Physics 23 Practice Problems Chapter 11

1. A sixty-kilogram person is wearing stiletto high-heel shoes. The circular base of a stiletto of each heel has a radius of 0.5 cm. If the wearer of these shoes rocks back onto his heels, and raises one foot off the floor, what would be the pressure exerted by the heel on the floor?

2. Use the atmospheric pressure versus height equation to determine the height at which P is only one percent of P_o. How many miles is this? (Note: There are 3.28 feet per meter, and 5280 feet per mile.)

3. Another unit of air pressure is the "bar." One "bar" = 100,000 Pa, which is roughly atmospheric pressure at sea-level. One millibar (mb) is one-thousandths of a bar, or 100 Pa. Atmospheric pressure at sea-level, therefore, is 101 millibars.

> Suppose a windowless building's roof is rectangular, 20 meters long and 15 meters wide. If the air pressure outside drops to a pressure 20 mb below the pressure inside the building, what will be the net air pressure force on the roof?

4. An object having a mass of 300 kg is sinking in water, accelerating at the rate of 1.6 m/s^2.
(a) What is the volume of the object? (b) What is its density?

5. A troy ounce (31.1 grams) of gold costs about $1300. What diameter (in cm) of a solid gold sphere would sell for $20,000? (Note: the density of gold is 19.3 grams/cm^3.)

6. Humans can withstand water pressures no greater than 4 P_o. To what depth could humans dive without a pressurized diving suit?

7. Modern nuclear attack submarine hulls are designed to withstand water pressures no greater than about 7.0 mega-newtons per square meter. How far below the surface may such submarines dive without being crushed?

8. SKIP THIS PROBLEM. A pipe at one place has a radius of 6.0 cm and a volume flow rate of 0.25 m^3/s.
(a) What is the speed of the water there? (b) At another point the radius is 2.0 cm. What is the speed of the water there?

9. A object weighing 600 N is *floating* in water. What is the buoyant force acting on the object?

10. A 40-kg object is floating in water. What mass of water is displaced?

11. An object having a mass of 12 kg and having a volume of 0.002 m^3 is placed under water and released. What is its acceleration? Is the object rising, or sinking?

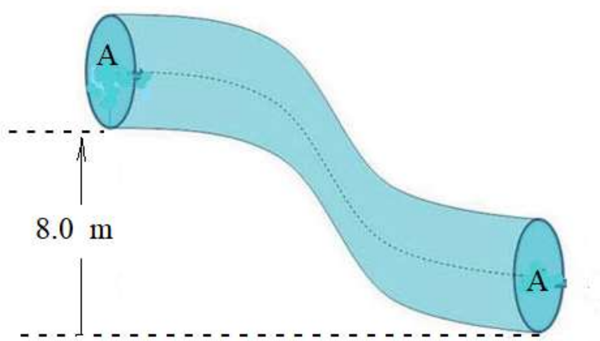
12. The mass of a ball held under water is 1.6 kg. The ball is then released and accelerates upward at 0.20 m/s^2. (a) What is the buoyant force (in newtons) acting on the ball? (b) What is the radius of the ball?

13. An object whose density is 300 kg/m^3 is floating in water. The volume of the object is 5.2 m^3. What volume of water is displaced?

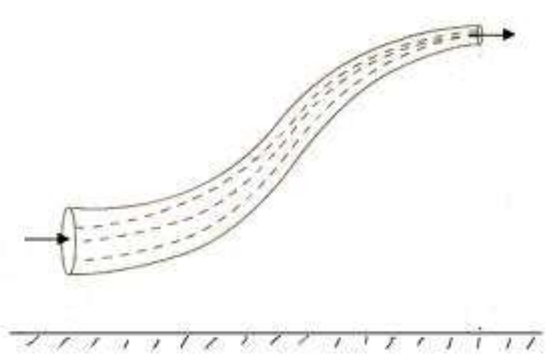
14. A hot air balloon is pulling a basket with a passenger upward. The total mass of balloon, the hot air inside it, the basket and passenger, is 160 kg. The radius of the balloon is 3.2 m. Given that the density of air near the surface of Earth is 1.2 kg/m^3, what is the acceleration of the balloon?

15. A solid object weighing 500 N consists of a certain metal whose density is 5000 kg/m^3. The object is dropped into a tank of water and sinks to the bottom. What is the contact force between the object and the bottom of the tank?

16. The cross-sectional area of the pipe below is the same at each end. The fluid flowing in the pipe is water; the difference in the heights is 8 meters. If the bottom of the tube is open to the atmosphere, what is the pressure at the top of the pipe?



17. At the lower end of the pipe below the water speed is 6 m/s. At the upper end the speed is 9 m/s. The upper end of the pipe is 2 meters higher than the lower end. How much higher is the pressure at the lower end of the pipe?



18. What is the boiling point of water at the top of the tallest mountain in the world? (Mt. Everest, 29,029 feet)

Chapter 11 Solutions

1.

$F = mg$
$= 60\,(9.8)$
$= 588$ N

$A = \pi(0.005)^2$
$= 7.85 \times 10^{-5}\ \text{m}^2$

$P = F/A$
$= 588 / 7.85 \times 10^{-5}$
$= 7.49 \times 10^{6}$ Pa

Note: 1.0 Pa is a very small pressure. A cube of butter has a weight of about 1.0 N. If one would spread the cube's butter evenly over a square one meter on a side, the spread butter's weight would cause a pressure of 1.0 N/m^2, or 1.0 Pa.

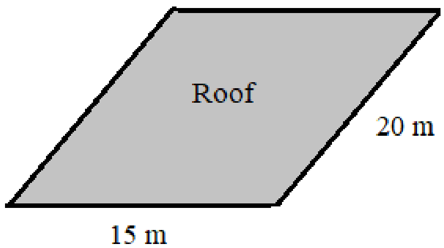
2.

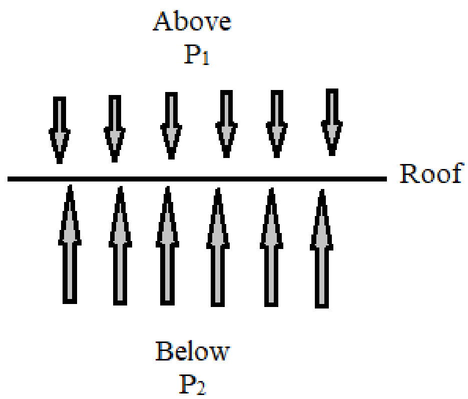
At what height h is $P = 0.01\ P_o$?

$P = P_o(1 - 2 \times 10^{-5}\,h)^5$
$0.01\ P_o = P_o(1 - 2 \times 10^{-5}\,h)^{-5}$
$h = 30{,}095$ m

(30,095 m) (3.28 ft/m)/5280 ft/mile
= 18.7 miles

3.





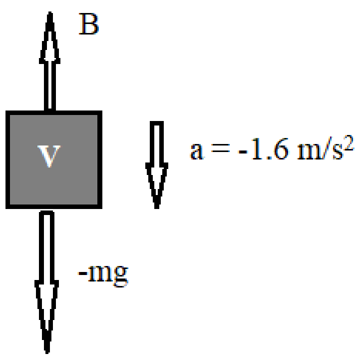
Recall: 1.0 mb = 100 Pa

$$P_2 - P_1 = 20 \text{ mb} = 2000 \text{ Pa}$$

$$A = 20(15) = 300 \text{ m}^2$$

$$\begin{aligned}\text{Net Force} &= F_2 - F_1 \\ &= P_2A - P_1A \\ &= (P_2 - P_1)A \\ &= (2000)\,(300) \\ &= 600{,}000 \text{ N}\end{aligned}$$

4.



(a)

$F = ma$
$B - 300(9.8) = 300\,(-1.6)$
$B = 2460$ N

Weight of Water = B

$(1000\ \text{kg/m}^3)V\,(9.8) = 2460$ N
$V = 0.25\ \text{m}^3$

(b)

$\rho = m/V$
$= 300 / 0.25$
$= 1200\ \text{kg/m}^3$

5.

\$1300.00 per ounce.
20,000/1300 = 15.38 ounces
There are 31.1 grams per troy ounce.

$$m = (15.38)\,(31.1)$$
$$= 478.32 \text{ grams}$$

$$V = m/\rho$$
$$= (478.32 \text{ g}) / (19.3 \text{ g/cm}^3)$$
$$= 24.78 \text{ cm}^3$$

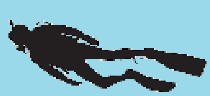
$$(4\pi/3)r^3 = 24.78$$
$$r = 1.81 \text{ cm}$$

$$\text{Diameter} = (2)(1.81)$$
$$= 3.62 \text{ cm}$$

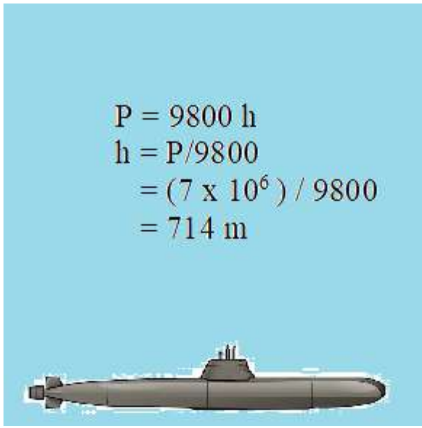
6.

$$P = \rho g h$$
$$= (1000)\,(9.8)\,h$$
$$= 9800\,h$$

$$9800\,h = 4\,P_o$$
$$= 4(101{,}000)$$
$$h = 41{,}22 \text{ m}$$



7.



8. SKIP

(a) $\pi\,(0.06)^2\,v_1 = 0.25\ m^3/s$

$v_1 = 22.10\ m/s$

(b) The volume flow rate in one place is the same as at any other place:

$\pi\,(0.02)^2\,v_2 = 0.25\ m^3/s$

$v_2 = 198.94\ m/s$

9.

Floating objects have zero acceleration, so the net force on the object is zero, which means the buoyant force upward matches the 600 N weight force downward:

B = 600 N

10.

For floating objects, the weight of the water displaced (the buoyant force) equals the weight of the object.

If two objects have the same weight, they have the same mass. Thus, the mass of water displaced is 40 kg

11.

$m = 12$ kg
$w = 12\ (9.8)$
$\quad = 117.6$ N

The object is completely under water, so the volume of water displaced is the same as the volume of the object.

$V = 0.002\ m^3$

$B = mg$ (weight of water displaced)
$\quad = \rho V g$
$\quad = (1000)\ (0.002)(9.8)$
$\quad = 19.6$ N

$F = -117.6 + 19.6$
$\quad = -98.0$ N (net force)

$a = F/m$
$\quad = -98.0/12.0$
$\quad = -8.17\ m/s^2$

The acceleration is negative, so the object is sinking.

12.

$$F = ma$$
$$B - 1.6\ (9.8) = 1.6\ (0.2)$$
$$B = 16 \text{ N}$$

$9800\ (4\pi/3)\ r^3 = 16$

$$r = 0.073 \text{ m}$$
$$= 7.3 \text{ cm}$$

13.

Fraction Under = Ratio of Densities
$= 300/1000$
$= 0.3$
$(0.3)\ (5.2) = 1.56\ m^3$

14.

Archimedes' Principle applies to objects floating or immersed in *any* fluid, including air.

Weight of Object:
$mg = (160)(9.8)$
$=1568\ N$

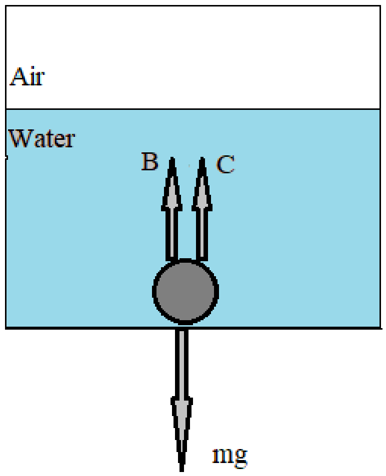
Volume of Air Displaced $= (4/3)\pi\ (3.2)^3$
$= 137.26\ m^3$

Density of Air: $1.2\ kg/m^3$
Mass of Air Displaced: $(1.2\ kg/m^3)\ (137.26\ m^3) = 164.71\ kg$
Weight of Air Displaced: $(164.71)\ (9.8) = 1614\ N$

$$B = 1614\ N$$

$$F = ma$$
$$B - mg = ma$$
$$1614 - 1568 = 160\ a$$
$$a = 0.29\ m/s^2$$

15.



$w = 500$ N
$m = 500/9.8$
$= 51.02$ kg

$V = 51.02/5000$
$= 0.0102\ m^3$

$B = (1000)\ (0.0102)\ (9.8)$
$= 100$ N

$F = ma$
$C + B - mg = 0$
$C + 100 - 500 = 0$
$C = 400$ N

16.

$P_1 + \rho g h_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2} \rho v_2^2$

The speeds are the same because the areas are the same, so the speed terms cancel.

$P_1 + \rho g h_1 = P_2 + \rho g h_2$

Water exiting a pipe into the atmosphere is at atmospheric pressure, 101,000 Pa.

$P_1 + 1000\,(9.8)(8) = 101{,}000 + 1000\,(9.8)(0)$
$P = 22{,}600$ Pa

17.

Left end: $h_1 = 0$

$P_1 + \rho g h_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2} \rho v_2^2$
$P_1 + 0 + \frac{1}{2}\,(1000)(6)^2 = P_2 + 1000(9.8)(2) + \frac{1}{2}(1000)(9)^2$
$P_1 - P_2 = 42{,}100$ Pa
$= 42.1$ kPa

18.

Convert Mt. Everest height in feet, to meters:
29,029 / 3.28 = 8850 m

Calculate pressure in kilopascals at 8850 meters elevation:
$P = 101\,(1 - 2.3 \times 10^{-5}\, h)^5$
$= 101\,(1 - 2.3 \times 10^{5} \times 8850)^5$
$= 32.37$ kPa

Calculate the boiling point of water at the top of Mt. Everest
$T = 71.6 + (7/25)P$
$= 71.6 + (7/25)\ 32.37$
$= 80.66\ ^{o}C$