Republic Polytechnic

A107 Physics

Problem 13 - Practice Question

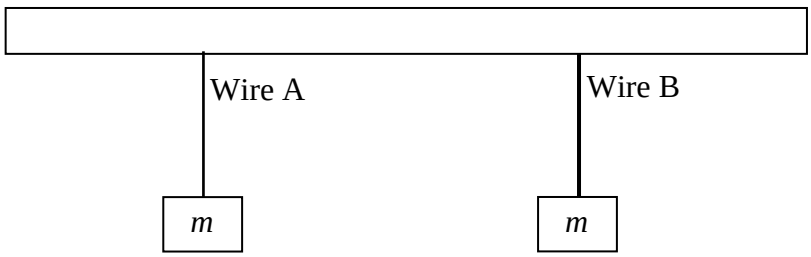
For this exercise, take acceleration due to gravity, g = 10 m/s^2 and π = 3.14. It is assumed that the elastic limit of the material is not exceeded.

1. A copper wire of length 4.0 m and diameter 6 mm is fixed at one end to the ceiling. A load of 18.0 kg is then applied to the copper wire. The load causes the length of the wire to extend by 0.23 mm

   Calculate:
   a. The cross-sectional area of the wire in m^2.
   b. The stress on the copper wire due to the load.
   c. The strain on the copper wire due to the load.
   d. The Young's modulus of copper.

   Suggested Answer
   a) $\pi(3 \times 10^{-3})^2 = 2.28 \times 10^{-5}$ m^2
   b) Stress = Force/Cross sectional area = $180/2.28 \times 10^{-5} = 7.89 \times 10^6$ N/m^2
   c) $\text{Strain} = \dfrac{\text{change in length}}{\text{original length}} = 0.23/4000 = 5.75 \times 10^{-5}$
   d) $\text{Stress} = \dfrac{F}{A} = 7.89 \times 10^6 / 5.75 \times 10^{-5} = 1.37 \times 10^{11}$ Pa

2. There are two equal length wires (A and B) hung on a ceiling. Both the wires are made of the same material but they have different cross-sectional area. The diameter of wire A is 0.01 m whereas the diameter of wire B is 0.04 m.
   a. If an object of mass m is hung at the free end of the wire, which wire will experience a greater stress?
   b. Find the ratio of the stress on A to that of B (i.e. Stress on A / Stress on B).

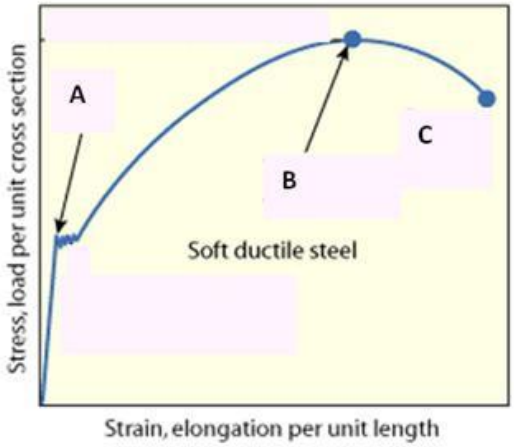


   Suggested Answer
   a) A will have a greater stress because its cross sectional area is smaller than wire B.
   b) Stress on A / Stress on B = 16

3. What is the strain on a rod of length 20 cm if its elongation is 0.0002 cm after being subjected to a tensile load? What other information is needed in order for you to calculate the amount of stress on the rod?

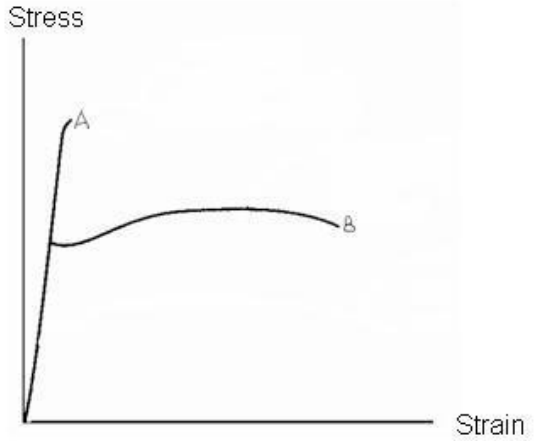
Suggested Answer
Strain = 0.0002/20 = 0.00001
Other information required is Young's Modulus.

4. The following figure shows the load-deformation characteristics of ductile steel. What do the points A, B and C signify?



Suggested Answer
A is proportional limit but in this case is also the elastic limit, B is ultimate tensile strength, C is the point where fracture occurs.

5. Peter performed a tensile test on two materials, A and B, of identical size and shape. The corresponding stress-strain graphs are shown in the figure below.



Which material would you choose to use as the body of a car? Justify your choice.

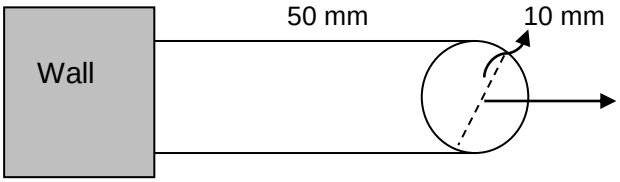
Suggested Answer
Material B. This is because material is more flexible and this allows the car to absorb the impact.

6. A cylindrical copper rod is subjected to a tensile load of 3000 N which extends its length by 3×10^{-4} m. Without the load, the length of the rod was 4 m. What was the diameter of the rod? (Properties of copper: Young's modulus, E = 11 GPa)

Suggested Answer
Young's modulus = Stress/Strain
$11 \times 10^{9} = (3000/ \pi r^{2})/(3 \times 10^{-4}/4)$

Diameter = 6.81×10^{-2} m

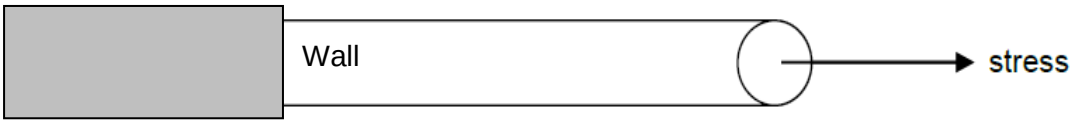
7. An aluminium sample with the dimensions of length 50 mm and diameter 10 mm is subjected to a tensile load of 35 kN, producing only elastic deformation. (Properties of aluminium: Young's modulus, E = 69 GPa)



Calculate the extension of the rod.

Suggested Answer
Young's modulus = Stress/Strain
$69 \times 10^9 = (35000/ \pi 0.005^2)/(\text{extension}/0.05)$
extension = 3.23×10^{-4} m

8. A tensile force of 4000 N is applied to a uniform rod with diameter of 5 mm and an initial length of 4 m as shown the figure below. The tensile force causes the wire length to become 4.1 m.



Calculate the Young's modulus of the material.

Suggested Answer
Young's modulus = Stress/Strain
$(4000/ \pi 0.0025^2)/(0.1/4) = 8.15 \times 10^9$ Pa

9. A 20 kg block is hung from the end of a vertical 0.40 m long steel wire with a cross-sectional area of 3.0 X 10^{-5} m^2. Given that the Young's modulus of steel: 2.0 X 10^{11} Pa.

Find the (i) stress and (ii) strain in the steel wire.

Suggested Answer
(i) Stress = Force/Cross sectional area = 20 X 10 /(3×10^{-5}) = 6.67×10^6 N/m^2

(ii) Young's modulus = Stress/Strain
2.0 X 10^{11} = 6.67×10^6 /Strain
Strain = 6.67×10^6 / (2.0 X 10^{11})
Strain = 3.33×10^{-5}