LESSON MAKER PRO

Underwater Forces

Calculate how buoyancy changes motion.

HIGH SCHOOL · P.4

P.4 "Use mathematics and computational thinking to analyze the effects of pressure changes and buoyant forces in fluid systems. a. Plan and carry out experiments to determine the density of objects. b..."

NAME _____ **DATE** _____

FORCES IN A FLUID

For a fully submerged object, buoyant force is $F_b = \rho V g$ and points upward. Weight is $W = mg$ and points downward. Ignoring drag, acceleration is $a = (F_b - W)/m$, where a positive result means upward; use $g = 10\ m/s^2$ throughout.

WORKED EXAMPLE

Use the table to find the object's buoyant force and acceleration.

FULLY SUBMERGED OBJECT

Quantity	Value
Fluid density	800 kg/m^3
Displaced volume	0.005 m^3
Object mass	2 kg

1. $F_b = 800 \times 0.005 \times 10 = 40$ N upward.
2. $W = 2 \times 10 = 20$ N downward.
3. $a = (40 - 20)/2 = 10\ m/s^2$ upward.

Answer: 40 N upward; 10 m/s^2 upward

PRACTICE 4 problems

1 A fully submerged object displaces 0.003 m^3 of water. If water's density is 1,000 kg/m^3, find the buoyant force.

ANSWER _____

2 A fully submerged object displaces 0.006 m^3 of a fluid with density 900 kg/m^3. Find the buoyant force.

ANSWER _____

3 An object has a mass of 4 kg and an upward buoyant force of 48 N. Find its net force and acceleration.

ANSWER _____

4 An object has a mass of 3 kg and an upward buoyant force of 18 N. Find its acceleration, including direction.

ANSWER _____

APPLY IT Show your work

1 A submerged robotics-club rover displaces 0.009 m^3 of water and has a mass of 6 kg. Water's density is 1,000 kg/m^3. Find its acceleration when released, ignoring drag.

WORK SPACE

ANSWER _____

2 A sealed camera case is fully submerged. It displaces 0.012 m^3 of water and has a mass of 15 kg. Water's density is 1,000 kg/m^3. Find its acceleration when released, ignoring drag.

WORK SPACE

ANSWER _____

CHALLENGE One step up

An 11 kg object displaces 0.01 m^3 when fully submerged. Use the table to find its acceleration in each fluid, ignoring drag. How does changing the fluid affect its motion when released?

FLUID DENSITIES

Fluid	Density
Water	1,000 kg/m^3
Concentrated brine	1,200 kg/m^3

WORK SPACE AND ANSWER

Underwater Forces

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	A fully submerged object displaces 0.003 m^3 of water. If water's density is 1,000 kg/m^3, find the buoyant force.	**30 N upward**
2	A fully submerged object displaces 0.006 m^3 of a fluid with density 900 kg/m^3. Find the buoyant force.	**54 N upward**
3	An object has a mass of 4 kg and an upward buoyant force of 48 N. Find its net force and acceleration.	**8 N upward; 2 m/s^2 upward**
4	An object has a mass of 3 kg and an upward buoyant force of 18 N. Find its acceleration, including direction.	**4 m/s^2 downward**

PART 2 · APPLY IT

1. **5 m/s^2 upward** Buoyant force is 90 N upward and weight is 60 N downward, so a = (90 − 60)/6 = 5 m/s^2 upward.
2. **2 m/s^2 downward** Buoyant force is 120 N upward and weight is 150 N downward, so the 30 N net force gives a = 30/15 = 2 m/s^2 downward.

CHALLENGE

In water, the buoyant force is 100 N and the acceleration is 10/11 m/s^2 downward. In brine, the buoyant force is 120 N and the acceleration is 10/11 m/s^2 upward. Increasing fluid density reverses the direction of motion when the object is released.

Accept equivalent exact fractions and signed accelerations if the upward-positive convention is clear. All accelerations ignore drag.