PHYsics 1050C
Homework
Chapter 10: 2, 11, 21, 22, 28, 36, 38, 40, 43, 45, 52, 56, 64

10.2 A telephone wire 125 m long and 1 mm in radius is stretched to a length of 125.25 m when a force of 800 N is applied. What is Young's modulus for the material of the wire?

$Y = {}^{stress}/_{strain}$

$stress = {}^{F}/_{A}$

$A = \pi r^2 = (3.14159)(0.001\ m)^2 = 3.14 \times 10^{-6}\ m^2$

$stress = {}^{F}/_{A} = {}^{800\ N}/_{3.14 \times 10^{-6}\ m^2} = 2.55 \times 10^8\ {}^{N}/_{m^2} = 2.55 \times 10^8\ Pa$

$strain = {}^{\Delta l}/_{l_o} = {}^{0.25\ m}/_{125\ m} = 0.002$

$Y = {}^{stress}/_{strain}$

$Y = {}^{2.55 \times 10^8\ Pa}/_{0.002}$

$Y = 1.27 \times 10^{11}\ Pa$

10.11 Steel will rupture if subjected to a shear stress of more that about 4.2×10^8 N/m^2. What sideward force is necessary to shear a steel bolt 1 cm in diameter?

$stress = {}^{F}/_{A} = 4.2 \times 10^8\ N/m^2$

$A = \pi r^2 = (3.14159)(0.005\ m)^2 = 7.85 \times 10^{-5}\ m^2$
$F = (A)(stress)$
$F = (7.85 \times 10^{-5}\ m^2)(4.2 \times 10^8\ N/m^2)$
$F = 3.3 \times 10^4\ N$

10.21 A steel piano wire has a radius of r_1 = 0.800 mm and a length l_o of 83.0 cm. One end of the wire is wound over a tuning peg in a circle that has a radius of r_2 = 3.2 mm. The other end is fastened rigidly to the soundboard. Assuming the tension in the wire is negligible initially, determine the tension after the peg has been turned through one complete turn.

In turning the tuning peg one complete turn, we stretch the wire a length Δl that is equal to the circumference of the tuning peg, $C = 2\pi r_2$.

$\Delta l = C = 2\pi r_2 = 2\,(3.14)(3.2\ mm) = 20.11\ mm = 2.011\ cm$

Starting with an initial length of l_o = 83 cm, this means the <u>strain</u> is

$strain = {}^{\Delta l}/_{l_o} = {}^{2.011\ cm}/_{83\ cm} = 2.423 \times 10^{-2} = 0.02423$

From Table 10.1, p 358, we can find Young's modulus for steel,

$$Y = 20 \times 10^{10}\ ^{N}/_{m^2}$$

and we can use that to find the stress

$$Y = {}^{stress}/_{strain}$$

$$stress = (Y)(strain) = (20 \times 10^{10}\ ^{N}/_{m^2})(0.02423) = 4.85 \times 10^{9}\ ^{N}/_{m^2}$$

$$stress = {}^{F}/_{A}$$

$$F = (A)(stress) = (\pi r^2)(4.85 \times 10^{9}\ ^{N}/_{m^2})$$

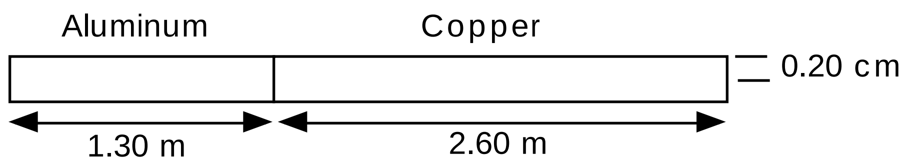
$$F = [\pi(0.800\ mm)^2](4.85 \times 10^{9}\ ^{N}/_{m^2})$$

$$F = [\pi(8 \times 10^{-4}\ m)^2][4.85 \times 10^{9}\ ^{N}/_{m^2}]$$

$$F = 9.75 \times 10^{3}\ N = 9{,}750\ N$$

F is the <u>tension</u> in the piano wire.

10.22 What is the elongation of the rod in Figure 20.39 if it is under a tension of 5.8×10^3 N?



The <u>tension</u> must be the <u>same</u> in both the rods.

$$F = 5.8 \times 10^3\ N$$

Since the two rods have the same cross section area, they will also have the same stress,

$$A = \pi r^2 = (3.14)(0.002\ m)^2 = 1.26 \times 10^{-5}\ m^2$$

$$stress = {}^{F}/_{A} = {}^{(5.8 \times 10^3\ N)}/_{(1.26 \times 10^{-5}\ m^2)} = 4.60 \times 10^{8}\ ^{N}/_{m^2}$$

From Table 10.1, p 358, we can find Young's modulus for Aluminum and for Copper,

$$Y_{Al} = 7.0 \times 10^{10}\ ^{N}/_{m^2}$$

$$Y_{Cu} = 11 \times 10^{10}\ ^{N}/_{m^2}$$

From these, we can calculate the strain, and then the elongation, of the Aluminum and of the Copper,

$$Y = {}^{stress}/_{strain}$$

$$strain = {}^{stress}/_{Y}$$

$$strain_{(Al)} = [\ 4.60 \times 10^{8}\ ^{N}/_{m^2}\ ]\ /\ [\ 7.0 \times 10^{10}\ ^{N}/_{m^2}\ ] = 6.58 \times 10^{-3}$$

$$strain_{(Cu)} = [\ 4.60 \times 10^{8}\ ^{N}/_{m^2}\ ]\ /\ [\ 11 \times 10^{10}\ ^{N}/_{m^2}\ ] = 4.18 \times 10^{-3}$$

$\text{strain} = \Delta l / l_o$

$\Delta l = (l_o)(\text{strain})$

$\Delta l_{(Al)} = (l_{o(Al)})(\text{strain}_{(Al)}) = (1.30\ m)(6.58 \times 10^{-3}) = 8.55 \times 10^{-3}\ m = 0.86\ cm$

$\Delta l_{(Cu)} = (l_{o(Cu)})(\text{strain}_{(Cu)}) = (2.60\ m)(4.18 \times 10^{-3}) = 1.09 \times 10^{-2}\ m = 1.09\ cm$

$\Delta l_{tot} = \Delta l_{(Al)} + \Delta l_{(Cu)} = 0.86\ cm + 1.09\ cm = 1.95\ cm$

10.28 What is the volume of a 2.5-kg sphere that is made of pure iron?

From Table 10.2, p 361, we find the density of iron is $\rho = 7860\ kg/m^3$.

$\rho = M/V$

$V = M/\rho$

$V = 2.5\ kg/[7860\ kg/m^3]$

$V = 3.18 \times 10^{-4}\ m^3$

10.36 To drink from a waterhole, a giraffe lowers its head 4.8 m from the upright position. What is the change in blood pressure at the brain when the giraffe raises its head back to the upright position?

$\Delta p = \rho\ g\ h$

$\Delta p = (1040\ kg/m^3)(9.8\ m/s^2)(4.8\ m)$

$\Delta p = 48{,}900\ N/m^2 = 48{,}900\ Pa = 48.9\ kPa$

10.38 If Earth's atmosphere had a uniform density of $1.290\ kg/m^3$, how high would the atmosphere have to extend in order to give rise to the observed sea-level atmospheric pressure of $1.013 \times 10^5\ N/m^2$.

$\Delta p = \rho\ g\ h$

$\Delta p = (1.290\ kg/m^3)(9.8\ m/s^2)(h) = 1.013 \times 10^5\ N/m^2$

$h = [1.013 \times 10^5\ N/m^2]/[(1.290\ kg/m^3)(9.8\ m/s^2)]$

$h = 8{,}000\ m = 8\ km$

10.40 A homeowner wishes to calibrate a new barometer. The home is on a hill 350 m above an airport where the barometric pressure is reported to be 99.1 kPa. What is the pressure difference, in kPa, between the home and the airport. To what kPa value should the homeowner set the barometer? What is this setting in millimeters of Mercury (mmHg)?

$\Delta p = \rho g h$

$\Delta p = (1.29\ kg/m^3)(9.8\ m/s^2)(350\ m)$

$\Delta p = 4{,}420\ Pa = 4.42\ kPa$

The homeowner is above the airport so her air pressure will be less; she should set her new barometer to

$p_{home} = p_{airport} - \Delta p = 99.1\ kPa - 4.4\ kPa$

$p_{home} = 94.7\ kPa$

$\Delta p = 4{,}420\ Pa\ [^{1\ mmHg}/_{133\ Pa}] = 33.23\ mmHg$

$p_{airport} = 99.1\ kPa = 99{,}100\ Pa\ [^{1\ mmHg}/_{133\ Pa}] = 745\ mmHg$

$p_{home} = p_{airport} - \Delta p = 745\ mmHg - 33\ mmHg$

$p_{home} = 712\ mmHg$

10.43 a mercury U-tube manometer shows a height difference of 18.5 cm from one arm to the other. What gauge pressure does this height difference correspond to, in Pa and in atmospheres?

$\Delta p = \rho g h$

$\Delta p = (13600\ kg/m^3)(9.8\ m/s^2)(0.185\ m)$

$\Delta p = 24{,}600\ Pa = 24.6\ kPa$

Or you might treat this simply as a units conversion problem,

$\Delta p = 18.5\ mmHg\ [^{133\ Pa}/_{1\ mmHg}] = 24{,}600\ Pa = 24.6\ kPa$

$\Delta p = 24.6\ kPa\ [^{1\ atm}/_{101.3\ kPa}] = 0.24\ atm$

10.45 A household vacuum cleaner produces a partial vacuum that is measured by a U-tube water manometer to be 55 cm H_2O below atmospheric pressure. What is the gauge pressure in Pa? The absolute pressure in Pa? What total force is available if the nozzle is 2.5 cm in diameter?

$\Delta p = \rho g h$

$\Delta p = (1000\ ^{kg}/_{m}3)(9.8\ m/s^2)(0.55\ m) = 5{,}390\ Pa = p_g$

$p_{abs} = p_g + p_o$

$p_{abs} = 5.4\ kPa + 101.3\ kPa = 106.7\ kPa$

$\Delta p = {}^{F}/_{A}$

$F = (\Delta p)(A) = (5{,}390\ Pa)(\pi(0.025\ m)^2) = 10.6\ N$

$F = 10.6\ N$

10.52 The hydraulic lift in Figure10.50 supports a car weighing 1.2×10^4 N. The radius of piston 1 is 2.0 cm, and the radius of piston 2 is 10 cm. What is the magnitude of the force **F** that must be applied to piston 1 to support the car?

$$P_1 = P_2$$

$$P_1 = F/A_1 = F/(\pi r^2) = F/(\pi (0.02\ m)^2) = F/1.26 \times 10^{-3}\ m^2$$

$$P_2 = W/A_2 = W/(\pi R^2) = 1.2 \times 10^4\ N/(\pi (0.10\ m)^2) = 382{,}000\ Pa$$

$$P_1 = P_2$$

$$F/1.26 \times 10^{-3}\ m^2 = 382{,}000\ N/m^2$$

$$F = (1.26 \times 10^{-3}\ m^2)(382{,}000\ N/m^2)$$

$$F = 480\ N$$

There are easier, more efficient ways to solve this as well.

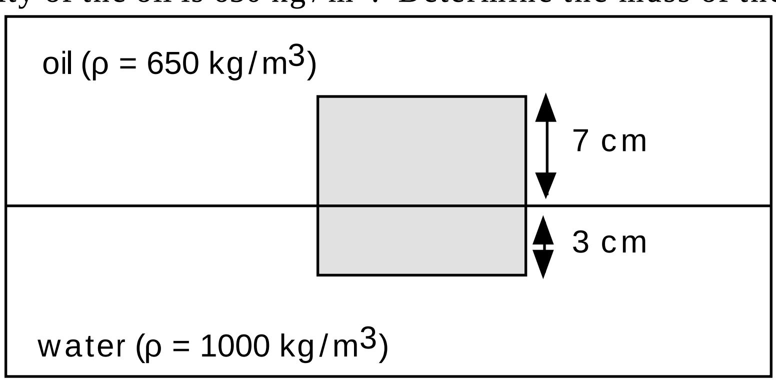
10.56 What percentage of a copper sphere floats above the surface of a container of mercury?

$$F_{bouy} = \rho(Hg)\ V_{submerged} = \rho(Cu)\ V_{total} = Wt_{(Cu)}$$

$$V_{submerged}/V_{total} = \rho(Cu)/\rho(Hg) = 8920/13600 = 0.65 = 65\%$$

Therefore 35% of the copper sphere will float above the mercury surface.

10.64 A 10-cm cube of wood floats in a container of oil and water as shown in Figure 10.54. The density of the oil is 650 kg/m^3. Determine the mass of the wood.



The total bouyant force equals the weight of the wood,

$$F_{b,tot} = F_{b,water} + F_{b,oil} = Wt_{wood}$$

The water exerts a bouyant force equal to the weight of the water displaced,

$$F_{b,water} = \rho(water)\ V_{water}\ g$$

$$F_{b,water} = (1000\ kg/m^3)\ (0.10\ m \times 0.10\ m \times 0.03\ m)(9.8\ m/s^2)$$

$F_{b,water} = 2.94\ N$

The oil exerts a bouyant force equal to the weight of the oil displaced,

$F_{b,oil} = \rho(oil)\ oil\ g$

$F_{b,oil} = (650\ ^{kg}/_{m}3)\ (0.10\ m \times 0.10\ m \times 0.07\ m)(9.8\ ^{m}/_{s}2)$

$F_{b,oil} = 4.46\ N$

Now we can add these bouyant forces together,

$F_{b,tot} = F_{b,water} + F_{b,oil} = Wt_{wood}$

$F_{b,tot} = 2.94\ N + 4.46\ N = 7.40\ N = Wt_{wood}$

$Wt_{wood} = M_{wood}\ g$

$M_{wood} = {}^{7.40\ N}/_{9.8\ m/s2} = 0.755\ kg$

$M_{wood} = 0.755\ kg$