

# Mass, weight and density

Typed version of the handwritten O Level Physics class notes. The original handwritten pages are on the same page of [megalecture.com](https://megalecture.com).

## Mass and weight

| Mass                                         | Weight                                               |
|----------------------------------------------|------------------------------------------------------|
| The amount of substance packed in an object  | The gravitational pull of the Earth on an object     |
| The mass of an object can never be zero      | The weight of an object can be zero (in outer space) |
| Directionless (scalar)                       | Acts downwards (vector)                              |
| Measured in kg                               | Measured in N (newtons)                              |
| Constant                                     | Measured using a newton meter                        |
| Measured using an electronic or beam balance | Depends on the gravitational pull                    |
| $m = \rho V$ , $m = F/a$ , $m = W/g$         | $W = mg$                                             |

For an object falling freely towards the Earth: force = weight, so  $ma = mg$  and  **$a = g$** .

- $g$  = gravitational field strength, in  $\text{m/s}^2$  or  $\text{N/kg}$ .
- $a$  = acceleration due to gravity,  $10 \text{ m/s}^2$ .

## Density

- The mass packed per unit volume; the ratio of the mass packed and the volume occupied.
- Density = mass / volume:  **$\rho = m / V$** , in  $\text{kg/m}^3$  or  $\text{g/cm}^3$ .
- It is a scalar quantity.
- It is the compactness of matter and is not related to heaviness or weight.
- If the mass is the same, then  $\rho \propto 1/V$  (a curve falling as  $V$  increases): larger volume means lower density, smaller volume means higher density.
- If the volume is the same, then  $\rho \propto m$  (a straight line through the origin).

Newtons =  $\text{kg m/s}^2$ .

### Heating and density

When an object is heated → its molecules gain energy (kinetic energy) → these molecules start to move faster → they make more forceful and frequent collisions → they push each other apart → the intermolecular spaces increase → the volume increases but the mass stays the same → hence, **density decreases on heating**.

- This is thermal expansion.



- Molecules never break; the space between them increases.
- Less dense things always float and more dense things sink.
- The density of a pure material at a given temperature is always the same.
- For  $\rho = m/V$ , an electronic mass balance is easier to read.

## To determine the density of a liquid

- Apparatus: beam balance, burette, beaker and stand.
- Find the mass of an empty beaker with a beam balance ( $m_1$ ).
- Shift a known volume of the liquid from the burette to the beaker.
- Find the mass of the beaker and the liquid with the beam balance ( $m_2$ ).
- Mass of liquid =  $m_2 - m_1$ ; density = mass / volume.

## To determine the density of a regular object

- Apparatus: beam balance, ruler, regular-shaped object.
- Determine the mass of the object with a beam balance.
- Measure the length, breadth and height using the metre rule.

## To determine the density of an irregular object

- Find the mass of the irregular object using a beam balance.
- Fill a measuring cylinder with water up to a volume  $V_1$ .
- Completely immerse the object in the water. Find the new volume.

Precautions:

- Avoid parallax error.
- Place the measuring cylinder on a flat surface.
- Read the volume from the bottom of the meniscus.
- Measure the mass before the volume.
- If the object floats in water, tie a sinker to the object and subtract the sinker's volume.
- If the object is too big to be lowered into the measuring cylinder, use a displacement can: the object is lowered into the full can and the displaced water runs from the spout into a measuring cylinder.

## Definitions

- **Parallax error:** an error in reading an instrument due to the eye of the observer and the pointer not being in a line perpendicular to the plane of the scale.
- **Meniscus:** the curved surface at the top of a column of a liquid.
- **Gravitational field:** a region in which a mass experiences a force due to gravitational attraction.
- **Gravitational field strength:** the gravitational force acting per unit mass, 10 N/kg (meaning the

force of gravity acting on an object of mass 1 kg is about 10 N on the Earth's surface).

- **Inertia:** the ability of a body to resist when its state of rest or uniform motion tends to be changed. It depends on the mass of the body: massive bodies have more resistance when their state of rest or motion is changed, i.e. they have higher inertia than lighter bodies.

### Checked by Mega Lecture

This typed version follows the handwritten notes. One correction: the mass of the liquid is written as  $m_2 - m_1$  (beaker with liquid minus empty beaker); the notes have the labels the other way round. The displacement-can diagram is described in words. Spelling corrected. Spotted a mistake? Tell us on WhatsApp: +92 336 780 1123.