**Friday 9th February 2024**

**Period 4**: 10Y2 Physics

**Title**: Density

Complete on paper or in your books – you will need to hand in this work after half term.

1. Using the text book pages 76 & 7 (copy on next page) Write out what **Density** means.

2. Write out the formula for Density.

3. Make notes on measuring the density of solids and liquids.

4. Answer summary questions 1-4.

5. Write out the key points in the bottom right of page 77.

6. Login to SENECA (remember to login using google) and complete the assignment named - Mr Middleton 09/02/24 Period 5 10Y2 Density

https://app.senecalearning.com/dashboard/class/l3urmkh93r/assignments/assignment/32285d2f-d1fc-4a67-9f3f-c45c10490dcf

# 6.1 Density

## Learning objectives

After this topic, you should know:

- how density is defined and its units of measurement
- how to measure the density of a solid object or a liquid
- how to use the density equation to calculate the mass or the volume of an object or a sample
- how to tell from its density if an object will float in water.



**Figure 1** *Materials of different densities*

### Synoptic link

The density of pure water is 1000 kg/m³. Objects that float in water have a density less than 1000 kg/m³. You will learn more about this in Topic P11.4.

### Rearranging equations

Rearranging the density equation $\rho = \frac{m}{V}$ gives:

$$m = \rho V \qquad \text{or} \qquad V = \frac{m}{\rho}$$



volume of cuboid = $a \times b \times c$

**Figure 2** *The volume of a cuboid*

## Density comparisons

Any builder knows that a concrete post is much heavier than a wooden post of the same size. This is because the **density** of concrete is much greater than the density of wood. A volume of one cubic metre of wood has a mass of about 800 kg. But a cubic metre of concrete has a mass of about 2400 kg. So the density of concrete is about three times the density of wood.

**The density of a substance is defined as its mass per unit volume.**

You can use the equation below to calculate the density $\rho$ of a substance if you know the mass m and the volume V of a sample of it.

$$\text{density, } \rho = \frac{\text{mass, m (kilograms, kg)}}{\text{volume, V (metres}^3, m^3)}$$

(kilogram per cubic metre, kg/m³)

### Converting units and using standard form

$1 \text{ kg} = 1000 \text{ g} = 10^3 \text{ g}$

$1 \text{ m} = 100 \text{ cm} = 10^2 \text{ cm}$

$1 \text{ m}^3 = 1\,000\,000 \text{ cm}^3 = 10^6 \text{ cm}^3$

So $1000 \text{ kg/m}^3 = 1\,000\,000 \text{ g}/1\,000\,000 \text{ cm}^3 = 1 \text{ g/cm}^3$

Standard form is useful when you are working with very large numbers, particularly when you need to convert values to SI units (e.g., converting MJ to J) for a calculation. In standard form, a number is written as $A \times 10^n$, where n is the number of places you have had to move the decimal point to the left (or right for a negative power of ten) to get the decimal number A, which is greater than 1 and less than 10.

### Worked example

A wooden post has a volume of 0.025 m³ and a mass of 20 kg. Calculate its density in kg/m³.

**Solution**

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{20 \text{ kg}}{0.025 \text{ m}^3} = 800 \text{ kg/m}^3$$

### Measuring the density of a solid object

To measure the mass of the object, use an electronic balance. Make sure the balance reads zero before you place the object on it.

To find the volume of a regular solid, such as a cube or a cuboid, measure its dimensions using a millimetre ruler, vernier callipers, or a micrometer – whichever is the most appropriate. Use the measurements and the equation shown in Figure 2 to calculate its volume.
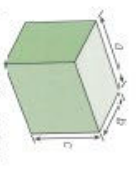
For a small irregular solid, lower it on a thread into a measuring cylinder partly filled with water. You can work out the volume of the object by the rise in the water level.

### Measuring the density of a liquid

Use a measuring cylinder to measure the volume of a particular amount of the liquid.

Measure the mass of an empty beaker using a balance. Remove the beaker from the balance and pour the liquid into the measuring cylinder into the beaker. Use the balance again to measure the total mass of the beaker and the liquid. You can calculate the mass of the liquid by subtracting the mass of the empty beaker from the total mass of the beaker and the liquid.



**Figure 3** *Using a measuring cylinder*

### Worked example

A measuring cylinder contained a volume of 120 cm³ of a particular liquid. The liquid was then poured into an empty beaker of mass 51 g. The total mass of the beaker and the liquid was then found to be 145 g.

a Calculate the mass of the liquid in grams.

b Calculate the density of the liquid in kg/m³.

**Solution**

a Mass of liquid = 145 − 51 = 94 g.

b $\text{density} = \dfrac{\text{mass}}{\text{volume}} = \dfrac{94 \text{ g}}{120 \text{ cm}^3} = \dfrac{0.094 \text{ kg}}{0.000120 \text{ m}^3} = 780 \text{ kg/m}^3$

1 A rectangular concrete slab is 0.80 m long, 0.60 m wide, and 0.05 m thick.

a Calculate its volume in m³. [1 mark]

b The mass of the concrete slab is 60 kg. Calculate its density in kg/m³. [2 marks]

2 A measuring cylinder contains 80 cm³ of a particular liquid. The liquid is poured into an empty beaker of mass 48 g. The total mass of the beaker and the liquid was found to be 136 g.

a Calculate the mass of the liquid in grams. [2 marks]

b Calculate the density of the liquid in g/cm³. [2 marks]

3 A rectangular block of gold is 0.10 m in length, 0.08 m in width, and 0.05 m in thickness.

a i Calculate the volume of the block. [1 mark]

ii The mass of the block is 7.6 kg. Calculate the density of gold. [2 marks]

b A thin gold sheet has a length of 0.15 m and a width of 0.12 m. The mass of the sheet is 0.0015 kg. Use these measurements and the result of your density calculation in part a ii to calculate the thickness of the sheet. [3 marks]

4 Describe how you would measure the density of a metal bolt. You may assume the bolt will fit into a measuring cylinder of capacity 100 cm³. [4 marks]
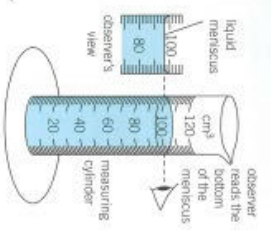
### Study tip

The instrument you choose to use to take a measurement is important – you should consider the resolution and range.

### Density tests

For each of the tests, measure the mass and the volume of the object as explained. Then use the equation $\text{density} = \dfrac{\text{mass}}{\text{volume}}$ to calculate the density of the object.

**Safety:** Take care not to spill any liquids and, if you do, let your teacher know.

| Instrument | resolution | range |
| --- | --- | --- |
| metre rule | ±0.5 mm | 1 m |
| mm scale | ±0.5 mm | 1 m |
| vernier callipers | ±0.05 mm | about 100 mm |
| micrometer | ±0.005 mm | about 30 mm |

### Key points

- density = $\dfrac{\text{mass}}{\text{volume}}$ (in kg/m³)
- To measure the density of a solid object or a liquid, measure its mass and its volume, then use the density equation $\rho = \dfrac{m}{V}$.
- Rearranging the density equation gives $m = \rho V$ or $V = \dfrac{m}{\rho}$
- Objects that have a lower density than water (i.e. < 1000 kg/m³) float in water.