Name _____ Class _____ Date _____

CHAPTER 7 Forces in Fluids

SECTION 1

Fluids and Pressure

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What are fluids?
- What is atmospheric pressure?
- What is water pressure?
- What causes fluids to flow?

What Are Fluids?

You have something in common with a dog, a sea gull, and a dolphin. You and all these other animals spend a lifetime moving through fluids. A **fluid** is any material that can flow and that takes the shape of its container. Fluids have these properties because their particles can easily move past each other. Liquids and gases are fluids. ☑

Fluids produce pressure. **Pressure** is the force exerted on a given area. The motions of the particles in a fluid are what produce pressure. For example, when you pump up a bicycle tire, you push air into the tire. Air is made up of tiny particles that are always moving. When air particles bump into the inside surface of the tire, the particles produce a force on the tire. The force exerted on the area of the tire creates air pressure inside the tire.

The air particles inside the tire hit the walls of the tire with a force. This force produces a pressure inside the tire. The pressure keeps the tire inflated.

PRESSURE AND BUBBLES

Why are bubbles round? It's because fluids (such as the gas inside the bubbles) exert the same pressure in all directions. This gives the bubbles their round shape.

STUDY TIP

Explain As you read this section, study each figure. In your notebook, describe what each figure tells you about pressure.

READING CHECK

1. Identify What is a fluid?

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TAKE A LOOK

2. Define What is pressure?

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CALCULATING PRESSURE

Remember that pressure is a force exerted on an area. You can use this equation to calculate pressure:

$$pressure = \frac{force}{area}$$

The SI unit of force is the pascal. One **pascal** (Pa) is equal to a force of one newton pushing on an area of one square meter (1 N/m^2). 1 Pa of pressure is very small. A stack of 120 sheets of notebook paper exerts a pressure of about 1 Pa on a table top. Therefore, scientists usually give pressure in kilopascals (kPa). 1 kPa equals 1,000 Pa.

Let's calculate a pressure. What is the pressure produced by a book that has an area of 0.2 m^2 and a weight of 10 N? Solve pressure problems using the following procedure:

Step 1: Write the equation. $pressure = \frac{force}{area}$

Step 2: Substitute and solve. $= \frac{10\ N}{0.2\ m^2} = 50\ \frac{N}{m^2} = 50\ Pa$

Math Focus

3. Calculate What pressure is exerted by a crate with a weight of 3,000 N on an area of 2 m^2? Show your work.

What Is Atmospheric Pressure?

The *atmosphere* is the layer of gases that surrounds Earth. Gravity holds the atmosphere in place. The pull of gravity gives air weight. The pressure caused by the weight of the atmosphere is called **atmospheric pressure**.

Atmospheric pressure is exerted on everything on Earth, including you. At sea level, the pressure is about 101,300 Pa (101.3 kPa). This means that every square centimeter of your body has about 10 N (2 lbs) of force pushing on it.

Why doesn't your body collapse under this pressure? Like the air in a balloon, the fluids inside your body exert pressure. This pressure inside your body acts against the atmospheric pressure.

TAKE A LOOK

4. Describe What would be the length of the arrows if the balloon were inflated more? Explain your answer.

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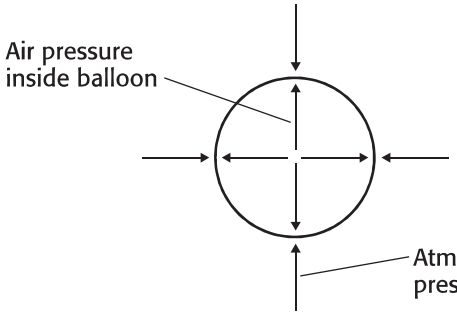

The air inside the balloon produces a pressure inside the balloon. The pressure inside the balloon equals the atmospheric pressure outside the balloon. Therefore, the balloon stays inflated.

PRESSURE, ALTITUDE, AND DEPTH

It is very difficult to climb Mount Everest. One reason is that there is not very much air at the top of Mount Everest. The atmospheric pressure on top of Mount Everest is only about one-third of that at sea level. As you climb higher, the pressure gets lower and lower. At the top of the atmosphere, the pressure is almost 0 Pa. ☑

12,000 m above sea level	Airplanes fly at about 12,000 m above sea level. Atmospheric pressure there is about 20 kPa.
9,000 m above sea level	The top of Mount Everest is about 9,000 m above sea level. Atmospheric pressure there is about 30 kPa.
4,000 m above sea level	La Paz, the capital of Bolivia, is about 4,000 m above sea level. Atmospheric pressure in La Paz is about 51 kPa.
0 m above sea level	At sea level, atmospheric pressure is about 101 kPa.

READING CHECK

5. Describe As altitude increases, what happens to atmospheric pressure?

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Math Focus

6. Calculate About what fraction of atmospheric pressure at sea level is atmospheric pressure at La Paz?

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Air pressure is greatest at Earth's surface because the entire weight of the atmosphere is pushing down there. This is true for all fluids. As you get deeper in a fluid, the pressure gets higher. You can think of being at sea level as being "deep" in the atmosphere. ☑

READING CHECK

7. Explain Why is atmospheric pressure greatest at the surface of Earth?

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PRESSURE CHANGES AND YOUR BODY

What happens to your body when atmospheric pressure changes? You may have felt your ears "popping" when you were in an airplane or in a car climbing a mountain. Air chambers behind your ears help to keep the pressure in your ears equal to air pressure. The "pop" happens because the pressure inside your ears changes as air pressure changes.

What Affects Water Pressure?

Water is a fluid. Therefore, it exerts a pressure. Like air pressure, water pressure increases as depth increases, as shown in the figure below. The pressure increases as the diver gets deeper because more and more water is pushing on her. In addition, the atmosphere pushes down on the water. Therefore, the total pressure on the diver is the sum of the water pressure and the atmospheric pressure. ☑

READING CHECK

8. Explain Why does pressure increase as depth increases?

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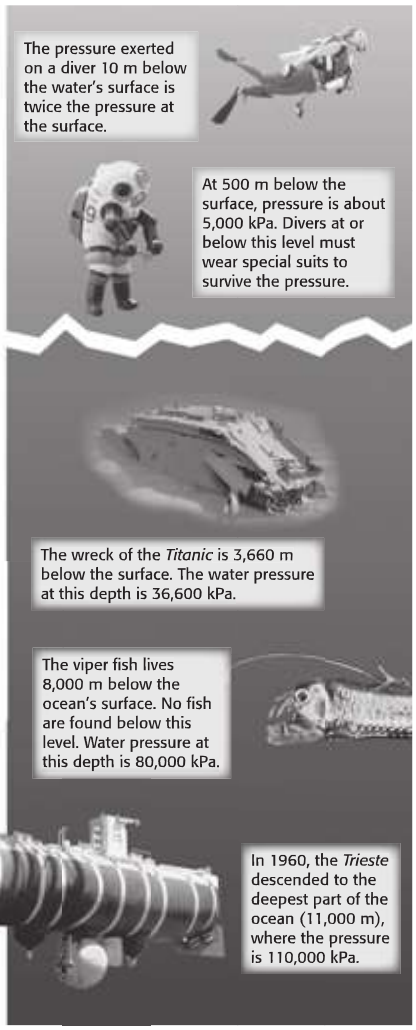

Say It

Discuss In a small group, talk about the kinds of adaptations that deep-water organisms, such as the viper fish, may have to help them survive at very high water pressures.

DENSITY EFFECTS ON WATER PRESSURE

Density is a measure of how closely packed the particles in a substance are. It is a ratio of the mass of an object to its volume. Water is about 1,000 times denser than air. Water has more mass (and weighs more) than the same volume of air. Therefore, water exerts more pressure than air. The pressure exerted by 10 m of water is 100 kPa. This is almost the same as the pressure exerted by the whole atmosphere.

Critical Thinking

9. Infer What is the total pressure in kPA 10 m below the water? Hint: the total pressure is the sum of the atmospheric pressure and the water pressure.

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What Causes Fluids to Flow?

All fluids flow from areas of high pressure to areas of low pressure. Imagine a straw in a glass of water. Before you suck on the straw, the air pressure inside the straw is equal to the air pressure on the water. When you suck on the straw, the air pressure inside the straw decreases. However, the pressure on the water outside the straw stays the same. The pressure difference forces water up the straw and into your mouth.

PRESSURE DIFFERENCE AND BREATHING

The flow of air from high pressure to low pressure is also what allows you to breathe. In order to inhale, a muscle in your chest moves down. This makes the volume of your chest bigger, so your lungs have more room to expand. As your lungs expand, the pressure inside them goes down. Atmospheric pressure is now higher than the pressure inside your lungs, so air flows into your lungs. The reverse of this process happens when you exhale, as shown in the figure below.

When you exhale, a muscle in your chest moves upward. The volume of your chest decreases.

As the volume of your chest decreases, the pressure in your lungs increases. The pressure in your lungs becomes greater than the pressure outside your lungs. Therefore, the air flows out of your lungs (higher pressure) into the air (lower pressure).

PRESSURE DIFFERENCES AND TORNADOES

During a tornado, wind speeds can reach 300 miles per hour or more! Some of the damaging winds caused by a tornado are due to pressure differences. The air pressure inside a tornado is very low. Because the air pressure outside the tornado is high, the air rushes into the tornado and produces strong winds. The winds cause the tornado to act as a giant vacuum cleaner. Objects are pulled in and lifted up by these winds.

Critical Thinking

10. Apply Concepts Why does the air pressure inside a straw go down when you suck on the straw?

TAKE A LOOK

11. Explain Why does air flow out of your lungs when you exhale?

Name _____ Class _____ Date _____

Section 1 Review

SECTION VOCABULARY

atmospheric pressure the pressure caused by the weight of the atmosphere **fluid** a nonsolid state of matter in which the atoms or molecules are free to move past each other, as in a gas or liquid	**pascal** the SI unit of pressure (symbol, Pa) **pressure** the amount of force exerted per unit area of a surface

1. **Describe** How do fluids exert pressure on a container?

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2. **Evaluate** Define density in terms of mass and volume. How does density affect pressure?

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3. **Calculate** The water in a glass has a weight of 2.5 N. The bottom of the glass has an area of 0.012 m^2. What is the pressure exerted by the water on the bottom of the glass? Show your work.

4. **Describe** Fill in the blank spaces in the chart below to show how air moves in and out of your lungs when you breathe.