



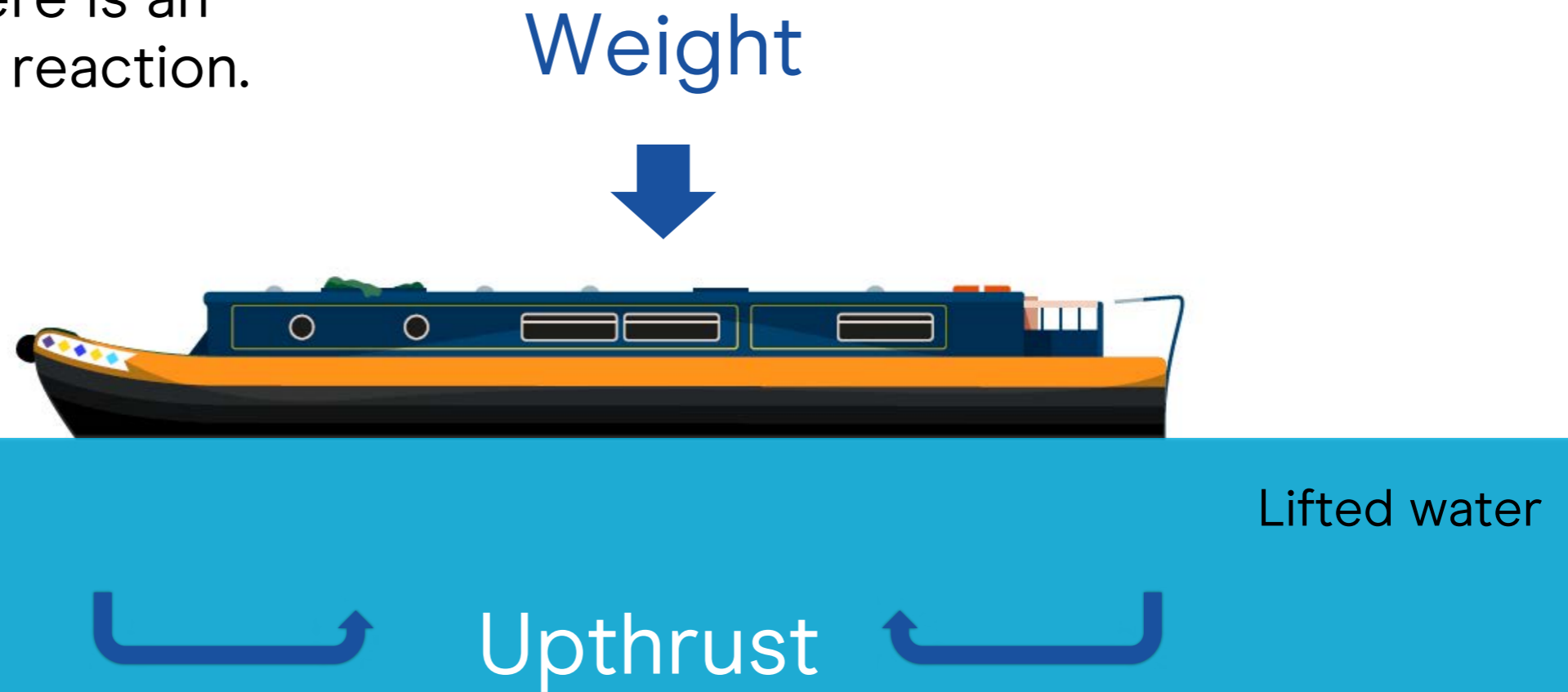
Objectives

- Describe and understand **upthrust**.
- Apply the concept of upthrust to **measuring mass**.
- Understand how **gauging rods** were used.



Upthrust

For every action there is an equal and opposite reaction.



Activity – Sink or float?

Object	Sink	Float
Brick		
Tile		
Half filled bottle of water		
Wood		
Sponge		
Golf ball		

Canal boats

The canal system grew rapidly in the 18th Century because of demand for coal to fuel factories.

Canals were a great way of transporting heavy goods including coal, pottery, clay, grain, limestone, and iron ore.



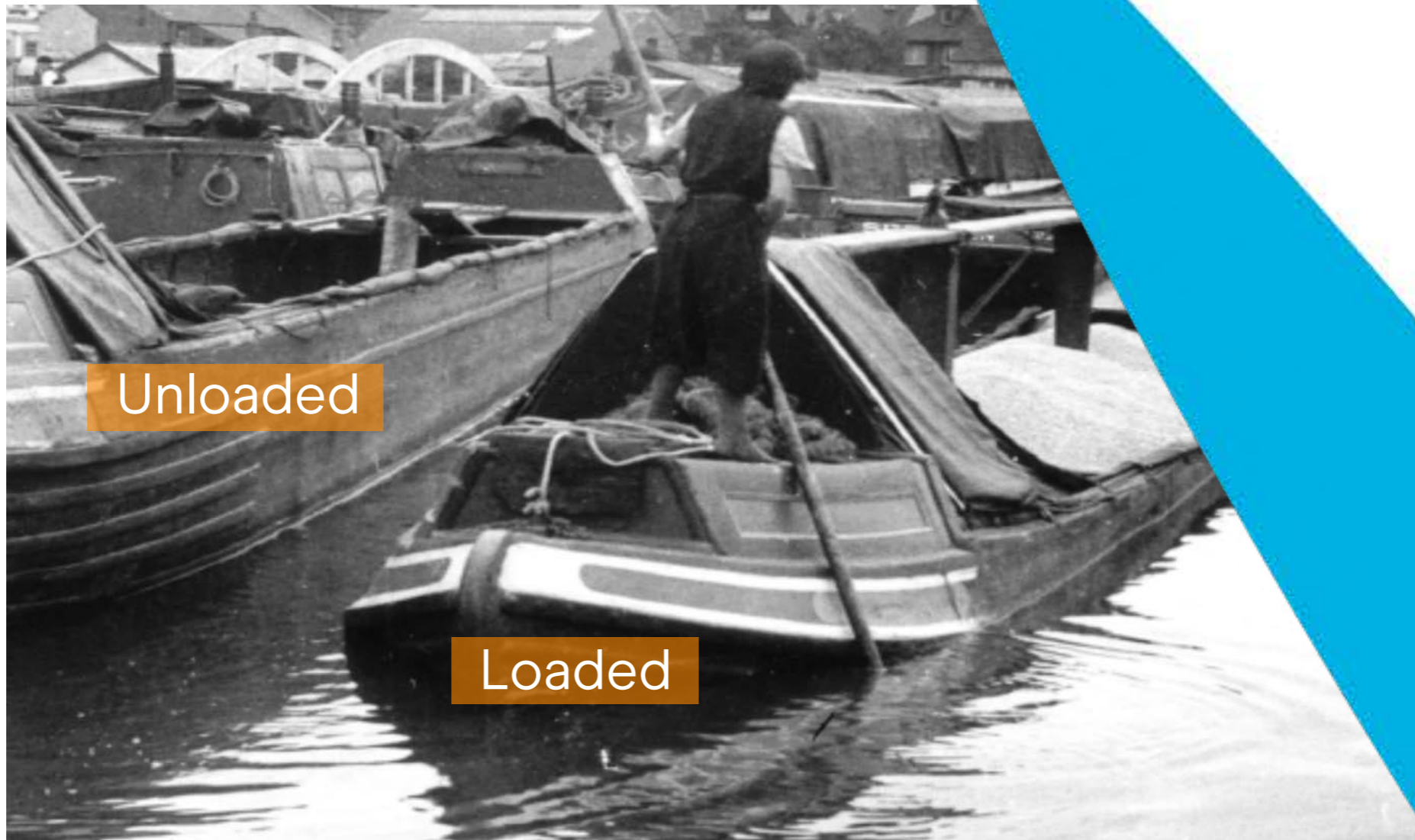
Toll charges

Boat owners paid to use the canals and were **charged by weight** of goods their boat carried.

How did they know
the weight of goods
on the boat?

Canal boats

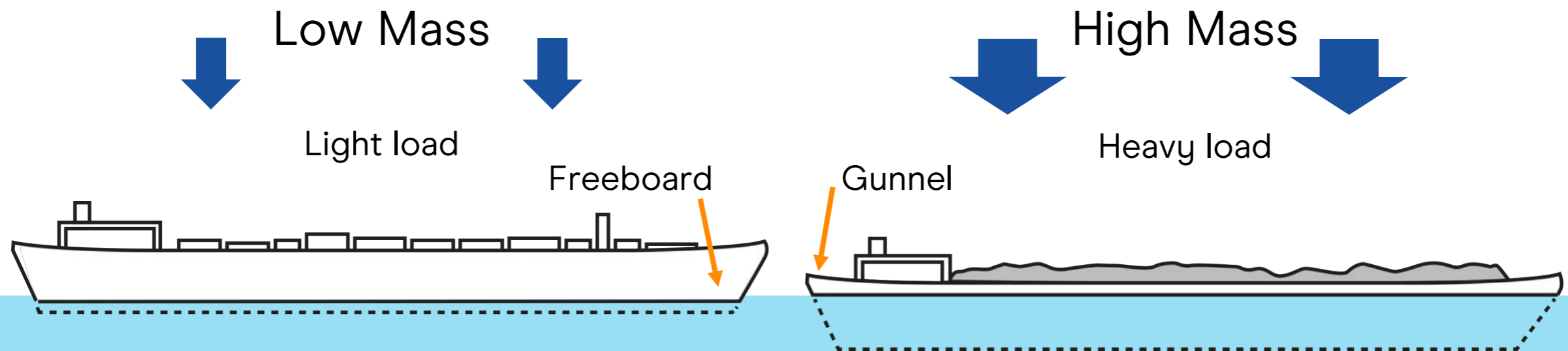
Look at the difference between loaded and unloaded boats.



Unloaded

Loaded

What happens when a boat is loaded?



- The **mass** in the boat acts as a **downward force** on the boat.
- **Pressure in Fluids** acts as the **upward force** – **Upthrust** - and keeps the boat floating.
- The **freeboard** is the **visible space** between the **water level** and the **gunnel** – there is not much freeboard on a heavily loaded boat as it sits **lower** in the water.

Gauging a canal boat

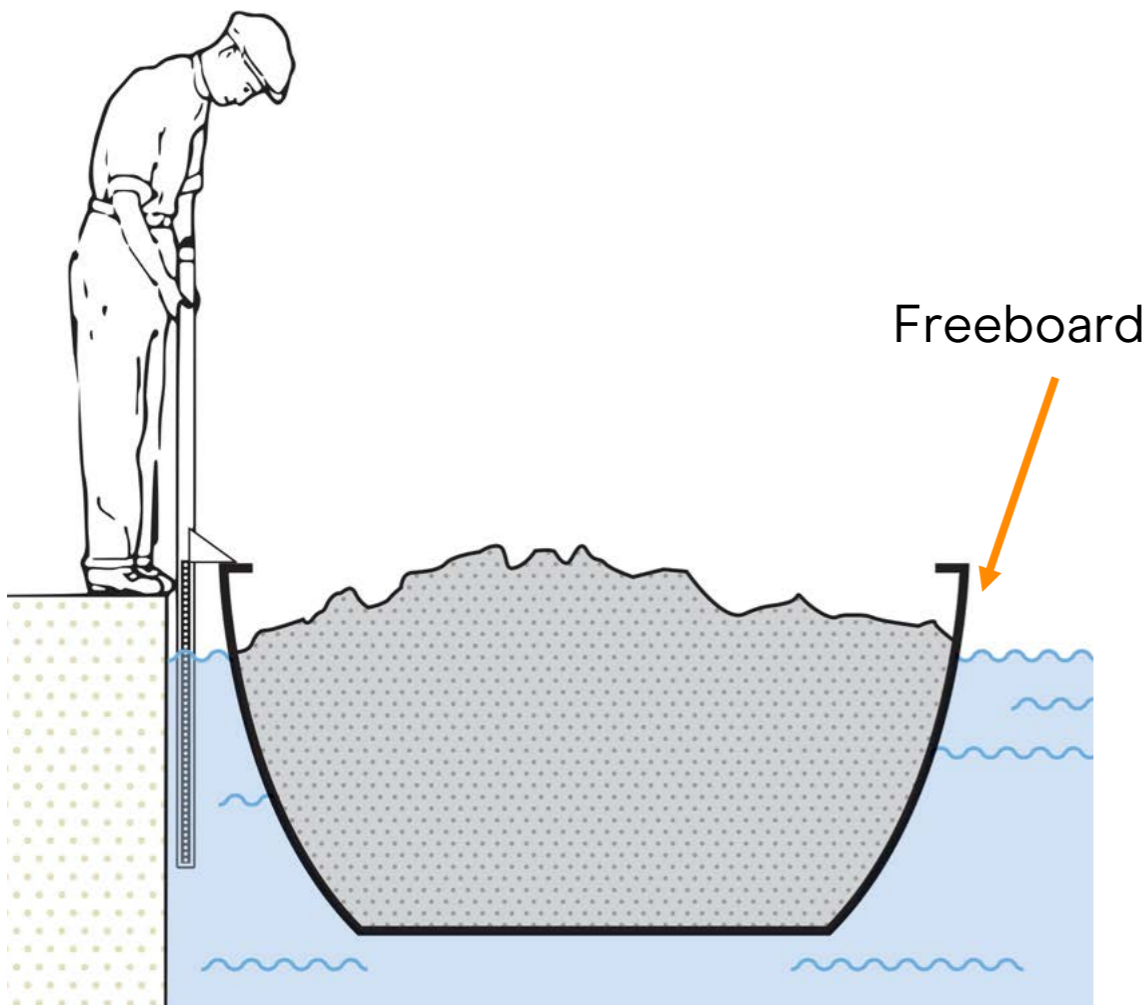
New boats were weighed and given gauging plates at special docks.



- **Measurements** for every kind of boat were recorded in large books kept at **toll houses**.
- The toll clerk would **compare** the **standard measurements** with the **readings** they had just taken and **calculate** the **toll** that should be charged.
- If there was **less freeboard**, there must be **more mass** (a heavier load) and the boater would pay a higher toll.

Gauging Rod

Toll charges



A gauging rod was a stick with measurements marked on it, used to measure the freeboard – space between the water level and the gunwale of the boat.

Canal toll

This picture shows a toll clerk using a gauging rod to measure the freeboard at set points around the canal boat, enabling them to calculate the toll to be paid.



Experiment 1: Measure of volume

1. Fill the tank to 10cm and place the boat into the water. Place your hand on the boat and press down to feel the upthrust.
2. Measure the height of the gunnel above the water at each corner. Calculate the average.
3. Weigh a cargo. Load it into the boat and measure the height of the gunwale above the water at each corner. Calculate the average. Is the lowest corner closest to the cargo, farthest away from the cargo or in between?
4. Repeat Step 3 for each cargo, record your results.



Findings: Upthrust

What did
you find
out?

RESULTS!

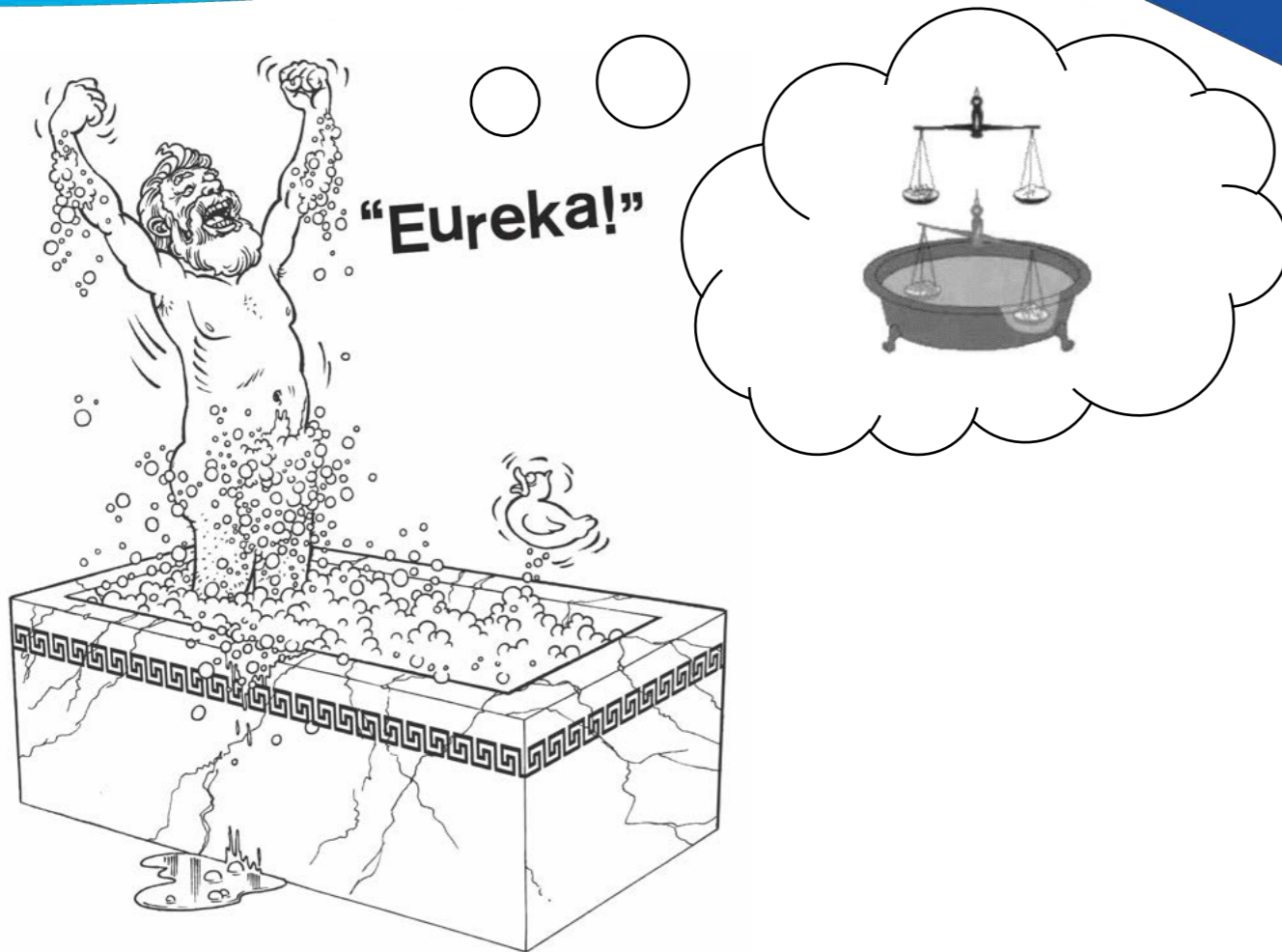
Findings: Upthrust

- Upthrust is the reaction of water to the **action of being lifted** by an object.
- Upthrust is **equivalent to the weight of the water lifted**.
- A floating object represents two forces in **equilibrium**.
- Since the area of the base of the boat is the same as the area of the water in contact with it, **the average water pressure is equal to the average pressure exerted by the boat**.
- **Archimedes used upthrust to measure volume by measuring weight of water displaced**.
- **Upthrust can be used to measure mass by measuring water displaced**.



Extension activity

Archimedes



Research the story of the Archimedes Principle and discuss what this demonstrates.