

Additional Teacher Background

Chapter 3, Lesson 4, p. 205

Another way to analyze the floating ship question is based on comparing the mass of the ship to the mass of water it displaces. When an object floats, the weight of the object equals the weight of the water that the object displaces. Even though a ship is very massive, the volume is so huge that the weight of water displaced by the ship is equal to the weight of the ship.

For example, a solid cube of steel displaces a volume of water equal to the volume of the cube. But since steel is more dense than water, the weight of the cube is greater than the weight of the displaced water, and the cube sinks. But if the cube is flattened and shaped into a large enough boat and placed in water, the boat will displace more water. Its weight hasn't changed, but the volume of water it displaces has increased. When the weight of the water displaced by the boat is equal to the weight of the boat, the boat floats.

But why does the weight of the water matter and what *really* is making the boat float? This question requires a more physics-like analysis. There is a force that makes objects float called the *buoyant force*. Some curricula attempt to teach aspects of density using the concept of buoyant force but we do not recommend it for middle school students. Here is a short explanation for you:

An object in a fluid is acted on by the pressure (force /unit area) exerted by the fluid surrounding it. Because the pressure (force) is greater the deeper you go, there is more force beneath the object pushing up than the force above the object pushing down. Therefore, the buoyant force on an object is a net upward force.

In the diagram, an imaginary ball of water (on the left) is suspended or floating in the water surrounding it. Since water has a particular density, this volume of water has a certain mass and weight. The net upward force due to the buoyant force of the surrounding water is strong enough to counteract the weight of the ball of water and keep it suspended or floating in place. This means that the buoyant force is equal to the weight of the ball of water.

But what happens if the ball of water is replaced by an object that is more dense than water, like a bowling ball?

Since the bowling ball is more dense, it weighs more than the ball of water of the same volume. The buoyant force of the surrounding water is not strong enough to support this extra weight and the bowling ball sinks.

If the ball of water is replaced by a ball that is less dense than water, that ball must weigh less than the ball of water. That ball will be pushed up by the buoyant force and will float to the surface.

