

ICSE Class 9 —

Upthrust, Archimedes Principle & Floatation

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1. Thrust

- Thrust is the force acting perpendicularly on a surface.
- It is a vector quantity, measured in Newton (N).
- Example: When you push down on a table, you exert thrust on the table.

2. Pressure

- Pressure is the thrust acting per unit area.
- Formula: Pressure = Thrust / Area ($P = F/A$)
- SI unit: Pascal (Pa) or N/m^2 .
- Greater the area, lesser the pressure for same thrust.

3. Upthrust (Buoyant Force)

- When an object is immersed in a liquid, the liquid exerts an upward force on the object.
- This upward force is called Upthrust or Buoyant Force.
- It is the reason why objects feel lighter when placed in water.

4. Archimedes Principle

- It states: When a body is immersed partially or fully in a liquid, it experiences an upthrust equal to the weight of the liquid displaced by the body.
- Mathematically: Upthrust = Weight of displaced liquid = $\rho \times V \times g$
where ρ = density of liquid, V = volume of displaced liquid, g = acceleration due to gravity.

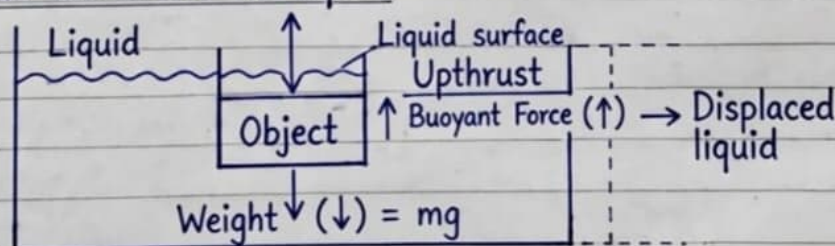
5. Factors affecting Upthrust

1. Density of the liquid — More the density, more the upthrust.
2. Volume of the object immersed (or volume of liquid displaced)
3. Acceleration due to gravity (g) — Larger volume $\rightarrow$ more upthrust
Upthrust is directly proportional to g .

6. Floatation

- An object floats if its weight is equal to the upthrust (buoyant force).
- If weight $>$ upthrust $\rightarrow$ object sinks.
- If weight $<$ upthrust $\rightarrow$ object rises/ floats.

Diagram: Object immersed in liquid



- Net force = Weight - Upthrust

1. Archimedes' Principle — Statement

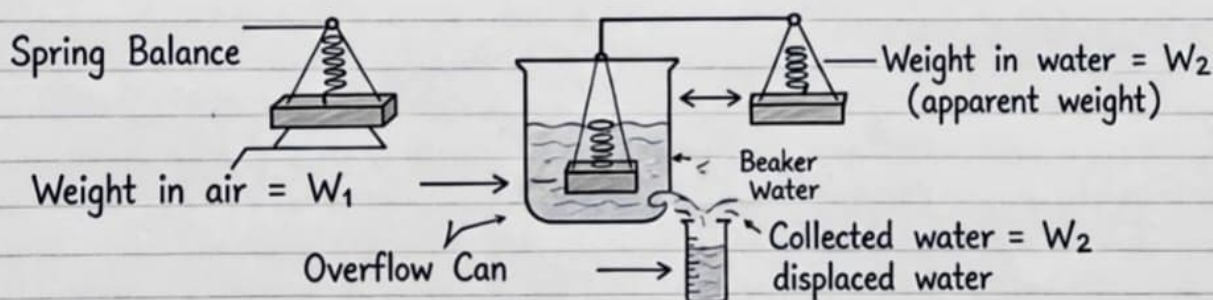
- When a body is immersed fully or partially in a fluid, it experiences an upward force called the upthrust (or buoyant force).
- This upthrust is equal to the weight of the fluid displaced by the body.
- It acts vertically upwards, opposite to the weight of the body.

2. Proof (Explanation)

- Consider a solid body of height h , cross-section area A , immersed in a liquid of density ρ .
- Pressure at top face = $P_1 = h_1 \rho g$
- Pressure at bottom face = $P_2 = h_2 \rho g$
- Force upward on bottom face = $P_2 \times A = h_2 \rho g A$
- Force downward on top face = $P_1 \times A = h_1 \rho g A$
- Net upward force (Upthrust) = $(P_2 - P_1) \times A = (h_2 - h_1) \rho g A$
- But $(h_2 - h_1) =$ height of body = h , and $A \times h =$ volume of body
 $=$ volume of liquid displaced.

$\therefore$ Upthrust = $\rho g \times$ (volume of liquid displaced) = weight of liquid displaced.

3. Experimental Verification — Diagram



Observation :

- The spring balance shows a lower reading when the body is in water.
- The water collected in measuring cylinder equals the volume of the immersed part of the body.

4. Formula

$$\text{Loss in weight} = \boxed{\text{Weight of liquid displaced}}$$

i.e. $\text{Loss in weight} = W_1 - W_2 = \rho \times V \times g$

Where:

W_1 = true weight in air

W_2 = apparent weight in water

ρ = density of liquid

V = volume of liquid displaced

g = acceleration due to gravity = 9.8 m/s^2

* This principle is used to explain why objects float or sink.

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Floatation

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- Floatation is the condition when a body floats on the surface of a liquid.
- A body floats when the upward force (upthrust) is equal to the downward force (weight of the body).

Law of Floatation

- The law states: For a floating body, the weight of the body is equal to the weight of the liquid displaced by the immersed part of the body.
- i.e. Weight of floating body = Upthrust = Weight of displaced liquid.

Relative Density

- Relative Density (R.D.) = $\frac{\text{Density of substance}}{\text{Density of water at } 4^{\circ}\text{C}}$
- It is a ratio, hence has no unit.
- If R.D. > 1 $\rightarrow$ substance sinks in water. If R.D. < 1 $\rightarrow$ substance floats in water.

Applications of Archimedes Principle

- Ships: Ships are designed with hollow hull so that the overall density becomes less than water. They displace a large volume of water, producing enough upthrust to balance their weight and hence they float.
- Submarines: Submarines have ballast tanks which can be filled with water to increase weight $\rightarrow$ submerges. Water is replaced by compressed air to decrease weight $\rightarrow$ rises and floats.
- Lactometer: An instrument used to measure the purity of milk. It works on Archimedes' principle. The less the density of milk, the more the lactometer sinks. The scale on it gives the relative density/purity.

Comparison Table : Sinking vs Floating

	Aspect	Sinking Body	Floating Body
Weight vs Upthrust	Weight > Upthrust	Weight > Upthrust	Weight = Upthrust
Relative Density	R.D. > 1	R.D. < 1	
Position in liquid	Settles at the bottom		Remains partly/fully on surface
Example	Stone, Iron nail	Wood, Iceberg, Ship	

* Note: The floating body displaces liquid equal to its own weight.