Answers to selected problems from Essential Physics, Chapter 9

1. The two buoyant forces are equal. In both cases, the buoyant force acting on the block must balance the force of gravity acting on the block, so the buoyant force in both cases is equal to the force of gravity that acts on the block.

3. (a) The aluminum ball has less mass than the steel ball, even though the balls are the same size, because aluminum is less dense than steel. (b) The balls displace equal volumes of water – because the balls are completely submerged, each ball displaces a volume of water that is equal to its own volume.

5. (a) When you suck on the straw, you remove air from the straw, reducing the pressure inside the straw. This produces a pressure imbalance – it is really the effect of atmospheric pressure acting on the surface of the liquid that forces the fluid to flow up through the straw and into your mouth. You do not suck the liquid up – you just reduce the pressure in the straw, and atmospheric pressure pushes the fluid up the straw.

(b) Once again, atmospheric pressure is responsible for this. When you seal the top of the straw, the pressure at the top of the straw is equal to atmospheric pressure. When you remove the straw from the liquid, the fluid at the bottom of the straw is also exposed to atmospheric pressure. With the pressures equal at the top and bottom, there is nothing to balance the weight of the column of liquid in the straw, so some of the liquid leaks out. The air at the top of the straw, above the column of liquid, then occupies a larger volume, and when the volume increases, the pressure decreases. The pressure at the bottom is still atmospheric pressure, however. The liquid is in equilibrium when the force of gravity acting down on the liquid is balanced by the force coming from the pressure difference between the top and bottom, multiplied by the cross-sectional area of the straw.

7. (a) $C > B > A$ (b) $A = B = C$

9. The scale reading increases. When you put your finger in the water, the water exerts an upward buoyant force on you. By Newton's third law, you exert an equal-and-opposite force down on the water, which is passed on by the water to the beaker, which passes it on to the scale.

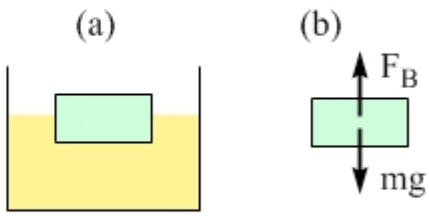
11. This all comes down to pressure. When you lie on a bed of nails, your weight is distributed over a large number of nails, so the upward normal force exerted on you by any one nail is small, and the pressure associated with that force is also relatively small. If you tried to support yourself on a single nail, however, the nail would have to exert a force on you equal to your weight. That force would be exerted over a very small area, leading to a very high pressure, most likely high enough to break the skin and cause plenty of pain!

13. (a) 300 kg/m^3 (b) 1500 kg/m^3

15. The ice will float higher in the glass. When the oil is poured in, the ice displaces some of the oil, so the oil exerts an upward buoyant force on the ice. This means that the

water exerts a smaller buoyant force on the ice than before, which requires the ice to displace less water – the ice must be floating higher in the glass than before to displace less water.

17.

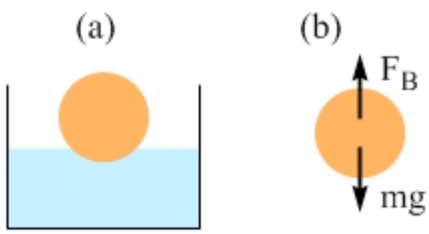


(c)

$$\sum \vec{F} = m\vec{a} = 0$$
$$+F_B - mg = 0$$
$$F_B = mg$$

(d) $F_B = 8.0$ N

19.



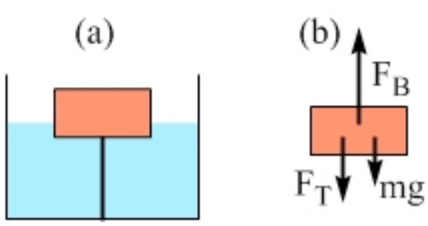
(c)

$$\sum \vec{F} = m\vec{a} = 0$$
$$+F_B - mg = 0$$
$$F_B = mg$$

(d) 5.0×10^{-4} m^3 (e) 5.5×10^{-3} m^3 (f) $V = \frac{4}{3}\pi r^3$ (g) 11 cm

(h) There is no need to use a particular value of *g* – the value of *g* cancels out in the equation.

21.

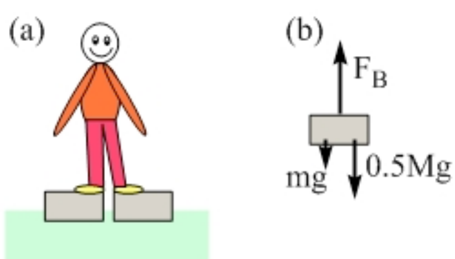


(c)

$$\sum \vec{F} = m\vec{a} = 0$$
$$+F_B - F_T - mg = 0$$
$$F_B = mg + F_T$$

(d) 75% (e) 10%

23.

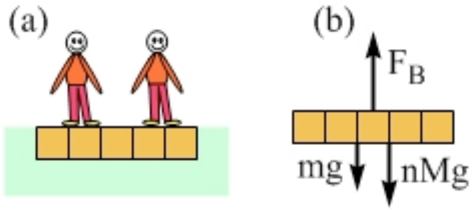


(c) Each styrofoam "shoe" has a weight of mg, and supports half of Mg, the weight of the person.

$$\sum \vec{F} = m\vec{a} = 0$$
$$+F_B - 0.5Mg - mg = 0$$
$$F_B = mg + 0.5Mg$$

(d) 8.4×10^{-2} m^3 (e) Estimating a shoebox to be 30 cm × 15 cm × 15 cm, with a volume of 6.75×10^{-3} m^3, each Styrofoam "shoe" is as big as 12 regular shoeboxes.

25.



(c) Assume the raft (mass m) is fully submerged, and that there are n kids standing on the raft, each with a mass M.

$$\sum \vec{F} = m\vec{a} = 0$$
$$+F_B - nMg - mg = 0$$
$$F_B = mg + nMg$$
$$\rho_{water} Vg = \rho_{wood} Vg + nMg$$

(d) 22 kids

27. 5.1 cm

29. (a) The liquid will fall in the tube. (b) 1.20 cm (c) 16.3 cm

31. (a) As the water drops, its speed increases. By the continuity equation, the product of the area and the speed must remain the same, so as the speed increases the cross-sectional area of the stream gets reduced. (b) 2.0 m/s (c) 0.10 cm^2

33. (a) $v = \sqrt{2gh}$ (b) $t = \sqrt{\dfrac{2(H-h)}{g}}$ (c) $\Delta x = vt = 2\sqrt{(H-h)h}$

35. (a) 116000 N/m^2 (b) 118000 N/m^2

37. (a) The wooden cube experiences a larger buoyant force – it is displacing more fluid. (b) 300 kg/m^3 (c) 39.2 N (d) 3700 kg/m^3

39. (a) The wooden block is less dense than the fluid, and it starts lower in the fluid than its equilibrium position, so the wooden block will accelerate upward. The metal cube is more dense than the fluid, so it will sink toward the bottom of the container. (b) The wooden block has an acceleration of 0.79 m/s^2 up, while the metal cube has an acceleration of 3.2 m/s^2 down. (c) After a long time, the wooden block floats at the surface, with 74% of its volume below the surface, while the metal cube is at rest on the bottom of the container.

41. 4.7 g

43. Using a constant density for air gives a height for the atmosphere of about 9 km. This is a very rough estimate, because the density of air is not constant with height – in general, the higher you go, the less dense the air is. Thus, because this calculation uses a value for density that is too large, the estimate for the atmosphere's height is too small – the number represents a lower bound on the height.

45. 1 atm = 14.7 psi (pounds per square inch) = 760 torr = 760 mm of mercury
= 1.01325 bar

47. (a) The normal force is the same no matter what orientation the brick has. The normal force is 150 N. (b) The maximum pressure is 12300 N/m^2, while the minimum pressure is 3270 N/m^2.

49. The boiling point of water depends on pressure. At high altitude, the pressure is lower than it is at sea level, so water boils at a lower temperature than it does at standard atmospheric pressure. As any British person will tell you, when making a cup of tea it is important that the water be very hot – at high altitude, the boiling water simply does not get hot enough to make a good cup of tea.

51. (a) 1960 N/m^2. (b) 0 (c) –2940 N/m^2.

53. (a) 980 Pa (b) 41 m/s

55. 8.5 m

57. (a) 17 m/s. (b) 346000 N/m^2

59. The problem does not have a valid solution, with the numbers given. If we set the absolute pressure at the pump to be 1.5 atmospheres, however, we can get a value for the area of the tube, so let's do that. This gives 2.0×10^{-5} m^2

61. Jaime has the right ideas. The other two have some misconceptions about how it all works.