Answer on Question #45597-Physics-Mechanics

In Searle's apparatus for measurement of Young's modulus, a steel wire of length $l = 2m$ and area of cross-section $A = 2.5 \cdot 10^{-6}\ m^2$ is suspended from a torsion head. When a weight of $m = 5\ kg$ is suspended at its free-end, its length increases. Calculate the work done on the wire. Take Young's modulus of steel as $Y = 2 \cdot 10^{11}\ Nm$.

Solution

The work done on the wire is

$$W = \frac{1}{2}Fe,$$

where $F = mg$ is the applied force, e is extension obtained at force F.

$$e = \frac{Fl}{YA},$$

where A is the area of the cross section of the object and l is the length of the object, Y is Young's modulus.

Therefore

$$W = \frac{1}{2}F\frac{Fl}{YA} = \frac{1}{2}\frac{F^2 l}{YA} = \frac{1}{2}\frac{(mg)^2 l}{YA} = \frac{1}{2}\frac{(5 \cdot 9.8)^2 \cdot 2}{2 \cdot 10^{11} \cdot 2.5 \cdot 10^{-6}} = 4.8 \cdot 10^{-3} J = 4.8\ mJ.$$

Answer: $\mathbf{4.8 \cdot 10^{-3} J}$