Chapter

11 Forces in Fluids

The BIG Idea
Science and Technology

How can you predict if an object will sink or float?

Chapter Preview

1. **Pressure**
   Discover Can You Blow Up a Balloon in a Bottle?
   Math Skills Area
   Try This Card Trick
   Design Your Own Lab Spinning Sprinklers
2. **Floating and Sinking**
   Discover What Can You Measure With a Straw?
   Try This Cartesian Diver
   At-Home Activity Changing Balloon Density
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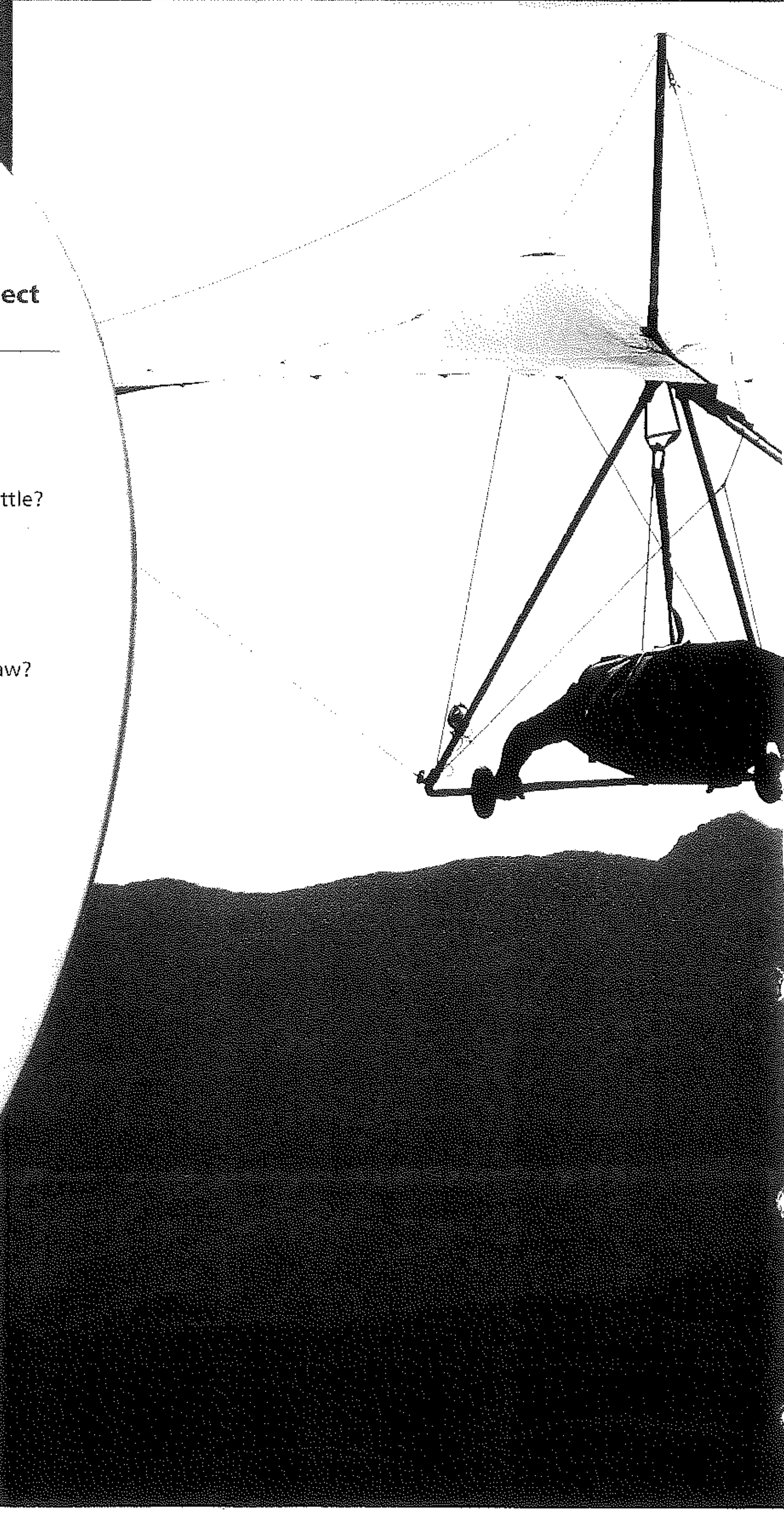
3. **Pascal's Principle**
   Discover How Does Pressure Change?
   Active Art Hydraulic Systems
   Analyzing Data Comparing Hydraulic Lifts
4. **Bernoulli's Principle**
   Discover Does the Movement of Air Affect Pressure?
   Try This Faucet Force
   At-Home Activity Paper Chimney



The force of air pushing on a hang glider's wing helps to keep the glider aloft. ▶

Lab zone™ Chapter **Project**

Staying Afloat

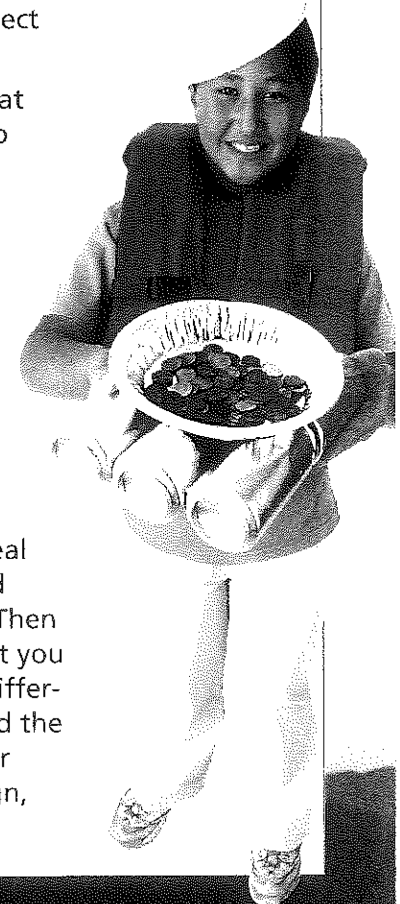
Whether an object sinks or floats depends on more than just its weight. In this Chapter Project, you will design and build a boat that can float in water and carry cargo. You will find out what forces in fluids make an object sink or float.

Your Goal To construct a boat that can float in water and carry cargo

Your boat must

- be made of metal only
- support a cargo of 50 pennies without allowing any water to enter for at least 10 seconds
- travel at least 1.5 meters
- be built following the safety guidelines in Appendix A

Plan It! Before you design your boat, think about the shape of real ships. Preview the chapter to find out what makes an object float. Then look for simple metal objects that you can form into a boat. Compare different materials and designs to build the most efficient boat you can. After your teacher approves your design, build your boat and test it.



Section 1

Pressure

Reading Preview

Key Concepts

- What does pressure depend on?
- How do fluids exert pressure?
- How does fluid pressure change with elevation and depth?

Key Terms

- pressure
- pascal
- fluid
- barometer

Target Reading Skill

Previewing Visuals Before you read, preview Figure 5. Then write two questions that you have about the diagram in a graphic organizer like the one below. As you read, answer your questions.

Pressure Variations

Q. Why does pressure change with elevation and depth?
A.
Q.

Lab zone Discover Activity

Can You Blow Up a Balloon in a Bottle?

1. Insert a balloon into the neck of an empty bottle. Try to blow up the balloon.
2. Now insert a straw into the bottle, next to the balloon. Keep one end of the straw sticking out of the bottle. Try again to blow up the balloon.

Think It Over

Developing Hypotheses Did using the straw make a difference? If it did, develop a hypothesis to explain why.

Outside, deep snow covers the ground. You put on your sneakers and head out, shovel in hand. When you step outside, your foot sinks deep into the snow. It's nearly up to your knees! Nearby, a sparrow hops across the surface of the snow. Unlike you, the bird does not sink. In fact, it barely leaves a mark! Why do you sink into the snow while the sparrow rests on the surface?

What Is Pressure?

The word *pressure* is related to the word *press*. It refers to a force exerted over an area on the surface of an object. You may recall that Earth's gravity pulls you downward with a force equal to your weight. Due to gravity, your feet exert a force on the surface of Earth over an area the size of your feet. In other words, your feet exert pressure on the ground.

Exerting pressure on snow ▶

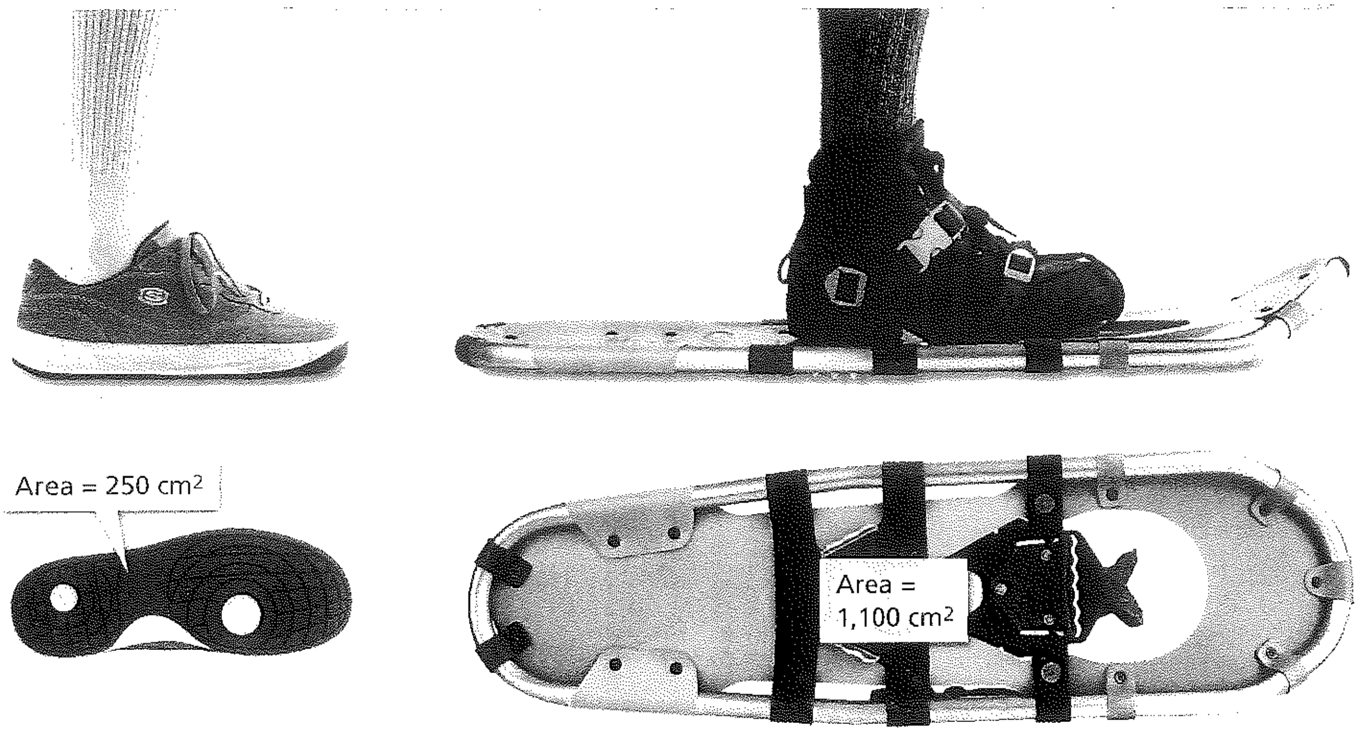


FIGURE 1
Pressure and Area
Pressure depends on the area over which a force is distributed.
Inferring *Which type of shoe would you use to keep from sinking into deep snow?*

Pressure and Area Force and pressure are closely related, but they are not the same thing. **Pressure decreases as the area over which a force is distributed increases.** The larger the area over which the force is distributed, the less pressure is exerted. In order to stand on snow without sinking, you can't make yourself weigh the same as a bird. However, you can change the area over which you exert the force of your weight.

If you wear sneakers, like those shown in Figure 1, your weight is distributed over the soles of both shoes. You'll exert pressure over an area of about 500 cm^2 and sink into the snow. But if you wear snowshoes, you'll exert pressure over a much greater area—about 2,200 cm^2. Because the force of your weight is distributed over a greater area, the overall pressure exerted on the snow is much less. Like a sparrow, you can stand on the snow without sinking!

Calculating Pressure The relationship of force, area, and pressure is summarized by a formula.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

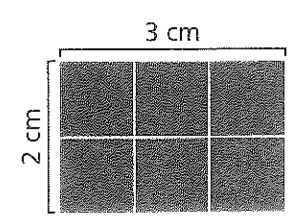
Pressure is equal to the force exerted on a surface divided by the total area over which the force is exerted. Force is measured in newtons (N). Area is measured in square meters (m^2). Since force is divided by area, the SI unit of pressure is the newton per square meter (N/m^2). This unit of pressure is also called the **pascal** (Pa): 1 N/m^2 = 1 Pa.

Reading Checkpoint **What is the SI unit of pressure called?**

Math Skills

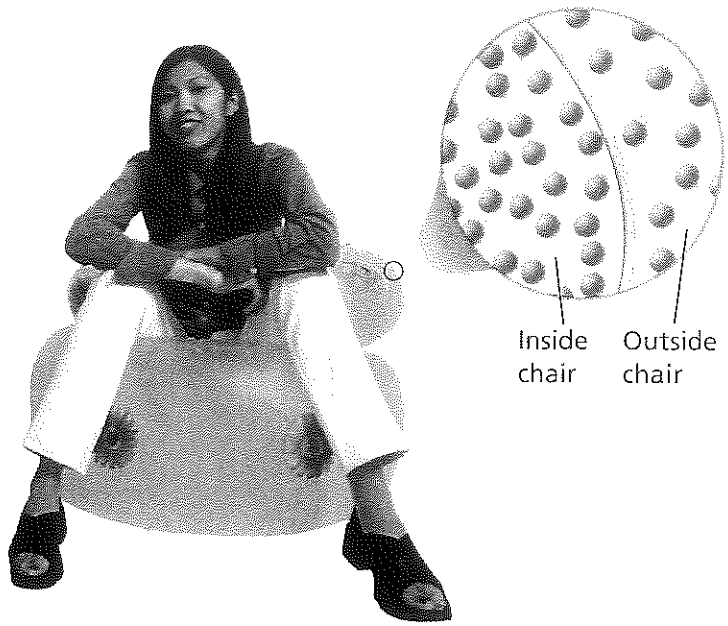
Area

The area of a surface is the number of square units that it covers. To find the area of a rectangle, multiply its length by its width. The area of the rectangle below is 2 cm × 3 cm, or 6 cm^2.



Practice Problem Which has a greater area: a rectangle that is 4 cm × 20 cm, or a square that is 10 cm × 10 cm?

FIGURE 2
Fluid Particles
The particles that make up a fluid move constantly in all directions. When a particle collides with a surface, it exerts a force on the surface.
Relating Cause and Effect *What will happen to the force exerted by the particles in the chair when you add more air to the chair?*



Fluid Pressure

Solids such as sneakers are not the only materials that exert pressure. Fluids also exert pressure. A **fluid** is a material that can easily flow. As a result, a fluid can change shape. Liquids such as water and oil and gases such as air and helium are examples of fluids.

What Causes Fluid Pressure? To understand how fluids exert forces that can result in pressure, think about the tiny particles that make up the fluid. Particles in a fluid constantly move in all directions, as shown in Figure 2. As they move, the particles collide with each other and with any surface that they meet.

As each particle in a fluid collides with a surface, it exerts a force on the surface. **All of the forces exerted by the individual particles in a fluid combine to make up the pressure exerted by the fluid.** Because the number of particles is large, you can consider the fluid as a whole. So, the fluid pressure is the total force exerted by the fluid divided by the area over which the force is exerted.

Air Pressure Did you know that you live at the bottom of 100 kilometers of fluid that surrounds Earth? This fluid, called air, is the mixture of gases that makes up Earth's atmosphere. These gases press down on everything on Earth's surface, all the time. Air exerts pressure because it has mass. You may forget that air has mass, but each cubic meter of air around you has a mass of about 1 kilogram. Because the force of gravity pulls down on this mass of air, the air has weight. The weight of the air is the force that produces air pressure, or atmospheric pressure.

Lab zone Try This Activity

Card Trick

1. Fill a small plastic cup to the brim with water. Gently place an index card over the top of the cup.
2. Hold the card in place and slowly turn the cup upside down. Let go of the card. What happens? Without touching the card, turn the container on its side.

Inferring Why does the water stay in the cup when you turn the cup upside down?

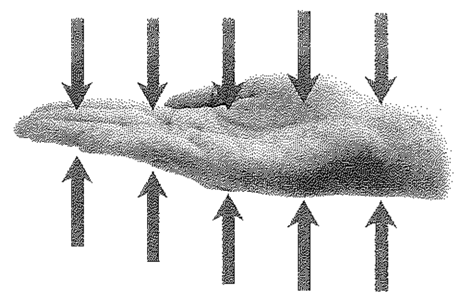
Balanced Pressure Hold out your hand, palm up. You are holding up air. At sea level, atmospheric pressure is about 10.13 N/cm^2. The surface area of your hand is about 100 cm^2. So, the weight supported by the surface area of your hand is about 1,000 newtons, or about the same weight as that of a large washing machine!

How could your hand possibly support that weight and not feel it? In a stationary fluid, pressure at a given point is exerted equally in all directions. The weight of the atmosphere does not just press down on your hand. It presses on your hand from every direction. The pressures balance each other.

Balanced pressures also explain why the tremendous air pressure pushing on you from all sides does not crush you. Your body contains fluids that exert outward pressure. For example, your lungs and sinus cavities contain air. Your cells and blood vessels contain liquids. So pressure from fluids inside your body balances the air pressure outside your body.

What happens when air pressure becomes unbalanced? Look at Figure 4. When the beach ball is full of air, the air pressure inside the beach ball balances the atmospheric pressure outside the beach ball. When air is removed from the beach ball, the unbalanced force of the outside air pressure deflates the ball.

FIGURE 3
Atmospheric Pressure
The pressure of Earth's atmosphere is exerted over the entire surface of your hand.



Reading Checkpoint **How is the pressure on your hand balanced?**

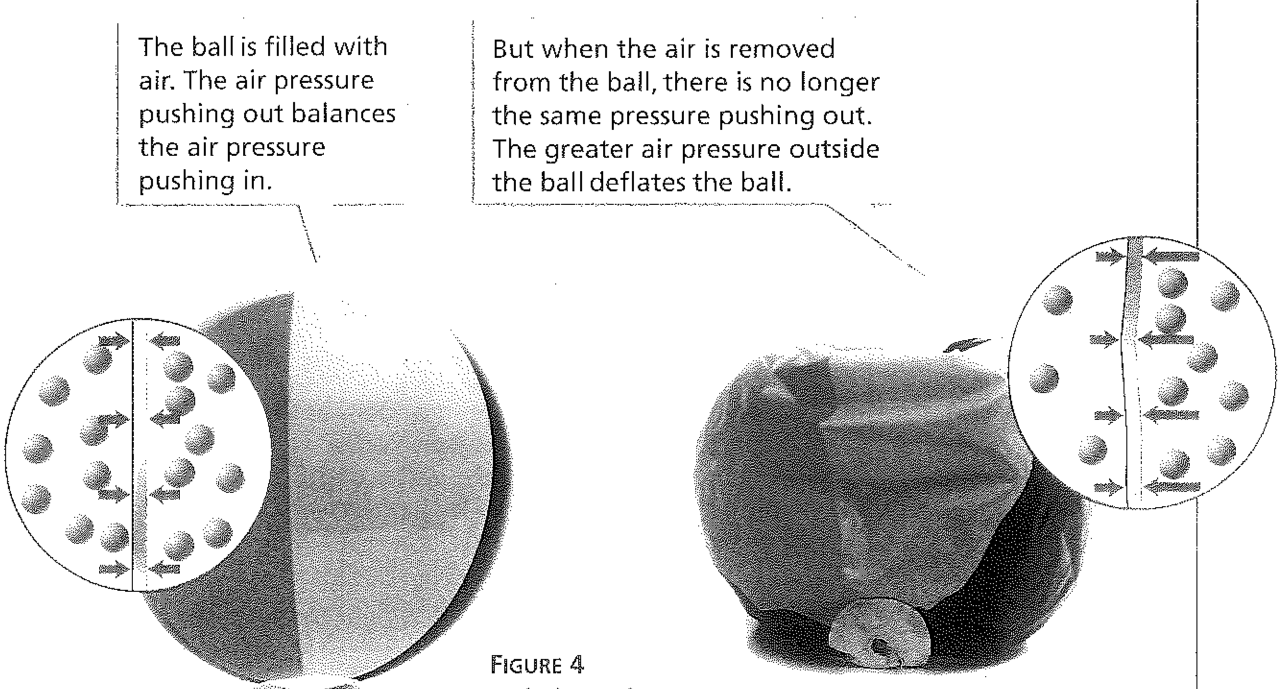


FIGURE 4
Unbalanced Pressure

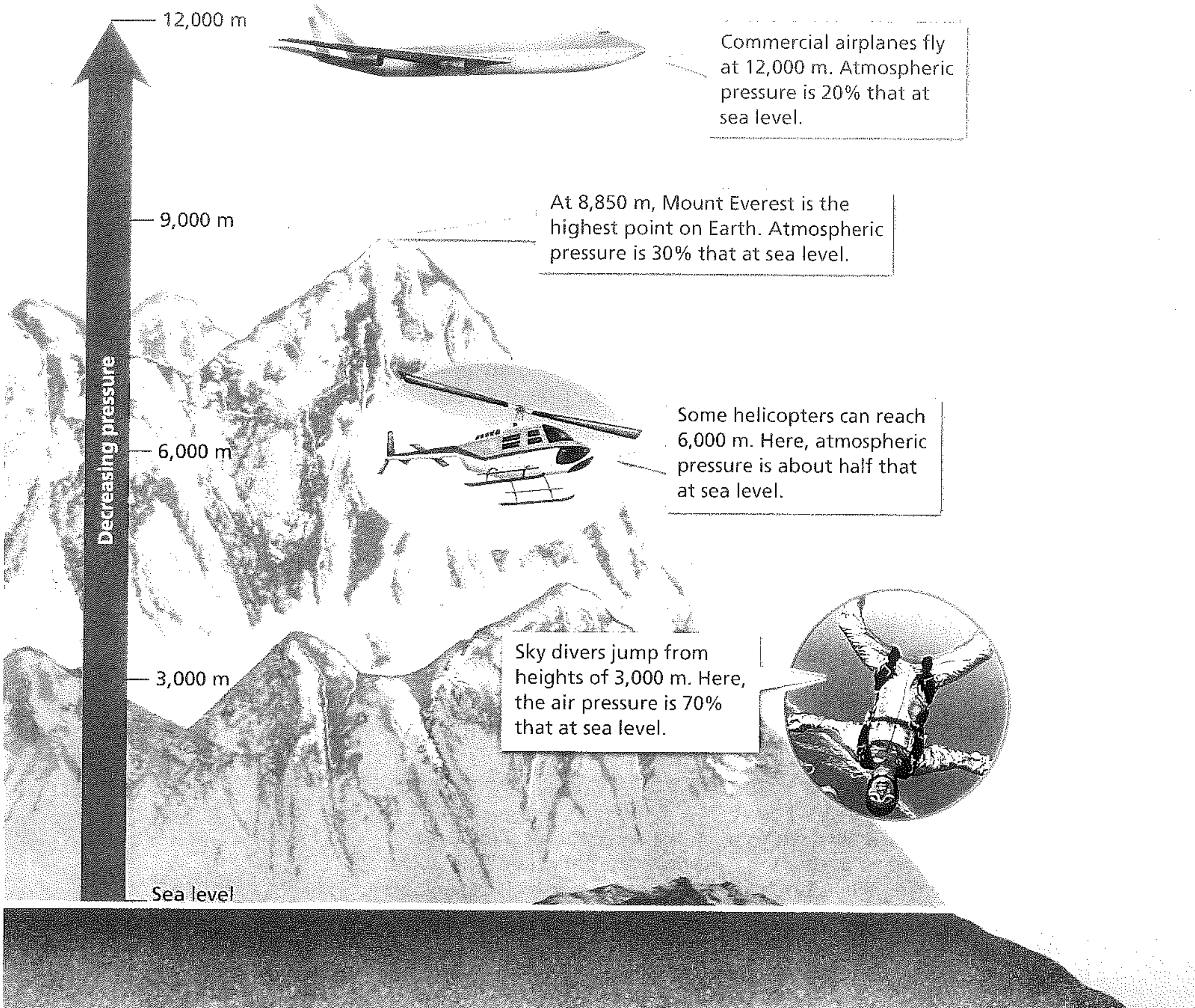


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FIGURE 5
Pressure Variations

Atmospheric pressure decreases gradually as the elevation above sea level increases. Water pressure increases rapidly as the water depth increases. **Applying Concepts** *Why do airplanes have pressurized cabins?*

Variations in Fluid Pressure

Does the pressure of a fluid ever change? What happens to pressure as you climb to a higher elevation or sink to a lower depth within a fluid? Figure 5 shows how pressure changes depending on where you are.

Atmospheric Pressure and Elevation Have you ever felt your ears "pop" as you rode up in an elevator? The "popping" has to do with changing air pressure. At higher elevations, there is less air above you and therefore less air pressure. **As your elevation increases, atmospheric pressure decreases.**

The fact that air pressure decreases as you move up in elevation explains why your ears pop. When the air pressure outside your body changes, the air pressure inside adjusts, but more slowly. So, for a moment, the air pressure behind your eardrums is greater than it is in the air outside. Your body releases this pressure with a "pop," balancing the pressures.

Water Pressure and Depth Fluid pressure depends on depth. The pressure at one meter below the surface of a swimming pool is the same as the pressure one meter below the surface of a lake. But if you dive deeper into either body of water, pressure becomes greater as you descend. The deeper you swim, the greater the pressure you feel. **Water pressure increases as depth increases.**

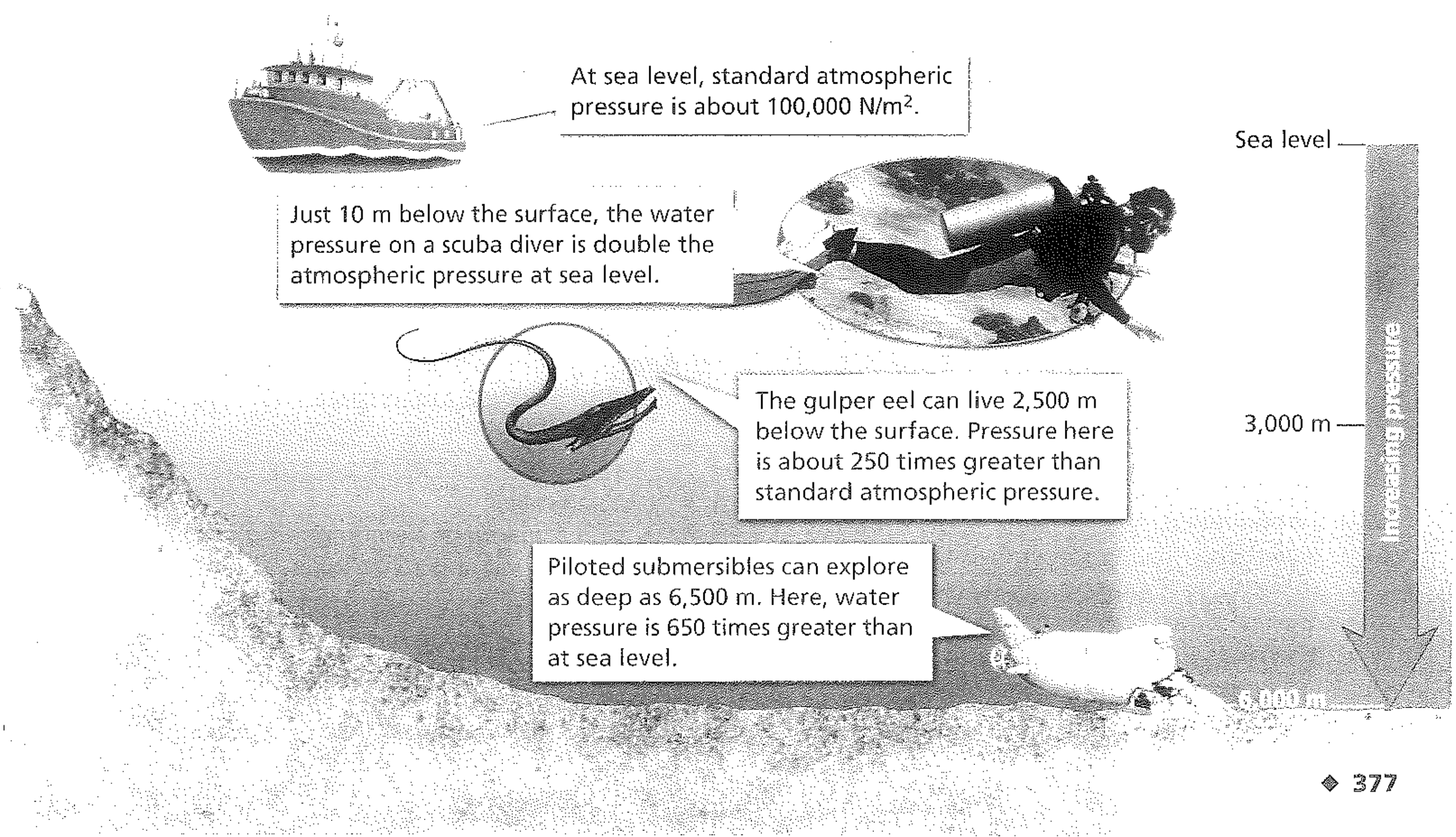
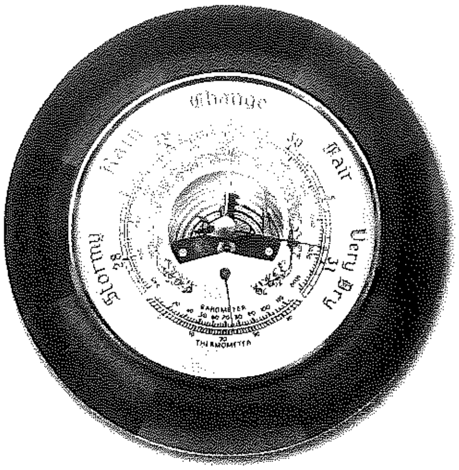


FIGURE 6
Aneroid Barometer
An aneroid barometer measures atmospheric pressure.
Interpreting Photographs *What type of weather might be coming when atmospheric pressure decreases?*



As with air, you can think of water pressure as being due to the weight of the water above a particular point. At greater depths, there is more water above that point and therefore more weight to support. In addition, air in the atmosphere pushes down on the water. Therefore, the total pressure at a given point beneath the water results from the weight of the water plus the weight of the air above it. In the deepest parts of the ocean, the pressure is more than 1,000 times the air pressure you experience every day.

Measuring Pressure You can measure atmospheric pressure with an instrument called a **barometer.** There are two types of barometers: a mercury barometer and an aneroid barometer. The aneroid barometer is the barometer you usually see hanging on a wall. Weather forecasters use the pressure reading from a barometer to help forecast the weather. Rapidly decreasing atmospheric pressure usually means a storm is on its way. Increasing pressure is often a sign of fair weather. You may hear barometric pressure readings expressed in millimeters, inches, or another unit called a millibar. For example, the standard barometric pressure at sea level may be reported as 760 millimeters, 29.92 inches, or 1,013.2 millibars.

Reading Checkpoint **What instrument measures atmospheric pressure?**

Section 1 Assessment

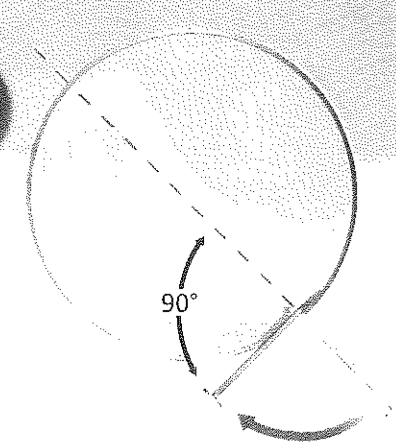
Target Reading Skill
Previewing Visuals Refer to your questions and answers about Figure 5 to help you answer Question 3 below.

Reviewing Key Concepts
1. a. Reviewing What two factors does pressure depend on?
   b. Comparing and Contrasting Who exerts more pressure on the ground—a 50-kg woman standing in high heels, or a 50-kg woman standing in work boots?
2. a. Summarizing How do fluids exert pressure?
   b. Explaining Since most of the weight of the atmosphere is above you, why aren't you crushed by it?
   c. Inferring How is your body similar to the ball containing air shown in Figure 4?
3. a. Describing How does atmospheric pressure change as you move away from the surface of Earth?
   b. Comparing and Contrasting Compare the change in atmospheric pressure with elevation to the change in water pressure with depth.
   c. Applying Concepts Why must an astronaut wear a pressurized suit in space?

Math Practice
4. Area Find the area of a rectangular photo that is 20 cm long and 15 cm wide.
5. Area Which has a greater area: a square table that measures 120 cm × 120 cm, or a rectangular table that measures 200 cm × 90 cm?

Lab zone Design Your Own Lab

Spinning Sprinklers



Problem

What factors affect the speed of rotation of a lawn sprinkler?

Skills Focus

designing experiments, controlling variables

Materials

- empty soda can
- fishing line, 30 cm
- waterproof marker
- wide-mouth jar or beaker
- stopwatch
- nails of various sizes
- large basin

Procedure

PART 1 Making a Sprinkler

1. Fill the jar with enough water to completely cover a soda can. Place the jar in the basin.
2. Bend up the tab of a can and tie the end of a length of fishing line to it. **CAUTION:** *The edge of the can opening can be sharp.*
3. Place a mark on the can to help you keep track of how many times the can spins.
4. Using the small nail, make a hole in the side of the can about 1 cm up from the bottom. Poke the nail straight in. Then twist the nail until it makes a right angle with the radius of the can as shown in the figure above. **CAUTION:** *Nails are sharp and should be used only to puncture the cans.*
5. Submerge the can in the jar and fill the can to the top with water.
6. Quickly lift the can with the fishing line so that it is 1–2 cm above the water level in the jar.
7. Practice counting how many spins the can completes in 15 seconds.

PART 2 What Factors Affect Spin?

8. How does the size of the hole affect the number of spins made by the can? Propose a hypothesis and then design an experiment to test the hypothesis. Obtain your teacher's approval before carrying out your experiment. Record all your data.
9. How does the number of holes affect the number of spins made by the can? Propose a hypothesis and then design an experiment to test the hypothesis. Obtain your teacher's approval before carrying out your experiment. Record all your data.

Analyze and Conclude

1. Designing Experiments How does the size of the hole affect the rate of spin of the can? How does the number of holes affect the rate of spin of the can?
2. Controlling Variables What other variables might affect the number of spins made by the can?
3. Interpreting Data Explain the motion of the can in terms of water pressure.
4. Classifying Which of Newton's three laws of motion could you use to explain the motion of the can? Explain.
5. Communicating Use the results of your experiment to write a paragraph that explains why a spinning lawn sprinkler spins.

More to Explore

Some sprinkler systems use water pressure to spin. Examine one of these sprinklers to see the size, direction of spin, and number of holes. What would happen if you connected a second sprinkler to the first with another length of hose? If possible, try it.

Section 2

Floating and Sinking

Reading Preview

Key Concepts

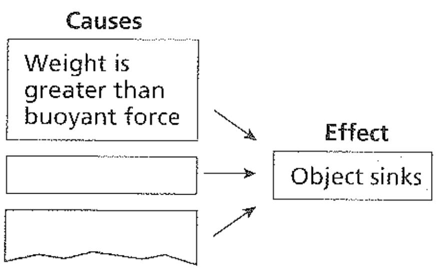
- What is the effect of the buoyant force?
- How can you use density to determine whether an object will float or sink in a fluid?

Key Terms

- buoyant force
- Archimedes' principle
- density

Target Reading Skill

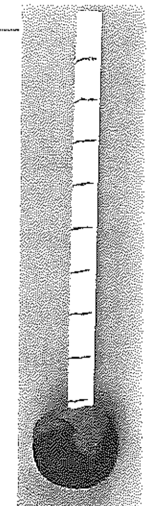
Relating Cause and Effect
As you read, identify the reasons why an object sinks. Write the information in a graphic organizer like the one below.



Lab zone Discover Activity

What Can You Measure With a Straw?

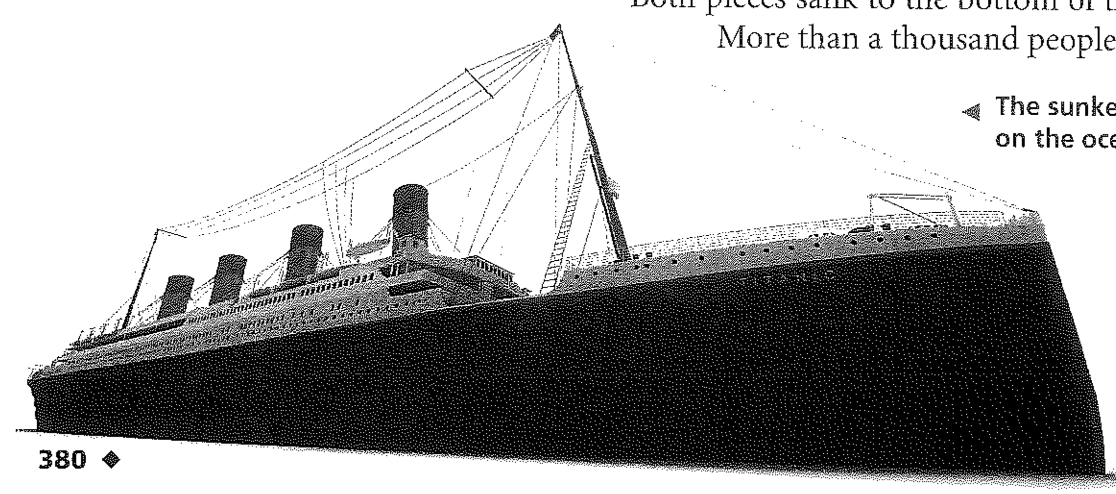
1. Cut a plastic straw to a 10-cm length.
2. Use a waterproof marker to make marks on the straw that are 1 cm apart.
3. Roll some modeling clay into a ball about 1.5 cm in diameter. Stick one end of the straw in the clay. You have built a device known as a hydrometer.
4. Place the hydrometer in a glass of water. About half of the straw should remain above water. If it sinks, remove some of the clay. Make sure no water gets into the straw.
5. Dissolve 10 spoonfuls of sugar in a glass of water. Try out your hydrometer in this liquid.



Think It Over
Predicting Compare your observations in Steps 4 and 5. Then predict what will happen if you use 20 spoonfuls of sugar in a glass of water. Test your prediction.

In April 1912, the *Titanic* departed from England on its first and only voyage. At the time, it was the largest ship afloat—nearly three football fields long. The *Titanic* was also the most technologically advanced ship in existence. Its hull was divided into compartments, and it was considered to be unsinkable.

Yet a few days into the voyage, the *Titanic* struck an iceberg. One compartment after another filled with water. Less than three hours later, the bow of the great ship slipped under the waves. As the stern rose high into the air, the ship broke in two. Both pieces sank to the bottom of the Atlantic Ocean. More than a thousand people died.



The sunken *Titanic* was found on the ocean floor in 1985.

Buoyancy

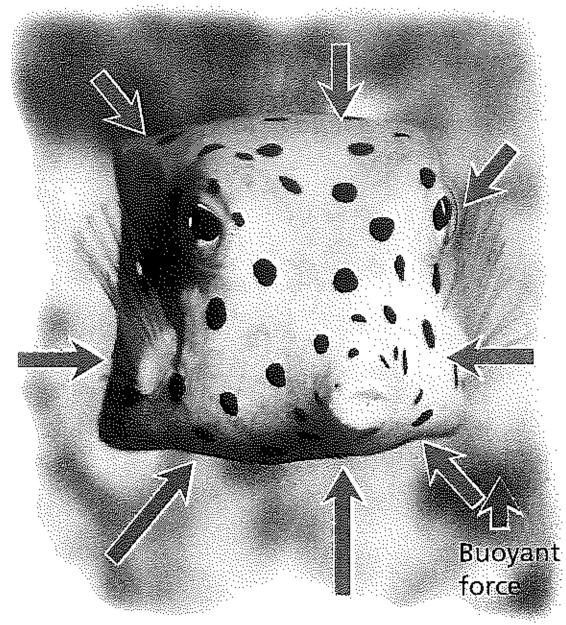
Ships are designed to have buoyancy—the ability to float. How is it possible that a huge ship can float easily on the surface of water under certain conditions, and then in a few hours become a sunken wreck? To answer this question, you need to understand the buoyant force.

Gravity and the Buoyant Force You have probably experienced the buoyant force. If you have ever picked up an object under water, you know that it seems much lighter in water than in air. Water and other fluids exert an upward force called the **buoyant force** that acts on a submerged object. **The buoyant force acts in the direction opposite to the force of gravity, so it makes an object feel lighter.**

As you can see in Figure 7, a fluid exerts pressure on all surfaces of a submerged object. Since the pressure in a fluid increases with depth, the upward pressure on the bottom of the object is greater than the downward pressure on the top. The result is a net force acting upward on the submerged object. This is the buoyant force.

Remember that the weight of a submerged object is a downward force. If an object's weight is greater than the buoyant force, a net force acts downward on the object. The object will sink. If the weight of an object is equal to the buoyant force, no net force acts on the object. The object will not sink. A submerged object whose weight is equal to the buoyant force also has no net force acting on it. The object will not sink. For example, both the jellyfish and the turtle shown in Figure 8 have balanced forces acting on them. Neither animal will rise or sink.

FIGURE 7
Buoyant Force
The pressure on the bottom of a submerged object is greater than the pressure on the top. The result is a net force in the upward direction.



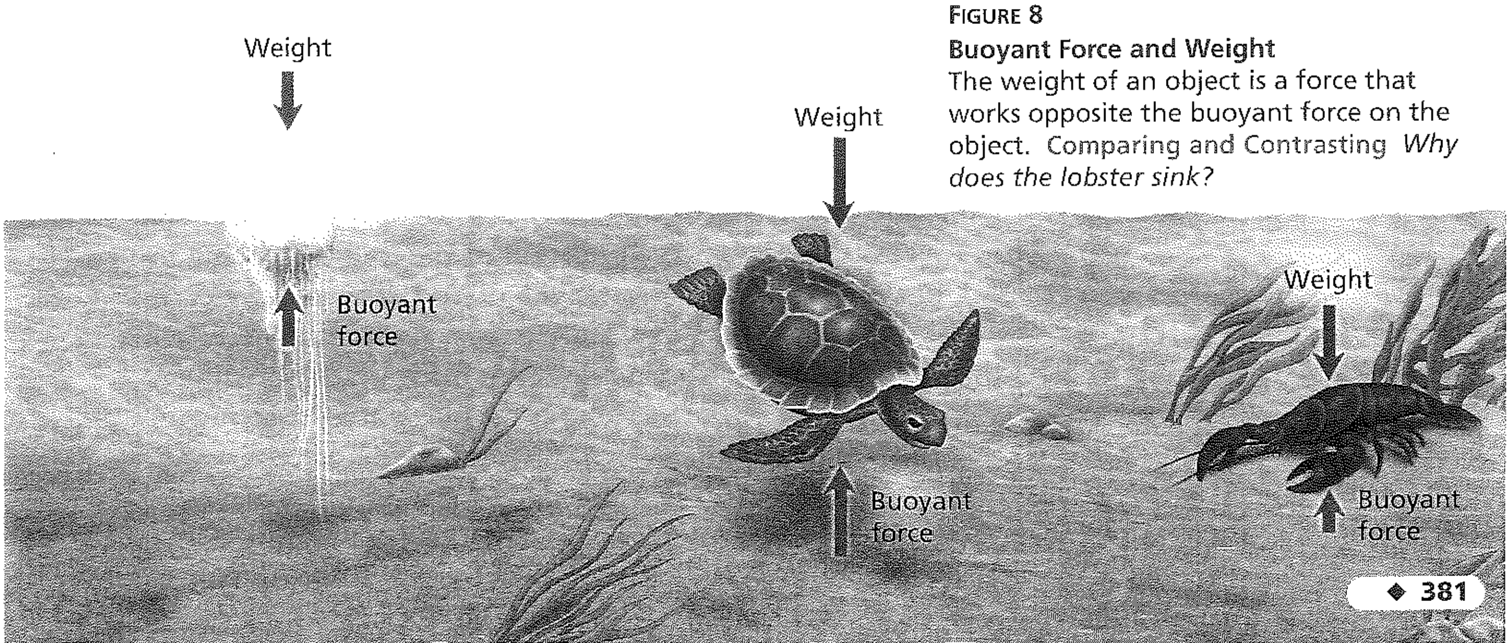
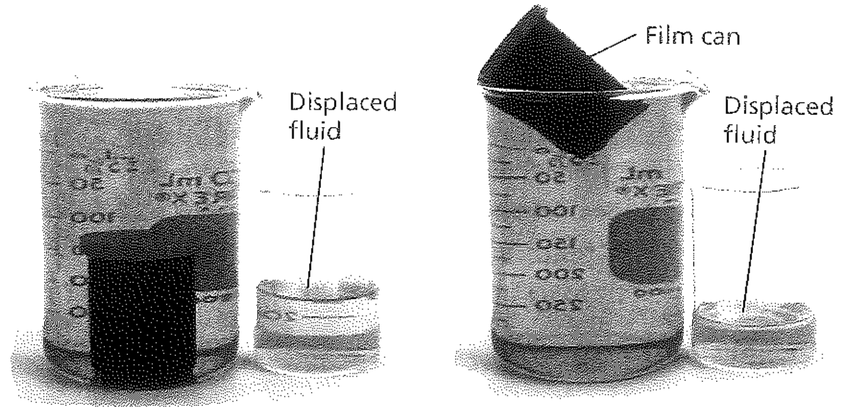


FIGURE 8
Buoyant Force and Weight
The weight of an object is a force that works opposite the buoyant force on the object. Comparing and Contrasting *Why does the lobster sink?*

FIGURE 9
Archimedes' Principle
Archimedes' principle applies to sinking and floating objects.
Predicting *If you press down on the floating film can, what will happen to the volume of the displaced fluid in the small beaker?*



Sinking
When the film can has film in it, it sinks. The volume of fluid displaced by the can is equal to the volume of the can.

Floating
When the film can is empty, it floats. The volume of displaced fluid is equal to the volume of the submerged portion of the can.

Archimedes' Principle You know that all objects take up space. A submerged object displaces, or takes the place of, a volume of fluid equal to its own volume. A partly submerged object, however, displaces a volume of fluid equal to the volume of its submerged portion only. You can see this in Figure 9.

Archimedes, a mathematician of ancient Greece, discovered a connection between the weight of a fluid displaced by an object and the buoyant force acting on it. This connection is known as Archimedes' principle. **Archimedes' principle** states that the buoyant force acting on a submerged object is equal to the weight of the fluid the object displaces. To understand what this means, think about swimming in a pool. Suppose your body displaces 50 liters of water. The buoyant force exerted on you will be equal to the weight of 50 liters of water, or about 500 N.

You can use Archimedes' principle to explain why a ship floats on the surface. Since the buoyant force equals the weight of the displaced fluid, the buoyant force will increase if more fluid is displaced. A large object displaces more fluid than a small object. A greater buoyant force acts on the larger object even if the large object has the same weight as the small object.

Look at Figure 10. The shape of a ship's hull causes the ship to displace a greater volume of water than a solid piece of steel with the same mass. A ship displaces a volume of water equal in weight to the submerged portion of the ship. According to Archimedes' principle, the weight of the displaced water is equal to the buoyant force. Since a ship displaces more water than a block of steel, a greater buoyant force acts on the ship. A ship floats on the surface as long as the buoyant force acting on it is equal to its weight.

Reading Checkpoint **Does a greater buoyant force act on a large object or a small object?**

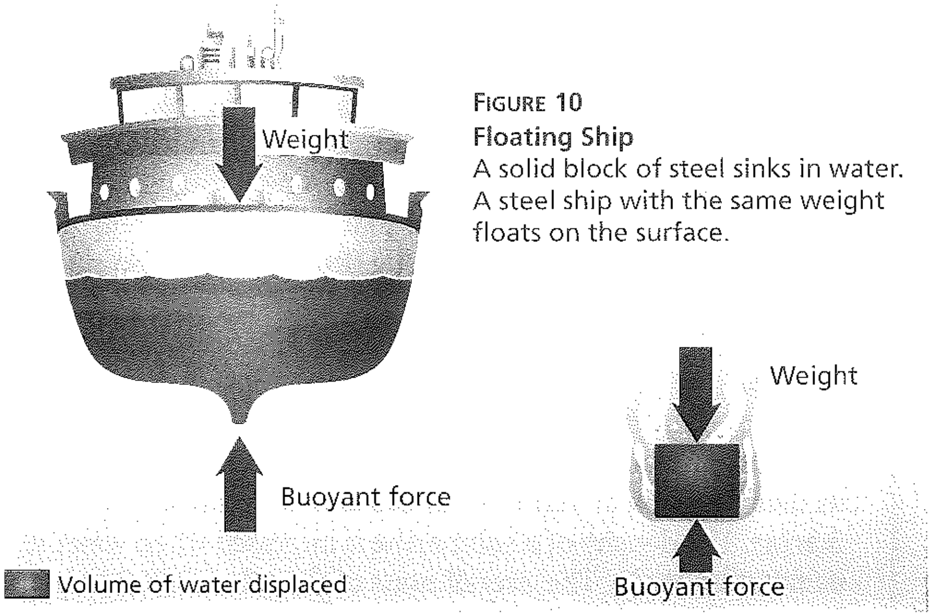


FIGURE 10
Floating Ship
A solid block of steel sinks in water. A steel ship with the same weight floats on the surface.

Density

Exactly why do some objects float and others sink? To find the answer, you must relate an object's mass to its volume. In other words, you need to know the object's density.

What Is Density? The **density** of a substance is its mass per unit volume.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

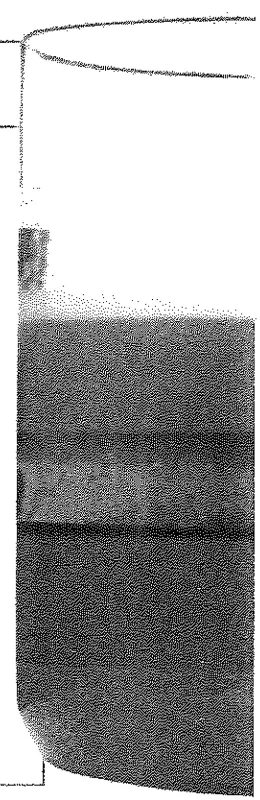
For example, one cubic centimeter (cm^3) of lead has a mass of 11.3 grams, so its density is 11.3 g/cm^3. In contrast, one cubic centimeter of cork has a mass of only about 0.25 gram. So the density of cork is about 0.25 g/cm^3. Lead is more dense than cork. The density of water is 1.0 g/cm^3. So water is less dense than lead but more dense than cork.

Comparing Densities of Substances In Figure 11, several liquids are shown in a cylinder. Notice that liquids can float on top of other liquids. (You may have seen salad oil floating on top of vinegar.) The liquids with the greatest densities are near the bottom of the cylinder.

By comparing densities, you can predict whether an object will float or sink in a fluid. An object that is more dense than the fluid in which it is immersed sinks. An object that is less dense than the fluid in which it is immersed floats to the surface. And if the density of an object is equal to the density of the fluid in which it is immersed, the object neither rises nor sinks in the fluid. Instead, it floats at a constant depth.

FIGURE 11
Densities of Substances
You can use density to predict whether an object will sink or float when placed in a liquid. Interpreting Data *Will a rubber washer sink or float in corn oil?*

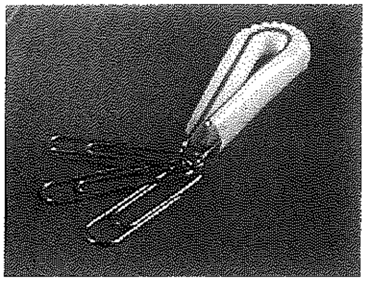
Substance	Density (g/cm^3)
Wood	0.7
Corn oil	0.925
Plastic	0.93
Water	1.00
Tar ball	1.02
Glycerin	1.26
Rubber washer	1.34
Corn syrup	1.38
Copper wire	8.8
Mercury	13.6



Lab zone Try This Activity

Dive!

1. Fill a plastic jar or bottle almost completely with water.



2. Bend a plastic straw into a U shape and cut the ends so that each side is 4 cm long. Attach the ends with a paper clip. Drop the straw in the jar, paper clip first.
3. Attach more paper clips to the first one until the straw floats with its top about 0.5 cm above the surface. This is the diver.
4. Put the lid on the jar. Observe what happens when you slowly squeeze and release the jar several times.

Drawing Conclusions Explain the behavior of the diver.

Changing Density Changing density can explain why an object floats or sinks. For example, you can change the density of water by freezing it into ice. Since water expands when it freezes, ice occupies more space than water. That's why ice is less dense than water. But it's just a little less dense! So most of an ice cube floating on the surface is below the water's surface. An iceberg like the one shown in Figure 12 is really a very large ice cube. The part that you see above water is only a small fraction of the entire iceberg.

You can make an object sink or float in a fluid by changing its density. Look at Figure 13 to see how this happens to a submarine. The density of a submarine is increased when water fills its flotation tanks. The overall mass of the submarine increases. Since its volume remains the same, its density increases when its mass increases. So the submarine will dive. To make the submarine float to the surface, water is pumped out of it, decreasing its mass. Its density decreases, and it rises toward the surface.

You can also explain why a submarine dives and floats by means of the buoyant force. Since the buoyant force is equal to the weight of the displaced fluid, the buoyant force on the submerged submarine stays the same. Changing the water level in the flotation tanks changes the weight of the submarine. The submarine dives when its weight is greater than the buoyant force. It rises to the surface when its weight is less than the buoyant force.

Don't forget that air is also a fluid. If you decrease the density of an object, such as a balloon, the object will float and not sink in air. Instead of air, you can fill a balloon with helium gas. A helium balloon rises because helium is less dense than air. A balloon filled with air, however, is denser than the surrounding air because the air inside it is under pressure. The denser air inside, along with the weight of the balloon, make it fall to the ground.

Reading Checkpoint **Why does a helium balloon float in air?**

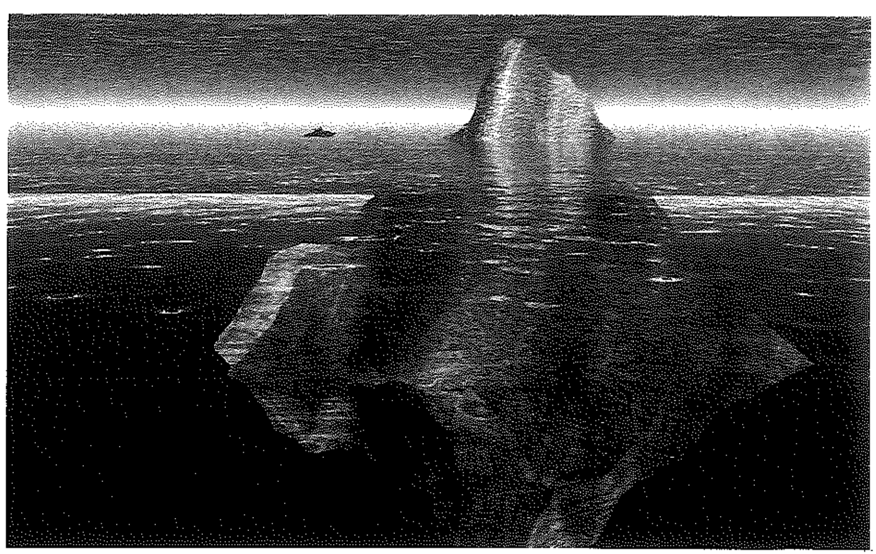


FIGURE 12
Iceberg
An iceberg is dangerous to ships because most of it is under water.

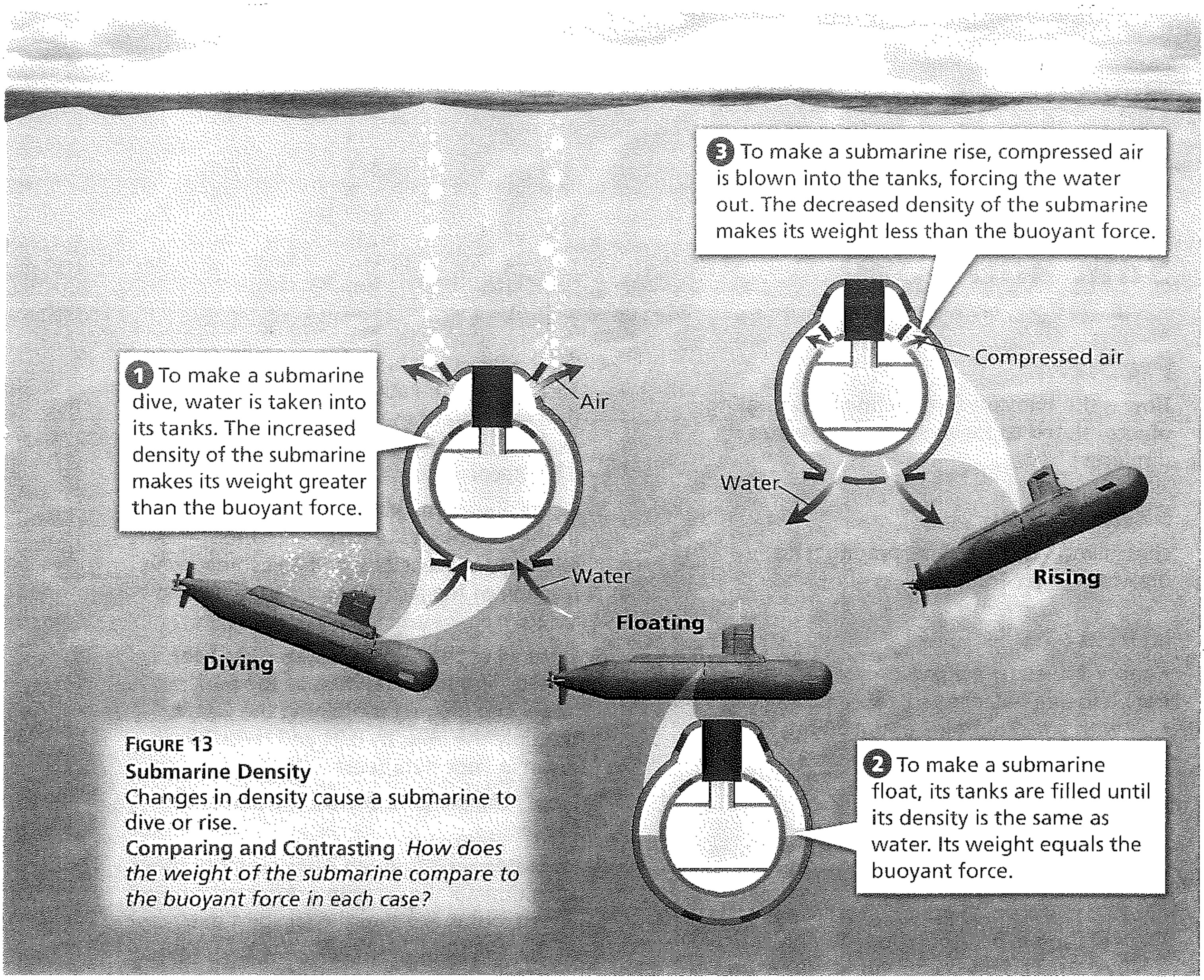


FIGURE 13
Submarine Density
Changes in density cause a submarine to dive or rise.
Comparing and Contrasting *How does the weight of the submarine compare to the buoyant force in each case?*

Section 2 Assessment

Target Reading Skill

Relating Cause and Effect Refer to your graphic organizer to help you answer the questions below.

Reviewing Key Concepts

1. a. Explaining How does the buoyant force affect a submerged object?
   b. Summarizing How does Archimedes' principle relate the buoyant force acting on an object to the fluid displaced by the object?
   c. Calculating An object that weighs 340 N floats on a lake. What is the weight of the displaced water? What is the buoyant force?
2. a. Defining What is density?
   b. Explaining How can you use the density of an object to predict whether it will float or sink in water?
   c. Applying Concepts Some canoes have compartments on either end that are hollow and watertight. These canoes won't sink, even when they capsize. Explain why.

Lab zone At-Home Activity

Changing Balloon Density Attach paper clips to the string of a helium balloon. Ask a family member to predict how many paper clips you will need to attach to make the balloon sink to the floor. How many paper clips can you attach and still keep the helium balloon suspended in the air? Explain how adding paper clips changes the overall density of the balloon.

Lab zone **Skills Lab**

Sink and Spill

Problem

How is the buoyant force acting on a floating object related to the weight of the water it displaces?

Skills Focus

controlling variables, interpreting data, drawing conclusions

Materials

- paper towels
- pie pan
- triple-beam balance
- beaker, 600-mL
- jar with watertight lid, about 30-mL
- table salt

Procedure

1. Preview the procedure and copy the data table into your notebook.
2. Find the mass, in grams, of a dry paper towel and the pie pan together. Multiply the mass by 0.01. This gives you the weight in newtons. Record it in your data table.
3. Place the 600-mL beaker, with the dry paper towel under it, in the middle of the pie pan. Fill the beaker to the very top with water.
4. Fill the jar about halfway with salt. (The jar and salt must be able to float in water.) Then find the mass of the salt and the dry jar (with its cover on) in grams. Multiply the mass by 0.01. Record this weight in your data table.
5. Gently lower the jar into the 600-mL beaker. (If the jar sinks, take it out and remove some salt. Repeat Steps 2, 3, and 4.) Estimate the fraction of the jar that is underwater, and record it.
6. Once all of the displaced water has been spilled, find the total mass of the paper towel and pie pan containing the water. Multiply the mass by 0.01 and record the result in your data table.
7. Empty the pie pan. Dry off the pan and the jar.
8. Repeat Steps 3 through 7 several more times. Each time fill the jar with a different amount of salt, but make sure the jar still floats.
9. Calculate the buoyant force for each trial and record it in your data table. (*Hint*: When an object floats, the buoyant force is equal to the weight of the object.)
10. Calculate the weight of the displaced water in each case. Record it in your data table.

Data Table

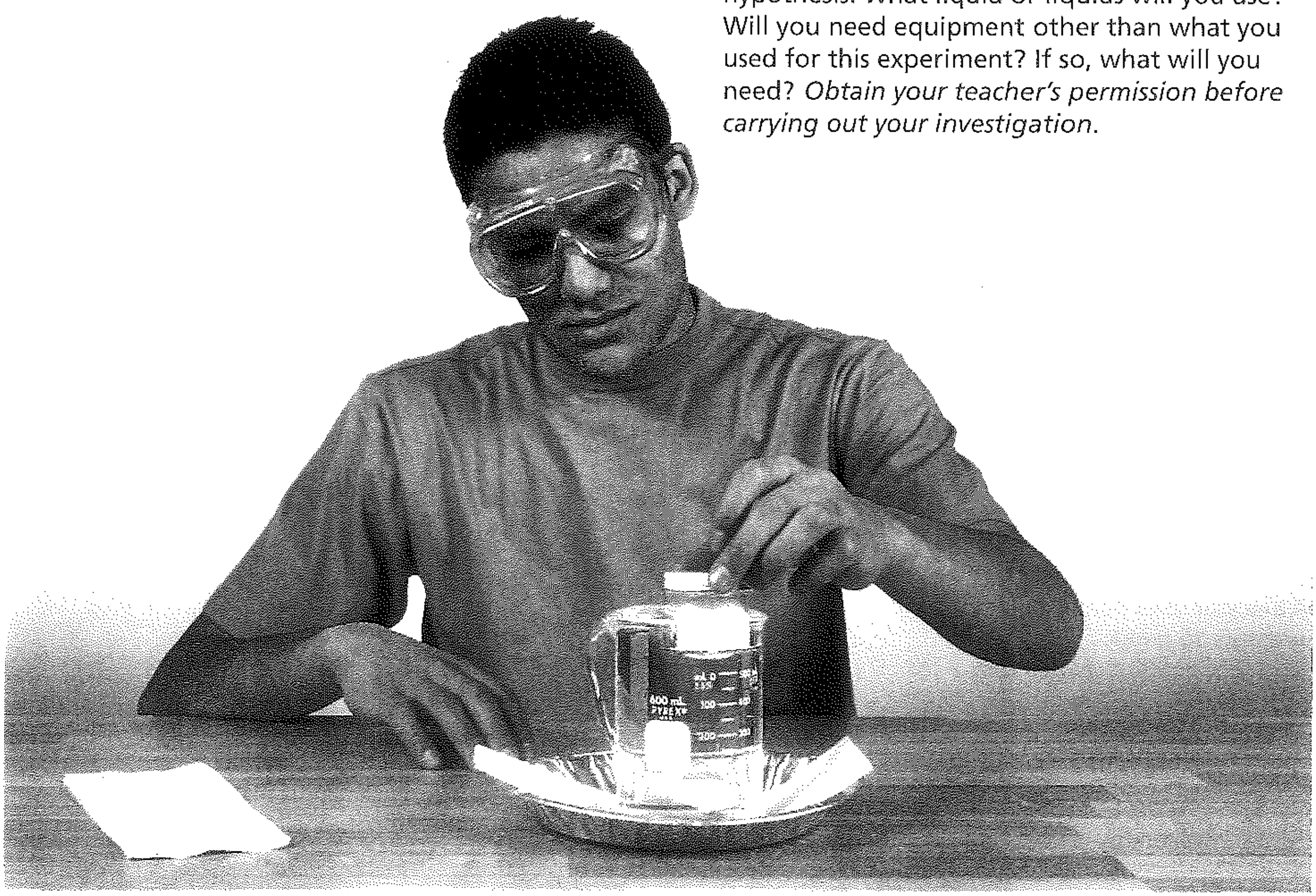
Jar	Weight of Empty Pie Pan and Dry Paper Towel (N)	Weight of Jar, Salt, and Cover (N)	Weight of Pie Pan With Displaced Water and Paper Towel (N)	Fraction of Jar Submerged in Water	Buoyant Force (N)	Weight of Displaced Water (N)
1						
2						
3						

Analyze and Conclude

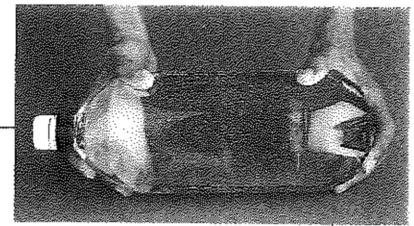
1. Controlling Variables In each trial, the jar had a different weight. How did this affect the way that the jar floated?
2. Interpreting Data The jar had the same volume in every trial. Why did the volume of displaced water vary?
3. Drawing Conclusions What can you conclude about the relationship between the buoyant force and the weight of the displaced water?
4. Drawing Conclusions If you put too much salt in the jar, it will sink. What can you conclude about the buoyant force in this case? How can you determine the buoyant force for an object that sinks?
5. Communicating Write a paragraph suggesting places where errors may have been introduced into the experiment. Propose some ways to control the errors.

Design an Experiment

How do you think your results would change if you used a liquid that is more dense or less dense than water? Design an experiment to test your hypothesis. What liquid or liquids will you use? Will you need equipment other than what you used for this experiment? If so, what will you need? *Obtain your teacher's permission before carrying out your investigation.*



Section 3
Pascal's Principle



Reading Preview

Key Concepts

- What does Pascal's principle say about change in fluid pressure?
- How does a hydraulic system work?

Key Terms

- Pascal's principle
- hydraulic system

Target Reading Skill

Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* or *how* question for each heading. As you read, write the answers to your questions.

Pascal's Principle

Question	Answer
How is pressure transmitted in a fluid?	Pressure is transmitted . . .

Lab zone Discover Activity

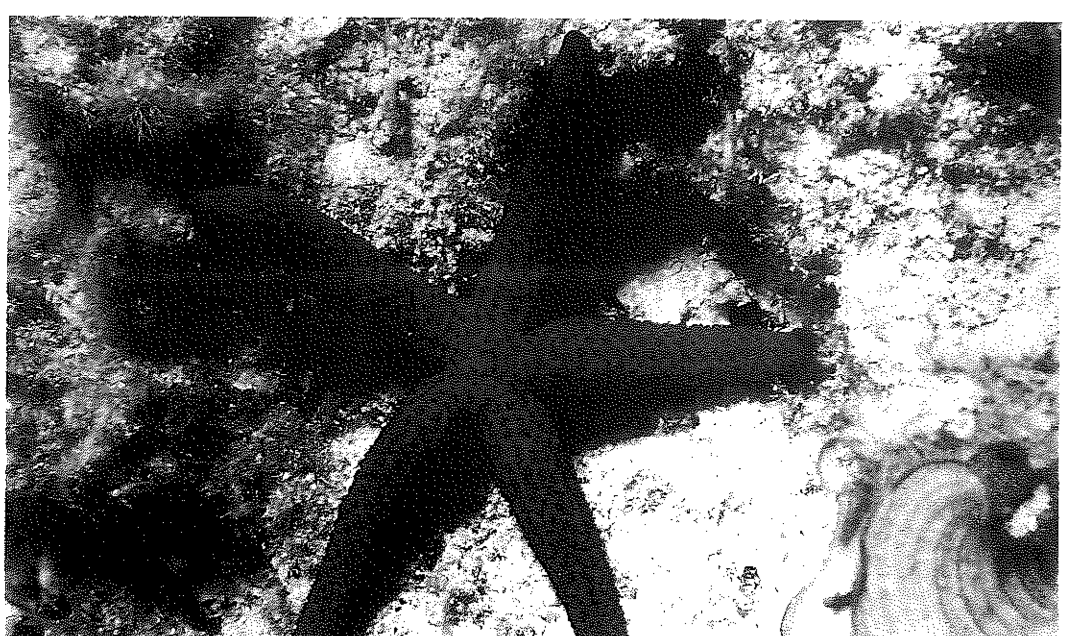
How Does Pressure Change?

1. Fill an empty 2-liter plastic bottle with water. Then screw on the cap. There should be no bubbles in the bottle (or only very small bubbles).
2. Lay the bottle on its side. At one spot, push in the bottle with your left thumb.
3. With your right thumb, push in fairly hard on a spot at the other end, as shown. What does your left thumb feel?
4. Pick another spot on the bottle for your left thumb and repeat Step 3.

Think It Over

Observing When you push in with your right thumb, does the water pressure in the bottle increase, decrease, or remain the same? How do you know?

At first, you hesitate, but then you hold out your hand. The aquarium attendant places the sea star in your palm. You can feel motion on your skin. The many tiny "feet" on the animal's underside look something like suction cups, and they tickle just a bit! The attendant explains that the sea star has a system of tubes containing water in its body. As the water moves around in the tubes, it creates fluid pressure that allows the sea star to move. The sea star also uses this system to obtain its food.



A sea star uses fluid pressure to move. ▶

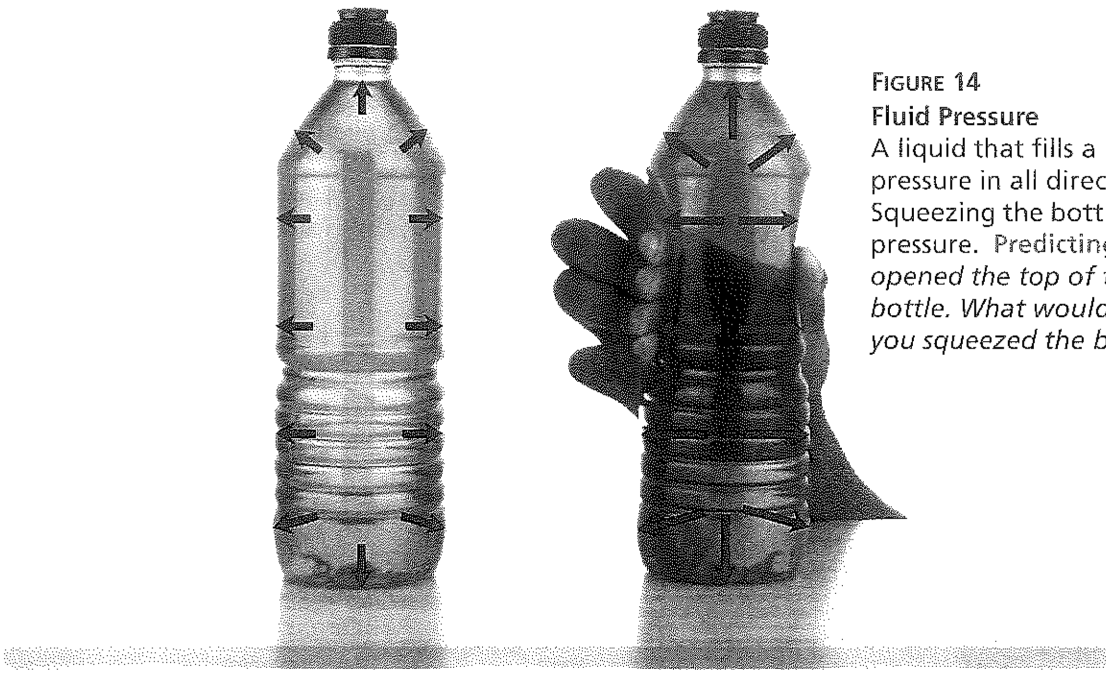


FIGURE 14
Fluid Pressure
A liquid that fills a bottle exerts pressure in all directions. Squeezing the bottle increases the pressure. Predicting *Suppose you opened the top of the water bottle. What would happen when you squeezed the bottle? Why?*

Transmitting Pressure in a Fluid

If you did the Discover Activity, you may be surprised to learn that a sea star's water-filled tube system is like the closed bottle you pushed your thumb against. Recall that the fluid pressure in the closed container increased when you pushed against its side. By changing the fluid pressure at any spot in the closed container, you transmitted pressure throughout the container. In the 1600s, a French mathematician named Blaise Pascal developed a principle to explain how pressure is transmitted in a fluid. Pascal's name is used for the unit of pressure.

What Is Pascal's Principle? As you may recall, fluid exerts pressure on any surface it touches. For example, the water in each bottle shown in Figure 14 exerts pressure on the entire surface of the bottle—up, down, and sideways.

What happens if you squeeze the bottle when its top is closed? The water has nowhere to go, so it presses harder on the inside surface of the bottle. The water pressure increases everywhere in the bottle. This is shown by the increased length of the arrows on the right in Figure 14.

Pascal discovered that pressure increases by the same amount throughout an enclosed or confined fluid. **When force is applied to a confined fluid, the change in pressure is transmitted equally to all parts of the fluid.** This relationship is known as **Pascal's principle.**

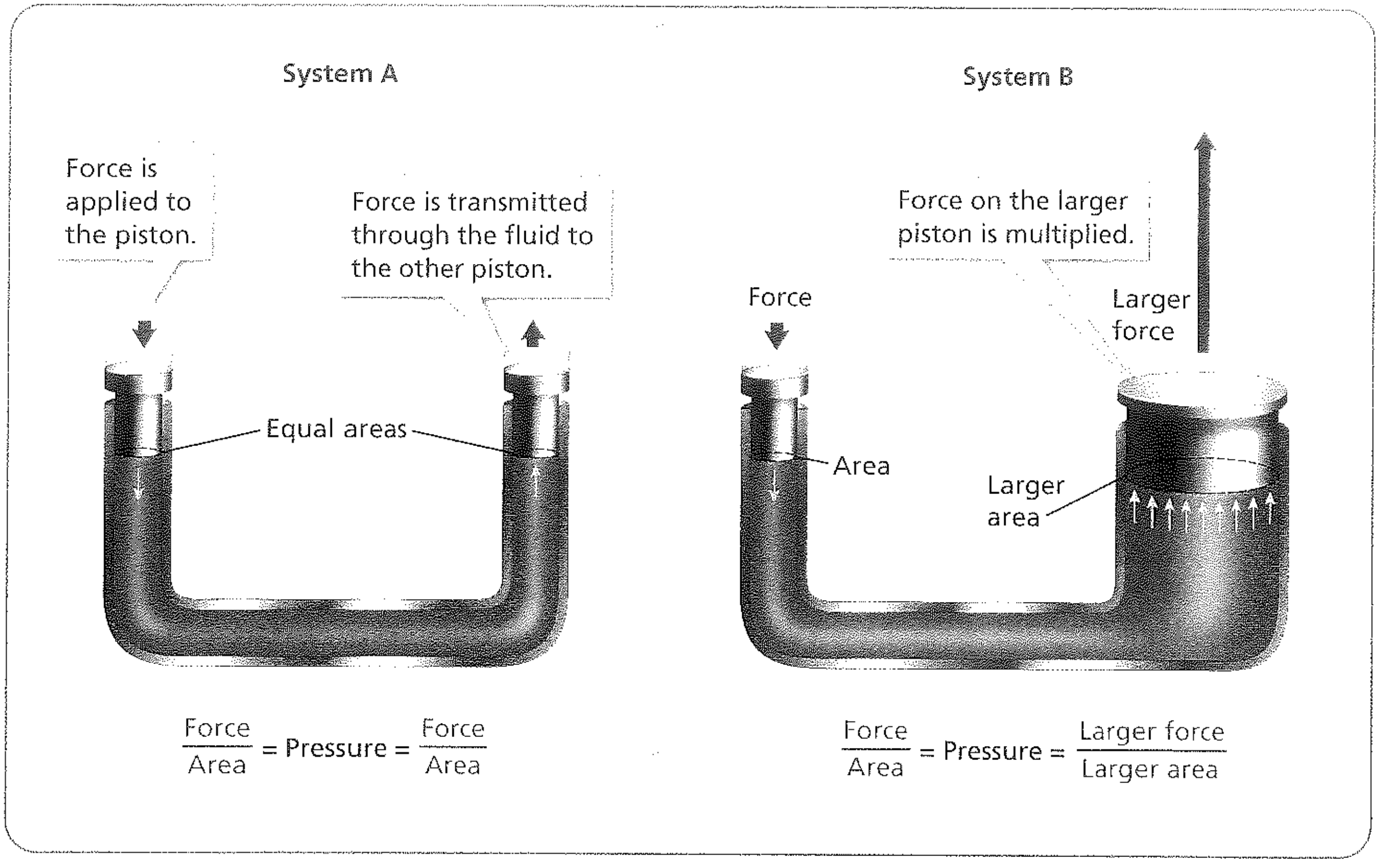


FIGURE 15
Hydraulic Devices
In a hydraulic device, a force applied to one piston increases the fluid pressure equally throughout the fluid. By changing the area of the pistons, the force can be multiplied.
Problem Solving *To multiply the force applied to the left piston four times, how large must the area of the right piston be?*

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Using Pascal's Principle You can see Pascal's principle at work in Figure 15, which shows a model of a hydraulic device. A hydraulic device works by applying a force to an enclosed fluid. The device consists of two pistons, one at each end of a U-shaped tube. A piston is like a stopper that slides up and down in a tube.

Suppose you fill System A with water and then push down on the left piston. The increase in fluid pressure will be transmitted to the right piston. According to Pascal's principle, both pistons experience the same fluid pressure. So, because both pistons have the same surface area, they will experience the same force.

Now look at System B. The right piston has a greater surface area than the left piston. Suppose the area of the small piston is 1 square centimeter and the area of the large piston is 9 square centimeters. The right piston has an area nine times greater than the area of the left piston. If you push down on the left piston, pressure is transmitted equally to the right piston. The force you exert on the left piston is multiplied nine times on the right piston. By changing the area of the pistons, you can multiply force by almost any amount you wish.

Reading Checkpoint **How is force multiplied in System B?**

Hydraulic Systems

Hydraulic systems make use of hydraulic devices to perform a variety of functions. A **hydraulic system** uses liquids to transmit pressure in a confined fluid. **A hydraulic system multiplies force by applying the force to a small surface area. The increase in pressure is then transmitted to another part of the confined fluid, which pushes on a larger surface area.** You have probably seen a number of hydraulic systems at work, including lift systems and the brakes of a car. Because they use fluids to transmit pressure, hydraulic systems have few moving parts that can jam, break, or wear down.

Hydraulic Lifts Hydraulic lift systems are used to raise cars off the ground so mechanics can repair them with ease. You may be surprised to learn that hydraulic systems are also used to lift the heavy ladder on a fire truck to reach the upper windows of a burning building. In addition, hydraulic lifts are used to operate many pieces of heavy construction equipment such as dump trucks, backhoes, snowplows, and cranes. Next time you see a construction vehicle at work, see if you can spot the hydraulic pistons in action.

Reading Checkpoint **What are some uses of hydraulic systems?**

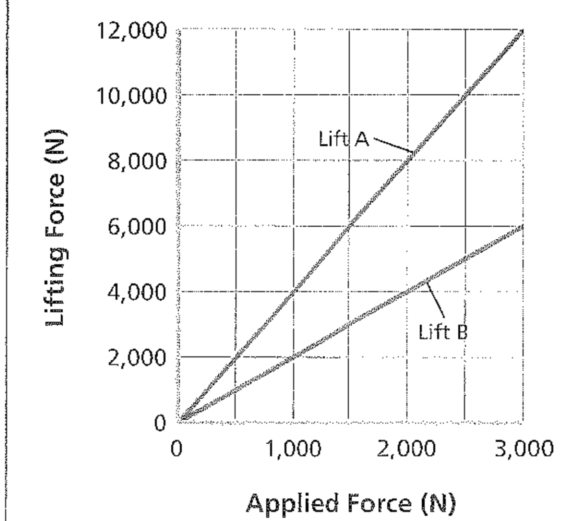
Math Analyzing Data

Comparing Hydraulic Lifts

In the hydraulic device in Figure 15, a force applied to the piston on the left produces a lifting force in the piston on the right. The graph shows the relationship between the applied force and the lifting force for two hydraulic lifts.

1. Reading Graphs Suppose a force of 1,000 N is applied to both lifts. Use the graph to determine the lifting force of each lift.
2. Reading Graphs For Lift A, how much force must be applied to lift a 12,000-N object?
3. Interpreting Data By how much is the applied force multiplied for each lift?
4. Interpreting Data What can you learn from the slope of the line for each lift?

Hydraulic Lifts



5. Drawing Conclusions Which lift would you choose if you wanted to produce the greater lifting force?

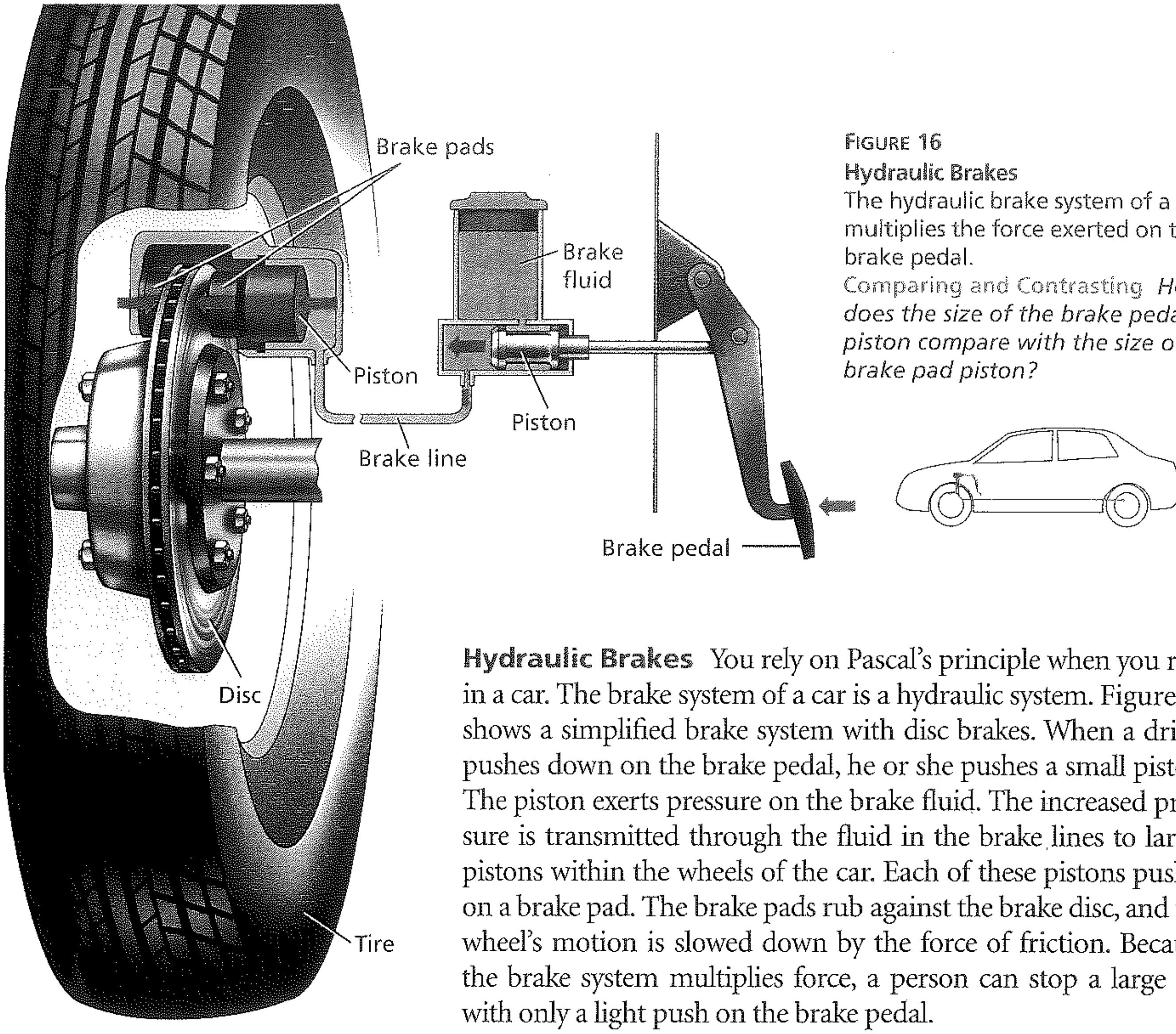


FIGURE 16
Hydraulic Brakes
The hydraulic brake system of a car multiplies the force exerted on the brake pedal.
Comparing and Contrasting *How does the size of the brake pedal piston compare with the size of a brake pad piston?*

Hydraulic Brakes You rely on Pascal's principle when you ride in a car. The brake system of a car is a hydraulic system. Figure 16 shows a simplified brake system with disc brakes. When a driver pushes down on the brake pedal, he or she pushes a small piston. The piston exerts pressure on the brake fluid. The increased pressure is transmitted through the fluid in the brake lines to larger pistons within the wheels of the car. Each of these pistons pushes on a brake pad. The brake pads rub against the brake disc, and the wheel's motion is slowed down by the force of friction. Because the brake system multiplies force, a person can stop a large car with only a light push on the brake pedal.

Section 3 Assessment

Target Reading Skill Asking Questions Use the answers to the questions you wrote about the headings to help you answer the questions below.

Reviewing Key Concepts

1. a. Reviewing According to Pascal's principle, how is pressure transmitted in a fluid?
   b. Relating Cause and Effect How does a hydraulic device multiply force?
   c. Calculating Suppose you apply a 10-N force to a 10-cm^2 piston in a hydraulic device. If the force is transmitted to another piston with an area of 100 cm^2, by how much will the force be multiplied?
2. a. Defining What is a hydraulic system?
   b. Explaining How does a hydraulic system work?
   c. Sequencing Describe what happens in the brake system of a car from the time a driver steps on the brake pedal to the time the car stops.

Writing in Science

Cause-and-Effect Letter You are a mechanic who fixes hydraulic brakes. A customer asks you why his brakes do not work. When you examine the car, you notice a leak in the brake line and repair it. Write a letter to the customer explaining why a leak in the brake line caused his brakes to fail.

Section 4

• Tech & Design •

Bernoulli's Principle

Reading Preview

Key Concepts

- According to Bernoulli's principle, how is fluid pressure related to the motion of a fluid?
- What are some applications of Bernoulli's principle?

Key Terms

- Bernoulli's principle
- lift

Target Reading Skill

Identifying Main Ideas As you read the Applying Bernoulli's Principle section, write the main idea in a graphic organizer like the one below. Then write three supporting details that give examples of the main idea.

Main Idea

Bernoulli's principle is a factor that helps explain . . .

Detail | Detail | Detail

Lab zone Discover Activity

Does the Movement of Air Affect Pressure?

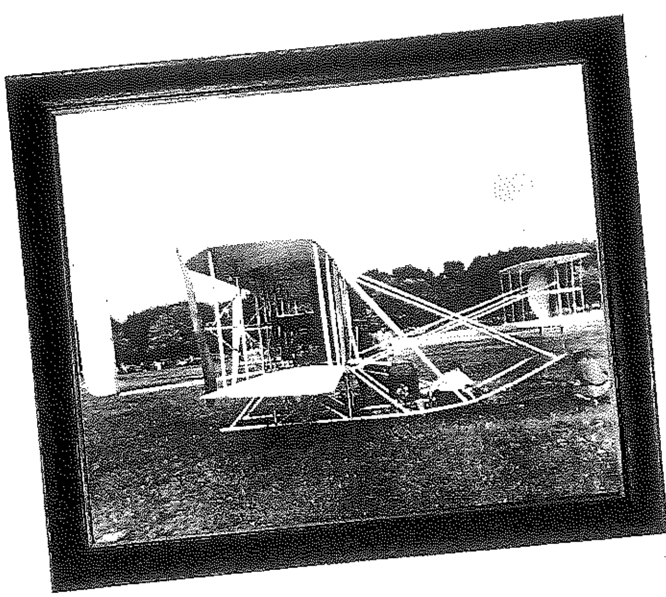
1. Use your thumb and forefinger to hold a sheet of paper by the corners.
2. Hold the paper just below your mouth, so that its edge is horizontal and the paper hangs down.
3. Blow across the top of the paper.
4. Repeat this several times, blowing harder each time.

Think It Over

Inferring On what side of the paper is the pressure lower? How do you know?

In December 1903, Wilbur and Orville Wright brought an odd-looking vehicle to a deserted beach in Kitty Hawk, North Carolina. People had flown in balloons for more than a hundred years, but the Wright brothers' goal was something no one had ever done before. They flew a plane that was heavier (denser) than air! They had spent years experimenting with different wing shapes and surfaces, and they had carefully studied the flight of birds. Their first flight at Kitty Hawk lasted just 12 seconds. The plane flew more than 36 meters and made history.

What did the Wright brothers know about flying that allowed them to construct the first airplane? And how can the principles they used explain how a jet can fly across the country? The answer has to do with fluid pressure and what happens when a fluid moves.

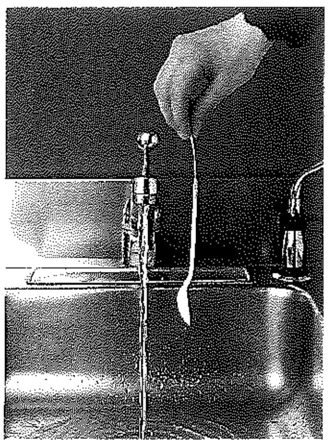


On December 17, 1903, the Wright brothers' plane *Flyer* flew for the first time.

Lab zone Try This Activity

Faucet Force

1. Hold a plastic spoon loosely by the edges of its handle so it swings freely between your fingers.
2. Turn on a faucet to produce a steady stream of water. Predict what will happen if you touch the bottom of the spoon to the stream of water.
3. Test your prediction. Repeat the test several times.



Developing Hypotheses Use your observations to develop a hypothesis explaining why the spoon moved as it did.

Pressure and Moving Fluids

So far in this chapter, you have learned about fluids that are not moving. What makes a fluid flow? And what happens to fluid pressure when a fluid moves?

Fluid Motion A fluid naturally flows from an area of high pressure to an area of low pressure. This happens, for example, when you sip a drink from a straw. When you start to sip, you remove the air from the straw. This creates an area of low pressure in the straw. The higher air pressure pushing down on the surface of your drink forces the drink up into the straw.

What Is Bernoulli's Principle? In the 1700s, Swiss scientist Daniel Bernoulli (bur NOO lee) discovered that the pressure of a moving fluid is different than the pressure of a fluid at rest. **Bernoulli's principle** states that the faster a fluid moves, the less pressure the fluid exerts.

If you did the Discover Activity, you saw that air moving over the paper caused the paper to rise. Bernoulli's principle explains the behavior of the paper. **Bernoulli's principle states that as the speed of a moving fluid increases, the pressure within the fluid decreases.** The air above the paper moves, but the air below the paper does not. The moving air exerts less pressure than the still air. As a result, the still air exerts greater pressure on the bottom of the paper, pushing the paper up.

Reading Checkpoint **What is Bernoulli's principle?**

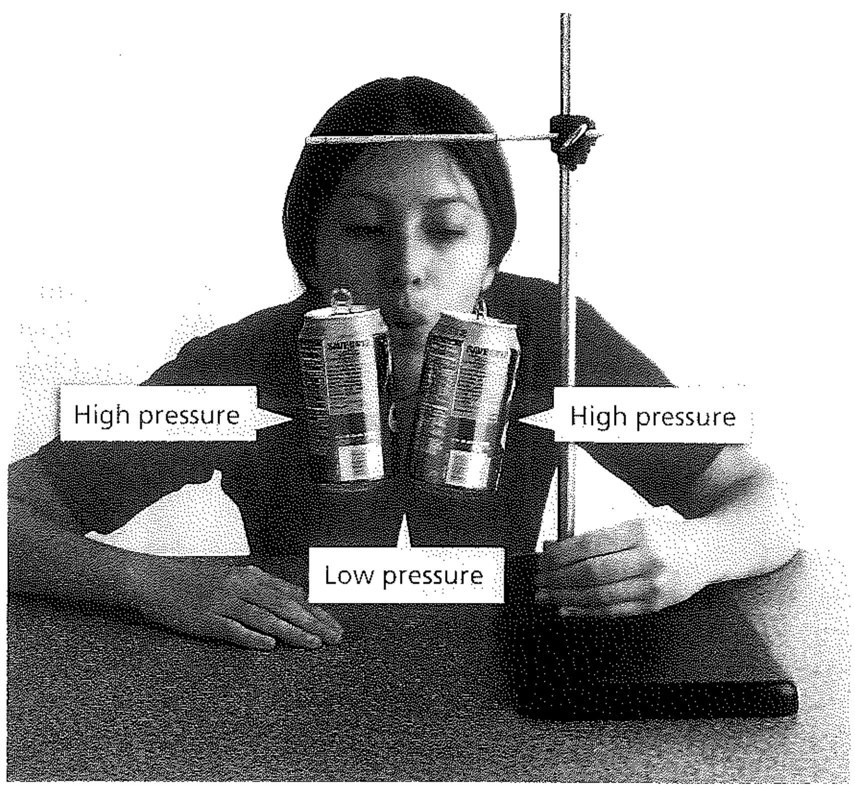


FIGURE 17
Making Air Move
Blowing air quickly between two cans lowers the air pressure between them. Higher pressure exerted by the still air to either side pushes the cans toward each other.
Relating Cause and Effect *How does the flowing air affect the air pressure around the two cans?*

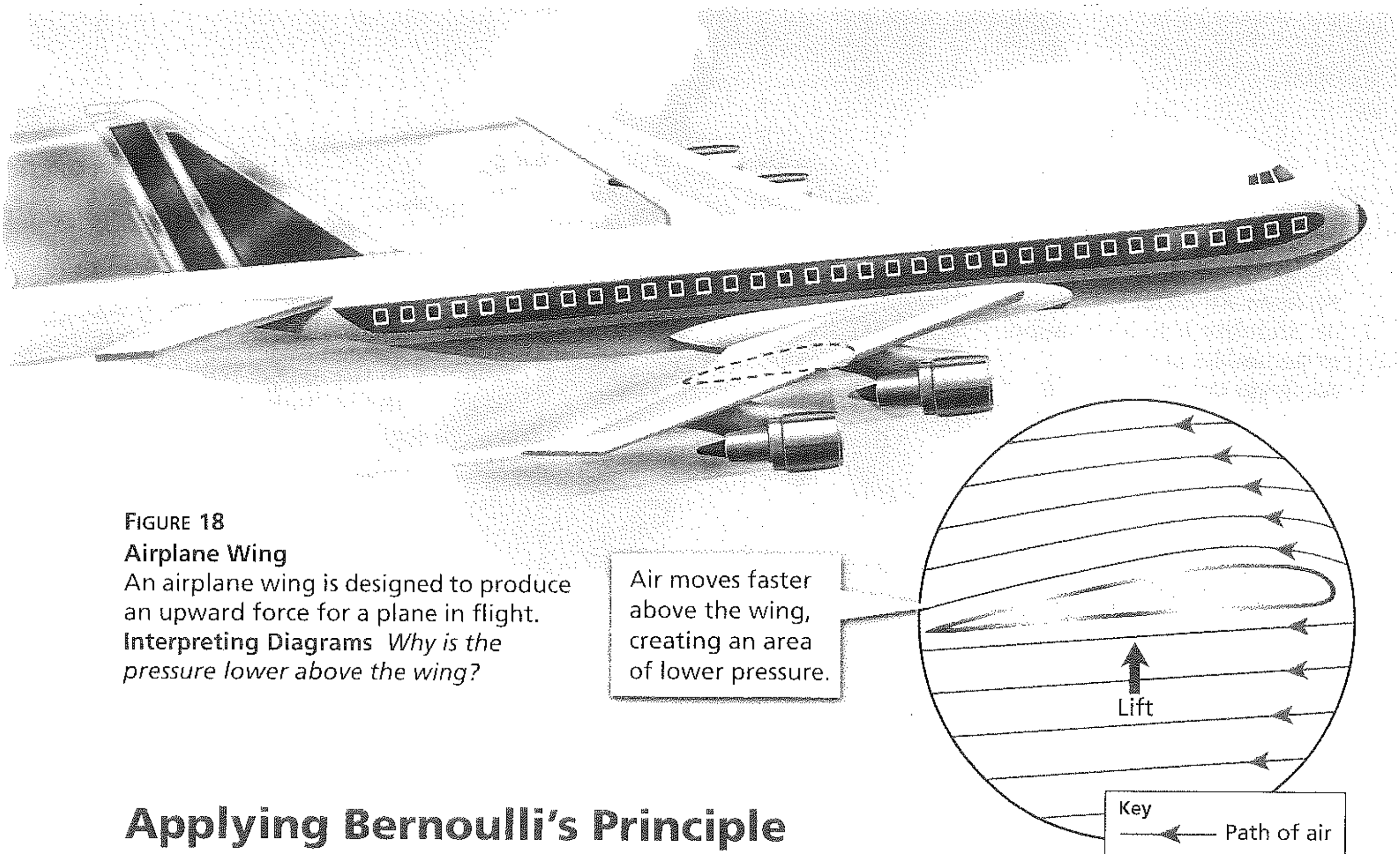


FIGURE 18
Airplane Wing
An airplane wing is designed to produce an upward force for a plane in flight.
Interpreting Diagrams *Why is the pressure lower above the wing?*

Applying Bernoulli's Principle

The Wright brothers understood Bernoulli's principle. They used it when they designed and built their plane. **Bernoulli's principle helps explain how planes fly. It also helps explain why smoke rises up a chimney, how an atomizer works, and how a flying disk glides through the air.**

Objects in Flight Bernoulli's principle is one factor that helps explain flight—from a small kite to a huge airplane. Objects can be designed so that their shapes cause air to move at different speeds above and below them. If the air moves faster above the object, fluid pressure pushes the object upward. If the air moves faster below the object, fluid pressure pushes it downward.

The wing of an airplane is designed to produce **lift,** or an upward force. Look at Figure 18 to see the design of a wing. Both the slant and the shape of the wing are sources of lift. Because the wing is slanted, the air that hits it is forced downward as the plane moves. The air exerts an equal and opposite force on the wing and pushes it upward. This upward force helps an airplane to take off.

The curved shape of a wing also gives an airplane lift. Because the top of the wing is curved, air moving over the top has a greater speed than air moving under the bottom. As a result, the air moving over the top exerts less pressure than the air below. The difference in air pressure above and below the wing creates lift.

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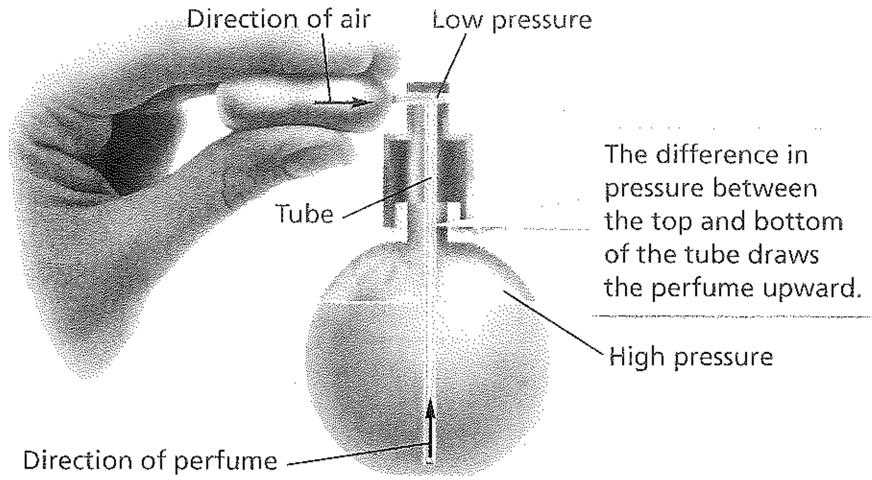


FIGURE 19
Perfume Atomizer
An atomizer is an application of Bernoulli's principle.
Applying Concepts *Why is the perfume pushed up and out of the flask?*

Atomizers Bernoulli's principle can help you understand how the perfume atomizer shown in Figure 19 works. When you squeeze the rubber bulb, air moves quickly past the top of the tube. The moving air lowers the pressure at the top of the tube. The greater pressure in the flask pushes the liquid up into the tube. The air stream breaks the liquid into small drops, and the liquid comes out as a fine mist. In a similar way, pressure differences in the carburetors of older gasoline engines push gasoline up a tube. There, the gasoline combines with air to create the mixture of air and fuel that runs the engine.

Chimneys You can sit next to a fireplace enjoying a cozy fire thanks in part to Bernoulli's principle. Smoke rises up the chimney partly because hot air rises, and partly because it is pushed. Wind blowing across the top of a chimney lowers the air pressure there. The higher pressure at the bottom pushes air and smoke up the chimney. Smoke will rise faster in a chimney on a windy day than on a calm day.

Reading Checkpoint **How does an atomizer work?**

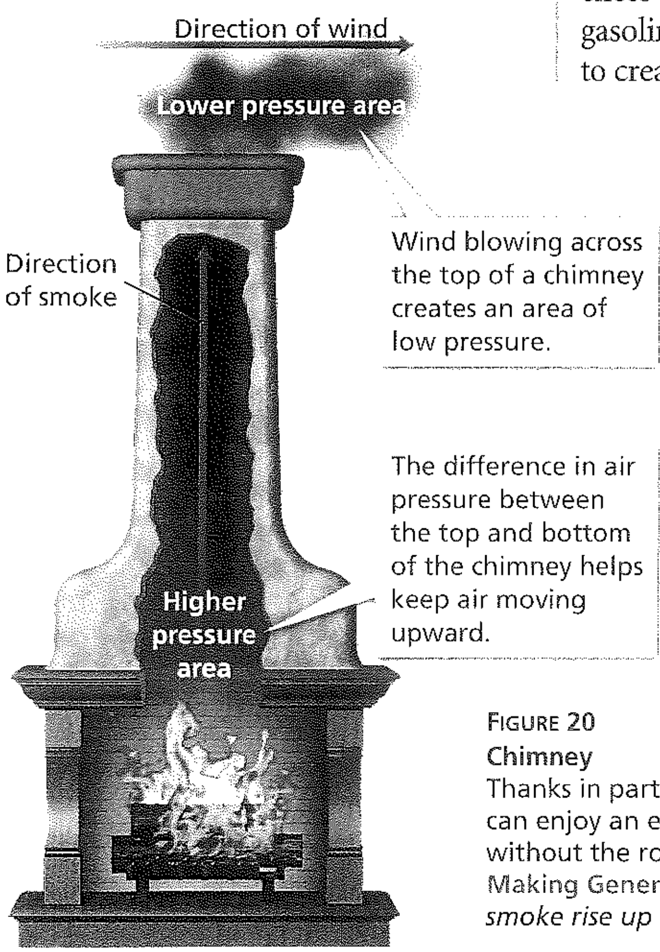
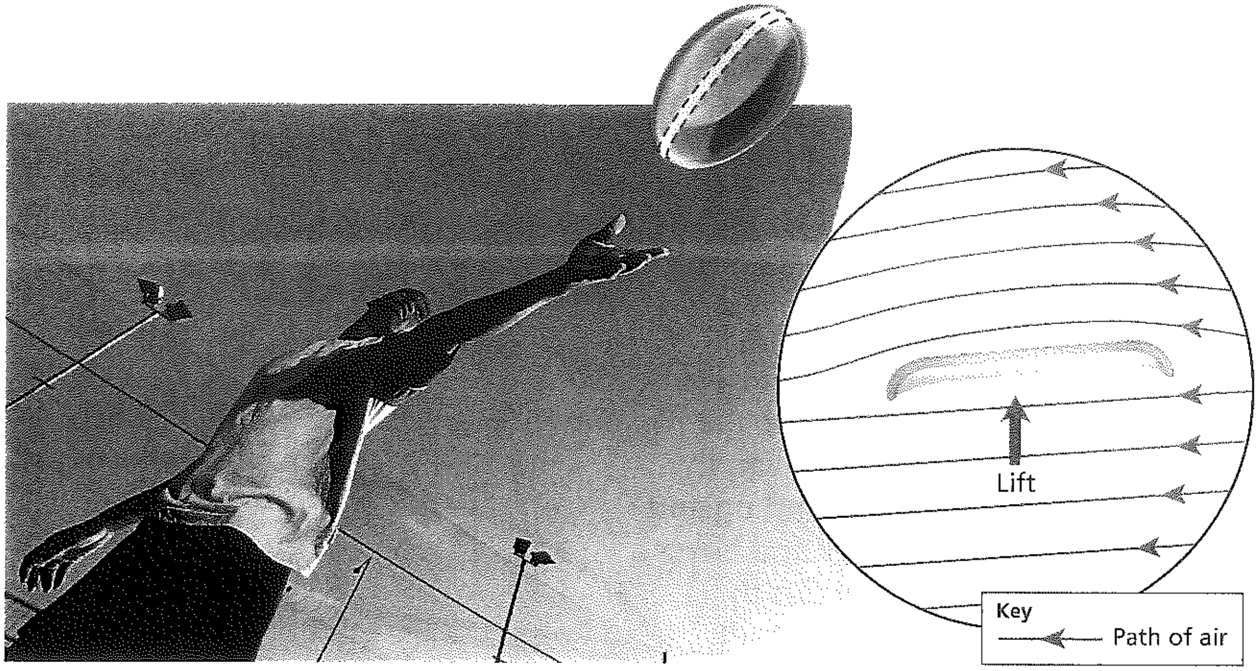


FIGURE 20
Chimney
Thanks in part to Bernoulli's principle, you can enjoy an evening by a warm fireplace without the room filling up with smoke.
Making Generalizations *Why does the smoke rise up the chimney?*



Flying Disks Did you ever wonder what allows a flying disk to glide through the air? The upper surface of a flying disk is curved like an airplane wing. Bernoulli's principle explains that the faster-moving air following the disk's curved upper surface exerts less pressure than the slower-moving air beneath it. A net force acts upward on the flying disk, creating lift. Tilting the disk slightly toward you as you throw it also helps to keep it in the air. A tilted disk pushes air down. The air exerts an equal and opposite force on the disk, pushing it up. The spinning motion of a flying disk keeps it stable as it flies.

FIGURE 21
Flying Disk
Like an airplane wing, a flying disk uses a curved upper surface to create lift. Comparing and Contrasting *How does a flying disk differ from an airplane wing?*

Section 4 Assessment

Target Reading Skill Identifying Main Ideas Use your graphic organizer to help you answer Question 1 below.

Reviewing Key Concepts

1. a. Reviewing What makes fluids flow?
   b. Summarizing What does Bernoulli's principle say about the pressure exerted by a moving fluid?
   c. Applying Concepts You are riding in a car on a highway when a large truck speeds by you. Explain why your car is pushed toward the truck.
2. a. Listing List four applications of Bernoulli's principle.
   b. Explaining Why does the air pressure above an airplane wing differ from the pressure below it? How is this pressure difference involved in flight?
   c. Relating Cause and Effect How could strong winds from a hurricane blow the roof off a house?

Lab zone At-Home Activity

Paper Chimney With a family member, see how a chimney works by using a paper cup and a hair dryer. Cut up several small pieces of tissue and place them in the bottom of a paper cup. Hold on to the paper cup with one hand. With your other hand, use the hair dryer to blow cool air across the top of the cup. Explain to your family member how Bernoulli's principle explains how the chimney works.

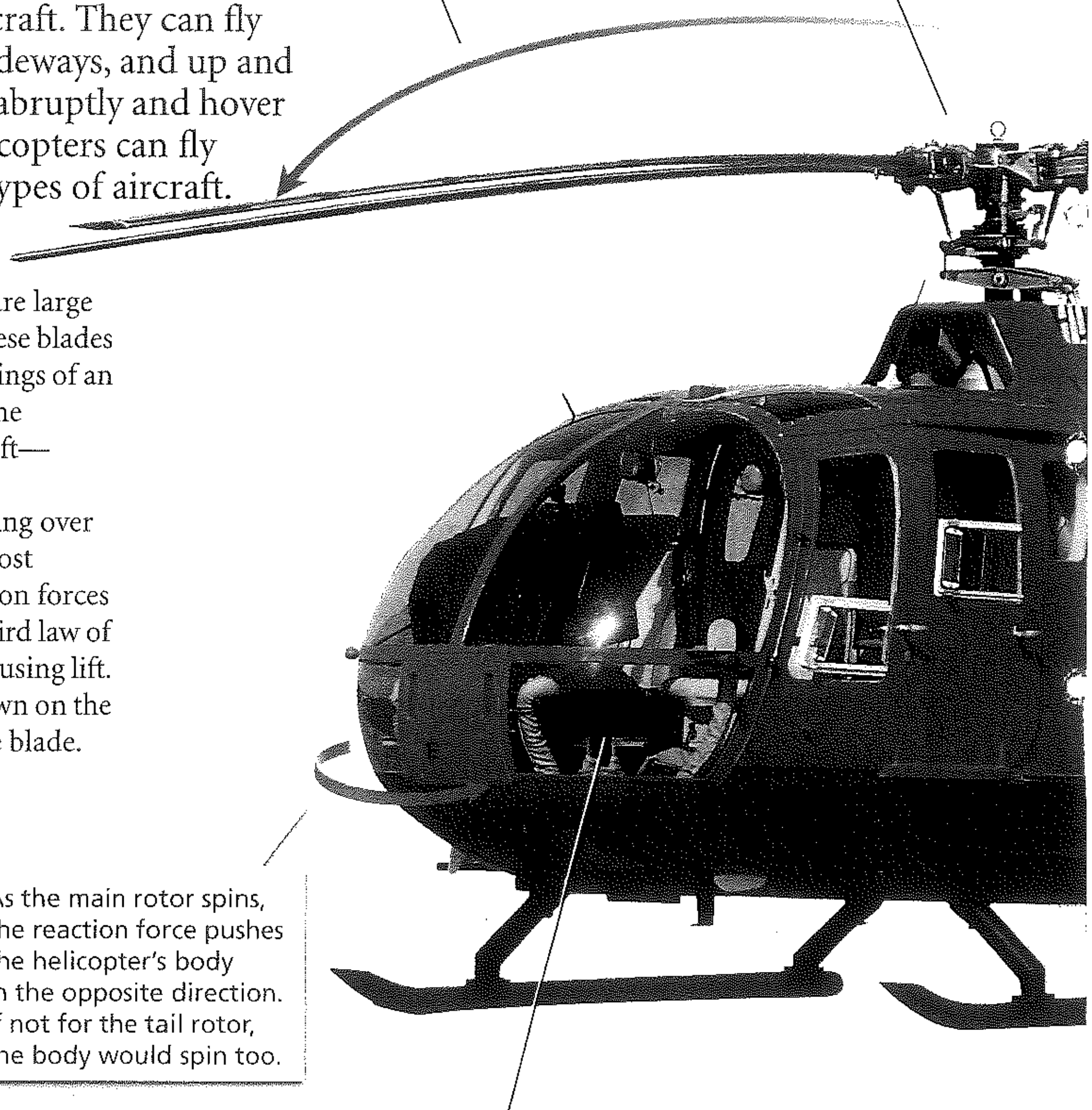
Technology and **Society** • Tech & Design •

Helicopters

Most aircraft are like eagles—they take off majestically, glide among the clouds, and land with ease. But helicopters are the hummingbirds of aircraft. They can fly forward, backward, sideways, and up and down. They can stop abruptly and hover in midair. In fact, helicopters can fly circles around other types of aircraft.

Science in Action

On the top of a helicopter are large blades that turn rapidly. These blades are curved on top like the wings of an airplane. Air flowing over the curved blades helps cause lift—the upward force for the helicopter—just as air flowing over wings helps cause lift for most airplanes. Action and reaction forces as described by Newton's third law of motion also play a role in causing lift. As the tilted blades push down on the air, the air pushes up on the blade.



Main Rotor
The main rotor turns the blades and controls their angle.

Blades
Air flows over the curved, rotating blades. Along with action and reaction forces, this helps to give the helicopter lift.

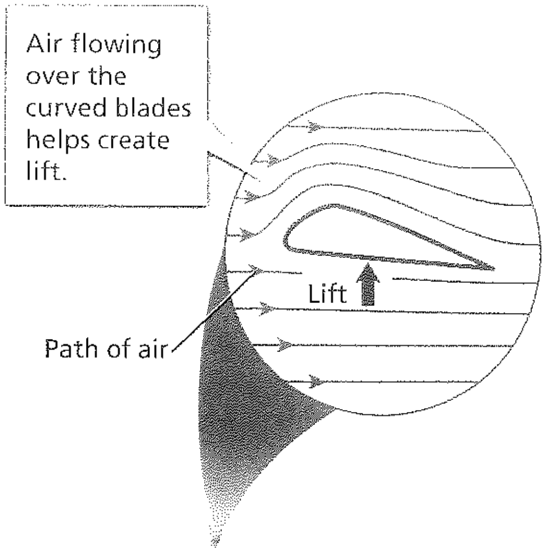
As the main rotor spins, the reaction force pushes the helicopter's body in the opposite direction. If not for the tail rotor, the body would spin too.

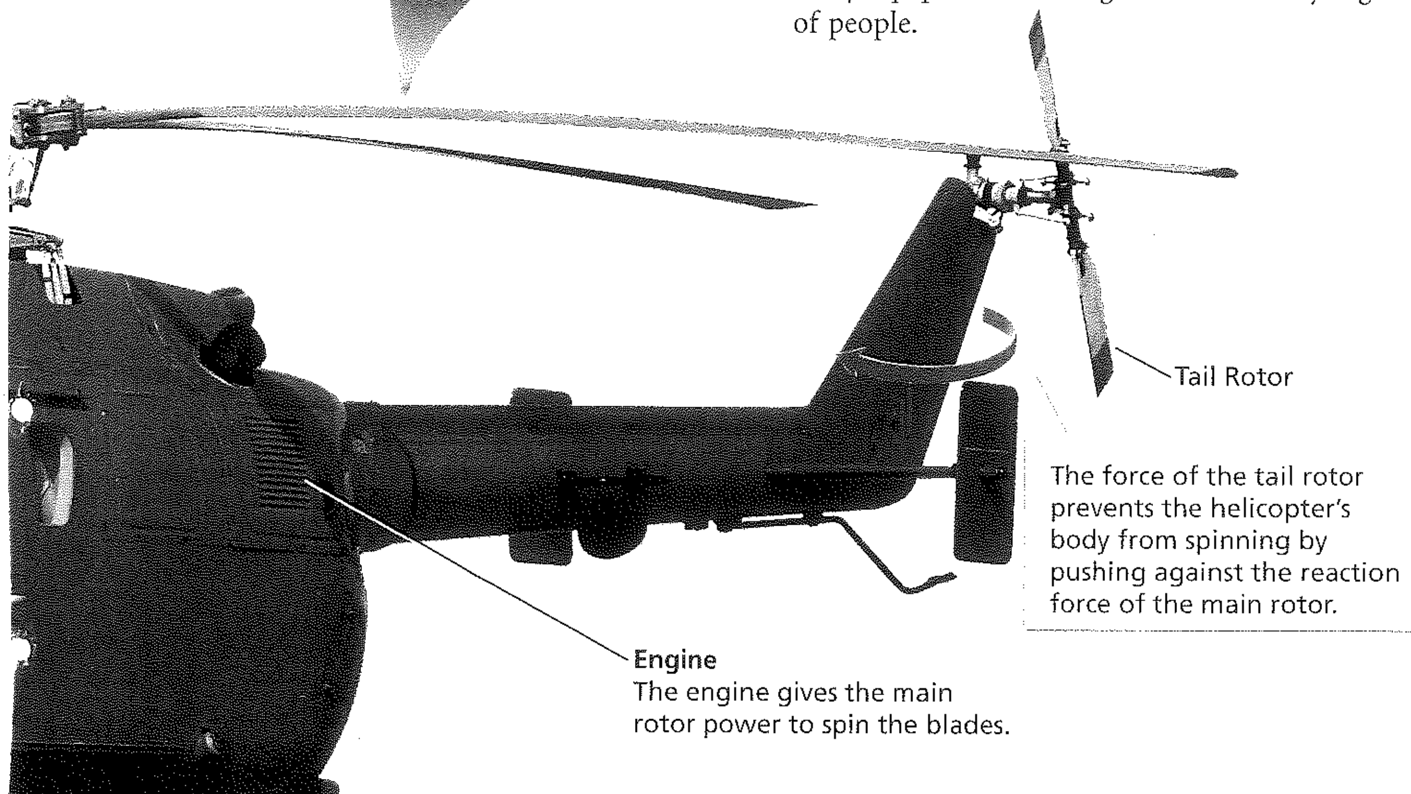
Hand Controls and Foot Pedals
These controls are connected to the main rotor. The collective control guides the helicopter up or down. The cyclic control guides the helicopter forward, backward, or sideways. The foot pedals allow the helicopter to rotate in tight circles.

The Aircraft of Choice—Or Not?

Helicopters can hover and land nearly anywhere. So they are often the aircraft of choice in emergency situations. They are used in search and rescue missions, in fighting forest fires, and in speeding injured people to the hospital. Construction companies also use helicopters to raise heavy equipment.

Despite these benefits, there are constraints to using helicopters. Compared to an airplane, a helicopter must refuel more often and can remain in the air for less time. Another constraint is that a helicopter cannot transport heavy equipment over long distances or carry large numbers of people.





Weigh the Impact

1. Identify the Need
What advantages do helicopters have over airplanes?

2. Research
Using the Internet, research how helicopters are used in national parks, such as Yellowstone National Park. Choose one helicopter mission. Make notes on the mission's difficulty level, purpose, location, procedures, and outcome.

3. Write
Suppose you are a park ranger. Use your notes to write a report to your supervisor explaining why a helicopter was or was not the best technology to use for this mission.

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Chapter 11 Study Guide

The BIG Idea **Science and Technology** If an object is less dense than a fluid, it will float. If an object is denser than a fluid, it will sink.

1 Pressure

Key Concepts

- Pressure decreases as the area over which a force is distributed increases.
- $\text{Pressure} = \dfrac{\text{Force}}{\text{Area}}$
- All of the forces exerted by the individual particles in a fluid combine to make up the pressure exerted by the fluid.
- As elevation increases, atmospheric pressure decreases.
- Water pressure increases as depth increases.

Key Terms

pressure
pascal
fluid
barometer

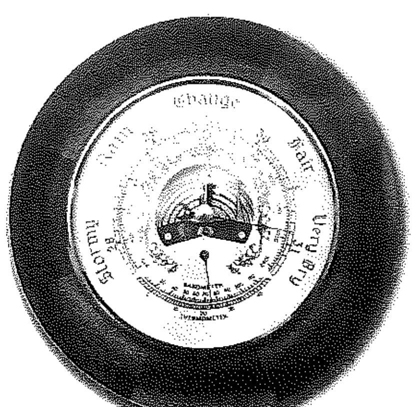
2 Floating and Sinking

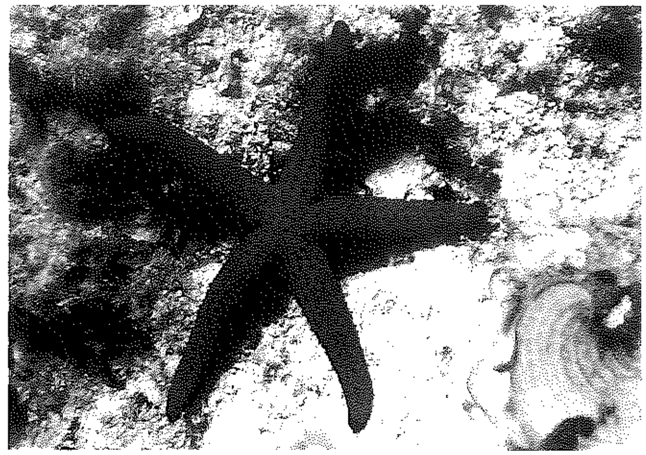
Key Concepts

- The buoyant force acts in the direction opposite to the force of gravity, so it makes an object feel lighter.
- By comparing densities, you can predict whether an object will float or sink in a fluid.
- $\text{Density} = \dfrac{\text{Mass}}{\text{Volume}}$

Key Terms

buoyant force
Archimedes' principle
density





3 Pascal's Principle

Key Concepts

- When force is applied to a confined fluid, the change in pressure is transmitted equally to all parts of the fluid.
- A hydraulic system multiplies force by applying the force to a small surface area. The increase in pressure is then transmitted to another part of the confined fluid, which pushes on a larger surface area.

Key Terms

Pascal's principle
hydraulic system

4 Bernoulli's Principle

Key Concepts

- Bernoulli's principle states that as the speed of a moving fluid increases, the pressure within the fluid decreases.
- Bernoulli's principle helps explain how planes fly. It also helps explain why smoke rises up a chimney, how an atomizer works, and how a flying disk glides through the air.

Key Terms

Bernoulli's principle
lift

Review and Assessment

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Organizing Information

Sequencing Create a flowchart that shows how a hydraulic device multiplies force. (For more on Sequencing, see the Skills Handbook.)

How a Hydraulic Device Works

Force applied to small piston
↓
a. ___?___
↓
b. ___?___
↓
c. ___?___
↓
d. ___?___

Reviewing Key Terms

Choose the letter of the best answer.

1. If you divide the force exerted on a surface by the total area of the surface, you will know
   a. density.
   b. pressure.
   c. lift.
   d. buoyant force.
2. If you know the weight of an object that floats, you know the
   a. object's density.
   b. object's mass.
   c. object's volume.
   d. buoyant force.
3. If you divide the mass of an object by its volume, you know the object's
   a. mass.
   b. weight.
   c. density.
   d. pressure.
4. The concept that an increase in pressure on a confined fluid is transmitted equally to all parts of the fluid is known as
   a. Pascal's principle.
   b. Bernoulli's principle.
   c. Archimedes' principle.
   d. Newton's third law.
5. The concept that the pressure in a fluid decreases as the speed of the fluid increases is known as
   a. Pascal's principle.
   b. Bernoulli's principle.
   c. Archimedes' principle.
   d. Newton's first law.

If the statement is true, write *true*. If it is false, change the underlined word or words to make the statement true.

6. Pressure is force per unit of <u>mass</u>.
7. A <u>fluid</u> is a material that can easily flow.
8. A factor that helps explain flight is <u>Archimedes' principle</u>.
9. A hydraulic system is designed to take advantage of <u>Pascal's principle</u>.
10. <u>Lift</u> is an upward force.

Writing in Science

News Report Suppose that you are a newspaper journalist on the day after the *Titanic* sank. Write a news report that tells what happened. Explain how the buoyancy of a ship is affected when it fills with water. Include information about the various fluid forces involved.

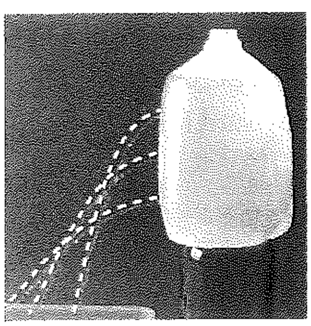
Review and Assessment

Checking Concepts

11. How does the amount of pressure you exert on the floor when you are lying down compare with the amount of pressure you exert when you are standing up?
12. Why aren't deep-sea fish crushed by the tremendous pressure they experience?
13. Why do you seem to weigh more in air than you do in water?
14. In a hydraulic system, why is the force exerted on a small piston multiplied when it acts on a larger piston?
15. Name two hydraulic systems that an auto mechanic would know well.
16. Why is air pressure at the top of a chimney less than air pressure at the bottom?

Thinking Critically

17. Making Generalizations How does the water pressure change at each level in the jug below? How can you tell?



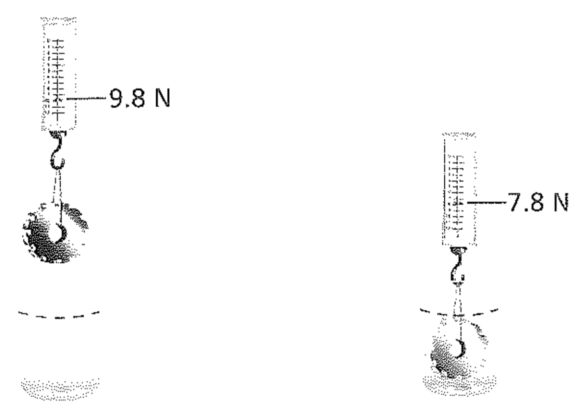
18. Developing Hypotheses A sphere made of steel is put in water and, surprisingly, it floats. Develop a possible explanation for this observation.
19. Applying Concepts One method of raising a sunken ship to the surface is to inflate large bags or balloons inside its hull. Explain why this procedure could work.
20. Problem Solving You have two fluids of unknown density. Suggest a method to determine which is denser, without mixing the two fluids.

Math Practice

21. Area The cover of your textbook measures about 28 cm × 22 cm. Find its area.
22. Area A dollar bill measures about 15.9 cm × 6.7 cm. The Chinese yuan note measures 14.5 cm × 7.0 cm. Which currency uses a larger bill?

Applying Skills

The illustration shows an object supported by a spring scale, both in and out of water. Use the illustration to answer Questions 23–25.



23. Inferring Why is there a difference between the weight of the object in air and its measured weight in water?
24. Calculating What is the buoyant force acting on the object?
25. Drawing Conclusions What can you conclude about the water above the dotted line?

Lab zone Chapter Project

Performance Assessment Test your boat to make sure it does not leak. Display the diagrams of different designs you tried and the observations and data you recorded for each design. Then demonstrate for the class how the boat floats. Point out to your classmates the features you used in your final design.

Standardized Test Prep

Test-Taking Tip

Anticipating the Answer

You can sometimes figure out an answer before you look at the answer choices. After you provide your own answer, compare it with the answer choices. Select the answer that most closely matches your own answer. This strategy can be especially useful for questions that test vocabulary. Try to answer the question below before you look at the answer choices.

Sample Question

Any material that can easily flow is considered a

A liquid.
B fluid.
C gas.
D metal.

Answer

Gases and liquids can easily flow. However, they are both fluids. The definition of a fluid is "a material that can easily flow." The correct answer is B.

Choose the letter of the best answer.

1. The upward force that acts on an airplane's wing is called
   A density.
   B inertia.
   C lift.
   D pressure.

2. Which of the following is an example of a hydraulic system?
   F a car's brakes
   G a barometer
   H an airplane's wing
   J a submarine's flotation tanks

3. A boat that weighs 28,800 N is loaded with 7,200 N of cargo. After it is loaded, what is the buoyant force acting on the boat?
   A 400 N
   B 22,000 N
   C 36,000 N
   D 360,000 N

4. Why doesn't air pressure crush human beings standing at sea level?
   F Air pressure at sea level is very low.
   G Clothing on our bodies shields us from air pressure.
   H Air is not as heavy as human beings.
   J Pressure from the fluids inside our bodies balances the air pressure outside.

5. You observe that a chunk of tar sinks in puddles of rainwater but floats on the ocean. An experiment to explain the behavior of the tar should measure
   A the difference between atmospheric pressure and water pressure.
   B the densities of fresh water, salt water, and tar.
   C the height from which the chunk of tar is dropped.
   D the depth of each type of water.

Constructed Response

Use the diagram below and your knowledge of science to help you answer Question 6.

6. Use Bernoulli's principle to explain why the fabric of a domed tent bulges outward on a windy day.