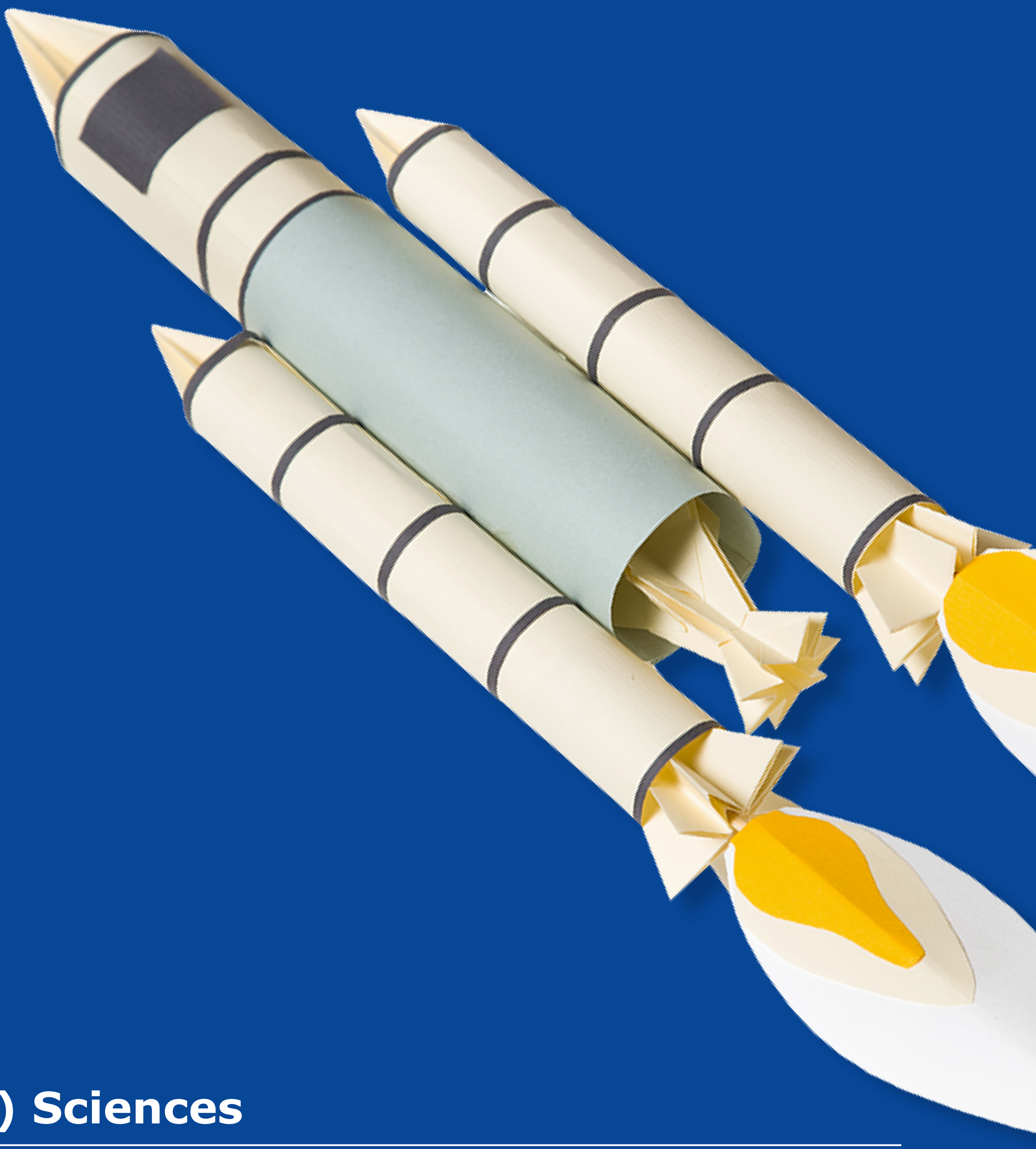
Teacher Guide iPDF
Core Practicals
GCSE Physics



GCSE (9–1) Sciences

Pearson Edexcel Level 1/Level 2 GCSE (9–1) Sciences

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Key

PRACTICAL SHOWN IN BOLD IS THE ADDITIONAL PRACTICAL REQUIRED FOR GCSE PHYSICS.

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Introduction

Purpose of this guide

This guide is designed to support you in delivering the core practicals for Edexcel. The following pages, for *each* core practical, will:

- Give you links to the specification content and highlight key areas to further your students' understanding.
- Contain key questions you can ask to focus your students, and get them thinking about why they are carrying out a particular practical in a certain way.
- Give you a sample question (where possible), with commentary relating to the assessment, which can be used as practice to consolidate students' understanding.

Changes to practical requirements in reformed GCSEs

There will not be any coursework in the GCSE (9–1) Science qualifications. Assessment of practical work is now included as part of the final exam, and a minimum of 15% of the total marks must be allocated to questions related to practical. In our exams, we will have questions on the core practicals in our specifications, as well as other questions on practicals related to the core practicals or techniques that students should be familiar with from their studies.

As well as the practical requirement, there is a list of apparatus and techniques that has been set out by the Department for Education (*Appendix 1*). Specifications must give students opportunities to cover the relevant apparatus and techniques, and this list has been mapped to our core practicals to show you how we are covering all of the requirements. As long as you carry out all of the core practicals, you will automatically cover the apparatus and techniques list. If you want to see how our core practicals map to this list, it is mapped (along with maths skills) in *Appendix 2*.

Approach to core practicals

In order to meet the requirements set out by Ofqual, you need to ensure your centre confirms that reasonable steps have been taken to secure that each learner has completed the practical activities set by us, and has made a contemporaneous record of the practical work and knowledge, skills and understanding derived from those practical activities.

The purpose of this statement is to ensure that practical work remains an important part of GCSE Science. In your day-to-day teaching, this just means that you need to ensure you cover the core practicals outlined by us and that your students are recording the work that they are doing as part of carrying out the core practicals. In practice, this could just be completing worksheets, taking results and doing some analysis or writing notes in their exercise books as a follow up to carrying out the practical. If you prefer, you can use a separate lab book for practical work, but this is not necessary. Indeed, as students will be required to have knowledge of these practical techniques and procedures for the final exam, it may be better to have this practical work sit alongside the relevant theoretical knowledge.

It is important to note that the approach to covering core practicals should be the same approach as you currently take to practical work in your science lessons. If you occasionally cover particular techniques as a carousel, or split students into groups to take readings, there is no reason why you cannot still do this—as long as you have taken reasonable steps to ensure your students all acquire experience of carrying out that particular procedure or technique.

Assessment of practical work

As a centre, you need to confirm that you have taken reasonable steps to ensure that each student has completed the compulsory core practicals and that the evidence for this is recorded. The practical record must include the knowledge, skills and understanding which that student has derived from those practical activities. To confirm that this has been done, centres must complete and submit an *authentication sheet* to confirm that all students have completed these core practicals. This authentication sheet can be found as an appendix in the specifications.

By signing this authentication sheet, you are confirming that reasonable steps have been taken to ensure that all students have been given the opportunity to carry out the core practicals outlined in the specifications. If students are ill or miss core practicals for any reason beyond the school's control, it does not require you to run catch up sessions for those individual students.

In exam papers, practical work will be assessed across the assessment objectives. The sample questions included in this core practical guide outline how you can use that question to consolidate your students' understanding of that particular core practical. The exam papers will assess student's understanding of the practical work, and they will be at an advantage if they have carried out all the core practicals in the course.

Maths skills

Practical activities offer a wide range of opportunities to cover particular mathematical skills. As part of this guide, we have outlined where there are good opportunities to cover mathematical techniques as part of each core practical. There is also a mapping in *Appendix 2* which maps the maths skills outlined by the DfE to the relevant core practical.

Note: There is a Guide to Maths for Scientists which you can download from the Edexcel website. This guide outlines the content that students will have covered in their maths lessons throughout KS3 and KS4. You can use this guide to help you understand how different areas are approached in maths, and therefore support your teaching of mathematical content in science lessons.

Physics

There are seven core practicals in the physics section of GCSE Combined Science. GCSE Physics covers the same seven practicals as well as an additional one, to make up eight core practicals in total.

Core practical descriptions

Note: 5.19P is separate GCSE Physics only.

Core practical		Description
2.19	*Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*	Different masses must be used to investigate the effect of varying masses on the acceleration of a trolley down a ramp. Appropriate methods must be used to measure the force and time taken for the trolley to travel down the ramp, and data analysis must include calculating the acceleration.
4.17	*Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*	This investigation involves looking at the characteristics of waves and using the equation: $v = f \times \lambda$ It is expected that students will have looked at waves in a liquid using a ripple tank, and waves in a solid using a metal rod and a method of measuring the frequency. Suitability of apparatus to take these measurements must also be considered.
5.9	*Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter*	A light source with grating must be used to produce a beam of light, which must then be used to investigate the effect of refraction using a glass block. An appreciation of the interaction of the light ray with the glass block and the effect of changing medium on the light ray (moving towards and away from the normal) must be included.
5.19P	*Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*	A minimum of four different beakers or test tubes must be covered in different materials (different colours, or shiny/dull surfaces). The same volume of hot water must then be poured into each container, and covered with a lid. Using a thermometer the temperature can be monitored and recorded at fixed times using a stopwatch.

10.17	*Construct electrical circuits to:* *a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* *b test series and parallel circuits using resistors and filament lamps*	This investigation involves constructing a circuit to investigate potential difference, current and resistance for a resistor and a filament lamp. The behaviour of parallel and series circuits must also be included, and this must be done using filament lamps. A series circuit should be set up initially with a resistor, ammeter and voltmeter. The current must be recorded at different voltages. This must then be repeated using a filament lamp instead of a resistor. To investigate series and parallel circuits, a parallel circuit must be set up with ammeters, voltmeters, and filament lamps. Readings from this circuit must then be compared with series circuits used initially. Analysis must include use of the equation $V = I \times R$
14.3	*Investigate the densities of solid and liquids*	The density of a solid object must be determined by measuring the mass and volume of the object, and then using the equation: $\rho = \frac{m}{v}$ The volume must be determined by putting the object into water, and measuring the volume of water that has been displaced. The density of a liquid can be calculated by weighing the liquid using a balance, and determining the volume. The equation: $\rho = \frac{m}{v}$ must then be used to calculate the density.
14.11	*Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice*	The temperature of crushed ice must be recorded using a thermometer. This must then be melted using a Bunsen burner and beaker of water as a water bath. The temperature must be monitored as the ice melts. To determine specific heat capacity of water, the temperature of water using a thermometer must be monitored while heating it using a heat supply connected to a joulemeter. This must then be used to calculate the specific heat capacity.
15.6	*Investigate the extension and work done when applying forces to a spring*	The stretching of a spring must be investigated by measuring the length of a spring with no weights, followed by adding varying masses and measuring the new length. This must include calculating the work done and an appreciation of the forces involved.

Core practical 1: Investigating force, mass and acceleration

2.19 Core practical: Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys

Links to the specification content

2.8	Recall and use the equation: acceleration (metre per second squared, m/s^2) = change in velocity (metre per second, m/s) ÷ time taken (second, s) $a = \frac{(v-u)}{t}$
2.11	Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates
2.15	Recall and use Newton's second law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2) $F = m \times a$
2.22	**Explain that inertial mass is a measure of how difficult it is to change the velocity of an object (including from rest) and know that it is defined as the ratio of force over acceleration**

Introducing the practical

This practical can be done in one session. Students should already be familiar with the use of light gates and dataloggers for measuring times and velocity. Dataloggers can be set to measure acceleration directly but calculating acceleration from velocity and time measurements can lead to a deeper understanding of the concepts involved. The practical can be adapted to the situation where dataloggers are not available.

Link to GCSE Science 2011: 'Investigate the relationship between force, mass and acceleration' is a practical embedded in the specification, Unit P2, Topic 3, 3.15.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why is one end of the ramp propped up?
- How would you calculate the force pulling the trolley?
- Why do you use the same force pulling the trolley each time?
- Why do you need two light gates?
- What effect does the mass on the end of the string have on the total mass in the table of results?
- What are the main errors involved in this procedure?
- How can you improve the procedure?
- This practical investigates the relationship between mass and acceleration. How could you use the same equipment to investigate the relationship between force and acceleration?

Skills that are covered in the practical:

- Using a digital balance to measure the mass of the trolley
- Using light gates
- Using data logging software to measure velocity and time
- Recording measurements systematically in a complex table

Maths skills

- Substituting measured values into the equation for acceleration
- Plotting a graph of acceleration against mass
- Drawing a smooth curve
- Interpreting a graph showing an inverse relationship
- Extending this to plot a graph of acceleration against 1/mass to produce a straight line
- Interpreting the straight line graph

Edexcel GCSE (9–1) **Sciences** **Phys CP1** **Investigating force, mass and acceleration**

Your teacher may watch to see if you can…

- follow instructions safely
- take careful measurements.

Aim

To investigate the effect of mass on the acceleration of a trolley.

Prediction

1 You will accelerate a trolley using a constant force. What effect do you think the mass of the trolley will have on the acceleration? Explain your prediction if you can.

Method

Apparatus

- trolley
- ramp
- blocks to prop up the end of the ramp
- string
- pulley
- masses
- sticky tape
- card
- sticky putty
- balance
- 2 light gates
- datalogger
- 2 clamps and stands
- box of crumpled newspaper

Safety

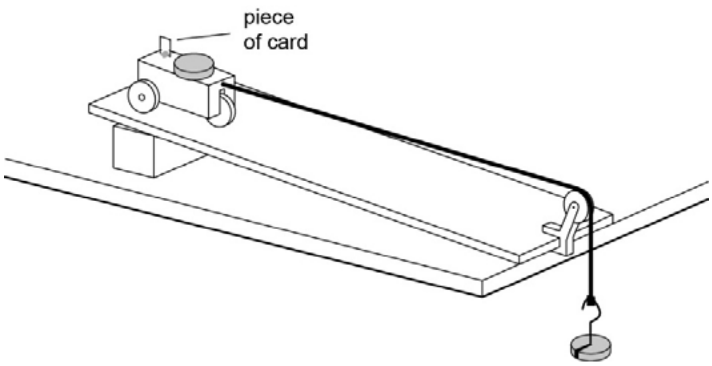
Make sure masses cannot fall on your feet by placing a box of crumpled newspaper on the floor beneath them.

A Prop up one end of the ramp and place a trolley on it. Adjust the slope of the ramp until the trolley just starts to move on its own. Gravity pulling the trolley down the slope is now slightly greater than the friction in the trolley's wheels.

B Stick a piece of card to the top of the trolley using sticky putty. Leave enough space to stack some masses on top of the trolley. Measure the length of the card and write it down.

C Find the mass of the trolley and write it down.

D Fasten the pulley at the bottom end of the ramp, and arrange the string and masses as shown below.



E Set up two light gates, one near the top of the ramp and one near the bottom. Adjust their positions so that the card on the top of the trolley passes through each gate as it runs down the ramp.

F Put a mass on the end of the string. You will keep this mass the same for all your tests. You will have to decide what mass to use.

G Release the trolley from the top of the ramp and write down the speed of the trolley (from the datalogger) as it passes through *each* light gate. Also write down the time it takes for the trolley to go from one light gate to the other. Repeat this two more times, so you have three sets of results.

H Repeat step **G** for other masses on the trolley. You will have to decide what masses to use and how many different masses you are going to test.

Recording your results

2 Draw a table like this for recording your results. You need to repeat the four rows here for every different mass you put on your trolley.

Mass added to trolley (kg)	Total mass of trolley and masses (kg)	Run number	*u* – 1st velocity reading (m/s)	*v* – 2nd velocity reading (m/s)	Time between velocity measurements (s)	Acceleration (m/s^2)
		1				
		2				
		3				
		Mean				

3 Calculate the acceleration for each run using the equation in the box.

4 Find the mean acceleration for each trolley mass.

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

$$a = \frac{(v - u)}{t}$$

Considering your results

5 Plot a scatter graph to show your results. Put the total mass of the trolley on the horizontal axis and the mean acceleration on the vertical axis. Draw a line or curve of best fit through your points.

6 a What relationship between acceleration and mass does your graph show?

b Is this what you predicted?

Evaluation

7 a How close are the points on your graph to the line of best fit?

b What does this tell you about the quality of the data you have gathered?

8 How do your results compare to the results obtained by other groups?

9 How certain are you that your conclusion is correct? Explain your answer.

Edexcel GCSE (9–1)
Sciences **Phys CP1** **Newton's Second Law**

Objectives

P2.15 Recall and use Newton's Second Law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2), $F = m \times a$.

P2.19 *Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys.*

P2.22 **H** Explain that inertial mass is a measure of how difficult it is to change the velocity of an object (including from rest) and know that it is defined as the ratio of force over acceleration.

Maths requirements

3a Understand and use the symbols: $=, <, <<, >>, >, \propto, \sim$.

3b Change the subject of an equation.

3c Substitute numerical values into algebraic equations using appropriate units for physical quantities.

3d Solve simple algebraic equations.

Learning outcomes

6th **SP2.15** Describe what an acceleration is.

6th **SP2.15** List the factors that affect the acceleration of an object.

6th **SP2.15** Recall the equation that relates the factors affecting acceleration.

8th **SP2.15** Use the equation relating force, mass and acceleration.

9th **SP2.15** Change the subject of the equation relating force, mass and acceleration.

7th **SP2.22** **H** Explain what inertial mass means.

Exploring

1. Investigating force, mass and acceleration – Core practical

This practical forms part of the core practical requirement of the specification. See Students' sheet CP1(Investigating force,mass,acceleration) for a full method for this practical. The method on the worksheet assumes that students are investigating the effects of mass on acceleration with a constant force.

If sufficient light gates are not available, students should mark a measured length on the ramp and use a stop clock to time how long the trolley takes to travel this distance. The acceleration can then be calculated using $a = (v - u) / t$ (students will have met this if they have studied Unit SP1).

Support: The practical could be simplified for students working at lower levels by asking them to time how long it takes the trolley from release to the end of the ramp. The time can be used as a measure of the acceleration. It will also be helpful to suggest the masses to be used and the number of repeats needed in their investigation. Ensure that students know how to draw a curve of best fit. Skills sheet PD6 *Scatter graphs* may be useful.

Stretch: Show students the apparatus and discuss the idea of a friction-compensated ramp. Show them how to set up light gates, and then ask them to plan their own method to investigate the effects of force and mass on acceleration. If time permits, students could investigate both variables or groups could be given just one of them to investigate. For students investigating the effects of force, note that the falling masses are also being accelerated and so form part of the overall system mass. The total mass of the system must therefore be kept the same. This is best done by using the same total number of masses for each run and transferring them from the trolley to the hanging stack to increase the force.

⚠ Safety

Ensure masses cannot fall on feet by placing a box full of crumpled newspaper beneath the weights.

Take care when moving ramps as these can be heavy. If the large 2 m ramps are being used, set these out before the lesson.

Expected results

If investigating the effect of mass, they should find that the acceleration is inversely proportional to mass (encourage students to plot acceleration against 1/mass to check for inverse proportionality). Students investigating the effects of force should find that acceleration is proportional to force if a fixed total mass is used.

Course resources

Phys Students' sheet CP1

Equipment

trolley, ramp, blocks, pulley, string, stacking masses, mass hanger, sticky tape, card, sticky tack, 2 light gates, 2 clamps and stands, access to balance, datalogger (set up to measure velocities from the light gate readings and the time between the two readings – students will need to enter the length of the card mounted on their trolley), box of crumpled newspaper

Sample question

This example is taken from the sample assessment material, paper 1PH0/1H, Q7, part (a) Although this is not about core practical 1 directly, the commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

7 A student investigates how the average speed of the trolley varies with starting height.

Figure 9 shows the trolley and runway.

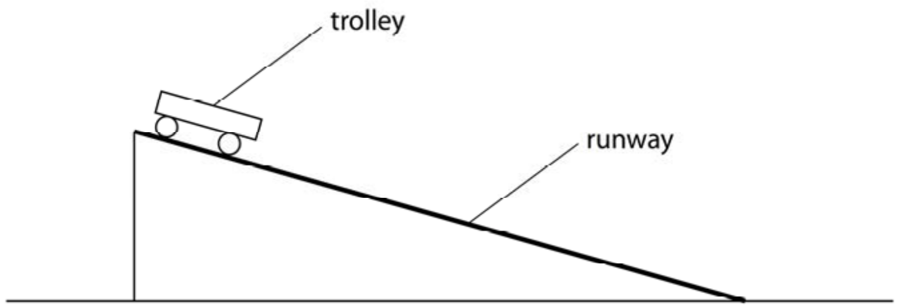


Figure 9

(a) Describe how the student can determine the average speed of the trolley.

(4)

Question number	Answer	Additional guidance	Mark
7(a)	An answer that combines the following points of understanding to provide a logical description: • measurement of time between(or at) two positions using suitable timing equipment (1) • measurement of suitable distance along the runway with metre rule (1) • measurement of vertical height to starting position (1) • repeats AND averages AND use of a correct equation (1)	allow stopwatch, light gates minimum is 0.5 m metal tape measure average speed = distance/time OR average speed = (speed at A – speed at B)/2	**(4)**

Part (a) requires students to demonstrate knowledge and understanding of scientific ideas and procedures related to this particular practical. They will have carried out a practical similar to this, using a similar method, but varied the mass of the trolley. This practical varies the height, but the principle is the same. Therefore students should be able to use their understanding of the core practical they have carried out to outline how the practical should be carried out.

Core practical 2: Measuring waves in solids and liquids

4.17 Core practical: Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid

Links to the specification content

4.3	Define and use the terms frequency and wavelength as applied to waves
4.4	Use the terms amplitude, period, wave velocity and wavefront as applied to waves
4.6	Recall and use both the equations below for all waves: wave speed (metre/second, m/s) = frequency (hertz, Hz) × wavelength (metre, m) $v = f \times \lambda$ wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s) $v = \frac{x}{t}$
4.7	Describe how to measure the velocity of sound in air and ripples on water surfaces

Introducing the practical

The emphasis in this practical should be on the different methods needed to measure these quantities for the different waves. For water waves, the speed, frequency and wavelength can all be measured separately, but the speed of sound in a solid is too fast to be measured by simply measuring distance and time. Here, the speed is calculated using the measurements made of frequency and wavelength.

> Link to GCSE Science 2011: 'Use the terms frequency, wavelength, amplitude and speed to describe waves' and 'Use the equations $v = f \times \lambda$ and $v = x/t$' appear in Unit 1 Topic 1, 1.13 and 1.15.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Waves can be transverse or longitudinal. What type of wave is
  (a) a water wave on the surface of the water in a ripple tank?
  (b) a sound wave in a metal rod?
- How would you measure the speed of sound in air?
- How would you measure the speed of water waves in a ripple tank?
- Why can you not measure the speed of sound waves in a metal rod in the same way?
- Is it possible to measure the speed of light?

Skills that are covered in the practical:

- Adjusting the components of a ripple tank to give parallel water waves of measurable wavelength
- Measuring the wavelength of a water wave in a ripple tank
- Measuring the speed of a wavefront (wave crest)

Maths skills:

- Substituting measured values into the equation relating speed, distance and time
- Substituting measured values into the equation relating speed, wavelength and frequency
- Changing the subject of an equation

Edexcel GCSE (9–1) **Sciences** **Phys CP2** **Measuring waves in solids and liquids – Core Practical**

Your teacher may watch to see if you can…

- follow instructions carefully
- make accurate measurements.

Introduction

The speed, frequency and wavelength of waves can be measured in different ways. The most suitable equipment for carrying out these measurements depends on the type of wave and on its speed.

Aim

To measure waves in different ways and evaluate the suitability of the equipment.

Part 1. Speed of waves on water

Method

A Set up a ripple tank with a straight dipper near one of the short sides of the tank. Fasten a ruler to one of the long sides so you can see the markings above the water level.

B Vary the current to the motor until you get waves with a wavelength about half as long as the ripple tank (so you can always see two waves).

C Count how many waves are formed in 10 s and write it down.

D Look at the waves against the ruler. Use the markings on the ruler to estimate the wavelength of the waves. If you have one, use a camera to take a photo of the waves with a ruler held just above them.

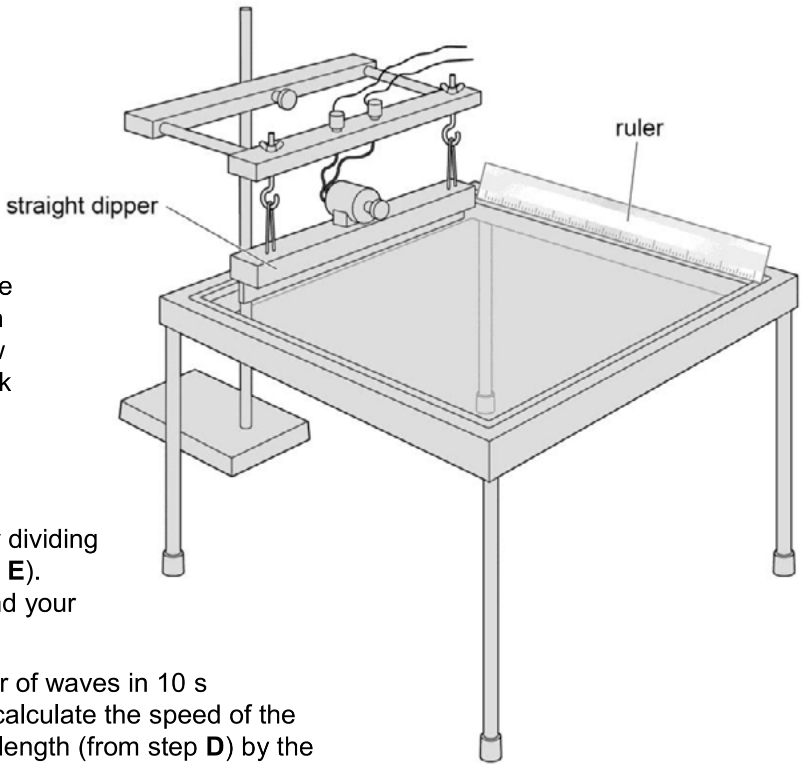
E Mark two points on the edge of the ripple tank and measure the distance between them. Use the stopwatch to find out how long it takes a wave to go from one mark to the other.

Apparatus

- ripple tank
- stopwatch
- ruler
- digital camera

⚠ Safety

Mop up any spilled water straight away



Recording your results

1 Calculate the speed of a single wave by dividing the distance by the time (both from step **E**). Make sure your distance is in metres and your time is in seconds.

2 Find the frequency by taking the number of waves in 10 s (from step **C**) and dividing by 10. Then calculate the speed of the series of waves by multiplying the wavelength (from step **D**) by the frequency you have just worked out.

Considering your results/conclusions

3 Compare your results from questions 1 and 2 with results obtained by other groups.

Evaluation

4 How easy was it to measure the frequency in step **C**? Why did you count the number of waves in 10 s?

5 How easy was it to measure the wavelength in step **D**? Why did you use a digital camera to help you?

6 How easy was it to time a single wave in step **E**? Is there any way you could improve this measurement?

Part 2. Measuring waves in a solid

Method

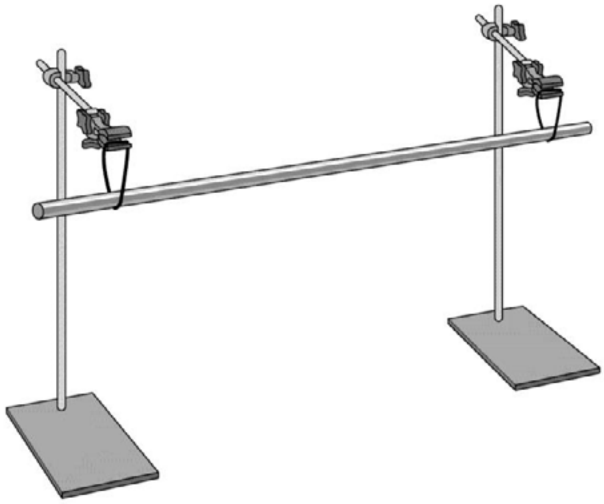
F Suspend a metal rod horizontally using clamp stands and rubber bands, as shown in the diagram below.

G Hit one end of the rod with a hammer. Hold a smartphone with a frequency app near the rod and note down the peak frequency.

H Measure the length of the rod and write it down. The wavelength will be twice the length of the rod.

Apparatus

- metre rule
- hammer
- 2 clamps and stands
- long metal rod
- rubber bands
- smartphone with frequency app



Recording your results

7 Use the frequency (from step **G**) and the wavelength (from step **H**) to calculate the speed of sound in the metal rod.

Considering your results/conclusions

8 What is the speed of sound in the material you tested?

Evaluation

9 Explain which of your measurements is the more accurate: the wavelength or the frequency.

10 Draw up a table to summarise the equipment you used for the measurements in both parts of this investigation, and how suitable the equipment was. You can use headings like this:

What was measured?	**Which material was this measured for?**	**How was it measured?**	**Why was this method chosen?**

11 You can measure walking speed using a tape measure and a stopwatch. Explain why these instruments are not suitable for measuring the speed of sound in a solid.

Edexcel GCSE (9–1) Sciences

Phys CP2 Wave speeds

Objectives

P4.6 Recall and use both the equations below for all waves:

wave speed (metre/second, m/s) = frequency (hertz, Hz) × wavelength (metre, m)

$v = f \times \lambda$

wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s)

$v = x/t$

P4.7 Describe how to measure the velocity of sound in air and ripples on water surfaces.

P4.17 *Investigate the suitability of equipment to measure the speed/frequency/wavelength of a wave in a solid and a fluid.*

Maths requirements

1a Recognise and use expressions in decimal form.

1b Recognise and use expressions in standard form.

2a Use an appropriate number of significant figures.

2b Find arithmetic means.

3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~.

3b Change the subject of an equation.

3c Substitute numerical values into algebraic equations using appropriate units for physical quantities.

3d Solve simple algebraic equations.

Learning outcomes

6th **SP4.6** Recall the equation relating wave speed, frequency and wavelength

8th **SP4.6** Use the equation relating wave speed, frequency and wavelength.

6th **SP4.6** Recall the equation relating wave speed, distance and time.

8th **SP4.6** Use the equation relating wave speed, distance and time.

7th **SP4.7** Describe how to measure the velocity of sound in air.

7th **SP4.7** Describe how to measure the velocity of waves on the surface of water.

Exploring

1. Measuring waves in liquids and solids – Core practical

This practical forms part of the Core Practical requirement of the specification. It is supported by the information on *Students' sheet CP1(Investigating speed, frequency, wavelength of a wave in a solid and a liquid)* and in the Student Book. This practical is described in two parts on *Students' sheet CP1(Investigating speed, frequency, wavelength of a wave in a solid and a liquid)*.

Speed of waves on water: Each group needs a ripple tank. Students are asked to estimate the speed of a wave by measuring how far it travels in a certain time, and also to calculate it from measurements of frequency and wavelength. Note that the speed of a wave in water depends on the wavelength and the depth, so the results students obtain will depend on both the depth of water in their tank and the frequency they set. They should use digital cameras, if available, to help them with the measurements.

Measuring waves in a solid: The method uses the fact that a standing wave in a cylindrical object has a wavelength twice the length of the object, but students are not expected to recall this fact. The rod is suspended using rubber bands and hit on one end with a hammer. Use a smartphone frequency app to detect the highest frequency.

Support: Students may need help setting up the ripple tank.

Stretch: If different lengths of rod are available, students could repeat the measurements in a solid and compare their results for various lengths (there should be no difference), and/or look up the speed of sound in the materials used and compare their results with published data.

Expected results

To compare the appropriateness of the apparatus used for measuring waves in different materials.

Course resources

Phys Students' sheet CP2

Equipment

Speed of waves on water: ripple tank (ideally with beaches to prevent reflections), stopwatch, ruler, digital camera

Speed of sound in solid: 2 clamps and stands, 2 rubber bands, long metal rod (up to 1 m long), metre rule, hammer, smartphone with frequency app

Sample question

This example is taken from the sample assessment material, paper 1PH0/1H, Q1, parts (a) and b(i) and (ii). It is directly related to core practical 2. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

1 There are many different types of waves.

(a) Waves on the surface of water are transverse waves.

Sound waves are longitudinal waves.

Describe the difference between transverse waves and longitudinal waves.

(2)

....

....

....

....

Question number	Answer	Mark
1(a)	An answer that provides a description by making reference to: • transverse waves have oscillations perpendicular to direction of travel of the wave (1) • whereas longitudinal waves have oscillations in the same direction as the direction of travel of the wave (1)	**(2)**

Part (a) requires students to demonstrate knowledge and understanding of scientific ideas related to core practical 2.

(b) Figure 1 shows a ripple tank.

This is used to study the behaviour of water waves.

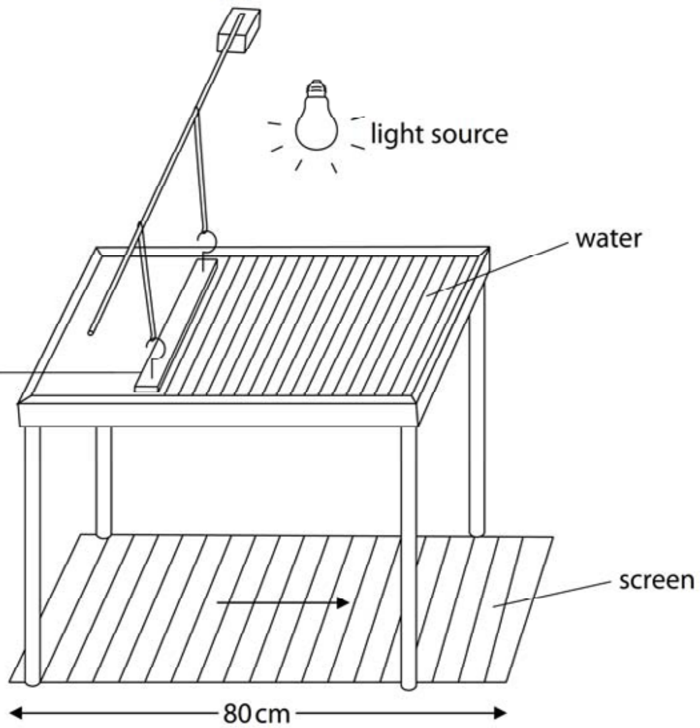


Figure 1

Water waves are produced in the tank.

The shadow of the waves is projected onto the screen below the tank.

The waves appear to move in the direction of the arrow.

(i) Describe how to determine the frequency of the waves.

(2)

Question number	Answer	Mark
1(b)(i)	An answer that combines the following points of understanding to provide a logical description: • take time T for waves to pass a fixed point (1) • and frequency = $\frac{\text{number of waves}}{\text{time taken}}$ (1)	**(2)**

(ii) The screen is 80 cm long.

What is the approximate wavelength of the waves as seen on the screen?

(1)

☐ **A** 4 cm

☐ **B** 8 cm

☐ **C** 40 cm

☐ **D** 80 cm

Question number	Answer	Mark
1(b)(ii)	A	**(1)**

Parts (b)(i) and (ii) require students to demonstrate knowledge and understanding of scientific techniques and procedures related to core practical 2.

Core practical 3: Investigating refraction

5.9 Core practical: Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter

Links to the specification content

4.9P	Describe the effects of a reflection b refraction c transmission d absorption of waves at material interfaces
4.10	Explain how waves will be refracted at a boundary in terms of the change of direction **and speed**
5.1P	Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle

Introducing the practical

This practical investigates the effect of changing medium on the path of a wave by looking at a light ray entering a glass (or clear plastic) block and tracing the ray as it passes through. Although the relationship between the angle of incidence and the angle of refraction can be treated graphically, recall of Snell's law or refractive index is not required.

Link to GCSE Science 2011: Unit P1, Topic 1, 1.10 'Recall that waves are reflected and refracted at boundaries between different materials'; 1.11 **'explain how waves will be refracted at a boundary in terms of the change of speed and direction'** Unit P3 Topic 1, 1.15 'Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle'.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why does a swimming pool appear to be less deep than it actually is?
- What do lenses do to light?
- What causes mirages?
- How can you produce a ray of light on a sheet of paper?

Skills that are covered in the practical:

- Producing and tracing rays (thin beams) of light using a ray box and a single slit.
- Accurate measurement of angles using a protractor
- Systematic recording of measurements

Maths skills:

- Graph plotting

Edexcel GCSE (9–1) **Sciences** **Phys CP3** **Investigating refraction**

Your teacher may watch to see if you can:

- measure angles accurately.

Aim

To investigate how light is affected when it travels from air into glass, or from glass into air.

Method

A Place a piece of plain paper on the desk. Set up the power supply, ray box and single slit so that you can shine a single ray of light across the paper on your desk.

B Place a rectangular glass block on the paper. Draw around the block.

C Shine a ray of light into your block. Use small crosses to mark where the rays of light go.

D Take the block off the paper. Use a ruler to join the crosses and show the path of the light. Then extend the line to meet the outline of the block. Join the points where the light entered and left the block to show where the light travelled inside the block.

E Measure the **angle of incidence** (*i*) and **angle of refraction** (*r*) where the light entered the block, and measure the angles where the light left the block.

F Repeat steps **C**–**E** with the ray entering the block at various different angles.

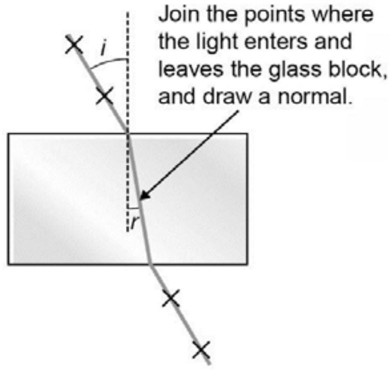
G Move the ray box so that the light ray reaches the **interface** at right angles. Note what happens to the light as it enters and leaves the block.

Apparatus

- ray box with single slit
- power supply
- rectangular glass block
- ruler
- protractor
- plain paper

⚠ Safety

The ray box may get hot enough to burn you, so take care.



Recording your results

1 Draw a table like this to record your results.

Air to glass (light entering the block)		Glass to air (light leaving the block)	
i	***r***	***i***	***r***

2 Draw a scatter graph to show your results. Put the angle of incidence (*i*) on the horizontal axis. Plot the air to glass points and draw a smooth curve of best fit. Repeat for the glass to air points on the same set of axes.

Considering your results/conclusions

3 Describe the results shown by your graph and your table of results.

4 How does the direction of the ray of light leaving the glass block compare with that of the ray entering the block?

5 Write a conclusion for your investigation.

Evaluation

6 How accurate were your measurements? Is there any way you could improve your measurements?

Edexcel GCSE (9–1)
Sciences Phys CP3 Ray diagrams

Objectives

SP5.1P Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle.

SP5.9 *Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter.*

Maths requirements

2g Use a scatter diagram to identify a correlation between two variables.

4c Plot two variables from experimental or other data.

5a Use angular measures in degrees.

5b Visualise and represent 2D and 3D forms, including two dimensional representations of 3D objects.

Learning outcomes

3rd **SP5.1P** Recall the law of reflection.

5th **SP5.1P** Draw ray diagrams to show how a mirror forms images.

6th **SP5.1P** Draw ray diagrams to show what happens when light is refracted.

6th **SP5.1P** Describe what total internal reflection is and when it happens.

7th **SP5.1P** Explain the significance of the critical angle in total internal reflection.

Edexcel GCSE (9–1) Sciences **Phys CP3** **Investigating total internal reflection**

Your teacher may watch to see if you can:

- make careful measurements.

Introduction

Light leaving transparent materials at certain angles can be **reflected** within the material. The angle at which this starts to happen is called the **critical angle**.

Aim

To determine the critical angle for different materials.

Method

A Place one of the semi-circular blocks on the piece of paper and draw around it. Remove the block and measure the straight edge. Draw a line at right angles to the centre of the straight edge on the paper. This line is the **normal**.

B Put the block back on the paper and aim a ray of light through the curved edge of the block towards the centre of the straight edge, as shown in the diagram. You may need to use a lens with your ray box to obtain a narrow ray.

C Move the ray box around, still aiming at the same point, until the ray of light emerging from the straight edge lies along the edge. Mark two crosses along the path of the light ray going into the block.

D Remove the block and draw a line through your marked points to the centre of the straight edge. The angle between this line and the normal is the **angle of incidence** of the light within the block. When the ray of light emerging from the block lies along the straight edge, the angle of incidence is the **critical angle** for the material.

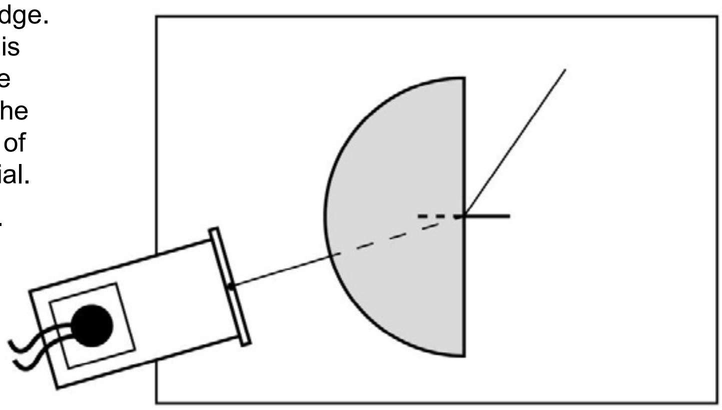
E Repeat steps **B** and **D** with the other blocks.

Apparatus

- ray box, lens and slit
- low voltage power supply
- protractor
- semi-circular blocks made of glass and other transparent materials
- plain paper
- ruler

⚠ Safety

The ray box may get hot enough to burn you, take care!



Recording your results

1 Record your results in a table, including the name of each material and its critical angle.

Evaluation

2 How accurate do you think your measured critical angles are? Explain your answer.

3 Explain why a semi-circular block is used in this investigation rather than a rectangular block. (*Hint:* think about the angle at which the ray of light goes into the block.)

Exploring

1. Investigating refraction

This practical forms part of the core practical requirement of the specification. See Students' sheet CP3(Investigating refraction in rectangular glass block) for a full method for this practical.

Support: Help students with the measuring of angles by providing them with a printed protractor that they can put their blocks on; these are widely available on the Internet. Use one with 0 in the centre, to ensure students measure their angles from the normal.

Stretch: Ask students to investigate refraction in glass blocks of different shapes or in different materials.

Expected results

Both sets of results should produce smooth curves on a scatter graph, with the angle of refraction less than the angle of incidence for light going from air to glass, and the angle of refraction greater than the angle of incidence for light going from glass to air. The ray emerging from the block should be parallel to the ray entering the block.

⚠ Safety

Warn students that the ray boxes can become very hot.

Course resources

Phys students' sheet CP3

Equipment

ray box and slit, low voltage power supply, protractor, rectangular glass block, plain paper, ruler

Sample question

This example is taken from the sample assessment material, paper 1PH0/1F, Q4, part (a). Although this is not about core practical 3 directly, the commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

4 A student investigates how light behaves as it leaves a clear plastic block.

Figure 4 shows some of her equipment and the path of a ray of light through the block.

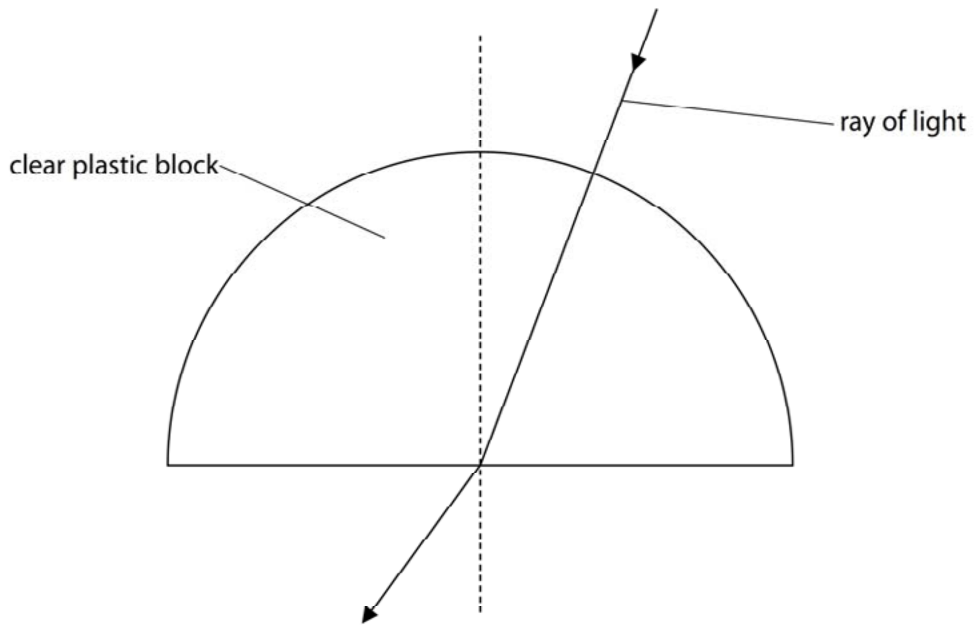


Figure 4

(a) Describe how the student can make sure the light does not change direction as it enters the block.

(2)

....

....

....

....

Question number	Answer	Additional guidance	Mark
4(a)	An answer that combines the following points of understanding to provide a logical description: • shine the light along a radius (1) • by marking it on the paper before putting the block down (1)	allow shine the ray at the centre of the straight edge before putting the block down	**(2)**

Part (a) requires students to demonstrate knowledge and understanding of scientific techniques and procedures similar to those used in core practical 2.

Core practical 4: Investigating thermal energy

5.19P Core practical: Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed

Links to the specification content

5.15P	Explain that all bodies emit radiation, that the intensity and wavelength distribution of any emission depends on their temperature
5.16P	**Explain that for a body to be at a constant temperature it needs to radiate the same average power that it absorbs**

Introducing the practical

This investigation is a good opportunity to demonstrate the need for controlling variables. In this case, the only difference between vessels used as radiators (or absorbers) should be the nature of the surfaces concerned. All other factors should be the same. It also provides an opportunity to use dataloggers and temperature sensors, producing real-time graphs.

Link to GCSE Science 2011: Unit P1, Topic 6, 6.6 'Demonstrate an understanding that for a system to be at a constant temperature it needs to radiate the same average power that it absorbs.'; 6.7 'Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed'.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why are buildings in hot countries often painted white?
- Why are the surfaces of solar water heaters often painted black?
- To test the effect of the nature of the surface for several absorbers or radiators, what other factors do you have to control?

Skills that are covered in the practical:

- Controlling variables
- Measuring temperature
- Systematic recording of measurements

Maths skills:

- Plotting temperature-time graphs.

Edexcel GCSE (9–1) **Sciences** **Phys CP4** **Investigating radiation**

Your teacher may watch to see if you can:

- take careful measurements
- present your results as a line graph.

Aim

You are going to investigate the effect of different coloured surfaces on the amount of energy transferred by radiation from a boiling tube of hot water.

Method

A Cover four boiling tubes in different coloured materials. Try to use the same type of material (e.g. paper) for each tube, and the same thickness. Fasten the materials in place with sticky tape.

B Use the measuring cylinder to help you to pour the same volume of hot, but not boiling, water from a kettle into each tube.

C Measure the temperature of the water in each tube and start a stop clock.

D Record the temperature of the water in each tube every two minutes for 20 minutes.

Apparatus

- four boiling tubes
- test tube rack
- measuring cylinder
- four thermometers
- stop clock
- insulating materials
- sticky tape
- hot water

Recording your results

1 Draw a table like this to record your results.

Time (min)	Temperature (°C)			
	Tube 1	Tube 2	Tube 3	Tube 4
0				
2				

2 Draw a line graph to present your results. Time should go on the horizontal axis. Plot all four sets of results on the same axes and join each set of points with a smooth curve.

Considering your results/conclusions

3 Describe what your graph shows about the rate of cooling of the water in each tube.

4 Which colour is best at emitting radiation? Which is the worst? Explain your conclusion.

Evaluation

5 How well do your results support your conclusion? Your answer should refer to your graph.

6 Can you draw a general conclusion from your results (such as that light colours emit more radiation than dark colours)? Explain your answer.

Objectives

SP5.15P	Explain that all bodies emit radiation, that the intensity and wavelength distribution of any emission depends on their temperature.
SP5.16P	H Explain that for a body to be at a constant temperature it needs to radiate the same average power that it absorbs.
SP5.17P	H Explain what happens to a body if the average power it radiates is less or more than the average power that it absorbs.
SP5.18P	H Explain how the temperature of the Earth is affected by factors controlling the balance between incoming radiation and radiation emitted.
SP5.19P	*Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed.*

Maths requirements

4c	Plot two variables from experimental or other data.

Learning outcomes

6th	SP5.15P	Describe how the intensity and wavelength of emitted radiation depends on the temperature of the body.
6th	SP5.16P	H Explain that the power radiated and absorbed must be the same to maintain a body at a constant temperature.
6th	SP5.17P	H Explain what happens to the temperature of a body when the average power radiated is not balanced by the average power absorbed.
6th	SP5.18P	H Describe the factors that affect the energy absorbed and radiated by the Earth.
8th	SP5.18P	H Explain how these factors affect the temperature of the Earth.

Edexcel GCSE (9–1) Sciences

Phys CP4 A model swimming pool

Your teacher may watch to see if you can:

- make accurate readings and record them clearly.

Introduction

You are going to use a laboratory water bath as a model for the control of water temperature in a public swimming pool. The pool should be maintained at a constant temperature for the comfort of swimmers. A laboratory water bath has a water heater, just like a swimming pool.

Prediction

1 Explain how you think the temperature of the water in the water bath will change if it is left on.

Apparatus

- clamp and stand
- stop clock
- thermometer
- water bath
- ruler

Method

A Set up your thermometer in the water bath, using a clamp and stand. If another group is using the same water bath, then it will be more interesting to compare the results if you position your thermometers at different depths. Measure the depth of the thermometer bulb under the water.

B Measure the starting temperature as you start your stop clock.

C Every 30 seconds, record the temperature of the water bath. Do not adjust the control settings on the water bath, but continue taking readings even if your teacher changes the controls. If your teacher *does* adjust the controls, note down the times at which this happened and how the control was changed.

D Your teacher may ask you to repeat the experiment using a different water bath.

Recording your results

2 Draw a table to record the temperature measurements.

Considering your results/conclusions

3 Plot a line graph showing how the temperature changed during the time for which you measured it. Time should be on the *x*-axis and temperature on the *y*-axis.

4 Describe how the temperature changes (or stays the same) over the time you measured it. Are there any big changes in temperature? Explain why you think the temperature behaved as it did.

5 Explain the transfer of energy (energy inputs and outputs) in each of the following situations.

a Water bath temperature remains constant.

b Water bath temperature is going up.

c Water bath temperature is falling.

Exploring

1. Investigating radiation

This practical forms part of the core practical requirement of the specification. It is supported by the information on *Students' sheet CP4(Investigating amount of thermal energy radiated or absorbed)* and in the Student Book.

Students' sheet CP4(Investigating amount of thermal energy radiated or absorbed) provides instructions for students to investigate the effect of different coloured coverings on the cooling rates of boiling tubes of hot water.

Support: Help students to draw the axes for their graphs and plot the points.

Stretch: Ask students to design a similar investigation to find out which colours are best at absorbing radiation. They could do this by aiming a heat lamp at their tubes or by standing them in strong sunshine. If time permits, students could carry out this investigation.

Expected results

Tubes covered in dark, dull material should cool down faster than tubes covered in light and/or shiny materials.

Expected results

Students should find that the water in the water bath maintains a constant temperature, because there is a balance between the rate at which heat arrives and the rate at which it leaves (the thermostat has a feedback mechanism to boost the heater if the temperature starts to fall). If the setting is adjusted (first turned up and then turned down), the temperature first rises to reach a new steady level then falls to reach a new steady level

Safety

Take care with high temperature settings on the water bath. Spilled water is a slip hazard.

Course resources

Phys Students' sheet CP4

Equipment

water baths with electrical thermostatic controls, retort stand and clamp holding thermometer, stop clocks

Sample question

This example is taken from the sample assessment material, paper 1PH0/1F, Q6, part (a). Although this is not about core practical 4 directly, the commentary below outlines how the knowledge and understanding students will have gained by carrying out the practical may be shown in the final exams.

6 (a) A student investigates how the surface of an object affects the radiation it emits.

Figure 7 shows the equipment he uses.

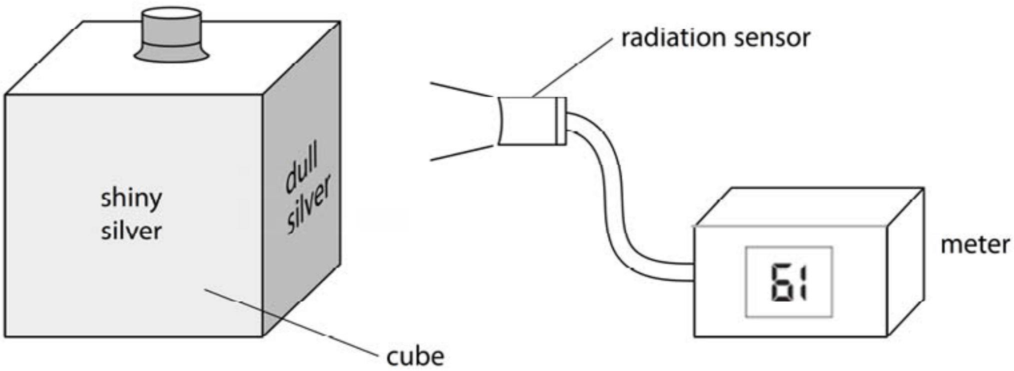


Figure 7

The cube has four different surfaces.

He fills the cube with boiling water so that the temperature of each surface is the same.

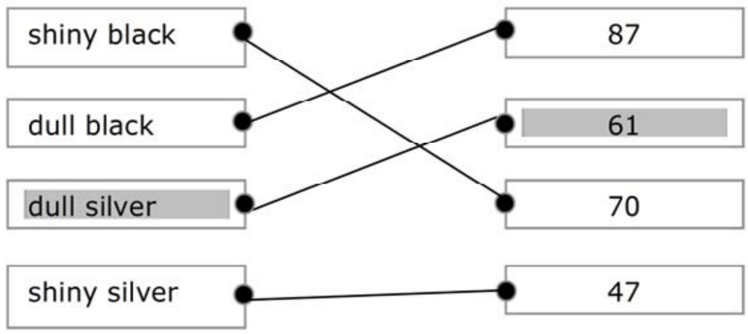
He uses the radiation sensor to measure the radiation emitted from each surface.

(i) His readings are shown.

Draw a line from each surface colour to its correct meter reading.
One has been done for you.

(2)

surface colour	meter reading
shiny black	87
dull black	61
dull silver	70
shiny silver	47

Question number	Answer	Mark
6(a)(i)	All three correct (2) One or two correct (1) 	**(2)**

(ii) The temperature of each surface is the same.

Give a reason why the radiation sensor gives a different reading for each surface.

(1)

Question number	Answer	Additional guidance	Mark
6(a)(ii)	Different surfaces emit (thermal) radiation at different rates	allow reference to surfaces in question	**(1)**

Parts (a)(i) and (ii) require students to apply their knowledge and understanding of scientific ideas gained from core practical in this new situation.

Core practical 5: Investigating resistance

10.17 Core practical: Construct electrical circuits to:

a *investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp*

b *test series and parallel circuits using resistors and filament lamps*

Links to the specification content

10.2	Draw and use electric circuit diagrams representing them with the conventions of positive and negative terminals, and the symbols that represent cells, including batteries, switches, voltmeters, ammeters, resistors, variable resistors, lamps, motors, diodes, thermistors, LDRs and LEDs
10.3	Describe the differences between series and parallel circuits
10.4	Recall that a voltmeter is connected in parallel with a component to measure the potential difference (voltage), in volt, across it
10.7	Recall that an ammeter is connected in series with a component to measure the current, in amp, in the component
10.11	Recall that current is conserved at a junction in a circuit
10.13	Recall and use the equation:
	potential difference (volt, V) = current (ampere, A) × resistance (ohm, Ω)
	$V = I \times R$
10.14	Explain why, if two resistors are in series, the net resistance is increased, whereas with two in parallel the net resistance is decreased
10.15	Calculate the currents, potential differences and resistances in series circuits
10.16	Explain the design and construction of series circuits for testing and measuring
10.18	Explain how current varies with potential difference for the following devices and how this relates to resistance
	a filament lamps
	c fixed resistors
10.21	Explain how the design and use of circuits can be used to explore the variation of resistance in the following devices
	a filament lamps

Introducing the practical

These investigations build on Key Stage 3 work on circuits. The work is more quantitative and will give students direct experience as they develop their understanding of difficult concepts such as potential difference

Link to GCSE Science 2011: 'Controlling and using electric current' is Unit P2 topic P2.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What are the circuit symbols for the following components?
  battery, switch, resistor, variable resistor, filament lamp, ammeter, voltmeter
- How is an ammeter connected into a circuit?
- How is a voltmeter connected into circuit?
- How could you vary the current and potential difference in a circuit?

Skills that are covered in the practical:

- Constructing electrical circuits
- Varying the current and potential difference in an electrical circuit
- Reading ammeters and voltmeters

Maths skills:

- Substituting measured values into the equation relating potential difference, current and resistance
- Changing the subject of an equation
- Plotting graphs of current against potential difference
- Drawing best fit straight lines
- Drawing smooth curves
- Interpreting graphs (straight lines and curves)

Phys CP5 Investigating resistance

Your teacher may watch to see if you can:

- follow safety instructions to work safely
- make accurate measurements.

Aim

To investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp.

Method

- power supply
- ammeter
- connecting wires
- 2 crocodile clips
- voltmeter
- resistor
- 2 filament lamps

Safety

Never use mains electricity for practical work with circuits.

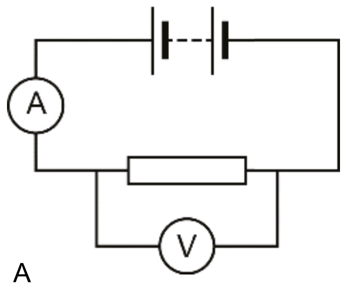
Ask your teacher to check your circuit before you switch it on.

A Connect the circuit shown in diagram A.

B Set the power pack to a potential difference of 1 V and switch on. Record the readings on the ammeter and voltmeter in a table and then switch off.

C Repeat step B for settings on the power pack of 2 V, 3 V, 4 V, 5 V and 6 V.

D Replace the resistor in circuit A with a filament lamp. Repeat steps B and C.



A

Recording your results

1 Record your results in two neat tables (one for the resistor and one for the filament lamp).

Considering your results/conclusions

2 Plot a scatter graph of your results. Plot the independent variable (potential difference) on the *x*-axis and the dependent variable (current) on the *y*-axis. Use the same axes for both the resistor and the filament lamp. Draw lines or curves of best fit through your points.

3 **a** Calculate the resistance of the resistor when the potential difference is 1 V and when it is 6 V.

b Calculate the resistance of the filament lamp when the potential difference is 1 V and when it is 6 V.

c Draw a conclusion about how the resistance of the two components changes with increasing potential difference.

d Use evidence from your graph and your calculations to explain how you came to your conclusion.

Evaluation

4 **a** For your graph for the resistor, how close were your points to the line of best fit?

b What does this tell you about the quality of data you have gathered?

5 How reproducible were your results? (Compare your results with those of other groups.)

Edexcel GCSE (9–1) **Sciences**

Phys CP5 Investigating resistance

Your teacher may watch to see if you can:

- follow safety instructions to work safely
- make accurate measurements.

Aim

To test series and parallel circuits using resistors and filament lamps.

Prediction

6 Look at circuits **B** and **C** below. Explain how you think the readings will compare in the two circuits for:

a the ammeters

b the voltmeters.

Method

Apparatus

- power supply
- 3 voltmeters
- 3 ammeters
- connecting wires
- 2 crocodile clips
- 2 filament lamps

Safety

Never use mains electricity for practical work with circuits.

Get your teacher to check your circuit before you switch it on.

E Connect the circuit shown in diagram **B**.

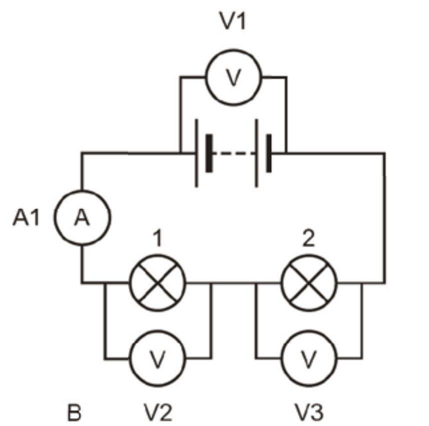
F Set the power pack to 1 V and switch on. Record the readings on the ammeter and the voltmeters and then switch off.

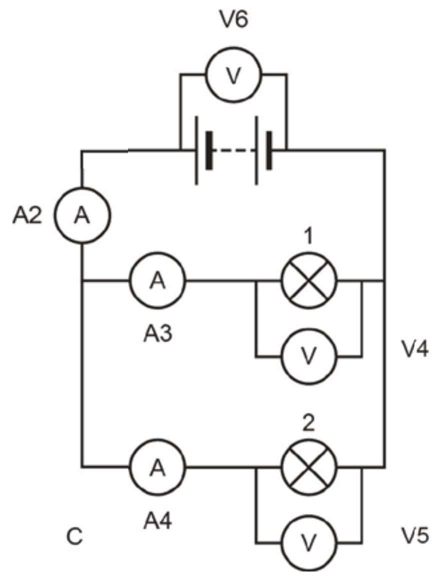
G Repeat step F for settings on the power pack of 2 V, 3 V, 4 V, 5 V and 6 V.

H Now set up the circuit shown in diagram **C**.

I Set the power pack to 1 V and switch on. Record the readings on the ammeters and the voltmeters and then switch off.

J Repeat step I for settings on the power pack of 2 V, 3 V, 4 V, 5 V and 6 V.





Recording your results

7 Record your results in two neat tables (one for the series circuit and one for the parallel circuit).

Considering your results/conclusions

8 **a** Compare the current through the two filament lamps when they are connected in series and when they are connected in parallel.

b Compare the potential difference across two filament lamps when they are connected in series and in parallel.

9 Does changing the potential difference across each circuit affect how these values compare?

Evaluation

10 Suggest what the answer would be to question **9** if fixed resistors replaced the lamps in the two circuits.

Edexcel GCSE (9–1) **Sciences** **Phys CP5** **Investigating resistance**

Name ______________________ **Class** __________ **Date** ____________

Investigating resistance – page 1

Recording your results

1 Record your results for circuit **A** in the table below.

Potential difference (V)	**Current (A)**	
	Resistor	**Filament lamp**
0	0	0
1		
2		
3		
4		
5		
6		

Considering your results/conclusions

3 You can calculate the resistance from the potential difference and the current, using the equation on the right.

$$\text{resistance } (\Omega) = \frac{\text{potential difference (V)}}{\text{current (A)}}$$

Investigating resistance – page 2

Recording your results

7 Record your results for circuits **B** and **C** in the table below.

Potential difference (volts)	**Circuit B (lamps in series) ammeter (A) and voltmeter (V) readings**				**Circuit C (lamps in parallel) ammeter (A) and voltmeter (V) readings**					
	A1	**V1**	**V2**	**V3**	**A2**	**A3**	**A4**	**V4**	**V5**	**V6**
0	0	0	0	0	0	0	0	0	0	0
1										
2										
3										
4										
5										
6										

The fixed resistor

1 This table shows the results of an experiment to measure the current and potential difference for a fixed resistor. The negative values for potential difference and current are when they are in the opposite direction.

Potential difference (V)	Current (A)
−6.00	−0.24
−4.00	−0.16
−2.00	−0.08
0.00	0.00
2.00	0.08
4.00	0.16
6.00	0.24

a Plot a scatter graph (scatter diagram) of current against potential difference. Draw a line of best fit through the points.

b Describe the shape of your graph.

c Calculate two values of R for this resistor using $V = I \times R$ and two pairs of values in the table.

d What is the relationship between the current and the potential difference for a fixed resistor?

The filament lamp

2 This table shows the result of an experiment to measure the current and potential difference for a filament lamp.

Potential difference (V)	Current (A)
0.00	0.00
2.00	0.38
4.00	0.64
6.00	0.83
8.00	0.98
10.00	1.10
12.00	1.18
14.00	1.24

a Plot a scatter graph of current against potential difference.

b Describe the shape of your graph.

c How can you tell from your graph that the resistance increases as the potential difference increases?

The diode

3 This table shows the result of an experiment to measure the current and potential difference for a **diode**. The negative values for potential difference and current are when they are in the opposite direction.

Potential difference (V)	Current (mA)
−0.2	0.00
0.00	0.00
0.2	0.00
0.5	1.0
0.6	2.0
0.7	4.0
0.8	10.0
0.9	20.0

a What does mA stand for?

b Plot a line graph of current against potential difference.

c Describe the shape of your graph. Use the word ‘gradient’ in your answer.

d How can you tell that the diode only conducts in one direction?

Edexcel GCSE (9–1) **Sciences** **Phys CP5** **More about resistance**

Objectives

P10.2 Draw and use electric circuit diagrams […] and the symbols that represent cells, including batteries, switches, voltmeters, ammeters, resistors, variable resistors, lamps, motors, diodes, thermistors, LDRs and LEDs.

P10.17 *Construct electrical circuits to:*

- **a** *investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp*
- **b** *test series and parallel circuits using resistors and filament lamps.*

P10.18 Explain how current varies with potential difference for the following devices and how this relates to resistance:

- **a** filament lamps
- **b** diodes
- **c** fixed resistors.

P10.19 Describe how the resistance of a light-dependent resistor (LDR) varies with light intensity.

P10.20 Describe how the resistance of a thermistor varies with change of temperature (negative temperature coefficient thermistors only).

P10.21 Explain how the design and use of circuits can be used to explore the variation of resistance in the following devices:

- **a** filament lamps
- **b** diodes
- **c** thermistors
- **d** LDRs.

Maths requirements

1b Recognise and use expressions in standard form.

2g Use a scatter diagram to identify a correlation between two variables.

3b Change the subject of an equation.

3c Substitute numerical values into algebraic equations using appropriate units for physical quantities.

4a Translate information between graphical and numeric form.

4c Plot two variables from experimental or other data.

4d Determine the slope and intercept of a linear graph.

Learning outcomes

6th **SP10.18** Explain how current changes with potential difference in fixed resistors.

6th **SP10.18** Explain how current and resistance change with potential difference in filament lamps.

6th **SP10.18** Explain how current and resistance change with potential difference in diodes, including light-emitting diodes (LEDs).

6th **SP10.19** Describe how the resistance of a light-dependent resistor (LDR) varies with changing light intensity.

6th **SP10.20** Describe how the resistance of a thermistor varies with changing temperature. (negative temperature coefficient only)

5th **SP10.21** Describe the uses of diodes, LDRs and thermistors.

Exploring

1. Core practical – Investigating resistance

This practical forms part of the core practical requirement of the specification and is supported by *SP10e Core Practical - Investigating resistance* in the Student Book. See Worksheet SP10e.1 for full instructions.

The worksheet is divided into three parts. The first page provides practical instructions for an investigation into the effect of changing the potential difference on the current in a resistor, and then a filament lamp. There are some directed questions at the bottom of the sheet to help students write a conclusion for the investigation. The second page of the worksheet provides practical instructions for students to investigate the current and the potential difference in filament lamps when they are connected in series and then in parallel. Again, there are some directed questions at the bottom of the page. The final page contains help (including pre-drawn results tables) for less confident students.

The practical work can be divided up over several lessons or students could be divided into groups and each group could be asked to carry out one of the four investigations. If there are insufficient ammeters and voltmeters, students can work in larger groups. More able groups can be given just one ammeter and one voltmeter and could move them between the positions shown in the circuit diagrams. This is not recommended for less confident students.

⚠ Safety

Ensure that students understand to use the low voltage power packs and do not use mains electricity. Make sure they do not use a voltage that is too high for the equipment they are using.

Support: Give students the third page of the worksheet (as well as pages 1 and/or 2). This third page provides tables that students can use to record their results. The page also contains support for the calculation of resistance using the readings for potential difference and current.

Stretch: Students should also carry out the practical on the second worksheet with resistors as well as filament lamps. Consider removing the directed questions from the bottoms of the two method sheets and asking students to write up their own work (with help from appropriate Skills Sheets as needed).

Expected results

Students' graphs of current against potential difference should show a straight line through the origin for the resistor, although a curve may result if the wires get hot. There will be a curve for the filament lamp because resistance increases with increasing potential difference and so the current decreases.

Theoretically Kirchoffs's laws will result from the series and parallel circuits investigation, but in practice, poor connections and non-identical lamps can cause problems. In series, the potential difference across each lamp should be the same and half of the total potential difference. In parallel, the two ammeter readings for the currents through individual lamps should be the same and half of the total. However, voltage should be the same throughout the circuit.

Course resources

Phys Students' sheet CP5

Equipment:

Investigating resistance:

Power supply; ammeter; voltmete; resistor; connecting wires; 2 crocodile clips; 2 filament lamps; graph paper

Filament lamps in series and parallel:

Power supply; 3 ammeters; 3 voltmeters; connecting wires; crocodile clips; 2 filament lamps; graph paper
Optional: 2 fixed resistors

2. Resistance in fixed resistors, filament lamps and diodes

Worksheet SP10e.2 has data for plotting graphs of current against potential difference for a fixed resistor, a filament lamp and a diode. The graphs are in order of increasing difficulty, so you may wish to allocate students to a particular graph, depending on ability. Alternatively, students could work in groups to discuss the choice of scales, work individually to plot the graphs, and then compare their graphs and discuss the questions.

Discuss as a class how the resistance of the devices changes with potential difference. Remind students of their work in the previous topic and show that (for the fixed resistor) the current doubles when potential difference doubles. Remind students that this is a directly proportional relationship.

Support: Discuss suitable scales, or provide graph paper with scales already marked.
Resistor: *y*-axis: ±0.3 A, 1 large square = 0.1 A; *x*-axis: ±6 V, 1 large square = 2 V.
Filament lamp: *y*-axis: 0 to 1.3 or 1.4 A, 1 large square = 0.2 A; *x*-axis: 0 to 14 V, 1 large square = 2 V.
Diode: *y*-axis: 0 to 20 mA, 1 large square = 0.4 mA; *x*-axis: −0.2 to 0.9 or 1.0 V, 1 large square = 0.2 V.

Stretch: After students have plotted the diode graph ask them to discuss what happens to the resistance as the potential difference changes. In particular, ask what happens when the potential difference is reversed (high resistance when it is negative and low resistance when it is positive) and what happens when the potential difference increases (there is a small positive potential difference required before the diode will conduct, but then it has very low resistance and current increases rapidly, which also means that the diode can overheat and be damaged). Ask students to identify the relationship as a linear relationship.

For the fixed resistor graph, ask students to calculate the gradient of the line. As an extension for the most able ask them to calculate 1/gradient and show that it is the resistance, or alternatively to plot a graph of voltage against current and calculate the gradient – showing that it is equal to resistance.

Equipment

graph paper, calculators

Course resources AAP:

Phys Students' sheet CP5

Sample question

This example is taken from the sample assessment material, paper 1PH0/2H, Q3. It is not directly related to core practical 5 as it tests a thermistor, but the circuit used is similar. The commentary below outlines how the skills students will have gained by carrying out core practical 5 may be shown in the final exams.

3 A student investigates how the resistance of a thermistor varies with temperature.

(a) The student sets up the circuit shown in Figure 5 to measure current and voltage.

He finds that it does not work.

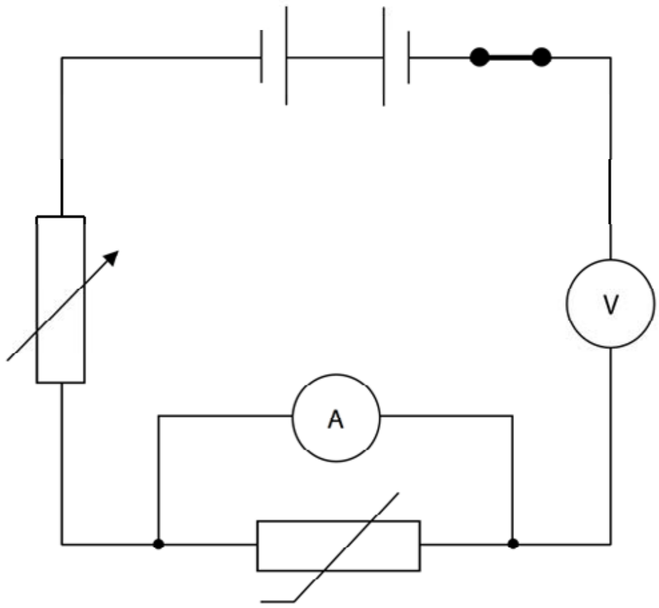


Figure 5

Give **three** modifications the student should make to the circuit so that the circuit works correctly.

(3)

1 ....

....

2 ....

....

3 ....

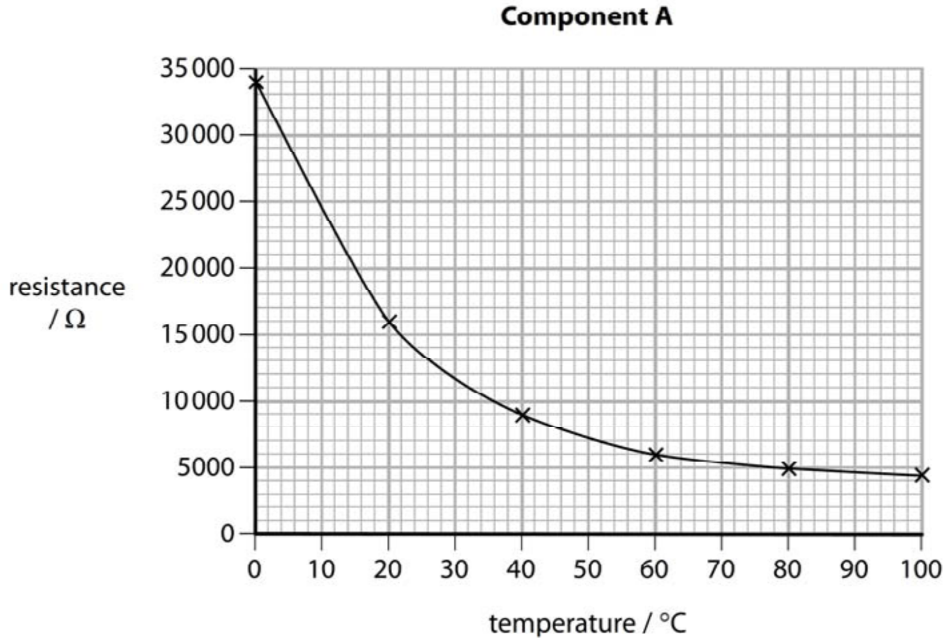
....

Question number	Answer	Additional guidance	Mark
3(a)	• connect ammeter in series (with thermistor) (1) • connect voltmeter in parallel (with thermistor) (1) • reverse (connections for) one of the cells (1)	allow idea that meters should be swapped for two marks (equivalent to first two points)	**(3)**

Part (a) requires students to demonstrate knowledge and understanding of scientific techniques and procedures to do with constructing circuits that they will have used in core practical 5.

(c) The student takes measurements for two other components, **A** and **B**.

The results for both these components are shown in Figure 7.



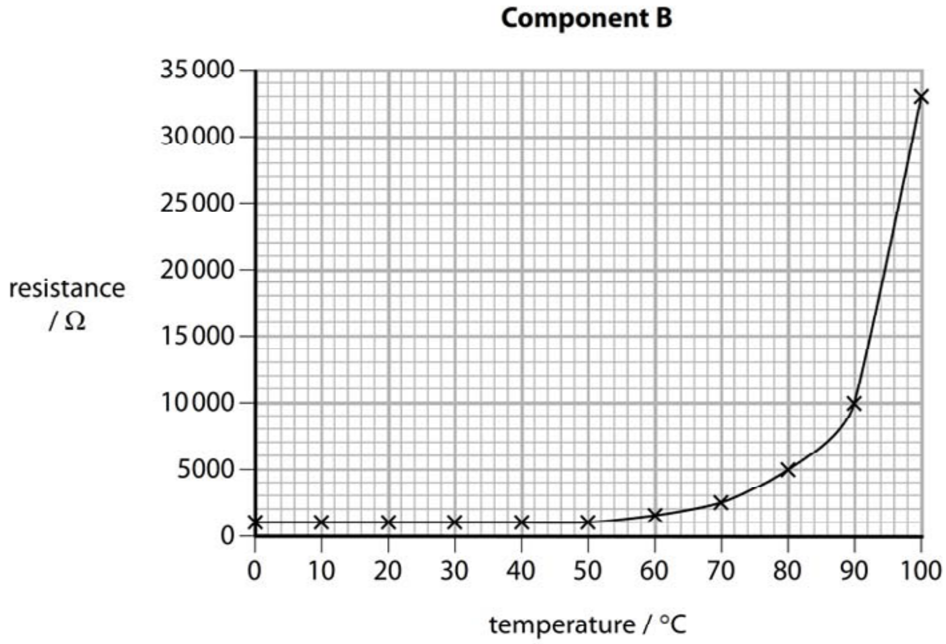


Figure 7

(i) Compare and contrast how the resistances of component **A** and component **B** vary with temperature.

(3)

Question number	Answer	Additional guidance	Mark
3(c)(i)	A comparison and contrast that must include at least **one** similarity and **one** difference from the following points to a maximum of three marks: Similarities • resistance of both changes with temperature (1) • both graphs show a non-linear relationship (1) • data comparison, e.g. both have the same resistance at 80°C (1)		**(3)**

Part (c)(i) requires students to analyse, interpret and evaluate information from the graphs to compare the two components.

Core practical 6: Investigating densities

14.3 Core practical: Investigate the densities of solid and liquids

Links to the specification content

14.2	Recall and use the equation: density (kilogram per cubic metre, kg/m^3) = mass (kilogram, kg) ÷ volume (cubic metre, m^3) $\rho = \frac{m}{V}$
14.4	Explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules

Introducing the practical

These are straightforward investigations that provide a starting point for more complex work on pressure and upthrust in fluids. They also present opportunities to practice using balances and measuring cylinders.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Think of examples of heavy objects that float on water.
- Think of some light objects that sink in water.
- Is the mass of an object the only factor that determines whether or not it will float on water?

Skills that are covered in the practical:

- Using a balance
- Using a measuring cylinder
- Using a displacement can

Maths skills:

- Substituting measured values into the equation relating density, mass and volume
- Changing the subject of an equation
- Calculating volume
- Changing units between kg/m^3 and g/cm^3

Your teacher may watch to see if you can:

- take careful measurements.

Aim

To compare the densities of different liquids and solids.

Densities of solids

Method

A Find the mass of a solid. Write the name of the material and the mass of the object in a table.

B Stand a displacement can on the bench with its spout over a bowl. Fill the can with water until the water just starts to come out of the spout.

C Hold a measuring cylinder under the spout and carefully drop your object into the can.

D If your object floats, carefully push it down until all of it is under the water. Your finger should not be in the water.

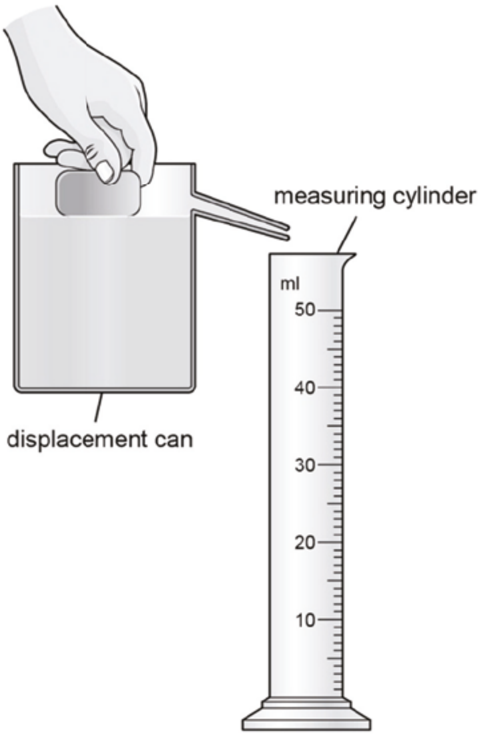
E Stand the measuring cylinder on the bench and read the volume of water you have collected. This is the same as the volume of your object. Write the volume down.

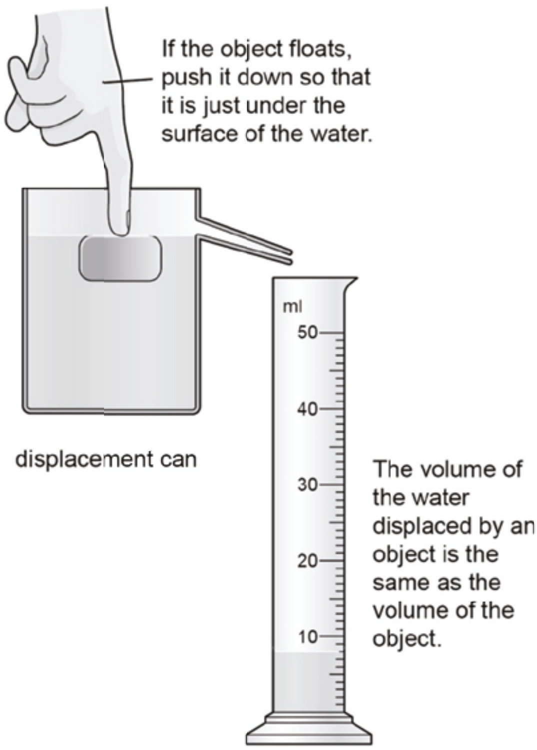
Apparatus

- balance
- displacement can
- measuring cylinder
- bowl
- solids

⚠ Safety

Mop up any spills straight away.





Recording your results

1 Draw a table like this for your results.

Material	Mass (g)	Volume (cm^3)	Density (g/cm^3)

2 Calculate the **density** of each solid and write it in the table. The equation you need is:

$$\text{density (g/cm}^3) = \frac{\text{mass (g)}}{\text{volume (cm}^3)}$$

Densities of liquids

Method

F Put an empty beaker on a balance and zero the balance.

G Use a measuring cylinder to measure 50 cm^3 of a liquid and pour it into the beaker. Write down the name of the liquid and the reading on the balance. This is the mass of 50 cm^3 of the liquid.

Apparatus
- balance
- measuring cylinder
- beaker
- liquids

Safety
Mop up any spills straight away.

Recording your results

3 Draw a table like this for your results.

Liquid	Mass of 50 cm^3 (g)	Density (g/cm^3)

4 Calculate the density of each liquid and write it in the table. The equation you need is:

$$\text{density } (g/cm^3) = \frac{\text{mass } (g)}{\text{volume } (cm^3)}$$

Considering your results/conclusions

5 **a** What is the range of densities for the solids you measured?

b What is the range of densities for the liquids?

6 Compare the densities of the solids and liquids that you tested.

Edexcel GCSE (9–1) Sciences **Phys CP6** Changing density

Aim

To observe how heating can change the **density** of a liquid.

Method – thermometers

Apparatus
- beaker of hot water
- thermometer

A Record the temperature shown on the thermometer. This is room temperature.

B Stand the thermometer in the beaker of hot water and note what happens to the liquid in the thermometer.

C When the liquid in the thermometer stops moving, record the temperature again.

Recording your results

1 Write down the room temperature and the temperature of the hot water.

2 What happened to the volume of the liquid in the thermometer when you put the thermometer in the hot water? Explain your answer.

Considering your results/conclusions

3 The volume of the liquid in the thermometer changed when it was heated. Explain what happened to the mass of the liquid inside the thermometer.

4 Explain what the change in volume of the liquid tells you about:

  a how the spacing of the particles in the liquid changed

  b how the density of the liquid changed.

Edexcel GCSE (9–1) Sciences **Phys CP6** Changing density

Aim

To observe how heating can change the density of a solid.

Method – bimetallic strip

Apparatus
- Bunsen burner
- heat resistant mat
- bimetallic strip

A Note down the shape of the bimetallic strip.

B Hold the handle of the bimetallic strip and gently heat the flat part with the Bunsen burner. Note what happens to it.

Recording your results

1 What shape was the bimetallic strip before you heated it?

2 What happened to the bimetallic strip when it was heated?

Considering your results/conclusions

3 A bimetallic strip is made of two different metals stuck together. The metals expand by different amounts. Which of the two metals expands the most for a certain increase in temperature – the one on the inside of the curve or the one on the outside?

4 a Does the density of the two metals change when they are heated? If so, does it increase or decrease? Explain your answers.

  b For which of the two metals is the change in density the greatest? Explain your answer.

Edexcel GCSE (9–1) Sciences

Phys CP6 Particles and density

Objectives

P14.1 Use a simple kinetic theory model to explain the different states of matter (solids, liquids and gases) in terms of the movement and arrangement of particles.

P14.2 Recall and use the equation: density (kilograms per cubic metre, kg/m^3) = mass (kilograms, kg) / volume (cubic metres, m^3).
$\rho = m/V$

P14.3 *Investigate the densities of solids and liquids.*

P14.4 Explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules.

P14.5 Describe that when substances melt, freeze, evaporate, boil, condense or sublimate mass is conserved and that these physical changes differ from some chemical changes because the material recovers its original properties if the change is reversed.

Maths requirements

1a Recognise and use expressions in decimal form.

1c Use ratios, fractions and percentages.

2a Use appropriate numbers of significant figures.

3a Understand and use the symbols: $=, <, \ll, \gg, >, \propto, \sim$

3b Change the subject of an equation.

3c Substitute numerical values into algebraic equations using appropriate units for physical quantities.

3d Solve simple algebraic equations.

5b Visualise and represent 2D and 3D forms, including two dimensional representations of 3D objects.

Learning outcomes

6th **SP14.1** Describe the arrangements of particles in solids, liquids and gases.

7th **SP14.1** Use the particle model to explain the different properties of solids, liquids and gases.

5th **SP14.2** Recall the formula relating density, mass and volume.

7th **SP14.2** Use the formula relating density, mass and volume.

7th **SP14.4** Use the particle model to explain why solids, liquids and gases have different densities.

4th **SP14.5** Describe what happens to the mass of a substance when it changes state.

Exploring

1. Investigating densities

This practical forms part of the core practical requirement of the specification and is supported by Students' sheet CP6 (Investigating densities) and *SP14a Core Practical – Investigating densities* in the Student Book.

See Students' sheet CP6 (Investigating densities) for a full method for this practical.

Provide students with a range of labelled liquids and solids and ask them to find the densities. The liquids can be reused if students pour them back into the containers.

Support: Ensure students know how to set balances to zero with a beaker on them. Some students may need help using the formula.

Stretch: Ask students to find the density of expanded polystyrene, and ask them to suggest how they would try to find the density of the polystyrene in it (as opposed to the overall density of the polystyrene and air combined). If necessary, suggest that students search the Internet for 'pressure Styrofoam cup', because increased pressure can force most of the air out of such materials.

⚠ Safety

Ensure any spills are mopped up right away. Ethanol is flammable, ensure there are no naked flames and the gas supply is turned off.

Expected results

Students calculate the densities of a range of liquids and solids from measurements of mass and volume.

Course resources

Phys Students' sheet CP6

Equipment

100 cm^3 beaker, balance, displacement can, measuring cylinder (50 cm^3), a range of liquids, a range of solid objects. Suitable liquids include tap water, salty water, cooking oil and ethanol (or white spirit, methylated spirit etc.). Suitable solids include metals, woods and plastics from materials kits, including expanded polystyrene.

2. Density changes

Students heat thermometers and bimetallic strips and observe the volume changes. Worksheet SP14a.2 provides instructions and questions to help students relate their observations to changes in density. The worksheet is split in two so that if time is short groups can do just one of the activities and report back to the class. Alternatively, the two activities can be demonstrated and the questions used as the basis for a class discussion.

Support: Allow students to follow the practical instructions, and then use the questions on the worksheet as the basis for a class discussion. Summarise the key points on the board for students to copy into their notebooks (heating causes an increase in volume; because the mass does not change the density must decrease).

Stretch: Show students a Galileo thermometer (or a picture of one), and ask them to explain how it works. You may need to remind students that objects float when they are less dense than the fluid they are in.

⚠ Safety

Hot water from the tap can be used – there is no need for boiling water.

Expected results

Students observe the change in volume of the liquid in a thermometer and the change in shape of a bimetallic strip when heated.

Course resources

Phys Students' sheet CP6

Equipment

beaker of hot water, liquid-in-glass thermometer, Bunsen burner, heat-resistant mat, bimetallic strip

Optional: Galileo thermometer

Sample question

This example is taken from the first question in a foundation tier paper in the sample assessment material, paper 1PH0/2F,, Q1 which reflects the straightforward nature of the core practical.

(b) A student investigates the density of a copper block and the density of a small stone, as shown in Figure 2.

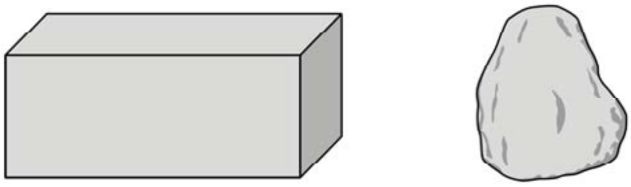


Figure 2

(i) The student calculates the volume of the block as 13 cm^3.

She finds that the mass of the block is 100 g.

Calculate the density of the block.

Use the equation

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

(2)

density = ... g/cm^3

Question number	Answer	Additional guidance	Mark
1(b)(i)	substitution (1) 100 ÷ 13 answer (1) 7.7 (g/cm^3)	award full marks for correct numerical answer without working allow 7.692 (g/cm^3)	**(2)**

Part (b)(i) requires students to apply their knowledge and understanding of scientific ideas by calculating density from given data and the equation as they will have done in core practical 6. It is worth noting that, further on in a paper, candidates could have been asked to <u>recall</u> and use the equation.

(ii) The student found the volume of the copper block by multiplying the area of its base by its height.

The small stone does not have straight sides.

Describe how the student could measure the volume of the small stone.
You may use a diagram if it helps your answer.

(3)

Question number	Answer	Additional guidance	Mark
1(b)(ii)	An answer that provides a description by making reference to: • part fill a measuring cylinder with water and record the starting volume (1) • completely immerse the stone in the water and record the final volume of water and stone (1) • volume of stone = final volume − initial volume (1)	accept valid alternative methods, e.g. fill a displacement can until some water overflows/flows out of spout completely immerse the stone in the displacement can and collect the displaced water in a measuring cylinder volume of water displaced = volume of stone	**(3)**

Parts (b)(ii) require students to demonstrate knowledge and understanding of scientific techniques and procedures related directly to core practical 6.

Core practical 7: Investigating water

14.11 Core practical: Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice

Links to the specification content

14.5	Describe that when substances melt, freeze, evaporate, boil, condense or sublimate mass is conserved and that these physical changes differ from some chemical changes because the material recovers its original properties if the change is reversed
14.6	Explain how heating a system will change the energy stored within the system and raise its temperature or produce changes of state
14.7	Define the terms specific heat capacity and specific latent heat and explain the differences between them
14.8	Use the equation: change in thermal energy (joule, J) = mass (kilogram, kg) × specific heat capacity (joule per kilogram degree Celsius, J/kg °C) × change in temperature (degree Celsius, °C) $\Delta Q = m \times c \times \Delta \theta$
14.9	Use the equation: thermal energy for a change of state (joule , J) = mass (kilogram, kg) × specific latent heat (joule per kilogram, J/kg) $Q = m \times L$
14.10	Explain ways of reducing unwanted energy transfer through thermal insulation

Introducing the practical

This material was not in the Science 2011 specification but has been in previous specifications. If a joulemeter is not available, a voltmeter, ammeter and stopwatch can be used to measure the energy supplied in the specific heat capacity investigation. The investigation could be extended by doing it first without insulation and then with insulation to support work on specification point 14.10.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What two things might happen to water if you heat it?
- How would you measure the temperature of ice?
- What happens to the temperature of ice when it is melting?
- What quantities will you need to measure before you can calculate specific heat capacity?
- If you heat water in a beaker, some of the thermal energy supplied is lost to the surroundings. How can you reduce this energy loss?

Skills that are covered in the practical:

- Using a Bunsen burner and a water bath to melt ice
- Reading a thermometer
- Positioning a thermometer to get an accurate reading
- Reading a thermometer at regular time intervals and recording the readings systematically
- Using a balance

Maths skills:

- Substituting measured values into the equation relating change in thermal energy, mass, specific heat capacity and change in temperature
- Changing the subject of an equation
- Plotting a temperature-time graph for melting ice
- Drawing an unfamiliar curve
- Interpreting a temperature-time graph for melting ice

Edexcel GCSE (9–1)
Sciences

Phys CP7a Specific heat capacity

Your teacher may watch to see if you can:
- take careful measurements.

Aim

To find the specific heat capacity of water.

Method

A Put a polystyrene cup in a beaker onto a balance, and zero the balance. Then fill the cup almost to the top with water and write down the mass of the water. Carefully remove the cup from the balance.

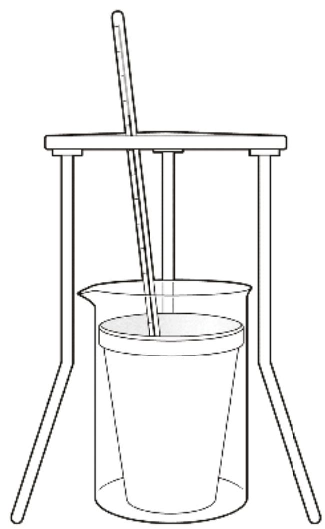
B Put a thermometer in the water and support it as shown in the diagram. Put a 12 V electric immersion heater into the water, making sure the heating element is completely below the water level. Connect the immersion heater to a joulemeter.

C Record the temperature of the water, and then switch the immersion heater on. Stir the water in the cup gently using the thermometer.

D After five minutes, record the temperature of the water again and also write down the reading on the joulemeter.

Apparatus

- polystyrene cup
- beaker
- tripod
- thermometer
- stop clock
- immersion heater
- joulemeter
- balance



Recording your results

1 Draw up a table to record your results, using the following headings:

Mass of water (g), mass of water (kg), starting temperature of water (°C), temperature after five minutes (°C), temperature change (°C), joulemeter reading (J).

Considering your results/conclusions

2 Divide the mass of water by 1000 to find the mass in kilograms.

3 Subtract the temperature of the water after five minutes from the starting temperature to find the temperature change.

4 Calculate the specific heat capacity of water using the following equation.

$$\text{specific heat capacity (J/kg °C)} = \frac{\text{change in thermal energy * (J)}}{\text{mass (kg)} \times \text{change in temperature (°C)}}$$

* The change in thermal energy is the same as energy transferred, and this is measured using the joulemeter.

Evaluation

5 Why did you use the glass beaker and the tripod?

6 Why did you put the water into a polystyrene cup instead of a beaker?

7 How would using a beaker have affected your results?

8 What are the possible sources of error in your investigation?

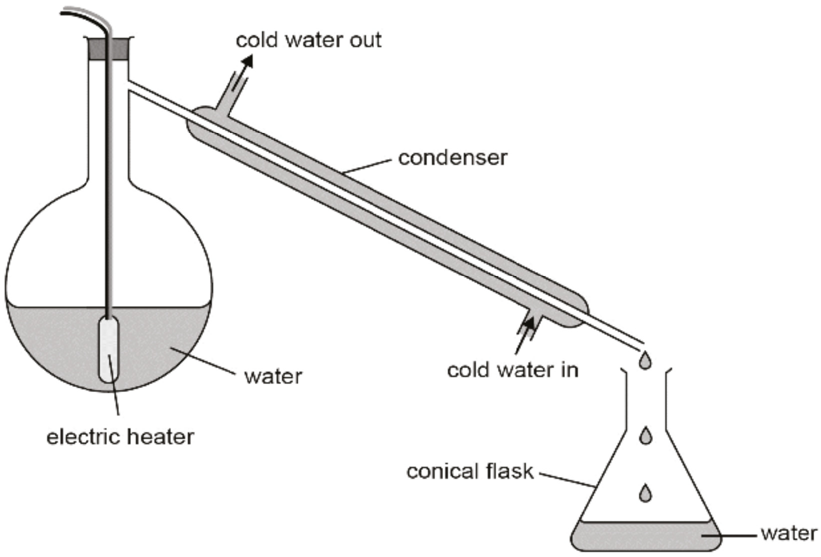
Edexcel GCSE (9–1)
Sciences

Phys CP7a Latent heat investigations

Some students carried out an experiment to find the **specific latent heat** of water. They used the apparatus shown in the diagram. The electric heater was connected to a joulemeter, which measures the energy transferred by electricity.

The students switched on the electric heater and left the apparatus until the water was boiling. Then they emptied the conical flask and reset the joulemeter. They left the heater on until they had collected some water in the conical flask. They then switched the heater off.

The table shows the measurements they made.



1 Calculate the mass of water evaporated in the experiment. Convert your answer to kilograms.

2 Calculate the energy transferred per kilogram of water.

Mass of empty conical flask (g)	80 g
Mass of conical flask with water (g)	85.7 g
Energy transferred	15 265 J

3 Your answer to question 2 is the specific latent heat of evaporation for water found in this experiment.

   a Would you expect this result to be higher or lower than the value found in reference books? Explain your answer. (*Hint:* does all the energy supplied by the heater get used for evaporating the boiling water?)

   b Explain how the condenser increases the accuracy of the result compared with using only a simple tube without a condenser between the two flasks.

   c Suggest how you could modify the apparatus to obtain a more accurate value.

4 The specific latent heat of melting for water can be found by adding some ice cubes to an insulated cup full of warm water. Energy from the warm water is transferred to the ice to melt it. The table shows the results of this experiment.

Mass of water at start	200 g
Temperature of water at start	30 °C
Mass of ice cubes	16 g
Temperature of water at end	22 °C

   a Calculate how much **thermal energy** is stored in the water at the start compared with that in the same mass of water at 0 °C.

   b At the end of the experiment, there is 216 g of water. Calculate how much energy is stored in this compared with in the same mass of water at 0 °C.

   c How much energy was transferred to the ice cubes?

   d Calculate the latent heat of melting of ice.

   e The water in the cup starts off warmer than the surrounding air and ends up cooler. A different group of students start with much hotter water; their water is still hotter than the surroundings when all the ice has melted. Explain which group you think will obtain the more accurate value for the specific latent heat of melting.

---

change in thermal energy (J) = mass (kg) × specific heat capacity (J/kg °C) × change in temperature (°C)

thermal energy needed for a change of state (J) = mass (kg) × specific latent heat (J/kg)

Edexcel GCSE (9–1) Sciences

Phys CP7a Energy calculations

Objectives

P14.8 Use the equation:
change in thermal energy (joule, J) = mass (kilogram, kg) × specific heat capacity (joule per kilogram degree Celsius, J/kg °C) × change in temperature (degree Celsius, °C)
$\Delta Q = m \times c \times \Delta\theta$

P14.9 Use the equation:
thermal energy for a change of state (joule, J) = mass (kilogram, kg) × specific latent heat (joule per kilogram, J/kg)
$Q = m \times L$

P14.11 *Core Practical: Investigate the properties of water by determining the specific heat capacity of water ~~and obtaining a temperature-time graph for melting ice~~.*

Maths requirements

1a Recognise and use expressions in decimal form.

1b Recognise and use expressions in standard form.

2a Use an appropriate number of significant figures.

3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~

3b Change the subject of an equation.

3c Substitute numerical values into algebraic equations using appropriate units for physical quantities.

3d Solve simple algebraic equations.

Learning outcomes

8th **SP14.8** Use the formula relating change in thermal energy, mass, temperature change and specific heat capacity.

8th **SP14.9** Use the formula relating thermal energy, mass and specific latent heat.

6th **SP14.9** Recall that the value of specific latent heat for a substance is different for melting/solidifying and for evaporating/condensing.

Exploring

1. Specific heat capacity

This practical forms part of the core practical requirement of the specification and is supported by Students' sheet CP7a (Investigating properties of water - specific heat capacity) and *SP14c Core Practical – Investigating water* in the Student Book. See Worksheet SP14c.1 for a full method for this practical.

The full method for the other part of this core practical can be found on *Students' sheet CP7b (Investigating properties of water -the construction of a temperature–time graph)*. The two practicals could be run together, if desired. If a joulemeter is not available, use an ammeter and voltmeter in the circuit with the immersion heater, and remind students that electrical power can be calculated by multiplying current and voltage, and that the energy transferred can be found from the power multiplied by the time in seconds (see *SP10g Power*). This practical can be extended by asking students to follow a similar method to find the specific heat capacities of various metals, using metal block calorimeters. A little oil in the thermometer hole improves the accuracy of the temperature readings.

Support: Students do only the practical to find the specific heat capacity of water. If a joulemeter is not available, help students to work out the energy transferred from the current, voltage and time.

Stretch: Provide students with some insulating material and ask them to repeat the measurements for one of the metal blocks, asking them to compare the values obtained with and without insulation, and to explain the difference.

⚠ Safety

Mop up any spilt water straight away.

Expected results

Students take measurements that allow them to determine the specific heat capacities of the substances tested.

Course resources

Phys Students' sheet CP7a

Equipment

Water: polystyrene cup, beaker, tripod, thermometer, stop clock, 12 V immersion heater, joulemeter (or power supply, ammeter, voltmeter, connecting leads), access to balance

Metals: metal block calorimeter, oil, thermometer, stop clock, 12 V immersion heater, joulemeter (or power supply, ammeter, voltmeter, connecting leads), access to balance

2. Latent heat investigations

Worksheet SP14c.2 provides descriptions and some results from investigations to measure the latent heats of evaporation and melting of water. Questions on the sheet help students to analyse the results and evaluate the methods. Students may need to be reminded of the two equations.

Support: Go through the sheet with students, discussing the answers to each question in turn and prompting students with suitable questions to help them with the evaluation work.

Stretch: An alternative method for finding the specific latent heat of melting of ice is to set up two funnels full of ice with a beaker to collect the water formed when the ice melts. One funnel also has an electric heater in the ice. Ask students to describe how they could use this apparatus to find the specific latent heat of melting, and to explain the purpose of the funnel of ice without the heater. (This will find the mass of ice melted due to energy being transferred to it from the surroundings – this should be subtracted from the mass of ice melted using the heater before calculating the latent heat.)

Course resources

Phys Students' sheet CP7a

Edexcel GCSE (9–1) **Sciences**

Phys CP7b

Melting ice

Your teacher may watch to see if you can:

- take careful measurements
- work safely.

Aim

To investigate how the **temperature** of ice changes as it melts.

Method

A Put a boiling tube full of crushed ice into a beaker. Put a thermometer in the ice and note the temperature.

B Put the beaker onto a tripod and gauze. Pour hot water from a kettle into the beaker. Keep the water warm using a Bunsen burner.

C Measure the temperature of the ice every minute and record your results in a table. Stop taking readings three minutes after all the ice has melted.

D Note the times at which the ice starts to melt and when it appears to be completely melted.

Apparatus

- boiling tube
- beaker
- thermometer
- eye protection
- heat resistant mat
- tripod and gauze
- Bunsen burner
- stop clock
- hot water
- crushed ice

⚠ Safety

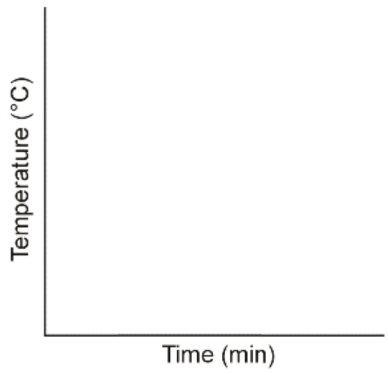
Wear eye protection.

Take care when handling hot apparatus.

Recording your results

1 Make a table like this for your results.

Time (min)	Temperature (°C)
0	
1	



2 Draw a line graph to show your results, using axes like the ones on the right.

3 Mark on your graph the times when the ice started to melt and when it had completely melted.

Considering your results/conclusions

4 Describe the shape of your graph.

5 Explain the shape of your graph using ideas about the way particles are arranged in solids and liquids, and what happens to particles when the state of a substance changes.

Evaluation

6 **a** What sources of systematic error could be present in your results?

b How could you avoid the errors in part **a**?

7 **a** What sources of random error could there be in your results?

b How could you avoid the errors in part **a**?

Edexcel GCSE (9–1) Sciences Phys CP7b Energy and changes of state

Objectives

P14.6 Explain how heating a system will change the energy stored within the system and raise its temperature or produce changes of state.

P14.7 Define the terms specific heat capacity and specific latent heat and explain the differences between them.

P14.10 Explain ways of reducing unwanted energy transfer through thermal insulation.

P14.11 *Core Practical: Investigate the properties of water by ~~determining the specific heat capacity of water and~~ obtaining a temperature-time graph for melting ice.*

Maths requirements

4a Translate information between graphic and numeric form.

4c Plot two variables from experimental or other data.

Learning outcomes

6th **SP14.6** Explain how heating affects the particles in a substance or object, including changes of state.

6th **SP14.6** Describe how the temperature of an object changes with time while being heated or cooled to make it change state.

6th **SP14.7** Define the term specific heat capacity.

6th **SP14.7** Define the term specific latent heat.

8th **SP14.7** Explain the difference between specific heat capacity and specific latent heat.

6th **SP14.10** Explain ways of reducing unwanted energy transfer through thermal insulation.

Exploring

1. Melting ice

This practical forms part of the core practical requirement of the specification and is supported by *Students' sheet CP7b (Investigating properties of water - the construction of a temperature–time graph)* and *SP14c Core Practical – Investigating water* in the Student Book. See *Students' sheet CP7b (Investigating properties of water - the construction of a temperature–time graph)* for a full method for this practical. The full method for the other part of this core practical (the determination of specific heat capacity) can be found on *Students' sheet CP7a (Investigating properties of water - specific heatt capacity)*. The two practicals could be run together after study of *SP14c Energy calculations*, if so desired. The evaluation questions on the worksheet ask about sources of error. Skills Sheet PI3 may be useful.

This practical can be extended by providing students with other substances to melt. Fatty acids are suitable, and it is best if students are provided with boiling tubes containing the solid substances with thermometers already in place. Warn students not to try to remove the thermometers from the solids as they may break. Students warm the substances in a water bath and take the temperature of the substance every minute until it has all melted and the temperature begins to rise. At this point the boiling tube can be carefully removed from the water bath and placed in an empty beaker to cool down again, with students continuing to record the temperature every minute until it has completely solidified. If there is any crushed ice left over, this could be put into the beaker to increase the cooling rate.

Support: Students do only the melting ice practical. They may need help with drawing the axes for their graph. Check they understand that the starting temperature of the ice should be recorded against time zero.

Stretch: Students produce melting and cooling curves for two of the suggested substances in addition to the melting ice practical, and compare the results. Alternatively, some groups could be given a mixture of two substances, asked to obtain melting and cooling curves and to compare the shape of these to the graphs obtained by groups using pure substances.

⚠ Safety

Wear eye protection. Warn students to take care with hot apparatus and hot liquids. Students should be warned not to try to remove thermometers from the solid substances, as this may break them. Mop up any spilled water straight away.

Expected results

Students produce a temperature-time graph for melting ice, and possibly also heating and cooling curves for other substances.

Course resources

Phys Students' sheet CP7b

Equipment

Melting ice: eye protection, boiling tube, beaker, thermometer, tripod and gauze, heat-resistant mat, Bunsen burner, stop clock, hot water from kettle, crushed ice

Optional: extra beaker, one or more of the following substances – stearic (octadecanoic) acid, salol (phenyl salicylate), lauric (dodecanoic) acid, or other fatty acids with melting points in the range 30 °C to 80 °C.

Sample question

These examples are taken from the sample assessment material, paper 1PH0/2F, Q3(b) and question 8(c). Although 3(b) is a slight variation on core practical 7, the commentary below the question outlines how the skills students will have gained by carrying out the practical may be shown in the final exams. 8(c) is an example of an extended open response (6 mark) question directly related to core practical 7.

3 An electric heater is used to heat some water.

Figure 8 shows the experimental setup used.

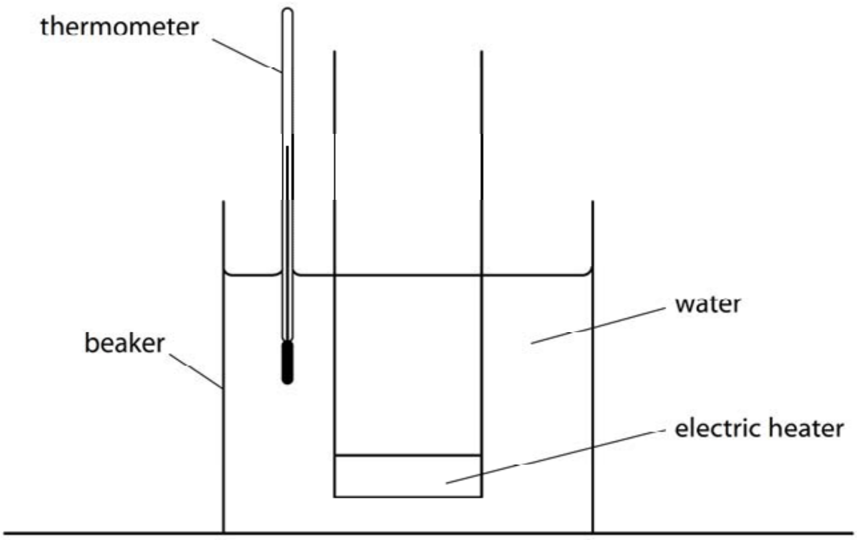


Figure 8

(b) Explain **one** way the experiment can be improved to reduce the amount of wasted energy.

(2)

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....

....

....

Question number	Answer	Additional guidance	Mark
3(b)	An explanation that combines identification – improvement of the experimental procedure (1 mark) and justification/reasoning which must be linked to the improvement (1 mark): • place the beaker on an insulator (1) • so this (material) will reduce rate of energy transfer (1) or • wrap the beaker in an insulator (1) • so this (material) will reduce the rate of energy transfer (1) or • reduce the surface areas of the water (1) • to give less evaporation (1)	allow named insulator, e.g. cork mat put a lid on the beaker/make the beaker taller and narrower	**(2)**

3(b) requires students to analyse information and ideas to improve experimental procedures.

*(c) Describe how the student should carry out an experiment to determine the specific heat capacity of water.

(6)

Question number	Indicative content	Mark
*8(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** • Use of top pan balance to measure mass • Insulate beaker to reduce heat loss • Ammeter connected in series with heater • Voltmeter connected in parallel with heater • Use of $E = I \times V \times t$ to determine energy supplied to the water • Accept use of joule-meter to measure energy supplied • Use of $\Delta E = m \times c \times \Delta\theta$ to determine the specific heat capacity of the water • Measure p.d. across heater • Use stopwatch to measure time liquid is heating • Measure current in heater • Determine mass of water as mass of (beaker and water) – mass of beaker • Measure temperature before and after heating	**(6)**

8(c) requires students to demonstrate their understanding of scientific techniques and procedures.

Core practical 8: Investigating springs

15.6 Core practical: Investigate the extension and work done when applying forces to a spring

Links to the specification content

15.1	Explain, using springs and other elastic objects, that stretching, bending or compressing an object requires more than one force
15.2	Describe the difference between elastic and inelastic distortion
15.3	Recall and use the equation for linear elastic distortion including calculating the spring constant: force exerted on a spring (newton, N) = spring constant (newton per metre, N/m) × extension (metre, m) $F = k \times x$
15.4	Use the equation to calculate the work done in stretching a spring: energy transferred in stretching (joules, J) = 0.5 × spring constant (newton per metre, N/m) × (extension (metre, m))^2 $E = \frac{1}{2} \times k \times x^2$
15.5	Describe the difference between linear and non-linear relationships between force and extension

Introducing the practical

These practicals build on Key Stage 3 work. The work did not appear in the Science 2011 Specification.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why is it difficult to measure the unstretched length of a spring?
- How would you measure the extension of a spring?
- What do the words 'elastic' and 'inelastic' mean when used in connection with stretching materials?
- In what circumstances can you use the equation $F = k \times x$ when stretching materials?
- Think of some examples where the energy stored in stretched spring might be used.

Skills that are covered in the practical:

- Setting up a safe system for stretching materials
- Measuring the length of unstretched materials
- Using reference points when measuring extensions

Maths skills:

- Substituting measured values into the equation relating force exerted on a spring, spring constant and extension
- Substituting measured values into the equation relating work done in stretching a spring, spring constant and extension
- Changing the subject of an equation
- Plotting force-extension graphs
- Relating work done in stretching a spring to the area under the line for a force-extension graph

Edexcel GCSE (9–1)

Sciences Phys CP8 Springs and rubber bands

Your teacher may watch to see if you can:

- take careful measurements.

Aim

To investigate the **extension** and work done when applying forces to a spring and a rubber band.

Method

A Set up the apparatus as shown in the diagram. The zero on the ruler should be level with the bottom of the unstretched spring.

B Measure the length of the spring with no masses hanging on it and write it down.

C Hang a 100 g mass on the spring. Record the extension of the spring (the length shown on the ruler).

D Repeat step **C** until you have found the extension of the spring with 10 different masses. Each 100 g mass puts a downwards force of 1 N on the spring.

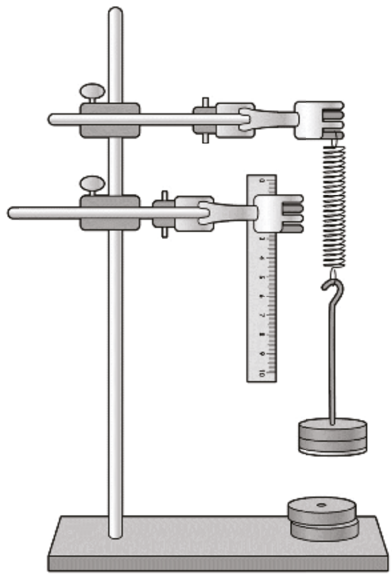
E Repeat steps **A–D** for a rubber band.

Apparatus

- stand and two clamps
- spring
- rubber band
- ruler
- masses
- eye protection

Safety

Wear eye protection.



Recording your results

1 Draw a table like this to record your results. You will need a separate table for the rubber band.

Force (N)	Extension (cm)	Extension (m)
0	0	0
1		

2 Draw a scatter graph to show force against extension. Put extension on the horizontal axis and force on the vertical axis. Plot points for the spring and the rubber band on the same graph and join them with smooth curves or lines of best fit.

Considering your results/conclusions

3 Compare and contrast the shapes of the two lines on your graph. (How are they similar? How are they different?)

4 Describe the relationship between force and extension for the spring and for the rubber band. Use some of the following words in your answer: directly proportional, linear, non-linear.

Phys CP8 Bending and stretching

Objectives

P15.1	Explain, using springs and other elastic objects, that stretching, bending or compressing an object requires more than one force.
P15.2	Describe the difference between elastic and inelastic distortion.
P15.5	Describe the difference between linear and non-linear relationships between force and extension.

Maths requirements

1a	Recognise and use expressions in decimal form.
2g	Use a scatter diagram to identify a correlation between two variables.
3a	Understand and use the symbols: =, <, <<, >>, >, ∝, ~
3c	Substitute numerical values into algebraic equations using appropriate units for physical quantities.
4a	Translate information between graphical and numeric form.
4c	Plot two variables from experimental or other data.
4d	Determine the slope and intercept of a linear graph.

Learning outcomes

4th	SP15.1	Explain that more than one force is needed to distort an object.
4th	SP15.2	Describe the difference between elastic and inelastic distortion.
4th	SP15.5	Describe the relationship between force and extension for a spring.
4th	SP15.5	Describe the relationship between force and extension for a rubber band.
6th	SP15.5	Compare the force–extension relationship for different objects.

Exploring

1. Springs and rubber bands

Students' sheet CP8(Investigating the extension of a spring) provides instructions for students to produce force–extension graphs for springs and rubber bands. If possible, have springs that produce similar extensions to the rubber bands available for testing. The worksheet does not suggest that students test springs beyond their elastic limit, but if you have cheap springs that you are prepared to discard, students could be encouraged to continue loading their springs beyond this point.

Support: Help students to work out suitable scales for the axes on their graphs, and help them to plot their points if necessary.

Stretch: If students have stretched their springs beyond the elastic limit, ask them to record the extension as they successively remove masses from the spring and to plot this information on the same graph. Ask them to write a couple of sentences to describe the shape of the graph and to explain it if they can.

⚠ Safety

Wear eye protection.

Expected results

Students obtain force–extension graphs for two or more springs, which should be straight lines through the origin. If students have stretched their springs past the elastic limit, the line for that part of the stretching will not be a straight line. Students doing the Stretch activity should find that when unloading the spring, the force–extension line does not return to the origin.

Course resources

Phys Students' sheet CP8

Equipment

eye protection, stand and two clamps, springs, ruler, 100 g mass hanger and stacking 100 g masses

Sample question

This example is taken from the sample assessment material, paper 1PH0/2H, Q5 (b)(ii) and (c). 5(b)(ii) relates directly to the core practical and (c) is an extension of this, The commentaries below the questions outline how the skills students will have gained by carrying out the practical may be shown in the final exams.

(b) The student investigates the stretching of a spring with the equipment shown in Figure 22.

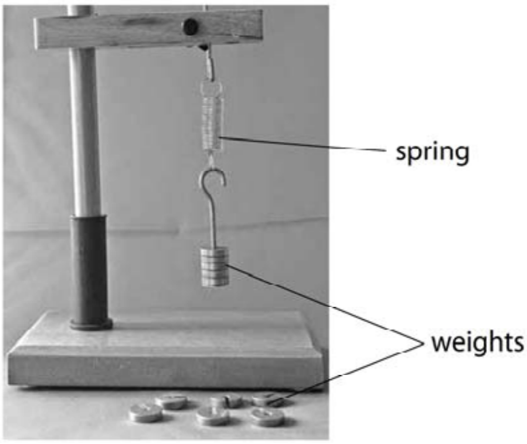


Figure 22

The student investigates the extension of the spring using six different weights.

The results are shown in Figure 23.

weight (N)	extension (mm)
0.20	4.0
0.40	8.0
0.60	12.0
0.80	16.0
1.00	20.0
1.20	24.0

Figure 23

(ii) The student writes this conclusion:

'The extension of the spring is directly proportional to the weight stretching the spring.'

Comment on the student's conclusion.

(3)

Question number	Answer	Additional guidance	Mark
5(b)(ii)	A comment that makes reference to the following points: (using table) • idea that equal increments of force/weight/mass cause equal increments of extension (1) • correct reference to figures in the table (1) OR (using graph) • the graph line is straight (1) • the graph line passes through the origin (1) AND therefore the student's conclusion is correct (1)	last marking point can only be achieved if at least one of the other two marks is awarded	**(3)**

5(b)(ii) requires students to analyse information and ideas to make judgements and draw conclusions. They will have done this with their own graphs in the core practical.

(c) The student extends the investigation by finding information about the stretching of wires.

The student finds the graph shown in Figure 24 for the stretching of a wire.

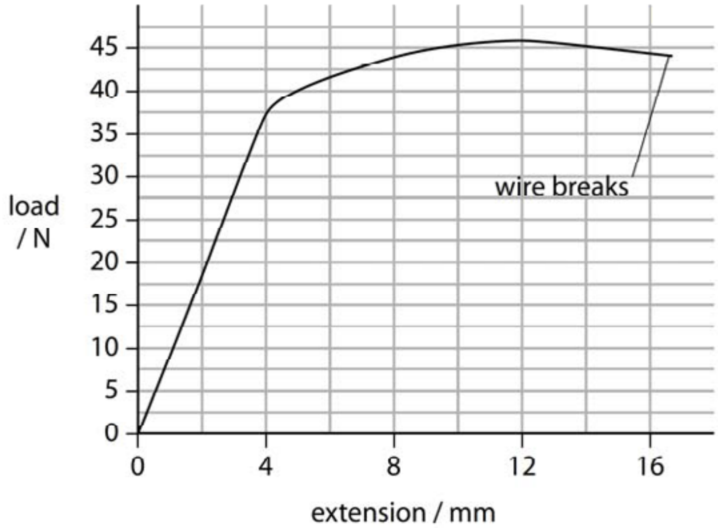


Figure 24

Describe the non-linear stretching of the wire shown in Figure 24.

(3)

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....

....

Question number	Answer	Additional guidance	Mark
5(c)	An answer that combines points of interpretation/evaluation to provide a logical description: • above 37.5 N/4 mm there are large increases of extension for small increases in load (1) • the maximum extension of the wire is about 16.5 mm before it breaks (1) • above 12 mm the wire keeps on extending when the load is reduced below 46 N (1)	accept extension is (much) greater for each 1 N increase in load above 37.5 N	(3)

5(b)(ii) requires students to analyse information and ideas to interpret and evaluate the graph of a new situation. Having done the core practical will assist them here.

Appendix 1

Department for Education: apparatus and techniques list

	PHYSICS
1	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature. Use of such measurements to determine densities of solid and liquid objects.
2	Use of appropriate apparatus to measure and observe the effects of forces including the extension of springs
3	Use of appropriate apparatus and techniques for measuring motion, including determination of speed and rate of change of speed (acceleration/deceleration)
4	Making observations of waves in fluids and solids to identify the suitability of apparatus to measure speed/frequency/wavelength. Making observations of the effects of the interaction of electromagnetic waves with matter.
5	Safe use of appropriate apparatus in a range of contexts to measure energy changes/transfers and associated values such as work done
6	Use of appropriate apparatus to measure current, potential difference (voltage) and resistance, and to explore the characteristics of a variety of circuit elements
7	Use of circuit diagrams to construct and check series and parallel circuits including a variety of common circuit elements
	Separate science only
8	Making observations of waves in fluids and solids to identify the suitability of apparatus to measure the effects of the interaction of waves with matter.

Appendix 2

Core practical mapping

The tables on the following pages show how each core practical in physics offers opportunities for students to develop some of the mathematical skills and how the practicals map to the practical techniques in Appendix 1.

Physics

Physics Core Practical	Practical technique 1	2	3	4	5	6	7	8	Mathematical skills
1. Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys (2.19)	✓	✓	✓						1a Recognise and use expressions in decimal form 2a Use an appropriate number of significant figures 2g Use a scatter diagram to identify a correlation between two variables 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations 4b Understand that y = mx + c represents a linear relationship 4c Plot two variables from experimental or other data

Physics Core Practical	Practical technique 1	2	3	4	5	6	7	8	Mathematical skills
2. Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid (4.17)	✓			✓				✓	1a Recognise and use expressions in decimal form 1b Recognise and use expressions in standard form 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations
3. Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter (5.9)				✓					4c Plot two variables from experimental or other data 5a Use angular measures in degrees
4. Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed (5.19P)				✓					4c Plot two variables from experimental or other data
5. Investigate the densities of solid and liquids (14.3)	✓								1a Recognise and use expressions in decimal form 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations

Physics Core Practical	Practical technique								Mathematical skills
	1	2	3	4	5	6	7	8	
6. Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature–time graph for melting ice (14.11)	✓				✓				1a Recognise and use expressions in decimal form 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations 4c Plot two variables from experimental or other data
7. Construct electrical circuits to: a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp b test series and parallel circuits using resistors and filament lamps (10.17)						✓	✓		1a Recognise and use expressions in decimal form 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations 4b Understand that $y = mx + c$ represents a linear relationship 4c Plot two variables from experimental or other data

Physics Core Practical	Practical technique 1	2	3	4	5	6	7	8	Mathematical skills
8. Investigate the extension and work done when applying forces to a spring (15.6)		✓			✓				1a Recognise and use expressions in decimal form 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations 4b Understand that y = mx + c represents a linear relationship 4c Plot two variables from experimental or other data 4f Understand the physical significance of area between a curve and the x-axis and measure it by counting squares as appropriate

Appendix 3

GCSE Sciences: Equipment list

The list below is for all core practicals in GCSE Combined Science and Separate sciences. The separate science equipment is draft, and will be updated with a final version on the Edexcel website soon.

Physics

Spec statement	Equipment list
2.19 Investigate the relationship between force, mass and acceleration by varying the masses added to trolley	trolley, ramp, blocks, pulley, string, stacking masses, mass hanger, sticky tack, 2 light gates, 2 clamps and stands, access to balance, datalogger
4.17 Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid	Speed of waves on water: ripple tank (ideally with beaches to prevent reflections), stopwatch, ruler, digital camera Speed of sound in solid: 2 clamps and stands; 2 rubber bands; long metal rod (up to a metre long); metre rule; hammer; smartphone with frequency app Speed of sound in air: 2 microphones, datalogger, connecting wires, two blocks of wood
5.9 Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic [PJ1] waves with matter.	Ray box with single slit, power supply, rectangular glass block, protractor.
5.19P Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed	4 beakers or test tubes; coloured paper or foil to cover at least 3 tubes, or 3 of the tubes painted different colours and card or foil to make lids; 4 thermometers; stopclock; hot water.

Spec statement	Equipment list
10.17 Construct electrical circuits to: a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp b test series and parallel circuits using resistors and filament lamps	Power supply, ammeters, voltmeters, resistors, filament lamps, connecting wires
14.3 Investigate the densities of solid and liquids	Samples of various materials (e.g. materials kit), displacement can, measuring cylinder, access to balance, beakers
14.11 Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice	Ice, thermometer, beaker, tripod, gauze, Bunsen burner, kettle, polystyrene cup, balance, electric immersion heater, joulemeter (or ammeter and voltmeter), stopclock
15.6 Investigate the extension and work done when applying forces to a spring	Spring, stand with 2 clamps, ruler, stacking masses

Appendix 4 Mapping to lab book

The table below can be used to map between the core practicals in the lab book (which follow the teaching order) and the core practicals in the specification (which is the ordering used in this guide).

specification reference		lesson ref from schemes of work	numbering in this guide	published lab book numbering
Physics				
2.19	*Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*	*CP2d.1*	Core practical 1	Core practical 1
4.17	*Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*	*CP4b.1*	Core practical 2	Core practical 2
5.9	*Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter*	*CP5a.1*	Core practical 3	Core practical 3
5.19P	*Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*	*SP5g*	Core practical 4	*[Lab book 2]*
10.17	*Construct electrical circuits to:* *a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* *b test series and parallel circuits using resistors and filament lamps*	*CP9d*	Core practical 5	*[Lab book 2]*
14.3	*Investigate the densities of solid and liquids*	*CP12a*	Core practical 6	*[Lab book 2]*
14.11	*Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice*	*CP12c*	Core practical 7	*[Lab book 2]*
15.6	*Investigate the extension and work done when applying forces to a spring*	*CP13b*	Core practical 8	*[Lab book 2]*