Cambridge Assessment International Education

Teaching Pack

Determining the density of solids and liquids

Cambridge IGCSE™

Combined Science 0653

This Teaching Pack can also be used with the following syllabuses:
- Cambridge IGCSE™ (9–1) Physics **0972**
- Cambridge IGCSE™ (9–1) Co-ordinated Sciences (Double Award) **0973**
- Cambridge IGCSE™ Physical Science **0652**
- Cambridge O Level Physics **5054**
- Cambridge O Level Combined Science **5129**

Version 2.0

Cambridge Pathway

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Briefing lesson

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Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities, this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, the pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

↓

Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.

↓

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases, it will also provide the opportunity to practise extended writing skills.

**the timings given here are guides; you may need to adapt the lessons to suit your circumstances.*

In this pack you will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Determining the density of solids and liquids

This Teaching Pack focuses on determining the density of solids and liquids.

The density of an object can be calculated by measuring its mass and volume. Measuring the mass is easy using a top pan balance. Volume measurement for regularly shaped objects is also straightforward. To measure the volume of irregularly shaped solids, the displacement method is used. The volume of liquids can be measured by graduated cylinders or similar containers.

This experiment has links to the following syllabus content (see syllabus for detail):

- P1.4 Density

The experiment covers the following skills, adapted from **AO3: Experimental skills and investigation** (see syllabus for assessment objectives):

- make and record observations, measurements and estimates
- evaluate methods and suggest possible improvements.

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- P1.1 Length and time
- P1.3 Mass and weight

Going forward

The knowledge and skills gained from this experiment can be used throughout the course as learners will develop their understanding of how to measure quantities carefully. Their understanding of density will be also used when they are required to predict whether an object will float.

Briefing lesson: Making accurate measurements

Resources	• Samples of several regular and irregular shaped solids, and various amounts of different liquids (such as water, oil, washing up liquid etc.) • Two utensils, e.g. spoons, of similar shape; one metal and one plastic • Blocks of the same dimensions but different materials • Top pan balances, graduated cylinders, displacement beaker • Worksheet A

Learning objectives	By the end of the lesson: • ***all*** learners should be able to explain that density of an object is calculated by the formula $\text{density} = \frac{\text{mass}}{\text{volume}}$. They should be able to safely and accurately take measurements and be able to suggest possible improvements for their methods • ***most*** learners will be able to evaluate methods and suggest two possible improvements for mass and volume measurements of solids and liquids • ***some*** learners will be able to evaluate methods and suggest several possible improvements for mass and volume measurements of solids and liquids

Timings	Activity
5 min	**Starter/Introduction** Show your learners the two different utensils. Ask them what differences they can identify, apart from what they are made of. Give them one minute to discuss this with their neighbours. Then ask if anyone would like to share their answers with the rest of the classroom. Show them the same size blocks of different materials. It is best if they can pick these up to discover that they have different masses. Some may use the phrase 'one is denser than the other'. Use this as a chance to probe their understanding of 'dense'.
10 min 10 min	**Main lesson** If not already discovered during the starter activity, clearly state that the utensils and blocks all have different masses. Ask how they can tell which one has more mass without using any instruments to measure this. Introduce the top pan balance and how it is used. Two important aspects are using it on a flat surface and making sure that it is zeroed beforehand. You may like to demonstrate the effect of a tilted surface on the measurement. Introduce the collection of regular shaped objects. Ask what they can measure about them. Guide them to the idea of volume. Check if they know how to find the volume of rectangular prisms, cubes, and spheres. Introduce the collection of irregular shaped objects. Ask them if they can come up with a method of measuring their volumes. Give them one or two minutes to either think quietly by themselves or discuss with a partner. Introduce and demonstrate the displacement method, clearly stating that the immersed solids will displace same volume of water as their volume. Remind them about the careful use of glassware. *Continues on the next page …*

Timings	Activity
10 min	You may like to challenge them on how to measure the volume of liquids, which, by their nature, do not have a regular shape. Show them how to use graduated cylinders to measure the volume of liquids. State and demonstrate the importance of putting the graduated cylinder on a flat surface and looking at the height of the liquid with your eyes directly opposite the top of the liquid surface. You may like to let them discover or demonstrate how to find out the volume of an irregular object by using a graduated cylinder. Discuss any possible problems such as overflowing. Guide them to the point that they need to start with enough water so that the object is fully submerged. There might be instances where that is not possible – hence the use of a displacement beaker. Show the displacement beaker and ask them how they can use it to measure the volume of an irregular object which is either too big to fit into a graduated cylinder or it cannot be fully submerged without any overflow.
10 min	Demonstrate the use of the displacement beaker. Either ask them to discuss how it could be used accurately or bring the following points to their attention: • the displacement beaker must be full to the spout • all of the displaced water must be caught by a graduated cylinder or beaker Demonstrate that the two similar utensils have almost the same volume by using the displacement method. State that in addition to having different masses they also have different densities. Introduce the concept of density as 'a measure of how much mass an object contains per unit volume'. Clearly state the difference between expressing the mass of an object and how much mass per unit volume. The latter is named as 'density'. Introduce the mathematical link between the three concepts: $\text{density} = \frac{\text{mass}}{\text{volume}}$ $\text{1 kilogram per cubic meter} = \frac{\text{1 kilogram}}{\text{1 cubic meter}}$ $1\,\frac{\text{kg}}{\text{m}^3} = \frac{1\text{ kg}}{1\text{ m}^3}$
5 min	If time allows, discuss the importance of repeating the measurements as a basis for assessing accuracy and repeatability.
10 min	**Plenary** Use Worksheet A to check learner understanding.

Lab lesson: Option 1 – run the experiment

Resources	• Equipment as outlined in the teacher notes • Worksheets B, C and D

Learning objectives	By the end of the lesson: • ***all*** learners should be able to use the formula density=$\frac{\text{mass}}{\text{volume}}$ to calculate density. They should be able to safely and accurately take measurements and be able to suggest possible improvements for their methods • ***most*** learners will be able to evaluate methods and suggest two possible improvements • ***some*** learners will be able to evaluate methods and suggest several possible improvements.

Activity

5 min

Starter/Introduction

Check your learners' understanding of the following statement.

- Density is a measure of how much mass an object has per unit volume, and is calculated by the formula: density=$\frac{\text{mass}}{\text{volume}}$

10 min

Main lesson

Outline that learners will work in groups They will be calculating the density of the following:

- three regularly shaped solids
- three irregularly shaped solids
- two different liquids

30 min

Provide learners with the method shown on Worksheet B.

Make sure that they have a table into which they can record their results and calculate the densities. Worksheet C has a pre-prepared results table.

Safety

Circulate the classroom at all times during the experiment so that you can make sure that your learners are safely using the equipment and that the data they are collecting is accurate. If any lead blocks are used wash your hands afterwards.

Each group selects the objects and liquids they wish to work with and they should measure their masses, dimensions and volumes. Using this data should allow them to calculate their densities.

If any group finishes early, ask what method they could use if the objects they needed to measure floated.

15 min

Plenary

Hand out Worksheet D. Learners should complete this and submit this at the end of the lesson.

Teacher notes

Watch the teacher walkthrough video and read these notes.

Each group will require:

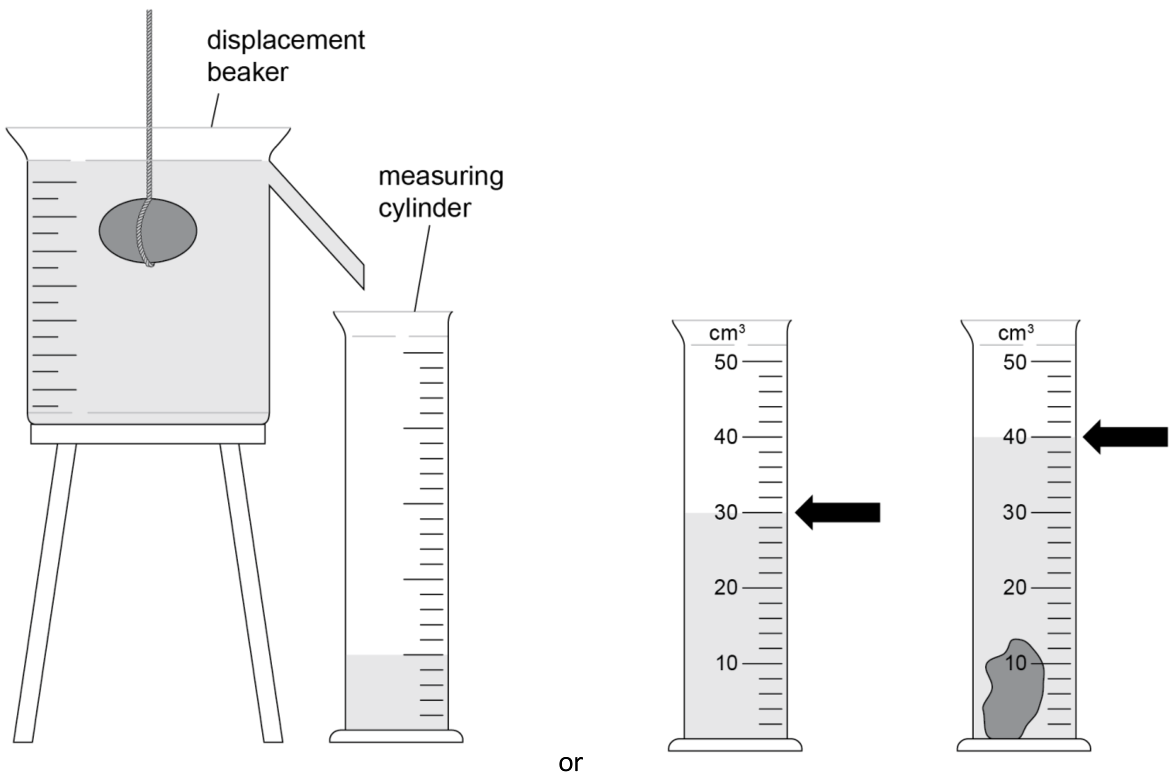
- Displacement beakers, beakers, 30 cm rulers and measuring cylinders.
- Three non-porous regularly shaped objects.
- Three non-porous irregularly shaped objects. Some should fit in the measuring cylinder and some should not (this will force learners to decide whether to use the cylinders or displacement beakers).
- 50 cm^3 of three different liquids, e.g. water, oil, washing up liquid.

Safety

No specific risks have been identified for this experiment.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

Equipment set-up



Teacher method

This is your version of the method. The learner method is on Worksheet B.

Before you begin
Plan how you will group your learners during the experiment.

Think about:
- the number of groups you will need (groups of three learners are generally good)
- depending on the ability of your learners and the materials available to you, you may like to increase the suggested number of solid and liquid samples.

Experiment
Circulate during the experiment in case learners encounter any difficulties. You may like to let them conduct some parts of the experiment weakly or imperfectly, as long as they are fully safe. Any problems they encounter could be used to evaluate the method.

Steps	Notes
1. Learners should collect all the equipment they need from the front of the class.	
2. For the regular shaped objects, learners should use a ruler to measure the dimensions and calculate the volume.	*Remind learners that the dimensions reported should match the resolution of the ruler they are using.*
3. To measure the volume of the irregular shape the learners will have to use the displacement beaker or a graduated cylinder with a known volume of liquid.	*Make sure that the displacement beaker is full to the spout and all of the displaced water is collected.*
4. To measure the volume of the liquid, learners should use a graduated cylinder.	*Learners should minimise the parallax error by reading from the bottom of the meniscus. They should report the volume in line with the cylinder's resolution.*
5. For each of the samples, learners should use the top pan balance to establish their mass.	*For the mass of the liquids, learners need to place the empty graduated cylinder on the balance and zero it.*
6. Using the collected data, learners should be able to calculate the densities of their samples.	

Clean-up
After the experiment learners should:
- clean all glassware and tidy up their work space
- ensure any spillages have been mopped up
- return all equipment.

Lab lesson: Option 2 – virtual experiment

Resources	• A data projector or similar • Determining density virtual experiment video • Worksheets E and F

Learning objectives	By the end of the lesson: • ***all*** learners should be able to use the formula density=$\frac{\text{mass}}{\text{volume}}$ to calculate density. They should be able to safely and accurately take measurements and suggest possible improvements for their methods • ***most*** learners will be able to evaluate methods and suggest two possible improvements • ***some*** learners will be able to evaluate methods and suggest several possible improvements.

Timings	Activity
10 min	**Starter/Introduction** The virtual experiment video shows how to find the density of an irregularly shaped object and a liquid. Check if your learners can describe density as a measure of how much mass is present per unit volume. You could guide a discussion on this using the following question: Is steel denser than wood? The masses of each atom and the spacing between them determine the density of materials. We think of density as the relative 'lightness' or 'heaviness' of materials of the same volume. It is a measure of the compactness of matter, of how much mass occupies a given space.
15 min 20 min 5 min	**Main lesson** Hand out Worksheet E. They will answer on the worksheet as they watch the video. The video will stop when they need to answer a question. Start the video. You may like to ask learners to share their answers as you go through. Use Worksheet F to allow learners to practise making density calculations for a range of objects and liquids. Learners can use the answer sheets provided to peer or self-assess their work. If answers are wrong, they must show how they should be corrected.
10 min	**Plenary** Learners should work in groups of two or three to identify at least two improvements for the experiment shown in the video.

Debriefing lesson: Extended writing skills

Resources	• Data collected from the experiment • Worksheets G, H and I

Learning objectives	By the end of the lesson: • ***all*** learners should have been able to summarise their findings • ***most*** learners will be able to review their work, improving it in line with the success criteria • ***some*** learners will be able to evaluate methods and suggest several possible improvements.

Timings	Activity
5 min 10 min	**Starter/Introduction** Ask learners to review their findings from the experiment. You may want them to share their work with other learners. Following this, ask pairs of learners to discuss what characterises a good science write up. They are likely to suggest things like: explains processes, uses clear language, the writing is concise, technical language is used or data is presented clearly. Show them Worksheet G which provides suggestions to help learners to write scientifically.
20 min 10 min 10 min	**Main lesson** Learners now need to write up their interpretations and evaluation of the experiment. Worksheet G is available to help them scaffold their writing. This worksheet identifies the key points learners need to include. It also shows learners the success criteria for the task. Before they begin, you may also want to share Worksheet H to discuss strategies that they can use to improve their extended writing. For weaker learners, there are sentence starter suggestions on Worksheet I. Now that learners have written up this part of the experiment, they are going to formatively assess their work. They should swap their writing with the person next to them. Using the success criteria, they should give each other feedback. There is a section on Worksheet G that has space for them to identify three things their partner has done well and one thing they need to improve. They can then cut this out and glue it in, or write the feedback straight into their partner's lab book. Learners should return the work to their partner. Each learner should read the feedback they have received. They need to act on this by rewriting a section of their work, building in the improvements that their partner has suggested.
5 min	**Plenary** Ask learners to share the improvements they suggested in their evaluations. Ask them to critique each other's suggestions.

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson*:		
A: Check your understanding	**14–15**	**27**
For use in *Lab lesson: Option 1*:		
B: Method	**16**	**—**
C: Results table	**17**	**—**
D: Evaluation of the experiment	**18**	**—**
For use in *Lab lesson: Option 2*:		
E: Virtual experiment	**19–20**	**28–29**
F: Density calculations practise	**21–22**	**30–31**
For use in the *Debriefing lesson*:		
G: Interpretation and evaluation	**23–24**	**—**
H: Using connectives	**25**	**—**
I: Sentence starters	**26**	**—**

Worksheet A: Check your understanding

For each of the questions, tick the box next to the best answer(s).

1. Which instrument would be the best to measure the dimensions of a mobile phone?

- ☐ A metre rule
- ☐ A 30 cm ruler
- ☐ A micrometer

2. Which instrument is best to measure the mass of an object?

- ☐ A top pan balance
- ☐ A newton meter

3. Which two statements describe how to use a top pan balance accurately?

- ☐ It is set to zero before any measurement is taken
- ☐ It is kept in a closed box when not in use
- ☐ It can measure at least 5000 g
- ☐ It sits on a flat surface

4. Which is the correct way to find the volume of a rectangular prism?

- ☐ Its length is multiplied by 3
- ☐ Its height is multiplied by 3
- ☐ The length, height and width are multiplied together

5. Which two statements describe how to measure accurately with a graduated cylinder?

- ☐ It needs to be long enough
- ☐ It needs to sit on a flat surface
- ☐ Your eye should be level with the surface of the liquid

Worksheet A: Check your understanding

6. What two things might be a problem when using an almost full graduated cylinder to measure an irregular object?

☐ If the cylinder is too full it will overflow

☐ Some irregular solids float

☐ The object displaces the same amount of water as its volume

7. A displacement beaker is used to measure the volume of an irregular object when:

☐ The object has a mass greater than 10 g

☐ The object is too large to fit in a graduated cylinder

8. What could be a problem when using a displacement beaker?

☐ All of the displaced water is caught in a graduated cylinder

☐ The displacement beaker has to be filled to the spout

☐ The graduated cylinder is removed too quickly from under the spout and some displaced water is not collected

9. Which two values are needed to calculate the density of an object?

☐ Mass and weight

☐ Mass and surface area

☐ Volume and mass

10. What is the density of a 24 kg cube with 2 m long sides?

☐ 12 kg/m^3

☐ 3 kg/m^3

☐ 8 kg/m^3

Worksheet B: Method

1. Collect all of your equipment from the front of the class.
2. For the regular shaped objects, use a ruler to measure their dimensions and calculate their volume.

Make sure that you report the dimensions of your samples accurately.

3. To measure the volumes of the irregular shapes you will have to use the displacement method.

Check that you have set up your displacement beaker or graduated cylinder accurately. You need a known quantity of liquid in the graduated cylinder, and once the object is in, it should not overflow. For the displacement beaker, make sure it is filled up to the level of the spout before you put your irregular object in.

4. To measure the volume of your liquid samples, use a graduated cylinder.

To measure the level of fluid in the cylinder accurately, make sure the cylinder is on a level surface and that you measure to the bottom of the meniscus.

5. For each of your samples, use the top pan balance to establish their mass.
6. Add the data of the volumes and masses to the table.

Make sure you calculate the volumes of the regular shapes accurately.

7. Use the equation $\text{density}=\frac{\text{mass}}{\text{volume}}$ to calculate the density of each sample.

Worksheet C: Results table

Use the table below to record the data you collect.

To calculate the density, use this formula:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Object	Mass / g	Volume / cm^3	Density / g/cm^3
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
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....	....	....	....
....	....	....	....
....	....	....	....
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Worksheet D: Evaluation of the experiment

Use the questions below to help you think about the experiment you have just completed.

1. Explain what you have done to make sure that your mass measurements were as accurate as possible.

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2. Explain what you have done to make sure that your volume measurements and/or calculations were as accurate and reliable as possible.

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3. Can you think of anything that you could improve to make the mass and volume readings more accurate?

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Worksheet E: Virtual experiment

As you watch the video, record your answers into the spaces below.

1. How can we make sure that the mass measurement is as accurate as possible?

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2. Is there anything specific to remember about the amount of water put into the displacement beaker?

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3. How can we make sure all of the water that is displaced is collected? What can be done to make sure the measurement of the displaced water is accurate?

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Worksheet E: Virtual experiment

4. $\frac{54.25}{9}$ is actually 6.027777. Why do we write our answer as 6.0?

- ☐ It is a recurring number. We need to cut it somewhere.
- ☐ The minimum number of significant figures used in the calculation was two, so the answer has to be in two significant figures as well.
- ☐ We always report any numerical answer in one or two decimal places.

5. What is the purpose of setting the top pan balance to zero?

- ☐ It needs to be reset in between every measurement.
- ☐ Setting the top pan balance to zero will mean that only the mass of the liquid in the beaker will be measured, not the mass of the beaker and liquid together.

6. Is there anything wrong with the amount of oil measured into the graduated cylinder?

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7. Can you think of a different way to measure the volume and mass of the liquid?

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8. Which one of the below is another acceptable unit for density measurement?

- ☐ N/m^3
- ☐ kg/m^2
- ☐ kg/m^3

Worksheet F: Density calculations practice

Complete these calculations to work out the densities of each substance. You need to show your working. The first one has been done for you.

Remember: density = $\frac{\text{mass}}{\text{volume}}$

1. A baker buys a 1200 g bag of sugar which has a volume of 750 cm^3. What is the density of the sugar?

   density= $\frac{\text{mass}}{\text{volume}}$ density= $\frac{1200}{750}$ density= 1.6 g/cm^3

2. A mechanic records the mass of a steel cube as 515 g. If one side of the cube measures 4 cm, what is the density of the steel?

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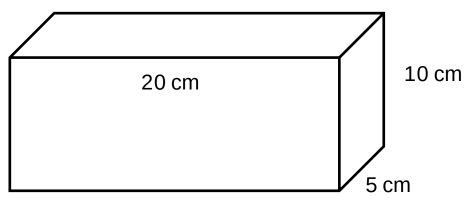
   ………

3. 28.5 g of iron is added to a graduated cylinder containing 45.5 cm^3 of water. The water level rises to 49.1 cm^3
   What is the density of the iron?

   ………

   ………

4. A builder needs to move this block of limestone which weighs 2560 g.
   What is the density of the limestone?

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5. A batch of calcium chloride for orange fireworks has a mass of 1300 g and volume of 604 cm^3.
   What is the density of the calcium chloride?

   ………

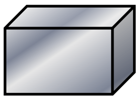
   ………

Worksheet F: Density calculations practice

Use this table to help identify the mystery objects.

Table of densities			
Substance	**Density / g/cm³**	**Substance**	**Density / g/cm³**
Granite	2.75	Bronze	7.58
Limestone	2.56	Gold	19.32
Sapphire	3.98	Silver	10.5

6. A block used as a doorstop measures 3 cm by 4 cm by 6 cm in size. It weighs 198 g. What is the block made out of?



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7. You think the stone in a brooch is a sapphire. It has a mass of 7.96 g and a volume of 2 cm^3. Is it a sapphire?

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8. You find a ring with a mass of 96.6 g. You put 10 cm^3 of water in a graduated cylinder and then add the ring. The water rises to the 15 cm^3 mark. What is the ring made of?

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9. You find an old coin. It has a mass of 11.37 g and a volume of 1.5 cm^3. What is the coin made out of?

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Worksheet G: Interpretation and evaluation

Use this worksheet to help you to write up your interpretations and evaluation for the experiment.

Interpretation

Use this section to explain each the measurements you made. Make sure you support this with the data collected. You should refer to:

- which materials you calculated the density for
- the states of the materials that you were calculating the densities for
- the physical properties of the materials you calculated the densities for

Evaluation

Use this section to describe the strengths of the experiment and what you could do to make it better. You should refer to:

- what went well and the reasons for this
- what problems you experienced and why
- how you could solve the problems if you did the experiment again.

Writing check

1. Have you explained each of your deductions, supported by data collected?

2. Have you identified what worked well and where improvements were needed?

3. Have you used a range of linking words (e.g. next, because) to extend your writing?

✂ -

Check it

Read your partner's work and look back at the success criteria.

Record **three** things they have done well and **one** thing they need to improve.

Cut along the dashed line and give this back to your partner.

The three things you have done well are:

1. ……………………………………………………………………………………………………

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2. ……………………………………………………………………………………………………

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3. ……………………………………………………………………………………………………

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To improve, you need to:

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Worksheet G: Interpretation and evaluation

This worksheet shows some ideas and techniques you might want to use when writing up your experiments.

Section	What to include
Plan	This section should explain the processes involved in your experiment. You might also need to explain a theory or concept linked to your experiment. • Begin with general statements to introduce the background, e.g. 'Density is a measure of the mass in a substance per unit volume. This means that …' • Your vocabulary should be precise and you should use relevant technical words. • Your language should be impersonal. Do not use words like 'I' or 'we'.
Instructions or method	This section should have a sequence of steps that show how a task should be carried out. • State what you want to achieve, e.g. 'How to measure the density of irregular shaped objects'. • Make sure you explain (or draw) the equipment and materials needed. • Explain clearly what steps should be taken to achieve the goal, e.g. 'Fill the displacement beaker to just below the spout'. • You should use imperatives like 'Zero the top pan balance and weight the dry, empty graduated cylinder.' Your instructions should be like a series of commands. • Use numbers or temporal connectives to show the stages involved. • Your language should be clear so that someone could repeat the experiment without mistakes.
Observations	This section should be made up of what you have been able to measure or observe. • Only record what can be seen or measured – do not make guesses about what the products of an experiment are without testing them, e.g. if you see bubbles, this is all you can say (unless you have tested the gas produced). • Your observations need to be as accurate as possible. Make sure you record them using the correct units. You may need to repeat observations.
Interpretations	This is where you need to make sense of the observations you have collected. • Now you can use your scientific knowledge to explain your observations. • Support points made with evidence from your observations or measurements, e.g. 'The bubbles observed turned the limewater cloudy, therefore it is clear these were carbon dioxide.'
Evaluation	The evaluation is an opportunity to discuss both the strengths and weaknesses of an experiment. • Identify both the strengths and weaknesses of the experiment. • Avoid meaningless comments like 'It did not work very well.' Be specific and explain why the experiment did not work well and how you could improve it. • Use connectives to balance the strengths and weaknesses, e.g. 'although' or 'however'; or to give evidence, e.g. 'This is because …' or 'this shows that'.

Worksheet H: Using connectives

Connectives help to develop your extended writing by allowing you to link ideas. This means that you can show how parts of the experiment link or how your observations might be supported by evidence.

In the table below there are examples of connectives you could use in your writing.

Useful connectives and where you might use them	
These connectives help you to show how time progresses. They are very useful in the planning and instruction sections.	• next • after • first, second, third etc. • 20 minutes later • meanwhile
These connectives help you to show cause and effect. They are very useful in the interpretation and evaluation sections.	• because • so • since • therefore • as a result
These connectives help you to show links and connections. They are very useful in the interpretation and evaluation sections.	• therefore • this shows • because • in fact • for example • furthermore • in conclusion
These help you to give comparisons, or to show differences. They are very useful in the interpretation and evaluation sections.	• although • while • similarly • equally • unless • whereas
These connectives help you to add evidence in your writing. They are very useful in the interpretation section.	• this shows that • as can be seen • as suggested by

Worksheet I: Sentence starters

Below are sentence starters for each of the points that should be addressed in the interpretation and method sections.

Interpretations

This section should include:

- which materials you calculated the density for
- the states of the materials that you were calculating the densities for
- the physical properties of the materials you calculated the densities for

Density was calculated for …

The density for a range of different states was measured. These included …

It was found that the densities of the materials tested in this experiment ranged from … to…

This compares to other materials like … and … which have densities of …

Evaluation

This section should include:

- what went well and the reasons for this
- what problems you experienced and why
- how you could solve the problems if you did the experiment again.

The method that worked particularly well was …

It worked well because …

There was a problem with …

This problem affected the results by …

To improve the experiment …

Worksheet A: Answers

For each of the questions, tick the box next to the best answer(s).

1. Which instrument would be the best to measure the dimensions of a mobile phone?

   ■ A 30 cm ruler

2. Which instrument is best to measure the mass of an object?

   ■ A top pan balance

3. Which two statements describe how to use a top pan balance accurately?

   ■ It is set to zero before any measurement is taken

   ■ It sits on a flat surface

4. Which is the correct way to find the volume of a rectangular prism?

   ■ The length, height and width are multiplied together

5. Which two statements describe how to measure accurately with a graduated cylinder?

   ■ It needs to sit on a flat surface

   ■ Your eye should be level with the surface of the liquid

6. What two things might be a problem when using an almost full graduated cylinder of water to measure an irregular object?

   ■ If the cylinder is too full it will overflow

7. A displacement beaker is used to measure the volume of an irregular object when:

   ■ The object is too large to fit in a graduated cylinder

8. What could be a problem when using a displacement beaker?

   ■ The graduated cylinder is removed too quickly from under the spout and some displaced water is not collected

9. Which two values are needed to calculate the density of an object?

   ■ Volume and mass

10. What is the density of a 24 kg cube with 2 m long sides?

    ■ 3 kg/m^3

Worksheet E: Answers

As you watch the video, record your answers into the spaces below.

1. How can we make sure that the mass measurement is as accurate as possible?

   The balance must be on a flat surface, and zeroed before measuring any mass.

2. Is there anything specific to remember about the amount of water put into the displacement beaker?

   The water level should be just below the spout.

3. How can we make sure all of the water that is displaced is collected? What can be done to make sure the measurement of the displaced water is accurate?

   Wait until all the water in the spout flows into the beaker. Sometimes touching the water in the spout with a needle may help (due to cohesive forces).

   The beaker and the graduated cylinder must be dry beforehand, and all of the contents of the beaker should be poured into the cylinder.

   The level of water in the cylinder should be read in such a way that the line of sight is level with the bottom of the meniscus created by the water surface.

4. $\frac{54.25}{9}$ is actually 6.027777. Why do we write our answer as 6.0?

   - The minimum number of significant figures used in the calculation was two, so the answer has to be in two significant figures as well.

5. What is the purpose of setting the top pan balance to zero?

   - Setting the top pan balance to zero will mean that only mass of the liquid in the beaker will be measured, not the mass of the beaker and liquid together.

6. Is there anything wrong with the amount of oil measured into the graduated cylinder?

   They intended amount was 30 ml of liquid but the amount in the cylinder is about 31 ml. This is a difference of about 3%, which could decrease the accuracy of the calculations.

Worksheet E: Answers

7. Can you think of a better way to measure the volume and mass of the liquid?

   The graduated cylinder could be used to measure both the volume and the mass. That would eliminate the problem of any measured volume of liquid remaining inside the cylinder after it got transferred into the beaker.

8. Which one of the below is another acceptable unit for density measurement?

   ■ kg/m^3

Worksheet F: Answers

Complete these calculations to work out the densities of each substance. You need to show your working. The first one has been done for you.

Remember: density $= \frac{\text{mass}}{\text{volume}}$

1. A baker buys a 1200 g bag of sugar which has a volume of 750 cm^3.
   What is the density of the sugar?

   density $= \frac{\text{mass}}{\text{volume}}$ density $= \frac{1200}{750}$ density $= 1.6$ g/cm^3

2. A mechanic records the mass of a steel cube as 515 g. If one side of the cube measures 4 cm, what is the density of the steel?

   Volume = 64 cm^3

   Density = 515/64

   Density = 8.04 g/cm^3

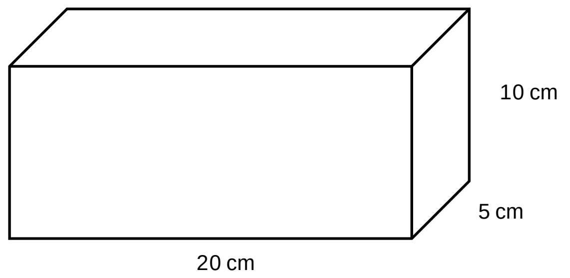
3. 28.5 g of iron is added to a graduated cylinder containing 45.5 cm^3 of water. The water level rises to 49.1 cm^3
   What is the density of the iron?

   Volume = 3.6 cm^3

   Density = 28.5/3.6

   Density = 7.92 g/cm^3

4. A builder needs to move this block of limestone which weighs 2560 g.
   What is the density of the limestone?

   Volume = 1000 cm^3

   Density = 2560/1000

   Density = 2.56 g/cm^3

5. A batch of calcium chloride for orange fireworks has a mass of 1300 g and a volume of 604 cm^3.
   What is the density of the magnesium?

   Density = 1300/604

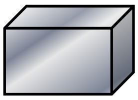
   Density = 2.15 g/cm^3

Worksheet F: Answers

Use this table to identify the objects.

Table of densities			
Substance	**Density / g/cm³**	**Substance**	**Density / g/cm³**
Granite	2.75	Bronze	7.58
Limestone	2.56	Gold	19.32
Sapphire	3.98	Silver	10.5

6. A block used as a doorstop measures 3 cm by 4 cm by 6 cm in size. It weighs 198 g.
   What is the block made out of?



   Volume = 72 cm³

   Density = 198/72

   Density = 2.75 g/cm³

   The block is granite.

7. You think the stone in a brooch is a sapphire. It has a mass of 7.96 g and a volume of 2 cm³.
   Is it a sapphire?

   Density = 7.96/2

   Density = 3.98 g/cm³

   The stone is a sapphire.

8. You find a ring with a mass of 96.6 g. You put 10 cm³ of water in a graduated cylinder and then add the ring. The water rises to the 15 cm³ mark.
   What is the ring made of?

   Volume = 5 cm³

   Density = 96.6/5

   Density = 19.32 g/cm³

   The ring is made of gold.

9. You find an old coin. It has a mass of 11.37 g and a volume of 1.5 cm³.
   What is the coin made out of?

   Density = 11.37/1.5

   Density = 7.58 g/cm³

   The coin is made of bronze.

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