What Keeps It Up?

Use displaced fluid to calculate buoyant force.

HS-PSII-3.2 "Qualitatively and quantitatively determine how the density of fluid or volume of fluid displaced is related to the force due to buoyancy acting on either a floating or submerged object as described by Archimedes' principle of buoyancy."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the rule for calculating buoyant force, then circle each fluid density and displaced volume. Use your marks to find the information needed for the questions.

Tests at the Harbor Lab

1. A harbor lab tests a sealed sensor in two tanks. The sensor stays completely below the surface, so it pushes aside its entire volume of liquid, 0.002 m^3. Archimedes' principle says the upward buoyant force equals the weight of that displaced liquid. In this lab, freshwater has a density of 1,000 kg/m^3, while concentrated brine has a density of 1,200 kg/m^3. The lab uses 10 N/kg for gravitational field strength. Multiply fluid density by displaced volume and then by gravitational field strength to find buoyant force in newtons.

2. Next, the team replaces the sensor with an expanded model that displaces 0.003 m^3 when completely underwater. Both models remain fully submerged in freshwater during this comparison. A submerged object does not have to float to experience buoyancy; a clamp can hold it in place while water pushes upward. Since each cubic meter of the same freshwater has the same weight, pushing aside more water produces a larger upward force. The size of the force depends on the amount of fluid displaced, not on how far below the surface the fully submerged model is held.

3. The lab also tests a small floating platform that weighs 15 newtons. It settles into the freshwater until it displaces enough water to produce an upward force of 15 newtons. The team then moves the same platform to the brine tank. It floats freely there, too, and its weight has not changed. A freely floating object is supported by the buoyant force, so that force equals the object's weight in either tank. Because each cubic meter of brine weighs more than a cubic meter of freshwater, the platform does not need to displace as much brine to stay afloat.

2 ANSWER WITH EVIDENCE

Use the passage

1. Calculate the buoyant force on the original sensor when fully submerged in freshwater and in brine. Which force is larger?

2. Calculate the buoyant force on the expanded model in freshwater. How does it compare with the force on the original sensor in freshwater?

3. How much freshwater must the floating platform displace? Show how you use its weight to find the volume.

4. How much brine must the platform displace? Explain why this volume differs from the freshwater volume even though the platform's weight stays the same.

3 YOUR TURN

Your own words

Plan a new test with a sealed probe whose volume is 0.004 m^3. Calculate its buoyant force when fully submerged in freshwater and in brine with a density of 1,100 kg/m^3, then calculate the force if only half the probe is submerged in freshwater and explain both changes.

What Keeps It Up?

PART 1 · READ AND MARK

Underline the rule for calculating buoyant force, then circle each fluid density and displaced volume. Use your marks to find the information needed for the questions. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Calculate the buoyant force on the original sensor when fully submerged in freshwater and in brine. Which force is larger?	**Freshwater: 1,000 × 0.002 × 10 = 20 N. Brine: 1,200 × 0.002 × 10 = 24 N. The force in brine is larger.**
2	Calculate the buoyant force on the expanded model in freshwater. How does it compare with the force on the original sensor in freshwater?	**1,000 × 0.003 × 10 = 30 N, which is 10 N greater than the original sensor's 20 N.**
3	How much freshwater must the floating platform displace? Show how you use its weight to find the volume.	**Its buoyant force must be 15 N, so the displaced volume is 15 ÷ (1,000 × 10) = 0.0015 m^3.**
4	How much brine must the platform displace? Explain why this volume differs from the freshwater volume even though the platform's weight stays the same.	**It must displace 15 ÷ (1,200 × 10) = 0.00125 m^3. Brine is denser, so a smaller volume weighs 15 N.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Fully submerged in freshwater, the probe experiences 1,000 × 0.004 × 10 = 40 N of buoyant force. In brine, the force is 1,100 × 0.004 × 10 = 44 N because the displaced fluid is denser. With only half the probe submerged in freshwater, it displaces 0.002 m^3, producing 1,000 × 0.002 × 10 = 20 N. Displacing half as much freshwater halves the force.

Accept equivalent calculations and units. For the half-submerged probe, students must use half its total volume as the displaced volume.