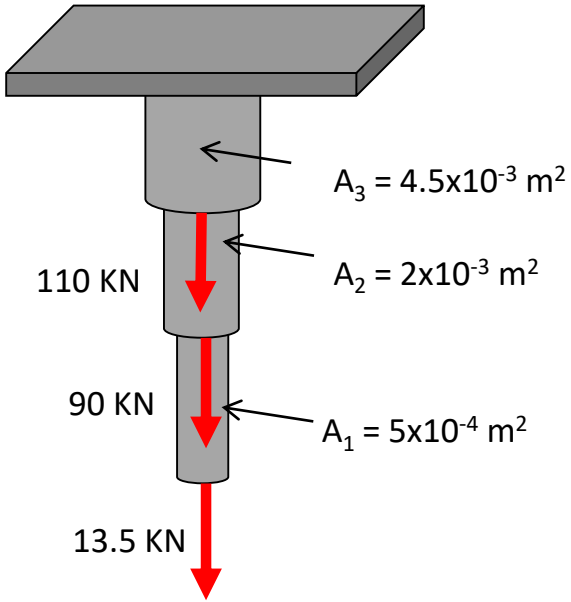
Problem 1 – Tensile Stress



A circular steel rod of varying cross section with dimensions shown is fixed at its upper end. Each section is subjected to the tension load indicated. The maximum tensile stress in the rod is most nearly:

(A) 27 MPa (B) 45 MPa
(C) 52 MPa (D) 98 MPa

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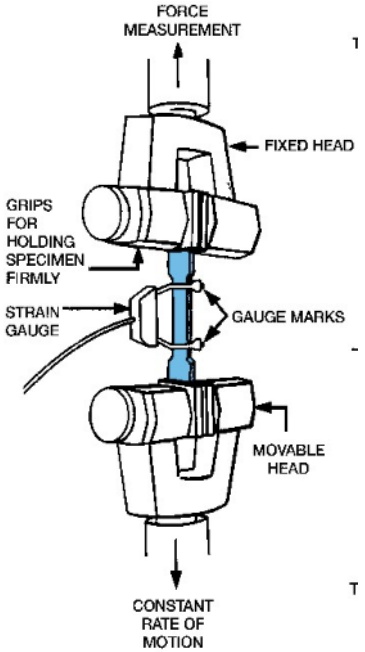
Problem 2 – Tensile Strain



During a tensile test (see sketch) the elongation of a test specimen is measured to be 0.375 mm over a gauge length of 15 cm. What is the percentage elongation of the specimen.

(A) 0.0025 % (B) 0.025 %
(C) 0.25 % (D) 2.5 %

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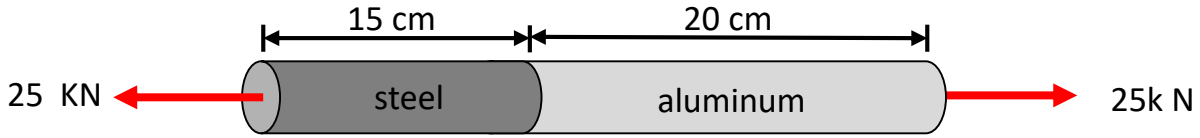
Problem 3 - Uniaxial Deformation



A 35 cm long circular metal tube is fabricated by welding together steel and aluminum sections of lengths shown. Each tube has a nominal diameter of 3 cm and wall thickness of 3 mm. Determine the elongation of this composite element when subjected to an axial load of 250 Newtons.

Es = 200 GPa, E_A = 69 GPa

(A) 0.066 (B) 0.33 mm (C) 0.66 mm (D) 3.3 mm

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Problem 4 – Elastic Modulus

In evaluating the material properties of a new copper alloy the results from a tensile test indicate linear behavior up to 0.15 % elongation. The stress at this level of deformation was measured as 175 MPa. Determine the value of the modulus of elasticity for this material.

(A) 107 GPa (B) 117 GPa (C) 127 GPa (D) 137 GPa

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Problem 5 – Shear Modulus

An average value of the elastic modulus E for a number of Aluminum alloys is 69 Gpa. For this same group the Poison's ratio is about 0.33. With this information determine an average value of the shear modulus G for these metals.

(A) 26 GPa (B) 30 GPa (C) 34 GPa (D) 138 GPa

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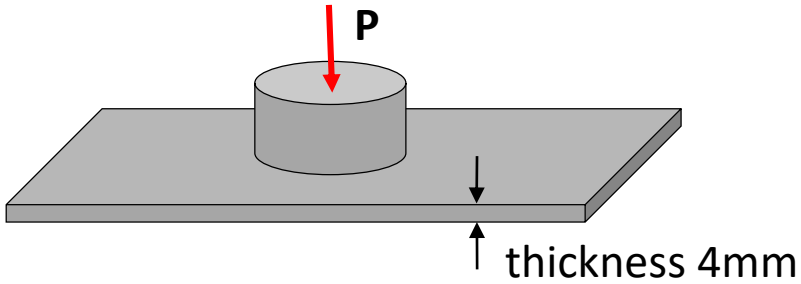
Problem 6 – Shear Stress



A circular die 30mm in diameter is used to punch a hole through a 4mm thick steel plate. If the yield stress in shear for the material is 450 MPa what force P is required to punch the hole.

(A) 170 N (B) 1700 N (C) $17x10^3$ N (D) $17x10^4$ N

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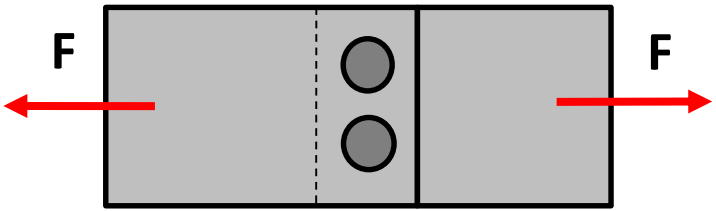
Problem 7 – Rivet Shear



Two steel bars attached in a lap joint with two rivets is subjected to an axial load of 8,000 Newtons. If the rivets have a diameter of 50 mm determine the value of the shear stress in the body of the rivets. Select an answer from those listed closest to the actual value.

(A) 4 MPa (B) 10 MPa
(C) 7 MPa (D) 13 MPa

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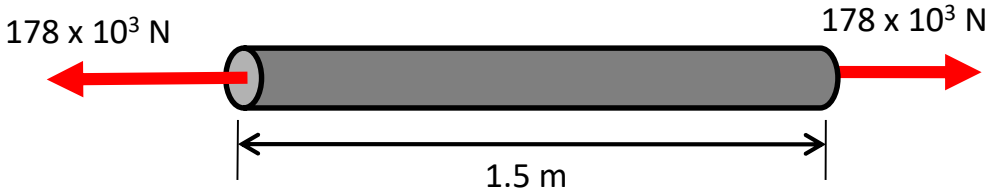
Problem 8 – Combined Deformations



A steel bar is loaded axially as shown. Determine the change in total length due to the applied tension and a temperature drop of 45ºC. The rod is circular with a diameter of 5cm.

Steel: $E = 203 \times 10^3$ MPA, $\alpha = 06.5 \times 10^{-6}$ mm/mm ºC

(A) .067cm (B) .044cm (C) .023cm (D) .090cm

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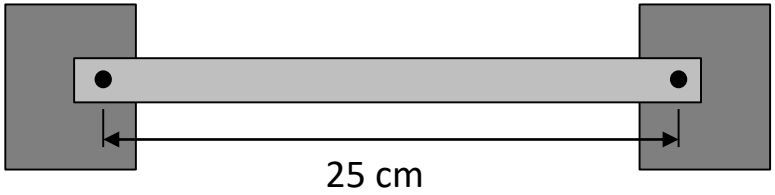
Problem 9 – Thermal Compression



A 4mm by 8 mm rectangular cross section Aluminum strut is anchored by pins between two rigid supports as shown. If the temperature is increased by 50° C determine the compressive stress generated in the strut. E_{al} = 69 Gpa, $a = 23.6 \times 10^{-6}$ /° C

(A) 50 MPa (B) 60 MPa (C) 70MPa (D) .80 MPa

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Thanks for watching

and

on the exam !

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