A Block Of Wood Weighs 160 N And Has A Specific Gravity Of 0.60. To Sink It In Fresh Water Requires An

Understanding the Problem: A Block of Wood in Fresh Water

Introduction to the Scenario

A Block Of Wood Weighs 160 N And Has A Specific Gravity Of 0.60. To Sink It In Fresh Water Requires An examination of the principles of buoyancy, specific gravity, and the forces involved when an object interacts with a fluid. The question posed hints at the fundamental physics concepts governing whether an object floats or sinks, based on its density relative to the fluid. In this article, we will explore the concepts step-by-step, analyze the data provided, and determine what additional force or condition is necessary for the wood to sink in fresh water.

Fundamentals of Buoyancy and Specific Gravity

Buoyancy and Archimedes' Principle

Buoyancy is the upward force exerted by a fluid on an immersed or floating object. According to Archimedes' principle, the buoyant force (F_b) acting on a submerged object equals the weight of the displaced fluid:

- F_b = ρ_fluid × g × V_displaced

where:
- ρ_fluid = density of the fluid
- g = acceleration due to gravity
- V_displaced = volume of fluid displaced by the object

The object will float or sink depending on the relationship between its weight and the buoyant force:

- If weight < buoyant force → object floats
- If weight > buoyant force → object sinks

Specific Gravity and Its Significance

Specific gravity (SG) is a dimensionless number expressing the ratio of an object's density to the density of water:

- $SG = \rho_{object} / \rho_{water}$

Given SG = 0.60 for the wood, the density of the wood (ρ_{wood}) can be calculated as:

- $\rho_{wood} = SG \times \rho_{water}$

Since the density of water (at 4°C) is approximately 1000 kg/m^3, the density of the wood becomes:

- $\rho_{wood} = 0.60 \times 1000\ kg/m^3 = 600\ kg/m^3$

Implication: Because the density of the wood is less than water, it naturally tends to float, which explains why it does not sink under the influence of gravity alone.

Calculating the Volume of the Wooden Block

Using the Weight to Find Volume

The weight of the wood is given as 160 N. To find the volume, first, determine the mass:

- Weight (W) = mass (m) × g

- $m = W / g = 160\ N / 9.8\ m/s^2 \approx 16.33\ kg$

The volume (V) of the wood is then:

- $V = m / \rho_{wood} = 16.33\ kg / 600\ kg/m^3 \approx 0.0272\ m^3$

Result: The volume of the wood block is approximately 0.0272 cubic meters.

Understanding Why It Floats

Since the wooden block’s density (600 kg/m^3) is less than water, it will float with part of it submerged and part above water. The fraction submerged can be calculated based on the ratio of the densities.

Fraction Submerged:
$$
\text{Fraction submerged} = \frac{\rho_{object}}{\rho_{water}} = \frac{600}{1000} = 0.60
$$
Thus, approximately 60% of the wood's volume is submerged when it is floating in water.

What Is Needed to Make the Wood Sink?

Conditions for Sinking

To sink the wooden block, the downward force (the weight of the wood) must be greater than the buoyant force that the displaced water can exert. Since the object’s density is less than water, it naturally floats. To make it sink, one must:

- Increase the effective downward force beyond the maximum buoyant force, or
- Reduce the buoyant force by altering the conditions (e.g., removing water or changing the medium), or
- Add an external force that overcomes buoyancy.

In the context of the question, the typical way to sink the block in fresh water is to apply an additional force or modify the situation so that the total downward force exceeds the buoyant force.

Calculating the Buoyant Force in Fresh Water

The maximum buoyant force when the block is fully submerged:
$$
F_b = \rho_{water} \times g \times V
$$
$$
F_b = 1000\, \text{kg/m}^3 \times 9.8\, \text{m/s}^2 \times 0.0272\, \text{m}^3 \approx 266.56\, \text{N}
$$

The weight of the block is 160 N, which is less than 266.56 N, confirming it floats with part of the volume submerged (about 60%). To sink it completely, the net downward force must be greater than the maximum buoyant force.

Determining the Additional Force Required

External Force Needed to Sink the Wood

The force required to overcome buoyancy and fully submerge the block:

$$
F_{additional} = F_b - W
$$

$$
F_{additional} = 266.56\, \text{N} - 160\, \text{N} \approx 106.56\, \text{N}
$$

Interpretation: Applying an additional downward force of approximately 106.56 N will be sufficient to push the wooden block below the water surface, causing it to sink.

Summary of the Conditions for Sinking

- The existing weight of the wood (160 N) is insufficient to overcome the buoyant force (~266.56 N) when fully submerged.

- An external downward force of about 106.56 N must be applied to fully submerge the block.

- Alternatively, increasing the weight of the block (e.g., by adding mass) to exceed the maximum buoyant force can also cause sinking.

Additional Considerations and Real-World Implications

Practical Methods to Sink the Wooden Block

- Adding Weight: Attach or embed additional dense material to increase the total weight beyond the buoyant force.
- External Force: Use tools or mechanisms to push or press the block downward.
- Changing Medium: Submerge the block in a denser fluid (e.g., saltwater)

that exerts a greater buoyant force, requiring more force to sink.
- Reducing Volume: If the block's volume is decreased (e.g., by cutting), its buoyant force reduces, making sinking easier.

Limitations and Assumptions

- The calculations assume the block is fully submerged when considering the maximum buoyant force.
- The fluid is still and the density of water remains constant.
- The external force is applied gradually and uniformly.

Conclusion: The Final Answer

To sink the wooden block in fresh water, an external downward force of approximately 106.56 N must be applied. This force exceeds the difference between the maximum buoyant force (about 266.56 N) and the weight of the block (160 N), overcoming buoyancy and causing the block to fully submerge and sink. Alternatively, increasing the block’s weight beyond this threshold would also achieve sinking.

Summary of Key Points

- The block’s density (600 kg/m^3) is less than water, so it naturally floats.
- The volume of the block is approximately 0.0272 m^3.
- The maximum buoyant force when fully submerged is around 266.56 N.
- Additional downward force of about 106.56 N is needed to sink the block.
- Applying this force ensures the downward force exceeds buoyancy, forcing the block beneath the water surface.

Understanding these principles not only clarifies the specific scenario but also provides fundamental insights into buoyancy, density, and the forces involved when objects interact with fluids.

Frequently Asked Questions

What is the weight of the block of wood?

The block of wood weighs 160 N.

What is the specific gravity of the block of wood?

The specific gravity of the wood is 0.60.

What does a specific gravity of 0.60 indicate about the wood's density?

It indicates that the density of the wood is 60% of the density of water.

How do you calculate the volume of the block of wood?

Volume = weight / (specific gravity × density of water) = 160 N / (0.60 × 9.8 m/s^2) ≈ 27.04 liters.

What is the buoyant force acting on the wood when submerged in water?

The buoyant force equals the weight of displaced water, which is 160 N, since the block is just submerged to sink.

How much additional force or weight is needed to sink the wooden block completely in fresh water?

Since the block's density is less than water, to sink it, you need to add enough weight to overcome the buoyant force, roughly equal to the difference between the weight and the weight of water displaced; in this case, slightly more than 160 N.

What is the minimum weight required to sink the block in freshwater?

A weight exceeding 160 N is required; practically, adding just over 160 N of additional weight will sink the block completely in fresh water.

Additional Resources

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Understanding the behavior of materials in fluid environments is fundamental in physics and engineering. When examining a block of wood with a known weight and specific gravity, it becomes essential to analyze the principles governing buoyancy, density, and the conditions under which the object sinks or floats. This article aims to comprehensively explore the scenario where a specific block of wood, weighing 160 N and possessing a specific gravity (SG) of 0.60, is immersed in fresh water, and to determine what conditions or additional factors are necessary to sink it entirely.

Fundamental Concepts: Weight, Density, and Specific Gravity

To understand how the wooden block interacts with water, it is crucial to first clarify the key concepts involved.

Weight and Mass

- Weight (W): The force exerted on an object due to gravity. It is expressed in Newtons (N). In this scenario, the block weighs 160 N.
- Mass (m): The amount of matter in the object, related to weight by the gravitational acceleration (g). Calculated as:

$$
m = \frac{W}{g}
$$

where $g \approx 9.81\, \text{m/s}^2$.

Calculation:

$$
m = \frac{160\, \text{N}}{9.81\, \text{m/s}^2} \approx 16.30\, \text{kg}
$$

Density of the Wood

- The density (ρ_{wood}) is the mass per unit volume:

$$
\rho_{wood} = \frac{m}{V}
$$

- To find the density, the volume V of the block must be known or derived from the specific gravity.

Specific Gravity (SG)

- Definition: The ratio of the density of a substance to the density of a reference substance, typically water at 4°C, which has a density of approximately 1000 kg/m³.

$$
SG = \frac{\rho_{object}}{\rho_{water}}
$$

- Given: $SG = 0.60$

- Implication: The density of the wood is:

$$
\rho_{wood} = SG \times \rho_{water} = 0.60 \times 1000\, \text{kg/m}^3 = 600\, \text{kg/m}^3
$$

Calculating the Volume of the Wooden Block

Knowing the density, we can now determine the volume of the block.

$$
V = \frac{m}{\rho_{wood}} = \frac{16.30\, \text{kg}}{600\, \text{kg/m}^3} \approx 0.02717\, \text{m}^3
$$

Interpretation:

- The block's volume is approximately 0.02717 cubic meters (or 27,170 cubic centimeters).

Buoyancy and Equilibrium: When Does the Block Float or Sink?

The principle governing whether the block floats or sinks is Archimedes' principle:

> An object submerged in a fluid experiences an upward buoyant force equal to the weight of the displaced fluid.

Key points:

- If the weight of the object exceeds the buoyant force, the object sinks.
- If the weight is less than or equal to the buoyant force, the object floats or remains buoyant.

Buoyant Force in Fresh Water

- The buoyant force (F_b) is:

$$
F_b = \rho_{water} \times V_{displaced} \times g
$$

- For a fully submerged object:

$$
F_b = \rho_{water} \times V_{object} \times g
$$

- The object will just float when:

$$
W = F_b
$$

Calculations:

- The weight of the water displaced when fully submerged:

$$
F_b = \rho_{water} \times V \times g = 1000\, \text{kg/m}^3 \times 0.02717\, \text{m}^3 \times 9.81\, \text{m/s}^2 \approx 266.8\, \text{N}
$$

Conclusion:

- The buoyant force at full submersion is approximately 267 N, which exceeds the block's weight of 160 N.
- Therefore, the block will float, with part of it submerged and part above water surface.

Determining the Submerged Volume for Equilibrium

In reality, the block does not need to be fully submerged to achieve equilibrium; it floats such that the buoyant force equals its weight.

Let:

- V_s = volume of the submerged part of the block.

Then:

$$
\rho_{water} \times V_s \times g = W
$$

Rearranged:

$$
V_s = \frac{W}{\rho_{water} \times g}
$$

Calculating:

$$
V_s = \frac{160\, \text{N}}{1000\, \text{kg/m}^3 \times 9.81\, \text{m/s}^2}
\approx 0.0163\, \text{m}^3
$$

Implication:

- To just float (not sink), approximately 0.0163 m^3 of the block must be submerged.
- Since the total volume is about 0.02717 m^3, the fraction submerged is:

$$
\frac{V_s}{V} \approx \frac{0.0163}{0.02717} \approx 0.6
$$

- Result: About 60% of the block's volume is submerged when floating in water, consistent with its specific gravity of 0.60.

What Is Needed to Sink the Block in Fresh Water?

Given the current conditions, the wooden block naturally floats because its density is less than water. To sink it entirely, we need to alter the conditions such that the entire volume is submerged and the weight exceeds the buoyant force.

Methods to Sink the Block:

1. Increase the Density of the Block:
- Add weight: Attach additional mass to increase the overall weight.
- Change material properties: Use denser materials or embed the existing block in a denser medium.

2. Reduce the Displaced Water Volume:
- Partially submerge: This doesn't help sink the block; it only affects how much is submerged.

3. Apply External Forces or Alter the Environment:
- Increase fluid density: Use saline water or other denser fluids.
- Increase the gravitational field: Not practical in normal Earth conditions.

Calculating the Additional Weight Needed

To sink the block completely (i.e., make it fully submerged with buoyant force less than the weight), the total weight must exceed the maximum buoyant force when fully submerged:

$$
W_{total} > \rho_{water} \times V \times g
$$

From previous calculations:

$$
\rho_{water} \times V \times g \approx 266.8\, \text{N}
$$

The current weight:

$$
W = 160\, \text{N}
$$

Additional weight needed:

$$
\Delta W = 266.8\, \text{N} - 160\, \text{N} = 106.8\, \text{N}
$$

Corresponding mass:

$$
\Delta m = \frac{\Delta W}{g} = \frac{106.8\, \text{N}}{9.81\, \text{m/s}^2}
\approx 10.9\, \text{kg}
$$

Conclusion:

- Attaching approximately 10.9 kg of additional mass to the block will make it sink completely in fresh water.

Additional Considerations: Practical Implications and Real-World Applications

Understanding the buoyancy and density relationships of wooden objects has practical importance across multiple fields.

Marine and Naval Engineering

- Designing ships and submarines involves controlling buoyancy. The understanding of specific gravity and weight allows engineers to determine how much ballast to add or remove.
- For wooden vessels, ensuring the material's density is appropriately less than water ensures floatation.

Material Selection and Construction

- Selecting wood with specific gravity near 0.60 makes it suitable for applications where buoyancy is critical, such as in boat building or floating devices.
- Analyzing how much additional weight is necessary to sink objects aids in designing fixtures, floats, or underwater equipment.

Environmental and Ecological Impacts

- The behavior of natural wooden debris in water bodies influences sedimentation and aquatic ecosystems.
- Understanding buoyancy helps in pollution management, especially in assessing how materials sink or float in water.

Summary and Final Remarks

In conclusion, the analysis

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