

# Density and Buoyancy in Action

Density and buoyancy are closely related characteristics of fluids that help us understand how plants and animals—including humans—make use of fluids.

## Oil and Water

Oil is usually less dense than water, so it floats on the surface of water. This property of oil is both harmful and helpful during oil spills. The oil is harmful to aquatic and shore plants and animals. It may contaminate their food, make it difficult for them to breathe, and destroy the insulating effect of fur or feathers.

However, the fact that oil is less dense than water is helpful in cleaning up oil spills. Floating booms are used to encircle oil spills on the surface of the water (Figure 1). Then, collection devices scoop, soak, or suck up much of the captured oil.



**Figure 1** This floating boom has trapped most of the spilled oil.

## Airships, Balloons, and Blimps

On May 6, 1937, the German airship *Hindenburg* completed its twenty-first crossing of the Atlantic Ocean. While docking in New Jersey, U.S.A., it caught fire and burned within seconds (Figure 2). The 245-metre-long craft was filled with hydrogen gas—less expensive and less dense than helium, but extremely explosive. Thirty-six people died in the disaster—thirty-three of them when they jumped from the burning airship.

Today, “lighter-than-air” craft are used mainly for advertising and recreation. Some, like the Goodyear blimps, are helium-filled airships that propel themselves through the air. Most, however, are hot air balloons filled with air heated by burners and attached to a basket or other type of passenger compartment. The balloon is open at the bottom. The heated air rises into the balloon, forcing the cooler, heavier air out the opening. The hot air inside the balloon is much less dense than the colder outside air and makes the balloon buoyant (Figure 3). 🌍

To learn more about the Hindenburg and other “lighter-than-air” craft,

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**Figure 2** The *Hindenburg* disaster reduced the number of large air ships used for commercial transportation.

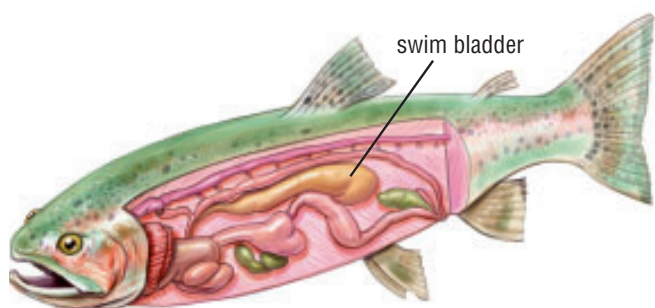


**Figure 3** Designers must consider density and buoyancy when creating specialized hot air balloons.



**Figure 4** The rounded portions of the water hyacinth stem contain air, making this water plant less dense than the water it lives in.

**swim bladder:** a controllable, balloon-like chamber that allows fish to alter their buoyancy



**Figure 5** The oxygen in a fish's swim bladder comes from the dissolved oxygen in the water.

**ballast tanks:** compartments in a ship or submarine that take in water to keep the ship stable or help a submarine dive below the surface

## The Importance of Buoyancy

Water hyacinth (Figure 4) is a floating plant used in pond gardens. Water hyacinth's buoyancy is due to numerous air chambers in its stem. Humans use this idea of flotation chambers in a wide range of devices, such as life preservers, float plane pontoons, and pool chairs.

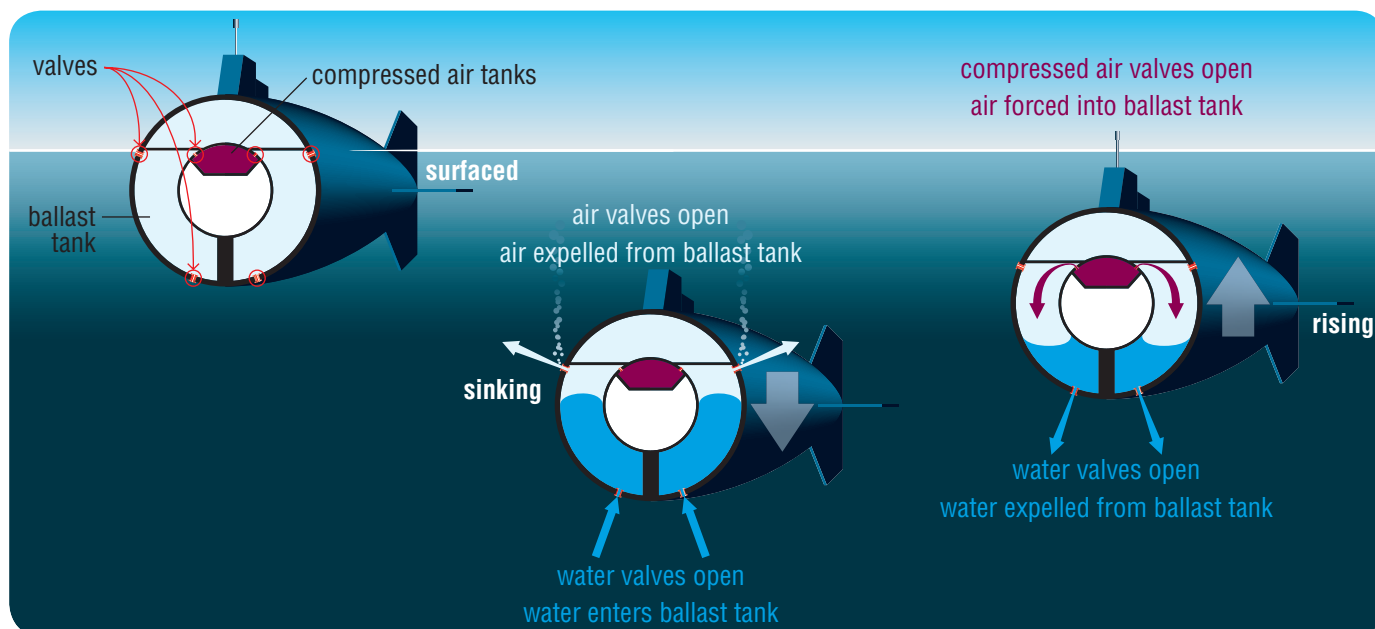
## The Buoyancy of Fish and Submarines

Most bony fish maintain their position in the water with the use of a **swim bladder**, a thin-walled sac in their bodies that contains mainly oxygen (Figure 5). Fish can alter the volume of water they displace and their overall density by adjusting the amount of oxygen in the bladder. This changes their buoyancy in the water. The more oxygen in the bladder, the higher they float; the less oxygen, the more they sink. This helps fish save energy while maintaining their depth in the water.

The oxygen comes from the dissolved oxygen in the water and enters and leaves the bladder through the fish's blood.

Submarines work in a similar manner to the swim bladder. Submarines contain ballast tanks in place of the bladders. **Ballast tanks** are specialized chambers that can be filled with air or water to control the depth of the submarine. To make the submarine descend, valves are opened to take on more water in the ballast tanks (Figure 6).

To surface, air from compressed air tanks is forced into the ballast tanks, displacing the water and reducing the ship's mass-to-volume ratio. This reduction in density causes the buoyant force of the surrounding water to carry the submarine to the surface.



**Figure 6** A submarine's ballast tank works like a fish's swim bladder.

By controlling the amount of air in these specialized chambers, submarines and fish can change their density, causing positive, negative, or neutral buoyancy. When positive buoyancy occurs, the object begins to float upward; negative buoyancy causes the object to sink. Neutral buoyancy occurs when the submarine or fish remains in one place, neither rising nor sinking.

### **TRY THIS:** Building a Cartesian Diver

**SKILLS MENU:** performing, observing, analyzing, communicating



The Cartesian diver, along with other toys based on it, has entertained science students and children around the world for hundreds of years. In this activity, you will build your own Cartesian diver.

**Equipment and Materials:** scissors; 2 L plastic pop bottle (labels removed) with lid; plastic drinking straw; metal paper clips; modelling clay (optional); container of water

1. Cut a plastic drinking straw in half. Bend the straw in half. Secure the bent straw by using a paper clip.
2. Loop four or five additional paper clips over the clip keeping the straw bent (alternatively, add a small lump of modelling clay to the paper clip). This is your diver.
3. Place the diver into the container of water. The diver should just float on the surface of the water (Figure 7). If it does not, add or remove weight (paper clips or modelling clay) from the diver until it floats.
4. Fill the 2 L bottle almost to the top with water. Place the diver in the bottle and put the lid on tightly.
5. When you squeeze the sides of the bottle, you force more water into the straw. Observe what happens to the diver. How can you get the diver to demonstrate positive, negative, and neutral buoyancy?

- A. In your notebook, make a labelled drawing of your Cartesian diver in a bottle.
- B. Record your observations as you squeeze and release the bottle.
- C. Explain how a Cartesian diver can demonstrate positive, negative, and neutral buoyancy. Use sketches if you wish.



**Figure 7** Your diver should just float on the surface of the water.

Cartesian divers, submarines, and fish with swim bladders all demonstrate a common principle: objects that displace a greater volume of fluid are more buoyant than those that displace less fluid.

**Unit Task** Buoyancy is often considered when designing air and water toys. How might you use buoyancy in designing your toy?

### **CHECK YOUR LEARNING**

1. What is the most important idea you learned in this section? Explain the reasons for your choice.
2. Describe two instances in which humans might have used examples from nature when designing devices that use the properties of density and buoyancy.
3. Is the density of oil helpful or harmful when dealing with oil spills? Explain your answer.
4. (a) Explain how ballast tanks work. You may use a diagram in your explanation.  
(b) How is a fish swim bladder similar to a submarine ballast tank?