Chapter 9 Problems

1, 2 = straightforward, intermediate

Section 9.3 Density and Pressure

15. Four acrobats of mass 75.0 kg, 68.0 kg, 62.0 kg, and 55.0 kg form a human tower, with each acrobat standing on the shoulders of another acrobat. The 75.0 kg acrobat is at the bottom of the tower. (a) What is the normal force acting on the 75 kg acrobat? (b) If the area of each of the 75.0 kg acrobat's shoes is 425 cm^2, what average pressure does the column of acrobats exert on the floor? (c) Will the pressure be the same if a different acrobat is on the bottom?

16. A large man sits on a four-legged chair with his feet off the floor. The combined mass of the man and chair is 95.0 kg. If the chair legs are circular and have a radius of 0.50 cm at the bottom, what pressure does each leg exert on the floor?

18. The four tires of an automobile are inflated to a gauge pressure of 2.0×10^5 Pa. Each tire has an area of 0.024 m^2 in contact with the ground. Determine the weight of the automobile.

Section 9.4 Variation of Pressure with Depth
Section 9.5 Pressure Measurements

21. Calculate the absolute pressure at the bottom of a freshwater lake at a depth of 27.5 m. Assume the density of the water is 1000 kg/m^3 and the air above is at a pressure of 101.3 kPa. (b) What force is exerted by the water on the window of an underwater vehicle at this depth if the window is circular and has a diameter of 35.0 cm?

22. When you suddenly stand up after lying down for a while, your body many not compensate quickly enough for the pressure changes and you might feel dizzy for a moment. If the gauge pressure of the blood at your heart is 13.3 kPa and your body doesn't compensate, (a) what would the pressure be at your ear, 50.0 cm above your heart? The density of blood is 1,060 kg/m^3. (b) What would it be at your feet, 130 cm below your heart?

23. A collapsible plastic bag (Figure P9.23) contains a glucose solution. If the average gauge pressure in the vein is 1.33×10^3 Pa, what must be the minimum height *h* of the bag in order to infuse glucose into the vein? Assume that the specific gravity of the solution is 1.02.

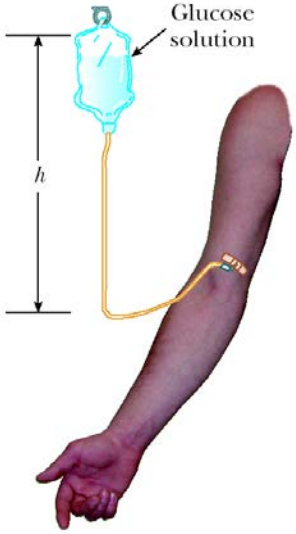

Figure P9.23

Homework 1 => 15, 16, 18, 21 – 27
Homework 2 => 29, 31, 38- 43
Homework 3 => 44, 46, 47, 51, 53, 54

24. The deepest point in the ocean is in the Mariana Trench, about 11 km deep. The pressure at the ocean floor is huge, about 1.13×10^8 N/m^2. (a) Calculate the density of water at the bottom of the Pacific. (b) The density of water at the surface is 1.03×10^3 kg/m^3. Find the change in volume of 1.00 m^3 when brought to the bottom of the Mariana Trench. incompressible?

25. A container is filled to a depth of 20.0 cm with water. On top of the water floats a 30.0-cm-thick layer of oil with specific gravity 0.700. What is the absolute pressure at the bottom of the container?

26. Piston ① in Figure P9.26 has a diameter of 0.25 in.; piston ② has a diameter of 1.5 in. In the absence of friction, determine the force piston 1 must exert to support the 500-lb weight. (You can use lb as the unit of force)

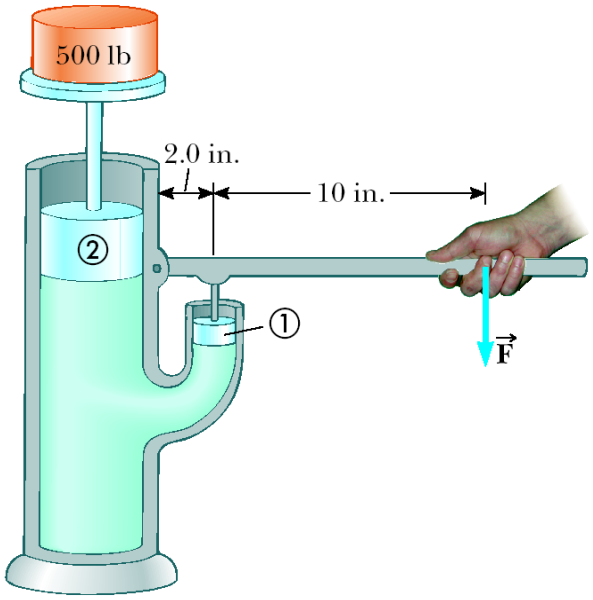

Figure P9.26

27. Figure P9.27 shows the essential parts of a hydraulic brake system. The area of the piston in the master cylinder is 1.8 cm^2, and that of the piston in the brake cylinder is 6.4 cm^2. The coefficient of friction between shoe and wheel drum is 0.50. Determine the frictional force about the axle when a force of 44 N is exerted on the brake pedal.

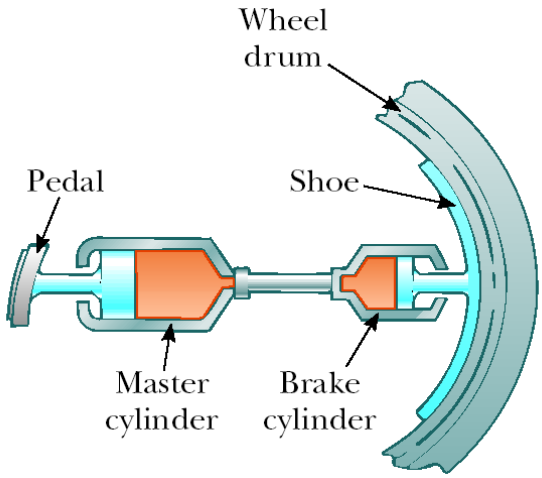

Figure P.27

Section 9.6 Buoyant Forces and Archimedes' Principle

29. A rubber ball filled with air has a diameter of 25.0 cm and a mass of 0.540 kg. (a) What force is required to hold the ball in equilibrium immediately below the surface of water in a swimming pool? (b) How will this force change if the ball is held just under the surface of a lake that has water with the same density?

31. A small ferryboat is 4.00 m wide and 6.00 m long. When a loaded truck pulls onto it, the boat sinks an additional 4.00 cm into the river. What is the weight of the truck?

38. A 10.0-kg block of metal is suspended from a scale and immersed in water, as in Figure P9.30. The dimensions of the block are 12.0 cm × 10.0 cm × 10.0 cm. The 12.0-cm dimension is vertical, and the top of the block is 5.00 cm below the surface of the water. (a) What are the forces exerted by the water on the top and bottom of the block? (Take $P_0 = 1.013\ 0 \times 10^5\ \text{N/m}^2$.) (b) What is the reading of the spring scale? (c) Show that the buoyant force equals the difference between the forces at the top and bottom of the block.

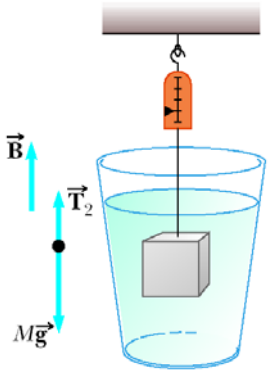

Figure P9.38

39. A bathysphere used for deep sea exploration has a radius of 1.50 m and a mass of 1.20×10^4 kg. In order to dive, the sphere takes on mass in the form of sea water. Determine the mass the bathysphere must take on so that it can descend at a constant speed of 1.20 m/s when the resistive force on it is 1 100 N upward. The density of sea water is $1.03 \times 10^3\ \text{kg/m}^3$.

40. A light spring of force constant $k = 160$ N/m rests vertically on the bottom of a large beaker of water (Fig. P9.40a). A 5.00-kg block of wood (density = 650 kg/m³) is connected to the spring, and the block–spring system is allowed to come to static equilibrium (Fig. P9.40b). What is the elongation ΔL of the spring?

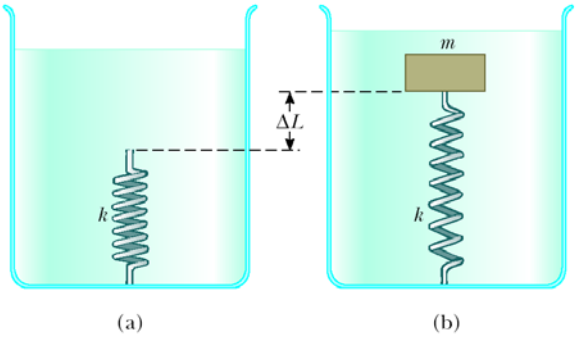

Figure P9.40

41. A sample of an unknown material appears to weigh 300 N in air and 200 N when immersed in alcohol (density = 700 kg/m³). What are (a) the volume and (b) the density of the material?

42. A thin spherical shell of mass 0.400 kg and diameter 0.200 m is filled with alcohol (ρ = 806 kg/m³). It is then released from rest at the bottom of a pool of water. Find the acceleration of the alcohol-filled shell as it starts to rise toward the surface of the water.

43. A 1.00-kg beaker containing 2.00 kg of oil (density = 916 kg/m³) rests on a scale. A 2.00-kg block of iron is suspended from a spring scale and is completely submerged in the oil (Fig. P9.43). Find the equilibrium readings of both scales.

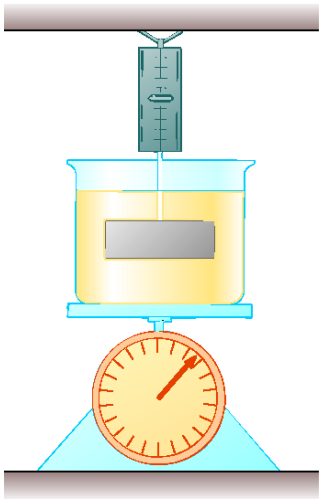
Figure P9.43

Section 9.7 Fluids in Motion
Section 9.8 Other Applications of Fluid Dynamics

44. Water flowing though a garden hose of diameter 2.74 cm fills a 25.0 L bucket in 1.50 min. (a) What is the speed of the water leaving the end of the hose? (b) A nozzle is now attached to the end of the hose. If the nozzle diameter is one-third the diameter of the hose, what is the speed of the water leaving the nozzle?

46. A liquid (ρ = 1.65 g/cm^3) flows through two horizontal sections of tubing joined end to end. In the first section, the cross-sectional area is 10.0 cm^2, the flow speed is 275 cm/s, and the pressure is 1.20 × 10^5 Pa. In the second section, the cross-sectional area is 2.50 cm^2. Calculate the smaller section's (a) flow speed and (b) pressure.

47. A hypodermic syringe contains a medicine with the density of water (Fig. P9.47). The barrel of the syringe has a cross-sectional area of 2.50 × 10^{-5} m^2. In the absence of a force on the plunger, the pressure everywhere is 1.00 atm. A force $\vec{\mathbf{F}}$ of magnitude 2.00 N is exerted on the plunger, making medicine squirt from the needle. Determine the medicine's flow speed through the needle. Assume that the pressure in the needle remains equal to 1.00 atm and that the syringe is horizontal.

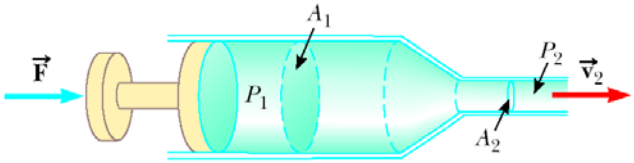

Figure P9.47

51. In a water pistol, a piston drives water through a larger tube of radius 1.0 cm into a smaller tube of radius 1.0 mm as in Figure P9.51. (a) If the pistol is fired horizontally at a height of 1.50 m, use ballistics to determine the time it takes water to travel from the nozzle to the ground (Neglect air resistance). (b) If the range of the stream is to be 8.0 m, with what speed must the stream leave the nozzle? (c) Given the areas of the nozzle and the cylinder, use the equation of continuity to calculate the speed at which the plunger must be moved. (d) What is the pressure at the nozzle? (e) Use Bernoulli's equation to find the pressure needed in the larger cylinder. Can gravity terms be neglected? (f) Calculate the force that must be exerted on the trigger to achieve the desired range. (The force that must be exerted is due to pressure over and above atmospheric pressure.)

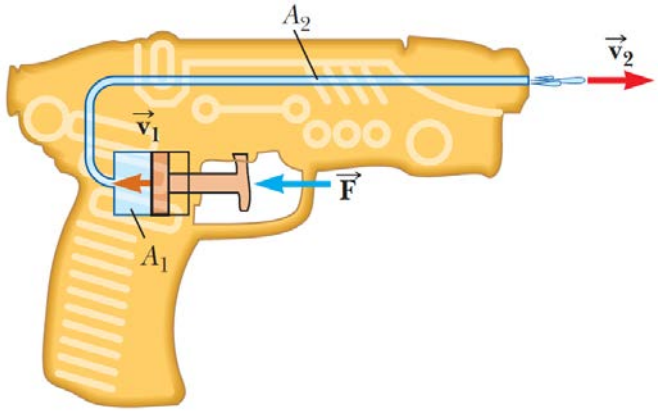

FIGURE P9.51

53. A jet of water squirts out horizontally from a hole near the bottom of the tank shown in Figure P9.53. If the hole has a diameter of 3.50 mm, what is the height h of the water level in the tank?

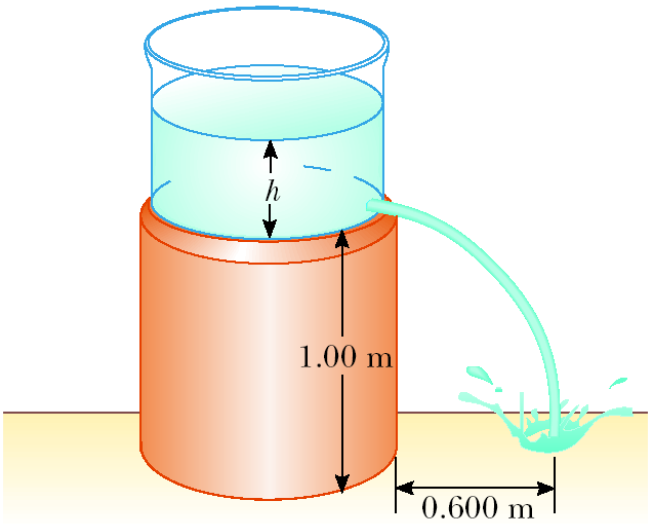

Figure P9.53

54. A large storage tank, open to the atmosphere at the top and filled with water, develops a small hole in its side at a point 16.0 m below the water level. If the rate of flow from the leak is 2.50×10^{-3} m^3/min, determine (a) the speed at which the water leaves the hole and (b) the diameter of the hole.