A 800-N Object Floats With Three-fourths Of Its Volume Beneath The Surface Of The Water. What Is The

A 800-N Object Floats With Three-fourths Of Its Volume Beneath The Surface Of The Water. What Is The phenomenon describing a common scenario in fluid mechanics and buoyancy studies, where an object of known weight floats with a specific portion submerged. Understanding this situation requires a detailed analysis of the principles of buoyancy, Archimedes' principle, and the relationship between an object's weight, volume, and the density of the fluid it displaces. This article aims to explore the underlying physics, derive the relevant formulas, and provide a comprehensive explanation to solve such problems effectively.

Understanding Buoyancy and Archimedes' Principle

What is Buoyancy?

Buoyancy is the upward force exerted by a fluid on an immersed or floating object. It is responsible for objects floating, sinking, or remaining suspended in a fluid. The magnitude of the buoyant force depends primarily on the volume of fluid displaced and the density of the fluid.

Archimedes' Principle

Archimedes' principle states that:
> An object submerged in a fluid experiences an upward buoyant force equal to the weight of the displaced fluid.

Mathematically, the buoyant force (F_b) is expressed as:
$$ F_b = \rho_{fluid} \times g \times V_{displaced} $$
where:
- ρ_{fluid} = density of the fluid
- g = acceleration due to gravity
- $V_{displaced}$ = volume of fluid displaced

This principle forms the foundation for analyzing floatation problems.

Analyzing the Given Problem

Problem Restatement

An object with a weight of 800 N floats in water such that three-fourths of its volume is submerged. The question is: What is the volume of the object? or What is the density of the object? (depending on specific queries).

The key points are:
- Weight of the object (W_{object}) = 800 N
- Fraction of volume submerged = $\frac{3}{4}$ or 75%

Step-by-Step Solution Approach

Step 1: Identify Known and Unknown Quantities

- Known:
- $W_{object} = 800\, \text{N}$
- $\text{Fraction submerged} = \frac{3}{4}$
- Density of water (ρ_{water}) ≈ $1000\, \text{kg/m}^3$
- Acceleration due to gravity (g) ≈ $9.8\, \text{m/s}^2$

- Unknown:
- Volume of the object (V_{total})
- Density of the object (ρ_{object}), if needed

Step 2: Relate Weight and Buoyant Force at Equilibrium

Since the object is floating, it is in equilibrium:
$$ \text{Weight of the object} = \text{Buoyant force} $$
$$ W_{object} = F_B $$

Expressing buoyant force:
$$ F_B = \rho_{water} \times g \times V_{submerged} $$

Where:
$$ V_{submerged} = \frac{3}{4} V_{total} $$

Thus:
$$ 800\, \text{N} = \rho_{water} \times g \times \frac{3}{4} V_{total} $$

Calculating the Total Volume of the Object

Step 3: Rearrange to Find V_{total}

$$ V_{total} = \frac{800}{\rho_{water} \times g \times \frac{3}{4}} $$

Plugging in the known values:
$$ V_{total} = \frac{800}{1000 \times 9.8 \times \frac{3}{4}} $$

Calculating denominator:
$$ 1000 \times 9.8 = 9800 $$
$$ 9800 \times \frac{3}{4} = 9800 \times 0.75 = 7350 $$

Therefore:
$$ V_{total} = \frac{800}{7350} \approx 0.1088\, \text{m}^3 $$

Result:
The total volume of the object is approximately 0.109 cubic meters.

Understanding the Implications of Volume and Density

Step 4: Determine the Density of the Object

Knowing the weight and volume, we can find the density:
$$\rho_{object} = \frac{\text{Mass of the object}}{V_{total}}$$

Since:
$$\text{Weight} = \text{Mass} \times g$$
$$\text{Mass} = \frac{W_{object}}{g} = \frac{800}{9.8} \approx 81.63\, \text{kg}$$

Now:
$$\rho_{object} = \frac{81.63}{0.1088} \approx 750\, \text{kg/m}^3$$

Conclusion:
The density of the object is approximately 750 kg/m^3, which is less than water's density, explaining why it floats.

Additional Insights and Applications

Why Does Three-Fourths of the Volume Submerge?

The fraction of the volume submerged relates directly to the ratio of the densities:
$$\frac{V_{submerged}}{V_{total}} = \frac{\rho_{object}}{\rho_{water}}$$

Given:
$$\frac{3}{4} = \frac{\rho_{object}}{1000}$$
$$\rho_{object} = \frac{3}{4} \times 1000 = 750\, \text{kg/m}^3$$

This confirms the previous calculation, illustrating the consistency between the physical intuition and the mathematical derivation.

Real-World Examples and Practical Applications

Ship Design and Buoyancy Considerations

- Engineers calculate the volume and density of ships to ensure they float with specific portions submerged.
- Adjusting the ship's hull volume controls its buoyancy and stability.

Submarine Operations

- Submarines control buoyancy by adjusting ballast tanks, changing the displaced water volume.
- Understanding how volume and weight affect buoyancy is crucial for safe and efficient submarine operation.

Archimedes' Principle in Daily Life

- Determining the volume of irregular objects by water displacement.
- Designing floating devices and understanding their stability.

Summary and Key Takeaways

- The weight of the object and the volume submerged are directly related via buoyant force.
- When an object floats with three-fourths of its volume submerged, its density is approximately 75% that of water.
- The total volume of the object can be derived using the weight, gravity, and displaced fluid volume.
- These principles are fundamental in fluid mechanics, engineering, and various scientific applications.

Conclusion

Understanding why an 800-N object floats with three-fourths of its volume submerged involves applying the principles of buoyancy and Archimedes' principle. By analyzing the balance of forces, calculating the total volume, and deriving the density, we gain insight into the physics governing floating objects. This knowledge not only aids in academic problem-solving but also plays a vital role in engineering designs, maritime navigation, and everyday life scenarios involving fluids.

Meta Description:
Discover how to calculate the volume and density of an object floating with three-fourths submerged, based on its weight of 800 N. Learn about buoyancy, Archimedes' principle, and practical applications in fluid mechanics.

Frequently Asked Questions

What is the principle that explains why an object floats with three-fourths of its volume submerged?

Archimedes' principle explains that an object floats when the buoyant force equals its weight; in this case, three-fourths of the volume is submerged because the object's density is three-fourths that of water.

How do you determine the density of the object based on its submerged volume?

The density of the object can be found by dividing its density relative to water. Since three-fourths of the volume is submerged, the object's density is approximately 0.75 times the density of water.

What is the significance of the object floating with three-fourths of its volume submerged?

It indicates that the object's density is less than water's, specifically about 75% of water's density, which results in three-fourths of its volume being submerged when floating.

If the object weighs 800 N and floats with three-fourths of its volume submerged, what is the density of the object?

The density of the object is approximately 0.75 times the density of water, assuming standard water density of 1000 kg/m^3, the object's density would be about 750 kg/m^3.

How can we calculate the volume of the object based on the given weight and buoyant condition?

Using the weight (800 N) and the fact that the buoyant force equals the weight, you can find the volume submerged by applying Archimedes' principle: buoyant force = weight, so volume submerged = weight / (density of water × gravity).

Why does only three-fourths of the object's volume need to be submerged for it to float?

Because the object's density is less than water's, it displaces enough water to balance its weight when three-fourths of its volume is submerged; if it were denser, it would sink more.

What is the relationship between the object's volume submerged and its overall volume?

The volume submerged is three-fourths of the total volume of the object, indicating its relative density compared to water.

Can the object be made of a material denser than water but still float with three-fourths submerged?

Generally, if an object is denser than water, it will sink; however, if it is a composite or hollow object with overall density less than water, it can float with part of it submerged, but a solid denser object cannot float with three-fourths submerged.

Additional Resources

Understanding Floating Objects and Buoyancy: An In-Depth Analysis of a 800-N Object with Three-Fourths Submerged

When examining the fascinating behavior of objects floating in water, the principles of buoyancy, density, and equilibrium come into play. In this detailed exploration, we analyze a specific scenario: an object weighing 800 N that floats with three-fourths of its volume submerged. Through this analysis, we will uncover the underlying physics, calculations, and implications involved in such a scenario.

Introduction to Buoyancy and Floating Objects

Buoyancy is the upward force exerted by a fluid on an object immersed in it. This force is responsible for objects floating, sinking, or remaining in equilibrium within the fluid.

- Archimedes' Principle states that the buoyant force on an object submerged in a fluid equals the weight of the displaced fluid:

$$
F_B = \rho_{fluid} \times V_{displaced} \times g
$$

where:
- ρ_{fluid} = density of the fluid,
- $V_{displaced}$ = volume of fluid displaced,
- g = acceleration due to gravity.

Scenario Breakdown

Given Data:

- Object weight, $W = 800\,N$
- The object floats with three-fourths of its volume submerged.

Goals:

- Determine the density of the object.
- Calculate the volume of the object.
- Understand the implications of the submerged volume ratio.

Analyzing the Physical Situation

1. Establishing the Equilibrium Condition

Since the object floats in equilibrium, the buoyant force equals its weight:

$$
F_B = W
$$

Given that:

$$
F_B = \rho_{water} \times V_{submerged} \times g
$$

And:

$$
W = m_{object} \times g
$$

Where:

- m_{object} = mass of the object,
- V_{total} = total volume of the object,
- $V_{submerged}$ = volume submerged in water.

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2. Relationship Between Submerged Volume and Total Volume

Given that three-fourths of the object's volume is submerged:

$$
V_{submerged} = \frac{3}{4} V_{total}
$$

This ratio is crucial because it directly links the volume displaced to the total volume.

Calculations and Derivations

1. Determining the Object's Mass

Given the weight:

$$
W = 800\,N
$$

Using $W = m_{object} \times g$:

$$
m_{object} = \frac{W}{g} = \frac{800\,N}{9.8\,m/s^2} \approx 81.63\,kg
$$

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2. Calculating the Volume of the Object

The density of the object, ρ_{object}, relates mass and volume:

$$
\rho_{object} = \frac{m_{object}}{V_{total}}
$$

The buoyant force balancing the weight yields:

$$
W = \rho_{water} \times V_{submerged} \times g
$$

Rearranged:

$$
V_{submerged} = \frac{W}{\rho_{water} \times g}
$$

Using the standard density of water:

$$
\rho_{water} = 1000\,kg/m^3
$$

Substituting values:

$$
V_{submerged} = \frac{800\,N}{1000\,kg/m^3 \times 9.8\,m/s^2} \approx \frac{800}{9800} \approx 0.08163\,m^3
$$

Because $V_{submerged} = \frac{3}{4} V_{total}$, the total volume:

$$
V_{total} = \frac{V_{submerged}}{\frac{3}{4}} = \frac{0.08163}{0.75} \approx 0.10884\,m^3
$$

---

3. Calculating the Density of the Object

Now, the object's density:

$$
\rho_{object} = \frac{m_{object}}{V_{total}} = \frac{81.63\,kg}{0.10884\,m^3} \approx 750.3\,kg/m^3
$$

Key Observation:
The object's density (~750 kg/m³) is less than water's density (1000 kg/m³), explaining why it floats with a significant volume submerged.

Implications and Physical Insights

1. Density Comparison

- Since $\rho_{object} < \rho_{water}$, the object is less dense than water.
- The ratio of the densities is approximately:

$$
\

$$
\frac{\rho_{object}}{\rho_{water}} \approx \frac{750}{1000} = 0.75
$$

which aligns with the volume submerged ratio (three-fourths), reflecting the principle that an object's submerged volume ratio equals the ratio of its density to the fluid density:

$$
\frac{V_{submerged}}{V_{total}} = \frac{\rho_{object}}{\rho_{water}}
$$

This confirms the theoretical consistency.

2. Significance of the Submerged Volume Ratio

- The fact that three-fourths of the object's volume is submerged indicates a density ratio of 0.75.
- If the object were denser (closer to 1000 kg/m³), less of it would be submerged.
- Conversely, if less dense, it would float with more volume submerged.

Additional Considerations

1. Effect of Gravity Variations

- The calculations assume standard gravity (9.8 m/s²).
- Variations in gravity (e.g., at different locations) could slightly alter the submerged volume and density calculations.

2. Material and Structural Implications

- The object's density suggests it could be made of materials like wood, certain plastics, or light metals.
- Understanding the density helps in designing objects for buoyancy control, such as ships, submarines, or floating platforms.

3. Real-World Applications

- Ship Design: Knowledge of how much of the vessel's volume is submerged to ensure stability.
- Submarine Ballast: Adjusting weight and volume to achieve desired buoyancy levels.
- Environmental Science: Studying floating debris, natural logs, or icebergs.

Summary and Final Remarks

This comprehensive analysis demonstrates how fundamental physics principles — primarily buoyancy and density — govern the floating behavior of objects. For an 800-N object floating with three-fourths of its volume

submerged:

- Its mass is approximately 81.63 kg.
- Its total volume is about 0.109 m^3.
- Its density is approximately 750 kg/m^3.
- The submerged volume ratio confirms the ratio of densities, illustrating the elegant correlation between physical properties and floating behavior.

Understanding these principles is essential in engineering, environmental science, and physics, providing insight into how objects interact with fluids and how to manipulate their buoyancy for various practical applications.

In conclusion, the object's behavior exemplifies classic buoyancy principles, serving as a perfect case study for students and professionals interested in fluid mechanics and material science. The ability to calculate and interpret such parameters enhances our understanding of the natural world and our capacity to design and utilize floating structures effectively.

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