# Physics PAG P1: Materials

### Combined Science PAG P1: Materials

# Suggested Activity 1: Determining density

## Instructions and answers for teachers & technicians

These instructions cover the learner activity section which can be found on [page 7](#_Student_Activity). This Practical activity supports OCR GCSE Physics.

**When distributing the activity section to the learners either as a printed copy or as a Word file you will need to remove the teacher instructions section.**

|  |
| --- |
| This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.  These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.  You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, [Royal Society of Biology](https://www.rsb.org.uk/education/teaching-resources/secondary-schools), [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry), [Institute of Physics](http://www.iop.org/education/teacher/resources/index.html), [CLEAPSS](http://science.cleapss.org.uk/) and [publishing companies](https://global.oup.com/education/content/secondary/key-issues/gcse_science_2016/?region=uk), or of your own devising.  Further details are available in the [specifications](http://www.ocr.org.uk/science) (Practical Skills Topics), and in these [videos](https://www.youtube.com/playlist?list=PLBD9B84FF4BD54AA4). |

**OCR recommendations:**

**Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.**

**CLEAPSS resources are useful for carrying out risk-assessments: (**<http://science.cleapss.org.uk>**).**

**Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.**

### Introduction

In this experiment learners will be determining the density of a variety of objects both solid and liquid.

### DfE Apparatus and Techniques covered

**1a***[1]***:** Use of appropriate apparatus to make and record a range of measurements accurately, including: **i**[*i*]) length; **iii**[*iii*]) mass; **v** *[viii]*) volume

**1b** *[13]*: Use of such measurements to determine: i) densities of solid objects; ii) densities of liquid objects

### Aims

To use appropriate apparatus to take measurements of length, volume and mass.

To calculate densities using measurements taken.

### Intended class time

50-60 minutes

### Links to Specifications:

### Gateway Science (Suite A) including Working Scientifically (WS)

P1.1d define density

P1.1f apply the relationship between density, mass and volume to changes where mass is conserved

WS1.2e Evaluate methods and suggest possible improvements and further investigations

WS1.4a Use scientific vocabulary, terminology and definitions

WS1.4b Recognise the importance of scientific quantities and understand how they are determined

WS1.4c Use SI units and IUPAC chemical nomenclature unless inappropriate

WS1.4e Interconvert units

WS1.4f Use an appropriate number of significant figures in calculations

WS2a Carry out experiments

WS2b Make and record observations and measurements using a range of apparatus and methods

### Twenty First Century Science (Suite B) including Ideas about Science (IaS)

P6.1.1a define density

P6.1.1b describe how to determine the densities of solid and liquid objects using measurements of length, mass and volume

P6.1.2 recall and apply the relationship between density, mass and volume to changes where mass is conserved: density (kg/m3) = mass (kg) ÷ volume (m3)

IaS1.3 Recognise the importance of scientific quantities and understand how they are determined

IaS2.2 When processing data use SI units where appropriate (e.g. kg, g, mg, km, m, mm, kJ, J)

IaS2.5 When processing data interconvert units

IaS2.6 When processing data use an appropriate number of significant figures

IaS2.10 Evaluate an experimental strategy, suggest improvements and explain why they would increase the quality (accuracy, precision, repeatability and reproducibility) of the data collected, and suggest further investigations

### Mathematical Skills covered

M1a Recognise and use expressions in decimal form

M1b Recognise and use expressions in standard form

M3b Change the subject of an equation

M3c Substitute numerical values into algebraic equations using appropriate units for physical quantities

M3d Solve simple algebraic equations

M5c Calculate areas of triangles and rectangles, surface areas and volumes of cubes

### Health and Safety

This is a very safe experiment when performed sensibly; metal blocks may be heavy so care must be taken to not drop them.

It is safe to touch solid lead with bare hands, but you should wash your hands after touching lead.

### Method 1: Finding the density regular shaped solids

Learners will use a ruler to measure the height, width and depth of the different material blocks, and use these measurements to calculate the volumes. They use the mass scales to record the mass in kg, and then they calculate the densities.

### Method 2: Finding the density of irregular shaped solids

Learners will use Eureka beakers to find the volume of irregular shaped plasticine. They will use mass scales to record the mass of the plasticine, and then they calculate the density.

### Method 3: Finding the densities of liquids

Learners will use mass scales and measuring cylinders to find the mass and volume of liquids and use these measurements to calculate the densities.

### Notes

Learners should be able to give reasons why their results for densities would differ from the actual densities. Encourage learners to consider where the inaccuracies in their measurements may be. This is a good opportunity to look at the resolution of the measuring equipment they are using.

### Technicians Notes

For this practical the teacher will require for a class of 30:

* 15 x cuboid blocks of wood (these can be varying sizes)
* 15 x cuboid blocks of lead (these can be varying sizes) NB this can be replaced by a different metal if needed
* 15 x cuboid blocks of plastic
* Plasticine (enough to make 15 small irregular shapes)
* 5 x mass scales
* 15 x Eureka beakers (if eureka beakers aren’t available these can be substituted for measuring cylinders)
* 30 cm rulers with mm divisions
* 15 x measuring cylinders (any size can be used but too big will lead to unnecessary spillage)
* Access to a tap
* Vegetable oil (a 1 litre bottle will be more than enough for a class)

### Answers for quiz questions

**1ai [3 marks]**

| **Material** | **Height (m)** | **Width (m)** | **Depth (m)** | **Volume (m3)** | **Mass (kg)** |
| --- | --- | --- | --- | --- | --- |
| Glass | 0.04 | 0.04 | 0.04 | 6.4x10-5 | **0.192 ✓** |
| Lead | 0.02 | 0.02 | 0.02 | 8.0x10-6 | 0.09 |
| Wood | **0.05 ✓** | 0.01 | 0.01 | **5.0x10-6 ✓** | 1.85x10-3 |

**1aii [5 marks]**

density = mass ÷ volume **✓**

apply equation to each material **✓**

Glass 3000 kg/m3 **✓**

Lead 11 250 kg/m3 **✓**

Wood 370 kg/m3 **✓**

**1bi [1 mark]**

**C** **✓**

**1bii [3 marks]**

**Either**

Place irregular shaped object in Eureka beaker full of water with a spout ✓ collect displaced water in the measuring cylinder ✓ the volume of water collected will be the volume of the object ✓

**Or**

Part fill the measuring cylinder with water and record the volume ✓ add the irregular shaped object and record the new value of the volume of water ✓ the difference between these two values is the volume of the object ✓

### Document updates

v1 Published on the qualification pages

v1.1 January 2017 Consolidated labelling of activities

v1.2 February 2017 Correction to Combined Science labelling

v1.3 June 2021 Updated to meet accessibility standards

v1.4 March 2023 Update to wording and equations

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# Physics PAG P1: Materials

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# Suggested Activity 1: Determining density

## Learner Activity

### Introduction

In this experiment you will be determining the density of a variety of objects both solid and liquid.

### Aims

To use appropriate apparatus to take measurements of length, volume and mass.

To calculate densities using measurements taken.

### Intended class time

50-60 minutes

### Equipment (per group)

* Cuboid block of wood
* Cuboid block of lead
* Cuboid block of plastic
* Plasticine
* Mass scales
* Eureka beaker
* Ruler
* Measuring cylinder
* Vegetable oil

### Health and Safety

This is a very safe experiment when performed sensibly; metal blocks may be heavy so care must be taken to not drop them.

It is safe to touch solid lead with bare hands, but you should wash your hands after touching lead.

### Method 1: Finding the density regular shaped solids

1.Use the ruler to measure the height (*h*), width (*w*) and depth (*d*) of each block in m. Record the measurements in the table below and calculate the volume in m3, using the equation

volume = height × width × depth

*h*

*d*

*w*

2. Use the mass scales to weigh the blocks one at a time and record the masses in kg in the table below.

3. Use the mass in kg and the volume in m to calculate the densities of the regular solid objects in kg/m3 using the equation:

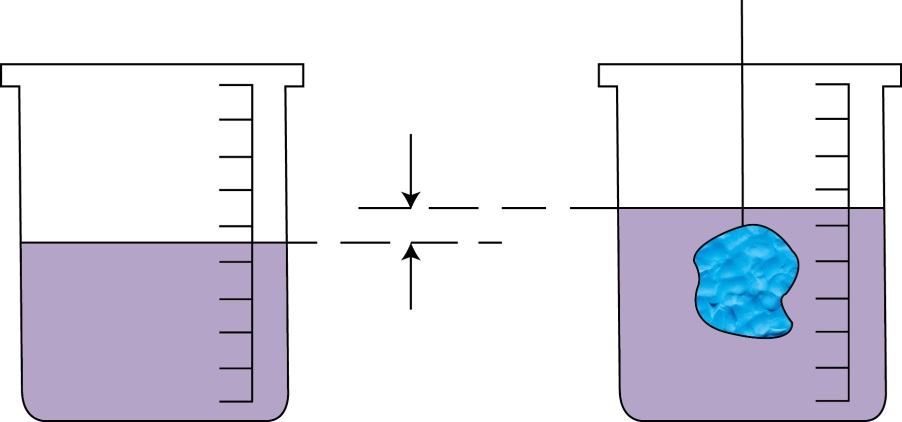
density = mass ÷ volume

### Results

| **Material** | **Wood** | **Lead** | **Plastic** |
| --- | --- | --- | --- |
| Height (m) |  |  |  |
| Width (m) |  |  |  |
| Depth (m) |  |  |  |
| Volume (m3) |  |  |  |
| Mass (kg) |  |  |  |
| Density (kg/m3) |  |  |  |

### Method 2: Finding the density of irregular shaped solids

1. Take some plasticine and make any shape you like with it. Draw your shape in the table below
2. Measure the mass of the shape using the scales and record the mass in kg in the table below
3. Fill the Eureka beaker up with water, record the starting level of water in the table below
4. Add your plasticine shape to the water and record the level of the water



Change in volume (∆V) = volume of object

1. Work out the volume of plasticine by using the calculation:

volume of object = volume of water after object added – volume of water before object added

1. Calculate the density of the plasticine

### Results

| **Plasticine shape** | **Mass (kg)** | **Initial volume of water (m3)** | **Final volume of water (m3)** | **Volume of plasticine (m3)** | **Density of plasticine (kg/m3)** |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |

### Method 3: Finding the densities of liquids

1. Take the empty measuring cylinder and place it on the mass scales. Record the mass in kg in the table below
2. Fill the measuring cylinder with water and record the volume of water added in the table
3. Place the measuring cylinder of water on the mass scales and record the mass in kg in the table
4. Work out the mass of the liquid by using the calculation:

mass of liquid = mass of cylinder and liquid – mass of empty cylinder

1. Calculate the density of the water
2. Repeat the above steps instead using the vegetable oil rather than the water

### Results

| **Liquid** | **Mass of empty cylinder (kg)** | **Mass of cylinder + liquid (kg)** | **Mass of liquid (kg)** | **Volume of liquid (m3)** | **Density of liquid (kg/m3)** |
| --- | --- | --- | --- | --- | --- |
| Water |  |  |  |  |  |
| Oil |  |  |  |  |  |

### Evaluation

| **Material** | **Calculated density (kg/m3)** | **Actual density (kg/m3)** |
| --- | --- | --- |
| Lead |  |  |
| Plastic |  |  |
| Wood |  |  |
| Water |  |  |
| Oil |  |  |

Suggest why there is a difference between the calculated and actual values for the densities.

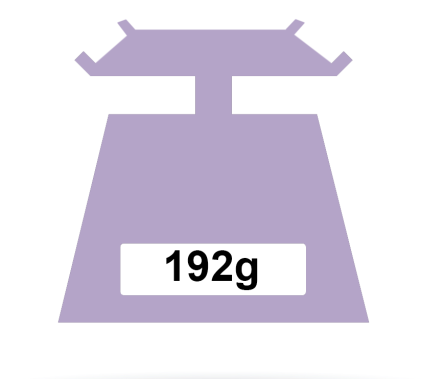
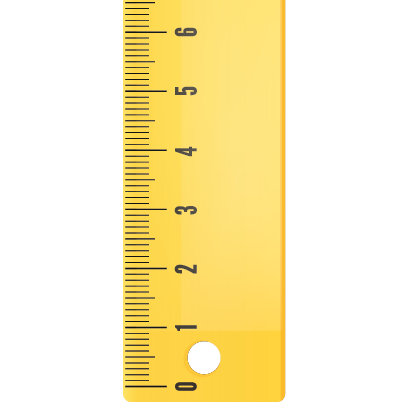
|  |  |  |
| --- | --- | --- |
|  |  |  |

### Quiz - test your knowledge and understanding

1. A student is trying to find the densities of the three different materials below.

Glass Lead Wood

30 cm ruler



|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **(a) (i)** | Complete the table below with the missing values. Use the images above to help. **[3 marks]** | | | | | |  |
| Material | | Height (m) | Width (m) | Depth (m) | Volume (m3) | Mass (kg) | |
| Glass | | 0.04 | 0.04 | 0.04 | 6.4x10-5 |  | |
| Lead | | 0.02 | 0.02 | 0.02 | 8.0x10-6 | 0.09 | |
| Wood | |  | 0.01 | 0.01 |  | 1.85x10-3 | |

|  |  |  |
| --- | --- | --- |
| **(a) (ii)** | Work out the densities of the materials. **[5 marks]** |  |

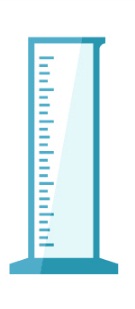
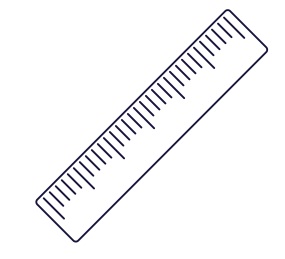
Glass kg/m3

Lead kg/m3

Wood kg/m3

|  |  |  |
| --- | --- | --- |
| **(b) (i)** | Which instrument, A, B C or D could be used to determine the volume of an irregular shaped solid? **[1 mark]** |  |

A B C D



|  |  |  |
| --- | --- | --- |
| **(b) (ii)** | How you would use it to find the volume? **[3 marks]** |  |
|  |  |  |

### DfE Apparatus and Techniques covered

If you are using the OCR Practical Activity Learner Record Sheet ([**Physics**](http://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) you may be able to tick off the following skills:

| **Physics** | | | |  | ***Combined Science*** | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1a-i | 1a-iii | 1a-v | 1b-i |  | *1-i* | *1-iii* | *1-viii* | *13-i* |
| 1b-ii |  |  |  |  | *13-ii* |  |  |  |