Archimedes' Principle

Name: _____ **Class:** _____ **Date:** _____

Quick Review

Archimedes' Principle states that an object partially or completely submerged in a fluid experiences an upward buoyant force equal to the weight of the fluid it displaces.

Key ideas:

- **Buoyant force (upthrust):** The upward force exerted by a fluid on an object.
- **Displaced fluid:** The fluid that would otherwise occupy the space taken up by the submerged part of an object.
- **Floating:** An object floating at rest experiences a buoyant force equal to its weight.
- **Sinking:** An object sinks when its weight is greater than the maximum buoyant force the fluid can provide.

Formula:

Buoyant force = weight of displaced fluid

$F_\beta = \rho \times g \times V$

Where:

- F_β = buoyant force (N)
- ρ = density of the fluid (kg/m³)
- g = gravitational field strength (N/kg)
- V = volume of displaced fluid (m³)

For this worksheet, use:

- g = 10 N/kg
- Density of water = 1000 kg/m³
- 1000 cm³ = 0.001 m³

Part A — Multiple Choice

1. What does Archimedes' Principle describe?

A. The relationship between speed and distance
B. The upward force on an object due to displaced fluid
C. The force of friction between two surfaces
D. The relationship between electricity and magnetism

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2. The buoyant force on a submerged object is equal to:

A. The object's mass
B. The object's volume
C. The weight of the displaced fluid
D. The pressure at the water's surface

3. Which force acts upward on an object in water?

A. Gravity
B. Friction
C. Weight
D. Buoyant force

4. What happens to a floating object at rest?

A. Its buoyant force equals its weight.
B. Its weight becomes zero.
C. Its buoyant force is always greater than its weight.
D. Gravity stops acting on it.

5. Why can a large steel ship float?

A. Steel has no weight.
B. Water does not exert pressure on steel.
C. Its hull displaces enough water to provide a buoyant force equal to its weight.
D. Gravity is weaker over oceans.

Part B — Matching

Match each term to its correct description.

Term	Answer
1. Buoyant force	_____
2. Displacement	_____
3. Density	_____
4. Floating equilibrium	_____
5. Archimedes' Principle	_____

Descriptions

A. Mass per unit volume
B. The upward force exerted by a fluid
C. The volume of fluid moved aside by an object
D. Buoyant force equals the weight of the displaced fluid
E. A floating object has balanced upward and downward forces

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Part C — Calculating Buoyant Force

Show your working and include units.

1. An object displaces water weighing 8 N.

What is the buoyant force acting on the object?

2. A submerged object displaces 0.002 m^3 of water.

Calculate the buoyant force.

$F_\beta = \rho \times g \times V$

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3. A rock displaces 0.005 m^3 of water.

Calculate the buoyant force.

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4. A submerged object experiences a buoyant force of 30 N.

Calculate the volume of water displaced.

$V = F_\beta \div (\rho \times g)$

Part D — Floating and Sinking

A scientist places three objects into a tank of water.

Object	Weight	Buoyant Force
A	12 N	12 N
B	20 N	15 N
C	8 N	8 N

1. Which objects have balanced forces?

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2. Which object experiences a net downward force?

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3. Calculate the net force on Object B.

4. What would happen to Object B if these forces remained unchanged? Explain.

Part E — Real-World Applications

1. Why does a person often feel lighter when standing in a swimming pool?

2. Explain how a submarine can control whether it rises or sinks.

3. Why does a large hollow steel ship float while a small solid steel ball sinks?

4. A wooden block floats in water. If extra weight is placed on top, what happens to the amount of water displaced? Explain.

Part F — Archimedes' Discovery

According to a famous story, Archimedes investigated whether a crown was made of pure gold. He realised that the volume of an irregular object could be determined by measuring the water it displaced.

1. Why is water displacement useful for measuring irregularly shaped objects?

2. How did Archimedes' Principle improve our understanding of floating and sinking?

3. Give one modern technology that uses Archimedes' Principle.

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Exit Ticket

1. State Archimedes' Principle in your own words.

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2. What determines the buoyant force on a submerged object?

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3. Calculate the buoyant force when an object displaces water weighing 25 N.

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4. Explain why a ship can float.

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5. Why was Archimedes' discovery important to science?

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Archimedes' Principle — Answer Key

Part A — Multiple Choice

1. B — The upward force on an object due to displaced fluid.
2. C — The weight of the displaced fluid.
3. D — Buoyant force.
4. A — Its buoyant force equals its weight.
5. C — Its hull displaces enough water to provide a buoyant force equal to its weight.

Part B — Matching

Term	Answer	Description
1. Buoyant force	B	The upward force exerted by a fluid
2. Displacement	C	The volume of fluid moved aside by an object
3. Density	A	Mass per unit volume
4. Floating equilibrium	E	A floating object has balanced upward and downward forces
5. Archimedes' Principle	D	Buoyant force equals the weight of the displaced fluid

Part C — Calculating Buoyant Force

Use:

- $F_\beta = \rho \times g \times V$
- $\rho = 1000\ kg/m^3$
- $g = 10\ N/kg$

1. An object displaces water weighing 8 N. What is the buoyant force?

Answer: 8 N upward

According to Archimedes' Principle, the buoyant force equals the weight of the displaced fluid.

2. A submerged object displaces 0.002 m^3 of water. Calculate the buoyant force.

$F_\beta = \rho \times g \times V$

$F_\beta = 1000 \times 10 \times 0.002$

$F_\beta = 20$ N upward

3. A rock displaces 0.005 m^3 of water. Calculate the buoyant force.

$F_\beta = \rho \times g \times V$

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$F_\beta = 1000 \times 10 \times 0.005$

$F_\beta = 50$ N upward

4. A submerged object experiences a buoyant force of 30 N. Calculate the volume of water displaced.

$V = F_\beta \div (\rho \times g)$

$V = 30 \div (1000 \times 10)$

$V = 30 \div 10{,}000$

$V = 0.003$ m³, or 3000 cm³

Part D — Floating and Sinking

Object	Weight	Buoyant Force	Net Force
A	12 N	12 N	0 N
B	20 N	15 N	5 N downward
C	8 N	8 N	0 N

1. Which objects have balanced forces?

Objects A and C.

Their buoyant forces equal their weights, so their resultant forces are zero.

2. Which object experiences a net downward force?

Object B.

Its weight is greater than its buoyant force.

3. Calculate the net force on Object B.

Net force = Weight − Buoyant force

Net force = 20 − 15

Net force = 5 N downward

4. What would happen to Object B if these forces remained unchanged? Explain.

Object B would accelerate downward because the downward gravitational force is greater than the upward buoyant force.

The unbalanced force of 5 N causes downward acceleration.

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Part E — Real-World Applications

1. Why does a person often feel lighter when standing in a swimming pool?

Water exerts an upward buoyant force on the person's body.

This upward force reduces the support force needed to hold the person up, making them feel lighter.

Their actual mass and gravitational weight do not change.

2. Explain how a submarine can control whether it rises or sinks.

Submarines use ballast tanks to control their overall density.

- To sink, water enters the ballast tanks, increasing the submarine's mass and average density.
- To rise, compressed air pushes water out of the tanks, decreasing its mass and average density.
- To remain at a constant depth, the submarine adjusts its ballast until buoyant force balances weight.

3. Why does a large hollow steel ship float while a small solid steel ball sinks?

A ship has a large hollow hull containing air. Its overall average density can be less than that of water.

The hull displaces enough water for the upward buoyant force to balance the ship's weight before the ship becomes fully submerged.

A solid steel ball is denser than water and cannot displace enough water to balance its weight, so it sinks.

4. A wooden block floats in water. If extra weight is placed on top, what happens to the amount of water displaced? Explain.

The block sinks deeper into the water and displaces more water.

The increased weight requires a greater buoyant force to maintain floating equilibrium.

According to Archimedes' Principle, a greater buoyant force requires a greater weight of displaced water.

This continues until the forces balance, provided the block can support the additional weight without becoming fully submerged and sinking.

Part F — Archimedes' Discovery

1. Why is water displacement useful for measuring irregularly shaped objects?

It allows scientists to determine the volume of an object without using complicated geometric calculations.

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When an object is completely submerged, the volume of water displaced equals the volume of the object.

For example, if a rock displaces 150 cm^3 of water, its volume is 150 cm^3.

2. How did Archimedes' Principle improve our understanding of floating and sinking?

Archimedes' Principle provided a scientific explanation for the upward force that fluids exert on submerged objects.

It established that buoyant force depends on the weight of displaced fluid.

This made it possible to explain and predict whether objects float, sink, or remain suspended in a fluid, and helped engineers design ships and other floating structures.

3. Give one modern technology that uses Archimedes' Principle.

Accept any appropriate example, including:

- Ships and boats
- Submarines
- Hydrometers
- Hot-air balloons
- Floating platforms

Exit Ticket

1. State Archimedes' Principle in your own words.

An object partially or completely submerged in a fluid experiences an upward buoyant force equal to the weight of the fluid it displaces.

2. What determines the buoyant force on a submerged object?

The weight of the displaced fluid.

The buoyant force depends on the fluid's density, the volume displaced, and gravitational field strength.

3. Calculate the buoyant force when an object displaces water weighing 25 N.

F_β = 25 N upward

4. Explain why a ship can float.

A ship floats because its hull displaces enough water to create an upward buoyant force equal to its weight.

Its hollow structure allows its overall average density to be less than that of water.

5. Why was Archimedes' discovery important to science?

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It explained the relationship between displaced fluid and buoyant force, helping scientists understand and predict floating and sinking.

It also provided a foundation for technologies such as ships, submarines, and instruments that measure fluid density.

Teaching Notes

A few useful points to reinforce during review:

- Buoyant force is not always equal to an object's weight. It equals the weight of the fluid displaced. The object's weight and buoyant force are equal when it floats at rest without other vertical forces.
- Floating does not mean an object has no weight. Gravity continues to act downward, balanced by the upward buoyant force.
- Displaced volume matters. For the same fluid, a greater submerged volume produces a greater buoyant force.
- Archimedes' Principle applies to gases as well as liquids. This explains the buoyancy of hot-air balloons.
- Water displacement measures volume. The famous crown story is traditionally associated with Archimedes, although its historical details are uncertain.

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