CHAPTER 8 Summary

BIG IDEA A fluid applies a pressure on objects that are in contact with the fluid.

SECTION 1 Fluids and Buoyant Force

- Force is a vector quantity that causes acceleration.
- A fluid is a material that can flow, and thus it has no definite shape. Both gases and liquids are fluids.
- Buoyant force is an upward force exerted by a fluid on an object floating on or submerged in the fluid.
- The magnitude of a buoyant force for a submerged object is determined by Archimedes' principle and is equal to the weight of the displaced fluid.
- The magnitude of a buoyant force for a floating object is equal to the weight of the object, because the object is in equilibrium.

KEY TERMS

fluid
mass density
buoyant force

SECTION 2 Fluid Pressure

- Pressure in a fluid is the force per unit area exerted by the fluid on the surface.
- According to Pascal's principle, pressure applied to a fluid in a closed container is transmitted equally to every point of the fluid and to the walls of the container.
- The pressure in a fluid increases with depth.

KEY TERM

pressure

SECTION 3 Fluids in Motion

- Moving fluids can exhibit laminar (smooth) flow or turbulent flow.
- An ideal fluid is incompressible, nonviscous, and, when undergoing ideal flow, nonturbulent.
- The continuity equation is derived from the fact that the amount of fluid leaving a pipe during some time interval equals the amount entering the pipe during that same time interval.
- According to Bernoulli's principle, the pressure of an ideal fluid flowing horizontally through some region decreases as the speed of the fluid increases.

KEY TERM

ideal fluid

VARIABLE SYMBOLS

Quantities		Units		Conversions
ρ	density	kg/m^3	kilogram per meter^3	$= 10^{-3}$ g/cm^3
P	pressure	Pa	pascal	$= N/m^2$ $= 10^{-5}$ atm

Problem Solving

See **Appendix D: Equations** for a summary of the equations introduced in this chapter. If you need more problem-solving practice, see **Appendix I: Additional Problems.**

CHAPTER 8 Review

Density and Buoyancy

REVIEWING MAIN IDEAS

1. How is weight affected by buoyant force?
2. Buoyant force equals what for any floating object?

CONCEPTUAL QUESTIONS

3. If an inflated beach ball is placed beneath the surface of a pool of water and released, the ball shoots upward. Why?
4. An ice cube is submerged in a glass of water. What happens to the level of the water as the ice melts?
5. Will a ship ride higher in an inland freshwater lake or in the ocean? Why?
6. Steel is much denser than water. How, then, do steel boats float?
7. A small piece of steel is tied to a block of wood. When the wood is placed in a tub of water with the steel on top, half of the block is submerged. If the block is inverted so that the steel is underwater, will the amount of the wooden block that is submerged increase, decrease, or remain the same?

PRACTICE PROBLEMS

For problems 8–9, see Sample Problem A.

8. An object weighs 315 N in air. When tied to a string, connected to a balance, and immersed in water, it weighs 265 N. When it is immersed in oil, it weighs 269 N. Find the following:
   a. the density of the object
   b. the density of the oil
9. A sample of an unknown material weighs 300.0 N in air and 200.0 N when submerged in an alcohol solution with a density of 0.70×10^3 kg/m^3. What is the density of the material?

Pressure

REVIEWING MAIN IDEAS

10. Is a large amount of pressure always caused by a large force? Explain your answer.
11. What is the SI unit of pressure? What is it equal to in terms of other SI units?

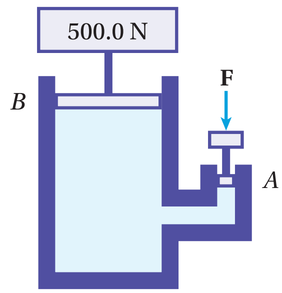
CONCEPTUAL QUESTIONS

12. After a long class, a physics teacher stretches out for a nap on a bed of nails. How is this possible?
13. When drinking through a straw, you reduce the pressure in your mouth, and the atmosphere moves the liquid. Could you use a straw to drink on the moon?

PRACTICE PROBLEMS

For problems 14–16, see Sample Problem B.

14. The four tires of an automobile are inflated to an absolute 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.
15. A pipe contains water at 5.00×10^5 Pa above atmospheric pressure. If you patch a 4.00 mm diameter hole in the pipe with a piece of bubble gum, how much force must the gum be able to withstand?
16. A piston, *A*, as shown at right, has a diameter of 0.64 cm. A second piston, *B*, has a diameter of 3.8 cm. Determine the force, **F**, necessary to support the 500.0 N weight in the absence of friction.



Fluid Flow

CONCEPTUAL QUESTIONS

17. Prairie dogs live in underground burrows with at least two entrances. They ventilate their burrows by building a mound around one entrance, which is open to a stream of air. A second entrance at ground level is open to almost stagnant air. Use Bernoulli's principle to explain how this construction creates air flow through the burrow.

18. Municipal water supplies are often provided by reservoirs built on high ground. Why does water from such a reservoir flow more rapidly out of a faucet on the ground floor of a building than out of an identical faucet on a higher floor?

19. If air from a hair dryer is blown over the top of a table-tennis ball, the ball can be suspended in air. Explain how this suspension is possible.

Mixed Review

REVIEWING MAIN IDEAS

20. An engineer weighs a sample of mercury ($\rho = 13.6 \times 10^3$ kg/m^3) and finds that the weight of the sample is 4.5 N. What is the sample's volume?

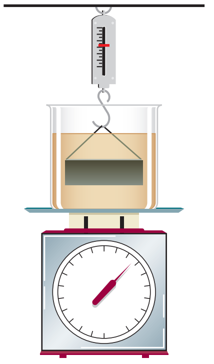
21. About how much force is exerted by the atmosphere on 1.00 km^2 of land at sea level?

22. A 70.0 kg man sits in a 5.0 kg chair so that his weight is evenly distributed on the legs of the chair. Assume that each leg makes contact with the floor over a circular area with a radius of 1.0 cm. What is the pressure exerted on the floor by each leg?

23. A frog in a hemispherical bowl, as shown below, just floats in a fluid with a density of 1.35×10^3 kg/m^3. If the bowl has a radius of 6.00 cm and negligible mass, what is the mass of the frog?

24. When a load of 1.0×10^6 N is placed on a battleship, the ship sinks only 2.5 cm in the water. Estimate the cross-sectional area of the ship at water level. (Hint: See **Figure 1.2** for the density of sea water.)

25. A 1.0 kg beaker containing 2.0 kg of oil with a density of 916 kg/m^3 rests on a scale. A 2.0 kg block of iron is suspended from a spring scale and completely submerged in the oil, as shown at right. Find the equilibrium readings of both scales. (Hint: See **Figure 1.2** for the density of iron.)



26. A raft is constructed of wood having a density of 600.0 kg/m^3. The surface area of the bottom of the raft is 5.7 m^2, and the volume of the raft is 0.60 m^3. When the raft is placed in fresh water having a density of 1.0×10^3 kg/m^3, how deep is the bottom of the raft below water level?

27. A physics book has a height of 26 cm, a width of 21 cm, and a thickness of 3.5 cm.

a. What is the density of the physics book if it weighs 19 N?

b. Find the pressure that the physics book exerts on a desktop when the book lies face up.

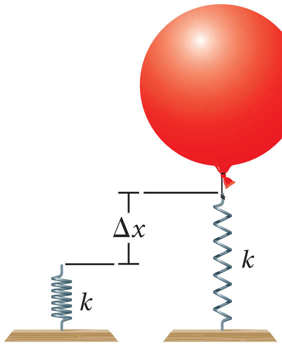
c. Find the pressure that the physics book exerts on the surface of a desktop when the book is balanced on its spine.

28. A natural-gas pipeline with a diameter of 0.250 m delivers 1.55 m^3 of gas per second. What is the flow speed of the gas?

29. A 2.0 cm thick bar of soap is floating in water, with 1.5 cm of the bar underwater. Bath oil with a density of 900.0 kg/m^3 is added and floats on top of the water. How high on the side of the bar will the oil reach when the soap is floating in only the oil?

30. Which dam must be stronger, one that holds back 1.0×10^5 m^3 of water 10 m deep or one that holds back 1.0×10^3 m^3 of water 20 m deep?

31. A light spring with a spring constant of 90.0 N/m rests vertically on a table, as shown in (**a**) below. A 2.00 g balloon is filled with helium (0°C and 1 atm pressure) to a volume of 5.00 m^3 and connected to the spring, causing the spring to stretch, as shown in (**b**). How much does the spring stretch when the system is in equilibrium? (Hint: See **Figure 1.2** for the density of helium. The magnitude of the spring force equals $k\Delta x$.)



(a) **(b)**

32. The aorta in an average adult has a cross-sectional area of 2.0 cm^2.

a. Calculate the flow rate (in grams per second) of blood ($\rho = 1.0$ g/cm^3) in the aorta if the flow speed is 42 cm/s.

b. Assume that the aorta branches to form a large number of capillaries with a combined cross-sectional area of 3.0×10^3 cm^2. What is the flow speed in the capillaries?

33. A 1.0 kg hollow ball with a radius of 0.10 m is filled with air and is released from rest at the bottom of a 2.0 m deep pool of water. How high above the surface of the water does the ball rise? Disregard friction and the ball's motion when the ball is only partially submerged.

34. In testing a new material for shielding spacecraft, 150 ball bearings each moving at a supersonic speed of 400.0 m/s collide head-on and elastically with the material during a 1.00 min interval. If the ball bearings each have a mass of 8.0 g and the area of the tested material is 0.75 m^2, what is the pressure exerted on the material?

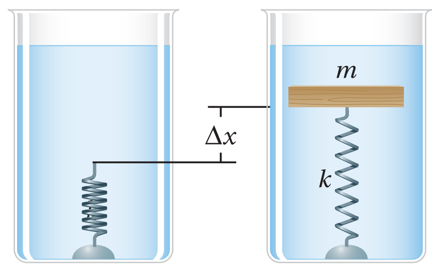
35. A thin, rigid, spherical shell with a mass of 4.00 kg and diameter of 0.200 m is filled with helium (adding negligible mass) at 0°C and 1 atm pressure. It is then released from rest on the bottom of a pool of water that is 4.00 m deep.

a. Determine the upward acceleration of the shell.

b. How long will it take for the top of the shell to reach the surface? Disregard frictional effects.

36. A student claims that if the strength of Earth's gravity doubled, people would be unable to float on water. Do you agree or disagree with this statement? Why?

37. A light spring with a spring constant of 16.0 N/m rests vertically on the bottom of a large beaker of water, as shown in (**a**) below. A 5.00×10^{-3} kg block of wood with a density of 650.0 kg/m^3 is connected to the spring, and the mass-spring system is allowed to come to static equilibrium, as shown in (**b**) below. How much does the spring stretch?



(a) **(b)**

38. Astronauts sometimes train underwater to simulate conditions in space. Explain why.

39. Explain why some balloonists use helium instead of air in balloons.

ALTERNATIVE ASSESSMENT

1. Build a hydrometer from a long test tube with some sand at the bottom and a stopper. Adjust the amount of sand as needed so that the tube floats in most liquids. Calibrate it, and place a label with markings on the tube. Measure the densities of the following liquid foods: skim milk, whole milk, vegetable oil, pancake syrup, and molasses. Summarize your findings in a chart or table.

2. The owner of a fleet of tractor-trailers has contacted you after a series of accidents involving tractor-trailers passing each other on the highway. The owner wants to know how drivers can minimize the pull exerted as one tractor-trailer passes another going in the same direction. Should the passing tractor-trailer try to pass as quickly as possible or as slowly as possible? Design experiments to determine the answer by using model motor boats in a swimming pool. Indicate exactly what you will measure and how. If your teacher approves your plan and you are able to locate the necessary equipment, perform the experiment.

3. Record any examples of pumps in the tools, machines, and appliances you encounter in one week, and briefly describe the appearance and function of each pump. Research how one of these pumps works, and evaluate the explanation of the pump's operation for strengths and weaknesses. Share your findings in a group meeting, and create a presentation, model, or diagram that summarizes the group's findings.

GRAPHING CALCULATOR PRACTICE

Flow Rates

Flow rate, as you learned earlier in this chapter, is described by the following equation:

$$\text{flow rate} = Av$$

Flow rate is a measure of the volume of a fluid that passes through a tube per unit time. A is the cross-sectional area of the tube, and v is the flow speed of the fluid. If A has units of centimeters squared and v has units of centimeters per second, flow rate will have units of cubic centimeters per second.

The graphing calculator will use the following equation to determine flow rate.

$$Y_1 = \pi * V(X/2)^2$$

You will use this equation to study the flow rates (Y_1) for various hose diameters (X) and flow speeds (V). The calculator will produce a table of flow rates in cubic centimeters per second versus hose diameters in centimeters.

In this graphing calculator activity, you will learn how to read a table on the calculator and to use that table to make predictions about flow rates.

Go online to HMHScience.com to find the skillsheet and program for this graphing calculator activity.