

# Buoyancy & Archimedes' Principle

## KEY IDEAS

**Buoyant force:** the upward push of a fluid on an object in it. **Archimedes' principle:** the buoyant force equals the weight of the fluid the object displaces. On this sheet, **100 mL of water weighs 1 N**.

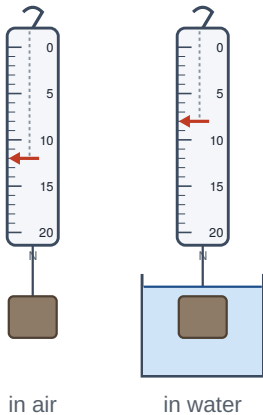
**Apparent weight** (what a spring scale reads underwater) = weight in air – buoyant force. An object **floats** when the buoyant force can equal its weight, and **sinks** when its weight is bigger.

## A Read the spring scales

3 marks (½ + ½ each)

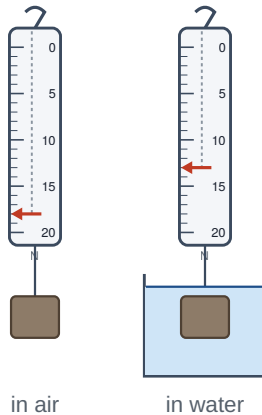
Each object is weighed in air, then fully underwater. Read both scales.

1.



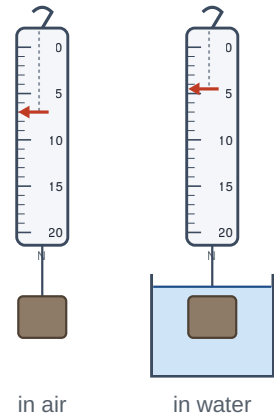
Buoyant force: \_\_\_\_\_  
Water displaced weighs: \_\_\_\_\_

2.



Buoyant force: \_\_\_\_\_  
Water displaced weighs: \_\_\_\_\_

3.



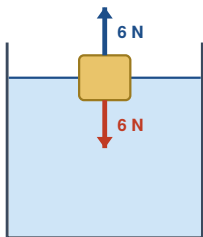
Buoyant force: \_\_\_\_\_  
Water displaced weighs: \_\_\_\_\_

## B Force diagrams

3 marks (½ + ½ each)

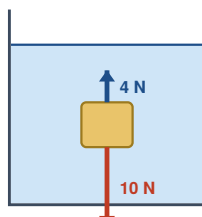
Blue arrow = buoyant force (up). Coral arrow = gravity, the object's weight (down).

4.



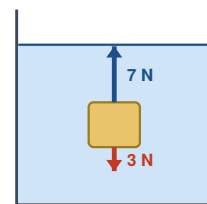
Net force: \_\_\_\_\_  
Floats, sinks or rises? \_\_\_\_\_

5.



Net force: \_\_\_\_\_  
Floats, sinks or rises? \_\_\_\_\_

6.



Net force: \_\_\_\_\_  
Floats, sinks or rises? \_\_\_\_\_

## C Archimedes' principle

8 marks (2 each)

7. A stone is lowered into water and pushes aside 250 mL of water. What is the buoyant force on it?

8. A block weighs 6 N in air. Underwater it displaces 400 mL of water. Find the buoyant force and what a spring scale reads underwater. Does it sink or float?

9. A toy boat weighs 3 N and floats. How much water does it displace?

10. A ball weighs 5 N and has a volume of 600 cm<sup>3</sup>. Will it float? Explain using Archimedes' principle.

**D True or false?**

3 marks (½ each)

|     | Statement                                                   | T / F | If false, correct it |
|-----|-------------------------------------------------------------|-------|----------------------|
| 11. | The buoyant force always pushes upward.                     |       |                      |
| 12. | When an object floats, the buoyant force equals its weight. |       |                      |
| 13. | Buoyant force on a rock depends on the rock's weight.       |       |                      |
| 14. | Salt water pushes up harder than fresh water.               |       |                      |
| 15. | An object sinks if buoyant force is more than its weight.   |       |                      |
| 16. | Objects weigh less in air than in water.                    |       |                      |

**E Buoyancy in real life**

6 marks (2 each)

17. A cargo ship sits lower in the water when it's fully loaded. Explain why.

18. It's easier to float in the ocean than in a freshwater lake. Explain why.

19. A submarine can dive and surface. Explain how filling its tanks with water or air controls this.

**F Investigation: lowering an object into water**

5 marks

An object weighs 5.0 N in air. A student lowers it into water on a spring scale, a little at a time.

| How far under? | Water displaced (mL) | Scale reading (N) | Buoyant force (N) |
|----------------|----------------------|-------------------|-------------------|
| just touching  | 0                    | 5.0               |                   |
| ¼ under        | 100                  | 4.0               |                   |
| ½ under        | 200                  | 3.0               |                   |
| ¾ under        | 300                  | 2.0               |                   |
| fully under    | 400                  | 1.0               |                   |
| deeper         | 400                  | 1.0               |                   |

20. Complete the **buoyant force** column (5.0 N – scale reading). (1 mark)

21. Describe the pattern. How do the results support Archimedes' principle? (2 marks)

22. Predict the reading if the fully submerged object were in salt water instead. Explain. (2 marks)

**G Spot the mistake**

2 marks

23. A student says, "A big rock feels a bigger buoyant force than a pebble, so the big rock will float." Explain the error.

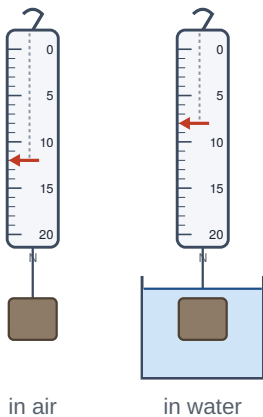
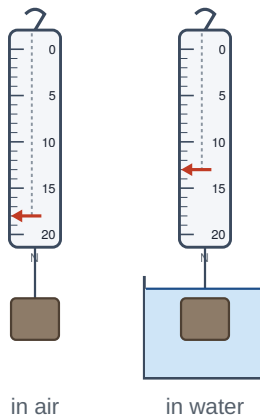
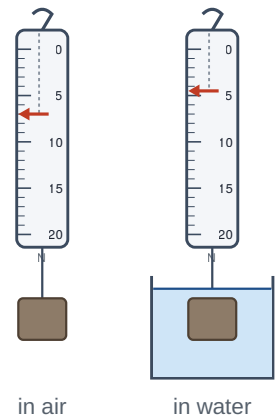
**Buoyancy & Archimedes' Principle****ANSWER KEY****KEY IDEAS**

**Buoyant force:** the upward push of a fluid on an object in it. **Archimedes' principle:** the buoyant force equals the weight of the fluid the object displaces. On this sheet, **100 mL of water weighs 1 N**.

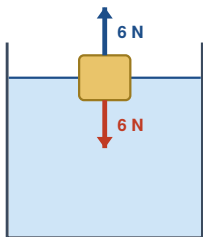
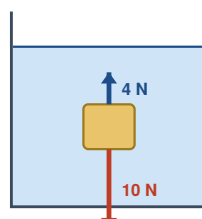
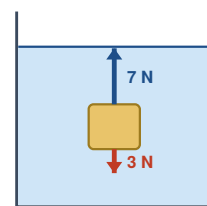
**Apparent weight** (what a spring scale reads underwater) = weight in air – buoyant force. An object **floats** when the buoyant force can equal its weight, and **sinks** when its weight is bigger.

**A Read the spring scales****3 marks (½ + ½ each)**

Each object is weighed in air, then fully underwater. Read both scales.

**1.**Buoyant force:  $12 - 8 = 4 \text{ N}$ Water displaced weighs:  $4 \text{ N}$ **2.**Buoyant force:  $18 - 13 = 5 \text{ N}$ Water displaced weighs:  $5 \text{ N}$ **3.**Buoyant force:  $7 - 4.5 = 2.5 \text{ N}$ Water displaced weighs:  $2.5 \text{ N}$ **B Force diagrams****3 marks (½ + ½ each)**

Blue arrow = buoyant force (up). Coral arrow = gravity, the object's weight (down).

**4.**Net force:  $0 \text{ N}$ Floats, sinks or rises? **floats****5.**Net force:  $6 \text{ N down}$ Floats, sinks or rises? **sinks****6.**Net force:  $4 \text{ N up}$ Floats, sinks or rises? **rises****C Archimedes' principle****8 marks (2 each)**

7. A stone is lowered into water and pushes aside 250 mL of water. What is the buoyant force on it?

250 mL of water weighs 2.5 N, so the buoyant force =  $2.5 \text{ N}$

8. A block weighs 6 N in air. Underwater it displaces 400 mL of water. Find the buoyant force and what a spring scale reads underwater. Does it sink or float?

Buoyant force =  $4 \text{ N}$ . Scale reads  $6 - 4 = 2 \text{ N}$ . It **sinks** ( $6 \text{ N} > 4 \text{ N}$ ).

9. A toy boat weighs 3 N and floats. How much water does it displace?

A floating object displaces its own weight of water: 3 N of water = **300 mL**.

10. A ball weighs 5 N and has a volume of 600 cm<sup>3</sup>. Will it float? Explain using Archimedes' principle.

Fully under, it displaces 600 mL = **6 N** > 5 N, so it **floats** (partly out of the water).

### D True or false?

3 marks (½ each)

|     | Statement                                                   | T / F | If false, correct it                 |
|-----|-------------------------------------------------------------|-------|--------------------------------------|
| 11. | The buoyant force always pushes upward.                     | True  | —                                    |
| 12. | When an object floats, the buoyant force equals its weight. | True  | —                                    |
| 13. | Buoyant force on a rock depends on the rock's weight.       | False | It depends on the water displaced.   |
| 14. | Salt water pushes up harder than fresh water.               | True  | —                                    |
| 15. | An object sinks if buoyant force is more than its weight.   | False | It sinks when its weight is greater. |
| 16. | Objects weigh less in air than in water.                    | False | They seem lighter in water.          |

### E Buoyancy in real life

6 marks (2 each)

17. A cargo ship sits lower in the water when it's fully loaded. Explain why.

More weight means it must displace more water to float, so it sits **deeper**.

18. It's easier to float in the ocean than in a freshwater lake. Explain why.

Salt water is **denser**. The same displaced volume weighs more, so it gives a **bigger buoyant force**.

19. A submarine can dive and surface. Explain how filling its tanks with water or air controls this.

**Water** in tanks: weight > buoyant force, so it sinks. **Air** in tanks: weight < buoyant force, so it rises.

### F Investigation: lowering an object into water

5 marks

An object weighs **5.0 N** in air. A student lowers it into water on a spring scale, a little at a time.

| How far under? | Water displaced (mL) | Scale reading (N) | Buoyant force (N) |
|----------------|----------------------|-------------------|-------------------|
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| fully under    | 400                  | 1.0               | <b>4.0</b>        |
| deeper         | 400                  | 1.0               | <b>4.0</b>        |

20. Complete the **buoyant force** column (5.0 N – scale reading). (1 mark)

21. Describe the pattern. How do the results support Archimedes' principle? (2 marks)

Each 100 mL displaced adds 1 N: buoyant force = **weight of water displaced**. Deeper doesn't change it.

22. Predict the reading if the fully submerged object were in salt water instead. Explain. (2 marks)

**Less than 1.0 N**. Salt water is denser, so the displaced water weighs more and the buoyant force is bigger.

### G Spot the mistake

2 marks

23. A student says, "A big rock feels a bigger buoyant force than a pebble, so the big rock will float." Explain the error.

Its **weight** is bigger too. Rock is denser than water, so its weight always beats the buoyant force.