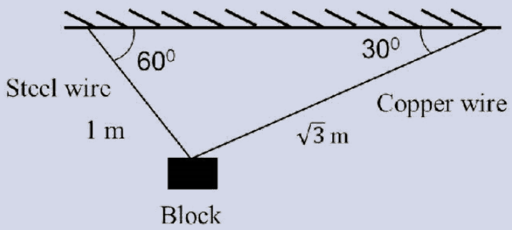
The Bored IITian

JEE Advanced 2019 - Paper 1 - Physics 14

Senan

Problem *[Numerical Value]*

A block of weight 100 N is suspended by copper and steel wires of same cross sectional area 0.5 cm^2 and, length $\sqrt{3}$ m and 1 m, respectively. Their other ends are fixed on a ceiling as shown in figure. The angles subtended by copper and steel wires with ceiling are 30° and 60°, respectively. If elongation in copper wire is (Δl_c) and elongation in steel wire is (Δl_s), then the ratio $\frac{\Delta l_c}{\Delta l_s}$ is ______.
[Young's modulus for copper and steel are 1×10^{11} N/m^2 and 2×10^{11} N/m^2, respectively.]



What to Observe:

- A block of weight 100 N is suspended by copper and steel wires.
- Both wires have the same cross-sectional area of 0.5 cm^2.
- Length of copper wire is $\sqrt{3}$ m.
- Length of steel wire is 1 m.
- The angle between the copper wire and the ceiling is 30°.
- The angle between the steel wire and the ceiling is 60°.
- Elongation in copper wire is denoted as (Δl_c).
- Elongation in steel wire is denoted as (Δl_s).
- Young's modulus for copper is 1×10^{11} N/m^2.
- Young's modulus for steel is 2×10^{11} N/m^2.

My Approach:

Ratio Expression

Thought

The question is simpler than it looks — creating a free body diagram would clarify the setup.
To proceed, we need the formula for **Young's modulus**, which is given by:

$$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{F/A}{\Delta L/L} = \frac{F \cdot L}{A \cdot \Delta L}$$

Rearranging for elongation ΔL:

$$\Delta L = \frac{F \cdot L}{A \cdot Y}$$

If we are comparing the **ratio of elongation** in steel and copper wires, and the **force is the tension** in the wires with **equal cross-sectional area** A, the equation simplifies to:

$$\frac{\Delta l_c}{\Delta l_s} = \frac{T_c \cdot L_c}{A \cdot Y_c} \cdot \frac{A \cdot Y_s}{T_s \cdot L_s} = \frac{T_c \cdot L_c \cdot Y_s}{T_s \cdot L_s \cdot Y_c}$$

So, the ratio of elongations in copper and steel is:

$$\frac{\Delta l_c}{\Delta l_s} = \frac{T_c}{T_s} \cdot \frac{L_c}{L_s} \cdot \frac{Y_s}{Y_c}$$

Calculation

Considering the following free body diagram:

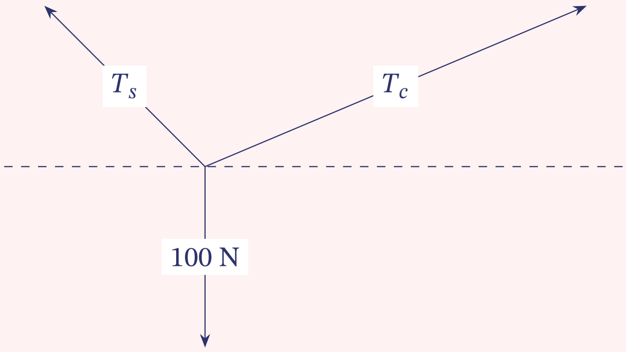


Figure 1. Free Body Diagram

Based on the diagram, by balancing forces along the horizontal direction, we have:

$$T_c \cos(30°) = T_s \cos(60°)$$

Thus, the ratio of the tensions is:

$$\frac{T_c}{T_s} = \frac{\cos(60°)}{\cos(30°)} = \frac{1}{\sqrt{3}}$$

Also, we are given:

$$\frac{L_c}{L_s} = \frac{\sqrt{3}}{1}$$

and

$$\frac{Y_s}{Y_c} = \frac{2 \times 10^{11}\ \text{N/m}^2}{1 \times 10^{11}\ \text{N/m}^2} = \frac{2}{1}$$

Therefore, the ratio of elongations is:

$$\frac{\Delta l_c}{\Delta l_s} = \frac{T_c}{T_s} \cdot \frac{L_c}{L_s} \cdot \frac{Y_s}{Y_c} = \frac{1}{\sqrt{3}} \cdot \sqrt{3} \cdot 2 = 2.00$$

Conclusion

Based on detailed analysis and the computed expression:

$$\boxed{\text{The value for } \frac{\Delta l_c}{\Delta l_s} \text{ is 2.00.}}$$

Support the Channel:

If you found this explanation helpful and it helped you think like a JEE Advanced ranker, consider supporting the channel!

- **Subscribe** to *The Bored IITian* for more such high-quality JEE problem breakdowns.
- **Share it with 3 friends** who have **never heard of the channel**. Help them level up too!
- Drop a comment or suggestion - your feedback helps improve future content.

Note from Senan: The way I solve and explain problems in this PDF is simply how I personally approach and think through JEE questions. This is **not** the only way to solve them. What I'm sharing here is my mindset and thought process - use it as inspiration, not as a prescription. Develop your own flow, but always stay curious and logical!

YouTube Channel: youtube.com/@bored_iitian