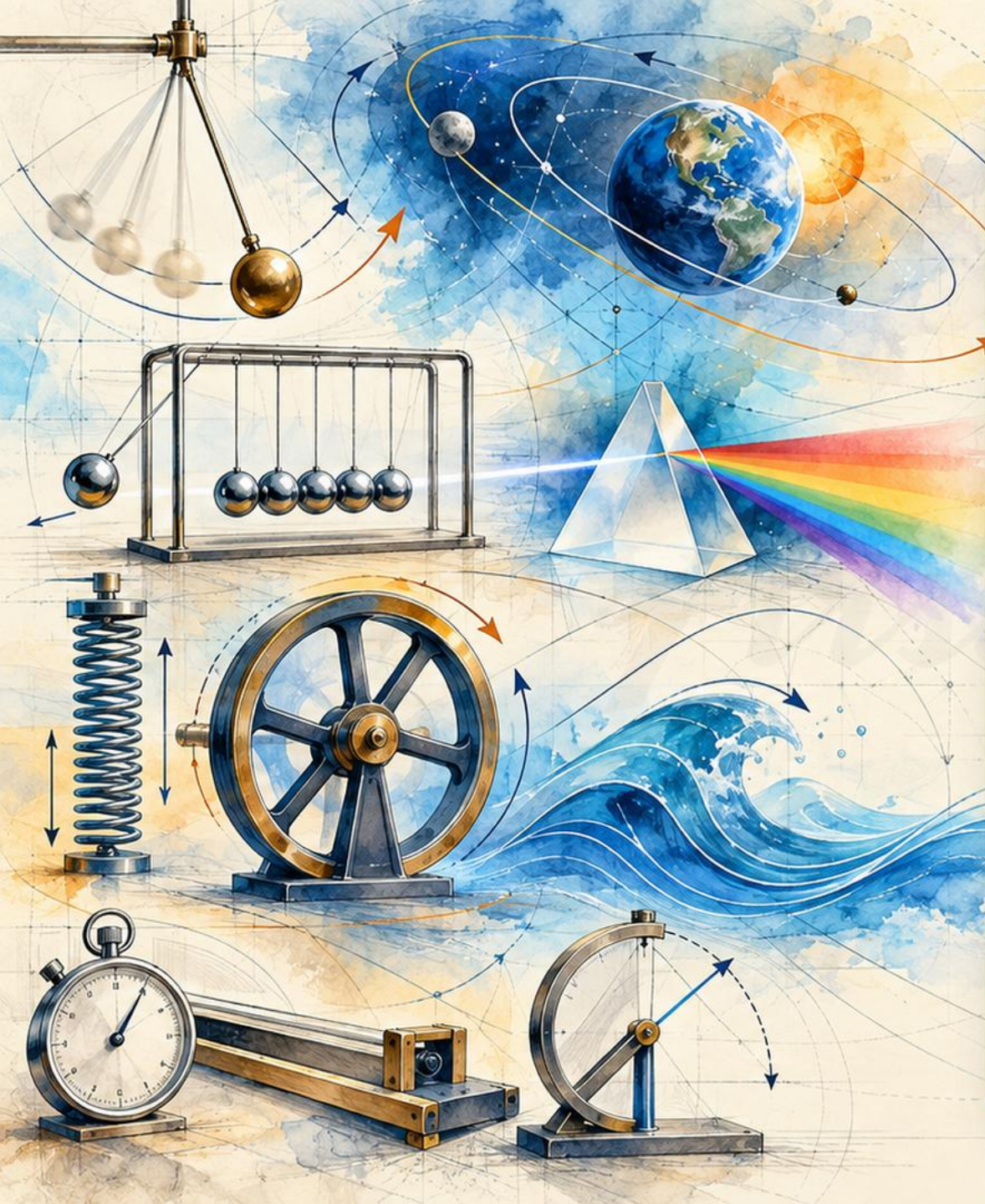




PHYSICS • CLASS 11

8

CHAPTER

Mechanical Properties of Solids

NCERT SOLUTIONS

EXERCISE SOLUTION: QUESTION 8.1

A steel wire of length 4.7 m and area $3.0 \times 10^{-5} \text{ m}^2$ stretches by the same amount as a copper wire of length 3.5 m and area $4.0 \times 10^{-5} \text{ m}^2$ under the same load. Find the ratio of their Young's moduli.

Answer:

Young's modulus relates the stress to the longitudinal strain.

The load and extension are the same for both wires.

$$Y = \frac{F/A}{\Delta L/L} = \frac{FL}{A\Delta L}$$

$$\frac{Y_s}{Y_c} = \frac{L_s/A_s}{L_c/A_c} = \frac{L_s A_c}{L_c A_s}$$

Since the load and extension are the same, they cancel in the ratio. Hence,

$$\begin{aligned}\frac{Y_s}{Y_c} &= \frac{(4.7)(4.0 \times 10^{-5})}{(3.5)(3.0 \times 10^{-5})} \\ &= \frac{18.8}{10.5} \\ &\approx 1.79\end{aligned}$$

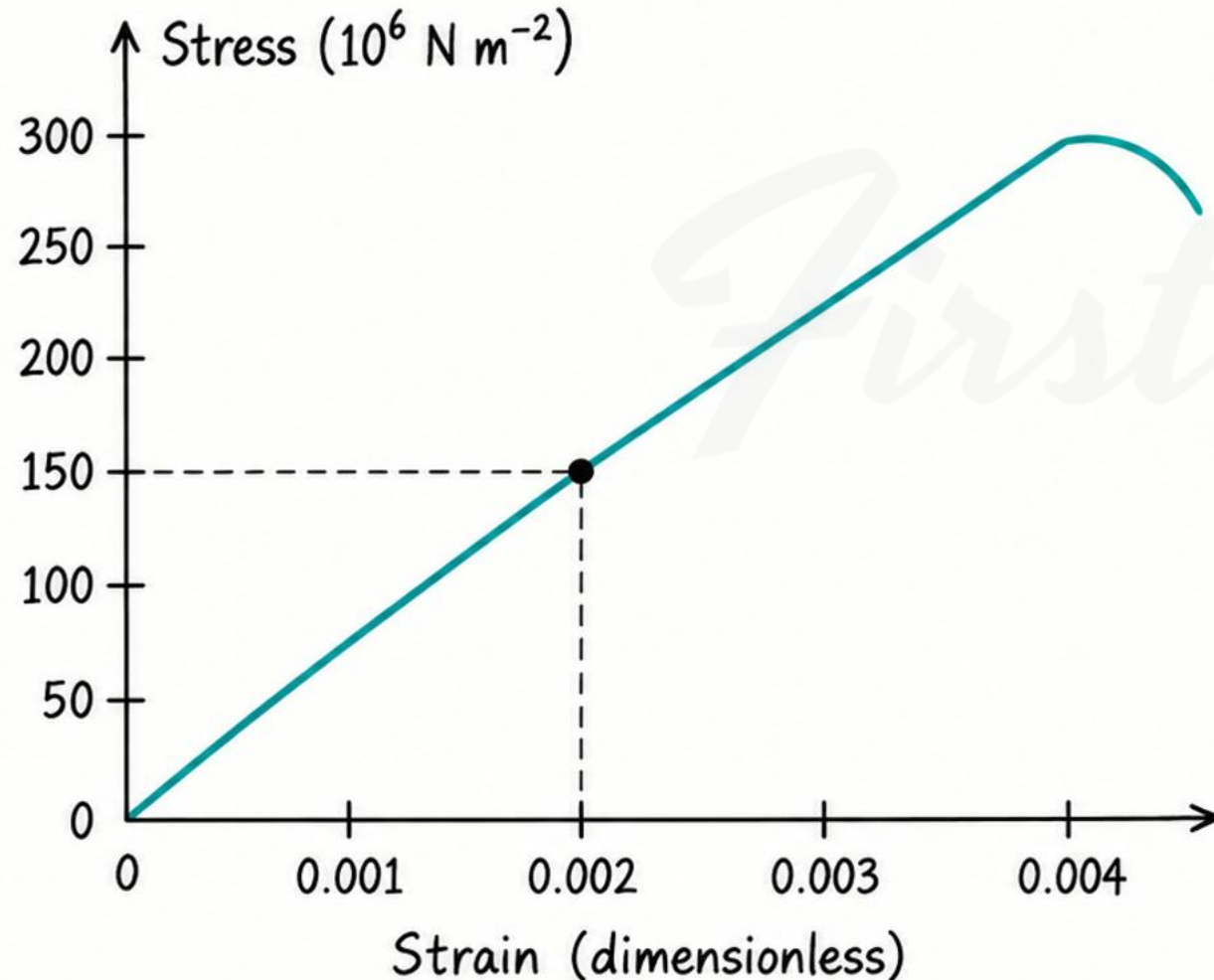
Young's modulus ratio, steel : copper
 $\approx 1.8 : 1$

The steel has the larger modulus.

The ratio has no unit because both moduli have the same unit.

EXERCISE SOLUTION: QUESTION 8.2

From the given stress-strain curve, find (a) Young's modulus and (b) the approximate yield strength.



Answer:

- (a) Use the slope of the straight part, not the curved part.

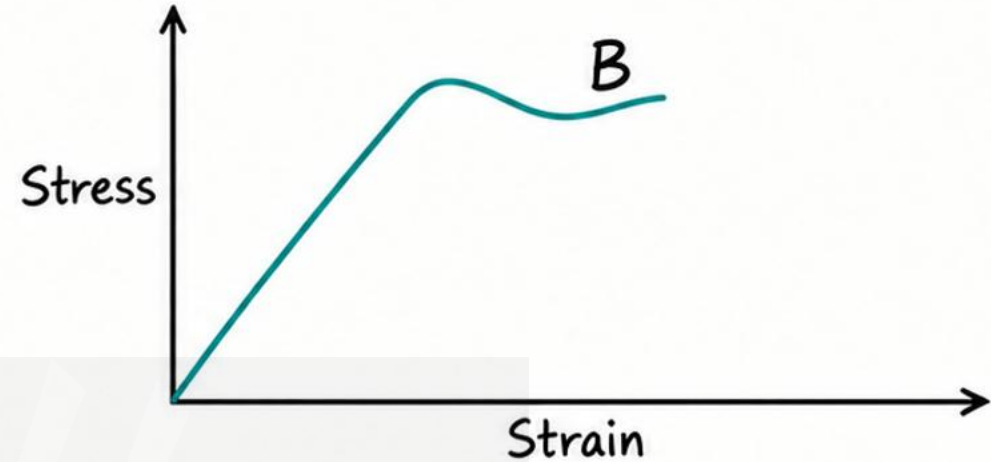
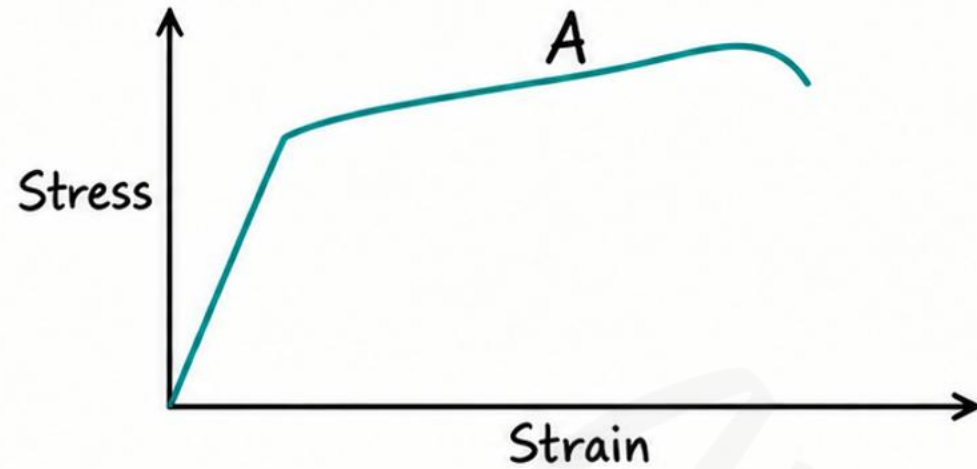
$$\begin{aligned} Y &= \frac{\text{stress}}{\text{strain}} \\ &= \frac{150 \times 10^6}{0.002} \\ &= 7.5 \times 10^{10} \text{ N m}^{-2} \\ &= 75 \text{ GPa} \end{aligned}$$

- (b) Read the stress near the end of the approximately linear region.

$$\begin{aligned} \text{Approximate yield strength} &\approx 300 \times 10^6 \text{ N m}^{-2} \\ &= 3 \times 10^8 \text{ Pa} \end{aligned}$$

Yield strength is a stress; Young's modulus is the slope of the elastic straight-line region.

EXERCISE SOLUTION: QUESTION 8.3



The stress-strain graphs of materials A and B use the same scale.

(a) Which has the greater Young's modulus? (b) Which is stronger?

(a) Material A.

Answer: Young's modulus is the slope of the initial straight portion. That slope is steeper for the first material.

$$Y_A > Y_B$$

(b) Material A.

Answer: It reaches a slightly higher maximum stress before failure in the supplied same-scale graphs. Greater maximum stress means greater tensile strength.

Stiffness is compared using the initial slope; strength is compared using the maximum stress, not the strain at breaking.

EXERCISE SOLUTION: QUESTION 8.4

(a) The Young's modulus of rubber is greater than that of steel.' State true or false, with a reason.

Answer: False.

Rubber undergoes much more strain than steel for the same tensile stress. Since Young's modulus is stress divided by strain, rubber has the smaller modulus.

$$Y = \frac{\text{stress}}{\text{strain}}$$

$$Y_{\text{rubber}} < Y_{\text{steel}}$$

Being easier to stretch does not mean having a larger Young's modulus.

(b) The stretching of a coil is determined by its shear modulus.' State true or false, with a reason.

Answer: True, for a close-coiled helical spring.

Pulling the spring mainly twists the wire that forms the coil. This produces shear deformation in the wire, so the relevant material property is its shear modulus.

The spring's overall extension is not mainly a direct lengthwise stretch of the wire.

The dimensions of the coil also affect its extension.



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