GCSE Physics: Required practical handbook

Version 3.8

The methods provided in this *Required practicals activities* guide are suggested examples, designed to help your students fulfil the Apparatus and Techniques requirements outlined in the specifications. Written papers will include questions requiring knowledge gained from carrying out the specified practicals.

Please note: it is the Apparatus and Techniques requirements which are compulsory and must be fulfilled. Teachers are encouraged to adapt or develop activities, resources and contexts to suit their equipment and provide the appropriate level of engagement and challenge for their own students.

Contents

Introduction

Students need to undertake the required practical activities listed in the GCSE Physics specification (8463) so that they have the opportunity to experience all of the apparatus and techniques required by Ofqual.

In this guide, we suggest methods and activities for carrying out the required practical activities to help you plan the best experience for your students.

All of the activities we describe have been written and trialled by practising teachers and use apparatus and materials that are commonly available in most schools.

Why do practical work?

Practical work is at the heart of science – that's why we have placed it at the heart of each of our GCSE science specifications.

There are three separate, but interconnected, reasons for doing practical work in schools.

1. To support and consolidate scientific concepts. Doing practical work enables students to make sense of new information and observations and provides them with insights into the development of scientific thinking.

2. To develop investigative skills. These transferable skills include:
   - devising and investigating testable questions
   - identifying and controlling variables
   - analysing, interpreting and evaluating data.

3. To build and master practical skills such as:
   - using specialist equipment to take measurements
   - handling and manipulating equipment with confidence and fluency
   - recognising hazards and planning how to minimise risk.

This guide signposts opportunities for developing these Working scientifically skills (WS). Working scientifically is explained in more detail in the GCSE Physics specification on page 9. There are blank spaces in the student sheets for students to write down the learning outcomes for each required practical activity.

Helping you to plan

This guide includes:

- teachers' notes providing information and tips on setting up and running practicals
- technical information providing guidance for technicians preparing for the practicals
- student sheets providing a method for students to carry out the practical.

By focusing on the reasons for carrying out a particular practical, you will help your students to:

- understand the subject better
- develop the skills of a scientist
- master the manipulative skills required for further study or jobs in STEM subjects.

At least 15% of the marks in the written exams will draw on the knowledge and understanding students have gained by carrying out the required practical activities. So it is essential that you plan your practical activities with reference to the specification and make students aware of the key content that they need to learn.

You can find examples of the type of practical questions students can expect in our guide, *Practicals in exams.*

We have designed the methods in this guide specifically to help your students fulfil the Apparatus and techniques requirements outlined in the specification. We encourage you to adapt or develop these activities, resources and contexts to suit your circumstances and to tailor the level of engagement and challenge to your students. To help you do this, we've provided the guide in an editable format.

The practical science statement

Unlike the A-levels, there will be no practical endorsement. Instead, we will provide the head of each school or college with a Practical science statement to sign confirming that reasonable steps have been taken to secure that each student has:

- completed the required practical activities detailed in the specification
- made a contemporaneous record of such work undertaken during the activities and the knowledge, skills and understanding derived from those activities.

The head of centre will need to return the signed statement to us by the date we will publish on our website, on our practicals page. We will also contact schools and colleges directly with the deadline date and send timely reminders if we don't receive the form. Failure to send this form counts as malpractice/maladministration, and may result in formal action or warning for the school or college.

Not having done some of the practicals, despite the school's best efforts, will not stop a student from entering for the GCSE. However, it may affect their grade, because there may be questions in the exams that they won't be able to answer.

Apparatus and techniques

The following table lists the physics Apparatus and techniques (AT). Students must be given the opportunity to experience all of these during their GCSE Physics course, regardless of the awarding body specification they study. The list includes opportunities for choice and use of appropriate laboratory apparatus for a variety of experimental problem-solving and/or enquiry-based activities.

Use and production of appropriate scientific diagrams to set up and record apparatus and procedures used in practical work is common to all science subjects and should be included wherever appropriate.

AT 1–7 are common with both of our GCSE Combined Science specifications. AT 8 is for GCSE Physics only.

Where possible, we have added links to the Apparatus and techniques in our A-level Physics course, to show how the skills progress from GCSE to A-level.

	Apparatus and techniques
AT 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 (links to A-level AT a and b).
AT 2	Use of appropriate apparatus to measure and observe the effects of forces including the extension of springs (links to A-level AT a).
AT 3	Use of appropriate apparatus and techniques for measuring motion, including determination of speed and rate of change of speed (acceleration/deceleration) (links to A-level AT a, b and d).
AT 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 (links to A-level AT i and j).
AT 5	Safe use of appropriate apparatus in a range of contexts to measure energy changes/ transfers and associated values such as work done (links to A-level AT a, b).
AT 6	Use of appropriate apparatus to measure current, potential difference (voltage) and resistance, and to explore the characteristics of a variety of circuit elements (links to A-level AT f).

AT 7	Use of circuit diagrams to construct and check series and parallel circuits including a variety of common circuit elements (links to A-level AT g).
AT 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 (links to A-level AT h, j).

Suggested practical apparatus list

Through their study of the new GCSE Sciences students must be given the opportunity to experience a wide range of apparatus. Hands-on experience will help them acquire the practical skills defined by the DfE in their Apparatus and Techniques criteria.

We have designed all the activities to use standard equipment and materials that can be found in most school laboratories.

The lists are not exhaustive, and we encourage teachers to modify the activities to suit their students' needs and learning objectives, and the resources available in their school/college.

Risk assessment

These required practical activities have been suggested by teachers who have successfully carried them out in the lab. However, it is the responsibility of the centre to ensure that full risk assessments have been carried out in each case.

Trialling

Teachers should trial the required practical activities to make sure that they are manageable and match the resources available in the school/college.

Lab equipment

- 1 kg copper, iron and aluminium metal blocks (each with two holes – one for heating rod and one for thermometer)
- 100 cm^3 beakers
- 12 V, 24 W lamps (eg ray box lamps)
- 250 cm^3 beakers
- 30 cm rulers
- 30 W, 12 V heaters
- 4 mm leads
- 800 cm^3 beakers
- ammeters (or multimeters)
- bench pulleys
- circuit component holders
- clamp stands

- clamps and bosses
- collimating slits and lenses
- connecting leads
- crocodile clips
- digital top-pan balances (capable of measuring 1 kg+; accurate to 0.01g)
- displacement cans
- diode and protective resistor (eg 10 Ω)
- g clamps
- heatproof mats
- infrared detector
- Leslie cube
- light gates, interface and computer software
- linear air track and gliders
- materials kits (ie various regular shaped objects made of iron, copper, aluminium)
- measuring cylinders (various eg 10 cm^3, 50 cm3, 100 cm^3)
- metre rulers
- milliammeters (or multimeters)
- multimeters
- power supplies (variable)
- protractors
- pulleys on clamps
- ray boxes
- rectangular transparent blocks – preferably of different materials (eg glass, Perspex)
- resistance wire (eg constantan of different diameters)
- resistors, (eg 100 Ω, 1 W)
- rheostats (eg 10 Ω, 5 A)
- ripple tank plus accessories
- sets of 100 g masses and hangers
- sets of 10 g masses and hangers
- small weight stacks (eg 1 N in steps of 0.2 N)
- large weight stacks (eg 10 N in steps of 1 N)
- springs of suitable stiffness (eg capable of extending more than 1 cm under a load of 1 N) with loops at each end
- stopwatches
- teat pipettes
- thermometers
- vibration generators
- voltmeters (or multimeters)
- wooden bridges (for *Waves* practical)

Risk assessment

Safety is an overriding requirement for all practical work. Although all of the suggested practical activities have been suggested by teachers who have successfully carried them out in the lab, schools and colleges are responsible for ensuring that appropriate safety procedures are followed whenever their students undertake practical work, and should undertake full risk assessments.

Required practicals summary

The practicals that have been selected will be familiar, using apparatus and materials that are readily available in most schools. This table summarises the ten practicals required for Physics GCSE.

A student who has undertaken all of the practicals will have had the opportunity to experience all of the apparatus and techniques required for the specification. Opportunities for developing mathematical skills and working scientifically skills have also been signposted.

Specific heat capacity	**Spec ref.**	**Skills**
Investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.	Physics 4.1.1.3 Trilogy 6.1.1.3 Synergy 4.1.1.4	AT 1 - use appropriate apparatus to make and record measurements of mass, time and temperature accurately. AT 5 – use, in a safe manner, appropriate apparatus to measure energy changes/transfers and associated values such as work done. MS 2a, MS 2b, MS 3b, MS 3c WS 2.1, WS 2.2, WS 2.3, WS 2.4, WS 2.6, WS 2.7 WS 3.1, WS 3.2, WS 3.3, WS 3.4, WS 3.5, WS 3.6, WS 3.7, WS 3.8 WS 4.2, WS 4.3, WS 4.6
Thermal Insulation (Physics only)	**Spec ref.**	**Skills**
Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material.	Physics 4.1.2.1	AT 1 - use appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature. AT 5 – use, in a safe manner, appropriate apparatus to measure energy changes/transfers. MS 2a, MS 2c, MS 4c, MS 5c WS 1.2 WS 2.1, WS 2.2, WS 2.3, WS 2.4, WS 2.6, WS 2.7

		WS 3.1, WS 3.3, WS 3.4, WS 3.5, WS 3.6, WS 3.8 WS 4.2, WS 4.3, WS 4.6
Resistance	**Spec ref.**	**Skills**
Use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of an electrical circuit. This should include: the length of a wire (at constant temperature); combinations of resistors in series and parallel.	Physics 4.2.1.3 Trilogy 6.2.1.3 Synergy 4.7.2.2	AT 1 - use appropriate apparatus to measure and record length accurately. AT 6 - use appropriate apparatus to measure current, potential difference and resistance. AT 7 - use circuit diagrams to construct and check series and parallel circuits. MS 2a, MS 2b, MS 4b, MS 4c, MS 4d WS 2.1, WS 2.2, WS 2.3, WS 2.4, WS 2.5, WS 2.6, WS 2.7 WS 3.1, WS 3.2, WS 3.3, WS 3.4, WS 3.5, WS 3.6, WS 3.7, WS 3.8 WS 4.2, WS 4.3, WS 4.6
I-V characteristics	**Spec ref.**	**Skills**
Use circuit diagrams to construct appropriate circuits to investigate the I-V characteristics of a variety of circuit elements including a filament lamp, a diode and a resistor at constant temperature.	Physics 4.2.1.4 Trilogy 6.2.1.4 Synergy 4.7.2.2	AT 6 - use appropriate apparatus to measure current and potential difference and to explore the characteristics of a variety of circuit elements. AT 7 - use circuit diagrams to construct and check series and parallel circuits including a variety of common circuit elements. MS 2a, MS 2g, MS 4b, MS 4c WS 2.1, WS 2.2, WS 2.3, WS 2.4, WS 2.5, WS 2.6, WS 2.7 WS 3.1, WS 3.4, WS 3.5, WS 3.6, WS 3.8 WS 4.2, WS 4.3 , WS 4.6
Density	**Spec ref.**	**Skills**
Use appropriate apparatus to make and record the measurements needed	Physics 4.3.1.1 Trilogy	AT 1 - use appropriate apparatus to make and record measurements of length, area, mass and volume accurately. Use such measurements to determine the density of solid objects and liquids.

to determine the densities of regular and irregular solid objects and liquids. Volume should be determined from the dimensions of regularly shaped objects and by a displacement technique for irregularly shaped objects. Dimensions to be measured using appropriate apparatus such as a ruler, micrometre or Vernier callipers.	6.3.1.1 Synergy 4.1.1.2	MS 2a, MS 2b, MS 5c WS 1.2 , WS 2.1, WS 2.2, WS 2.3, WS 2.4, WS 2.6, WS 2.7 WS 3.1, WS 3.5, WS 3.8 WS 4.2, WS 4.3, WS 4.6
Light (Physics only)	**Spec ref.**	**Skills**
Investigate the reflection of light by different types of surface and the refraction of light by different substances.	Physics 4.6.1.3	AT 4 - make observations of the effects of the interaction of electromagnetic waves (light) with matter. AT 8 - make observations of waves in fluids and solids to identify the suitability of apparatus to measure the effects of the interaction of waves with matter. MS 2g, MS 4c, MS 5a, MS 5b WS 2.1, WS 2.2, WS 2.3, WS 2.4, WS 2.7 WS 3.1, WS 3.4, WS 3.6, WS 3.8 WS 4.2, WS 4.3
Force and Extension	**Spec ref.**	**Skills**
Investigate the relationship between force and extension for a spring.	Physics 4.5.3 Trilogy 6.5.3 Synergy 4.6.1.6	AT 1 - use appropriate apparatus to make and record length accurately. AT 2 - use appropriate apparatus to measure and observe the effect of force on the extension of springs and collect the data required to plot a force-extension graph. MS 2a, MS 2b, MS 4a, MS 4b, MS 4c WS 2.1, WS 2.2, WS 2.3, WS 2.4, WS 2.6 WS 3.1, WS 3.2, WS 3.3, WS 3.5, WS 3.8

		WS 4.6
Acceleration	**Spec ref.**	**Skills**
Investigate the effect of varying the force on the acceleration of an object of constant mass and the effect of varying the mass of an object on the acceleration produced by a constant force.	Physics 4.5.6.2.2 Trilogy 6.5.4.2.2 Synergy 4.7.1.6	AT 1 - use appropriate apparatus to make and record measurements of length, mass and time accurately. AT 2 - use appropriate apparatus to measure and observe the effect of force. AT 3 - use appropriate apparatus and techniques for measuring motion, including determination of speed and rate of change of speed (acceleration/deceleration) MS 2a, MS 2b, MS 2g, MS 4a, MS 4b, MS 4c WS 2.1, WS 2.2, WS 2.3, WS 2.4, WS 2.6, WS 2.7 WS 3.1, WS 3.2, WS 3.3, WS 3.4, WS 3.5, WS 3.6, WS 3.7 WS 4.2, WS 4.3, WS 4.6
Waves	**Spec ref.**	**Skills**
Make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements.	Physics 4.6.1.2 Trilogy 6.6.1.2 Synergy 4.1.4.1	AT 4 – make observations of waves in fluids and solids to identify the suitability of apparatus to measure speed, frequency and wavelength. WS 2.3, WS 2.6 WS 3.8 WS 4.2, WS 4.3
Radiation and absorption	**Spec ref.**	**Skills**
Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.	Physics 4.6.2.2 Trilogy 6.6.2.2 Synergy 4.1.4.3	AT 1 - use appropriate apparatus to make and record temperature accurately. AT 4 – make observations of the effects of the interaction of electromagnetic waves with matter. MS 2c WS 3.8

GCSE Physics required practical activity: Specific heat capacity

Teachers' notes

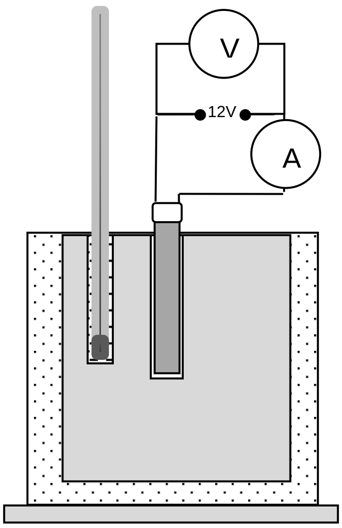
Required practical activity	Apparatus and techniques
An investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.	AT 1, AT 5

What is the specific heat capacity of copper?

Materials

In addition to access to general laboratory equipment, each group needs:

- 1 kg copper block with two holes – one for the heater and one for the thermometer
- 1 kg iron, aluminium or lead blocks for comparison
- thermometer
- pipette to put water in the thermometer hole
- 30 W heater
- 12 V power supply
- insulation to wrap around the blocks
- ammeter and voltmeter
- 4mm leads
- stop watch or stop clock
- balance (capable of measuring more than 1 kg) to determine the mass of the blocks
- heatproof mat.



Technical information

The method involves using the electric heaters to raise the temperature of the blocks. You may have blocks made for this experiment. The blocks usually have a mass of 1 kg and have holes that fit the heater and the thermometer. The heaters fit snugly but there is usually an air gap around the thermometer. A drop of water provides a better thermal contact. The blocks should be insulated to reduce heat loss to the surroundings.

The students will switch on the power supply and measure the current and potential difference. This is to obtain the power of the heater (power = IV) which should remain constant. Typically the heaters are either about 30 W or 50 W. The students can be told the power of the heater rather than measure it if preferred. The students measure and record the temperature of the block every minute for about 10 minutes. They then plot a graph of temperature against electrical work done by the heater. There is some thermal inertia as the block warms up so the beginning of the student's graphs will not be linear if they start timing from when they switch on.

The student work sheet suggests comparing the specific heat capacities of three metals – aluminium, copper and iron. If you don't have all three types of block, the experiment can become a simple measurement of one of them.

Additional information

The specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius.

The students obtain values for current and potential difference (to work out the power), time and temperature. From the power and time they can work out the energy used, or electrical work done by the heater. A graph of temperature against electrical work done should be a straight line once the block has warmed a bit. Students use the gradient of this line and the mass of the block to work out the specific heat capacity. Having blocks of different materials allows students to see that specific heat capacities vary significantly, even between metals.

Metal	**Copper**	**Aluminium**	**Iron**	**Lead**
Specific heat capacity ($J\ kg^{-1}\ K^{-1}$)	385	913	500	126

Using a 30 W heater for 10 minutes transfers $30 \times 60 \times 10 = 18\ 000$ J

This would be sufficient to raise the temperature of 1 kg of copper from room temperature to about 70 ˚C, aluminium to about 40 ˚C and iron to 55 ˚C. This supports the idea that 10 minutes is an adequate length of time for the experiment.

An alternative method involves calculating the specific heat capacity of lead shot in a sealed tube. If the tube is turned, the lead shot will fall generating heat when it hits the bottom. If this is repeated 40 times, the work done can be calculated and the temperature rise of the shot can be used to calculate the specific heat capacity.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- The mains leads of the power supplies should be checked. The heater connections should also be checked. They will also get hot, particularly if left on without being in contact with the blocks.

Trialling

The practical should be trialled before use with students.

GCSE Physics required practical activity: Specific heat capacity

Student sheet

Required practical activity	Apparatus and techniques
An investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.	AT 1, AT 5

What is the specific heat capacity of copper?

In this investigation you will heat up a block of copper using an electric heater.

You will measure:

- mass
- work done by the heater
- temperature.

You will plot a graph of temperature against work done. The gradient of this graph and the mass of the block will be used to determine the specific heat capacity of copper.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically**

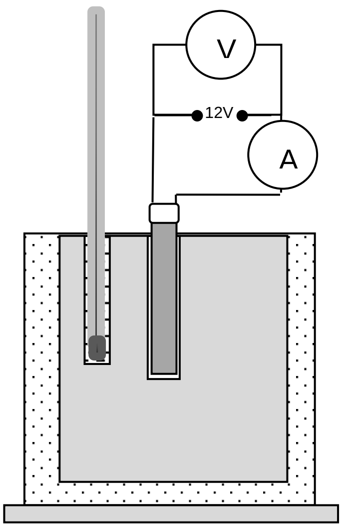
Method

You are provided with the following:

- copper block wrapped in insulation, with two holes for a thermometer and heater
- thermometer
- pipette to put water in the thermometer hole
- 30 W heater
- 12 V power supply
- insulation to wrap around the blocks
- ammeter and voltmeter
- five 4 mm leads
- stop watch or stop clock
- balance.

Read these instructions carefully before you start work.

1. Measure and record the mass of the copper block in kg.
2. Place a heater in the larger hole in the block.
3. Connect the ammeter, power pack and heater in series.
4. Connect the voltmeter across the power pack.



5. Use the pipette to put a small amount of water in the other hole.

6. Put the thermometer in this hole.

7. Switch the power pack to 12 V. Switch it on.

8. Record the ammeter and voltmeter readings. These shouldn't change during the experiment.

9. Measure the temperature and switch on the stop clock.

10. Record the temperature every minute for 10 minutes.

    Add your results to a table such as the one below.

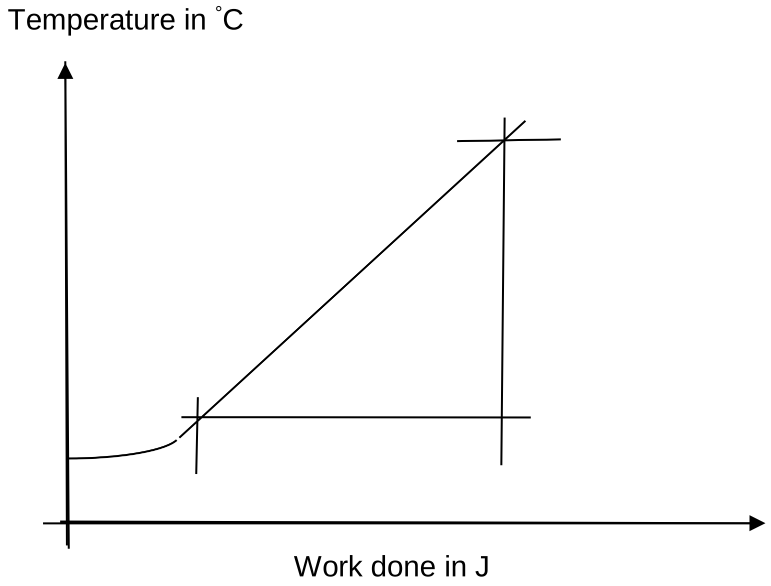
Time in seconds	Work done in J	Temperature in ˚C
0		
60		
120		
180		
240		
300		
360		
420		
480		
540		
600		

11. Calculate the power of the heater in watts.

    To do this, multiply the ammeter reading by the voltmeter reading.

12. Calculate the work done by the heater. To do this, multiply the time in seconds by the power of the heater.

13. Plot a graph of temperature in ^{o}C against work done in J.



14. Draw a line of best fit. Take care as the beginning of the graph may be curved.

15. Mark two points on the line you have drawn and calculate the change in temperature *(θ)* and the change in work done *(E)* between these points

16. Calculate the specific heat capacity of the copper (*c*) by using the equation

$$c = \frac{E}{m \times \theta}$$ where *m* is the mass of the copper block

17. Repeat this experiment for blocks made from other materials such as aluminium and iron.

18. Look at the following hypothesis:

Metal blocks with the same mass, yet bigger volume have a bigger specific heat capacity.

Is this true for the blocks you tested?

GCSE Physics required practical activity: Thermal insulation

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material.	AT 1, AT 5

This investigation is divided into two parts:

1. Investigating the effectiveness of different materials as thermal insulators.

In this part of the experiment students will measure the rate of cooling of a beaker of hot water when insulated with different materials.

They will plot cooling curves to determine which is the best thermal insulator.

2. Investigating factors that may affect the thermal insulation properties of a material.

In this part of the experiment students will measure the rate of cooling of a beaker of hot water when insulated with different thicknesses of the same materials.

They will plot cooling curves to determine the effect of changing the thickness of an insulator

Materials

In addition to access to general laboratory equipment, each group needs:

- 100 ml beaker (×5)
- 250 ml beaker (×5)
- 800 ml beaker (×5)
- thermometer (×5)
- kettle to heat water
- piece of cardboard
- scissors
- stopwatch

- insulating material, eg newspaper, corrugated cardboard, bubble wrap, sawdust, polystyrene granules
- rubber bands.

Additional information

If time is short, class results may be pooled so that each student has a complete set of results. It is important however that each student carries out the experiment for at least one type of insulator in part 1 and at least one thickness of insulator in part 2.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Care should be taken when using boiling water.

Trialling

The practical should be trialled before use with students.

GCSE Physics required practical activity: Thermal insulation

Student sheet

Required practical activity	Apparatus and techniques
Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material.	AT 1, AT 5

1. Investigating the effectiveness of different materials as thermal insulators

You will measure the rate of cooling of a beaker of hot water when insulated with different materials.

You will plot cooling curves to determine which is the best thermal insulator.

Learning outcomes
1
2
3
Teachers to add these with particular reference to working scientifically

Risk assessment

Take great care when pouring the near-boiling water from the kettle. If you splash any on yourself, immediately wash the affected area with cold water.

Method

You are provided with the following:

- large beaker eg 800 ml
- small beaker eg 250 ml
- thermometer
- kettle to heat water
- piece of cardboard

- scissors
- stop clock
- selection of insulating materials, eg polystyrene granules, sawdust, bubble wrap, newspaper.

Read these instructions carefully before you start work.

1. Put the small beaker inside the larger beaker.
2. Use the kettle to boil water. Put 80 ml of this hot water into the small beaker.
3. Use a piece of cardboard as a lid for the large beaker. The cardboard must have a hole for the thermometer.
4. Insert the thermometer through the hole in the cardboard lid so that its bulb is in the hot water.
5. Record the temperature of the water and start the stopwatch.
6. Record the temperature of the water every 3 minutes for 20 minutes Add your results to a table such as the one below.

Material used for insulation	**Temperature in °C**				
	At the start	**After 5 minutes**	**After 10 minutes**	**After 15 minutes**	**After 20 minutes**
No insulation					
Bubble wrap granules					
Newspaper					
Polystyrene					
Sawdust					

7. Repeat steps **1–6** using the different materials each time to fill the space between the small and large beaker.

   Make sure you use the same volume of water each time.

8. Plot cooling curve graphs for each material with:

- ‘Temperature in °C’ on the y-axis
- ‘Time in minutes’ on the x-axis.

Use your graphs to determine which material is the best insulator.

Additional information

If you are working on your own in this investigation, you should be provided with at least 5 beakers of each size, and 5 thermometers. This will enable you to set up the equipment for all of the different insulators at the same time.

Alternatively, your teacher may decide to pool the class results so that you only need to set up the equipment for a particular number of layers.

2. Investigating factors that may affect the thermal insulation properties of a material.

You will measure the rate of cooling of a beaker of hot water. The beaker is insulated with different thicknesses of the same materials. You will plot cooling curves to determine the effect of changing the thickness of an insulator.

Risk assessment

- Take great care when pouring the near-boiling water from the kettle. If you splash any on yourself, immediately wash the affected area with cold water.

Method

You are provided with the following:

- beaker eg 250 ml
- thermometer
- kettle to heat water
- piece of cardboard
- scissors
- stopwatch
- insulating material eg newspaper, corrugated cardboard, bubble wrap
- rubber bands.

Read these instructions carefully before you start work.

1. Use the kettle to boil water. Put 200 ml of this hot water into a 250 ml beaker.

2. Use a piece of cardboard as a lid for the beaker. The cardboard must have a hole for the thermometer.

3. Insert the thermometer through the hole in the cardboard lid so that its bulb is in the hot water.

4. Record the temperature of the water and start the stopwatch.

5. Record the temperature of the water every 3 minutes for 20 minutes.

   Add your results to a table such as the one below.

Number of layers of material used for insulation	**Temperature in °C**				
	At the start	**After 5 minutes**	**After 10 minutes**	**After 15 minutes**	**After 20 minutes**
0					
2					
4					
6					
8					

6. Repeat steps **1–5** using one or more layers of insulating material wrapped around the beaker.

   Make sure you add the insulating material before you add the water.

   The insulating material may be held in place by using rubber bands.

   Do not add insulating material the bottom of the beaker.

   Make sure you use the same volume of water each time.

7. Plot cooling curve graphs for each different number of layers of insulation with:
   - ‘Temperature in °C’ on the y-axis
   - ‘Time in minutes’ on the x-axis.

8. Use your graphs to determine which material is the best indicator.

9. Use your graphs to write a conclusion about the effect of changing the numbers of layers of insulation.

Additional information

If you are working on your own in this investigation, you should be provided with at least 5 beakers of each size, and 5 thermometers. This will enable you to set up the equipment for all of the different insulators at the same time.

Alternatively, your teacher may decide to pool the class results so that you only need to set up the equipment for a particular number of layers.

GCSE Physics required practical activity: Resistance

Teachers' notes

Required practical activity	Apparatus and techniques
Use circuit diagrams to set up an appropriate circuit to investigate a factor/the factors that affect the resistance of an electrical component. This should include: • the length of a wire at constant temperature • combinations of resistors in series and parallel.	AT 1, AT 6, AT 7

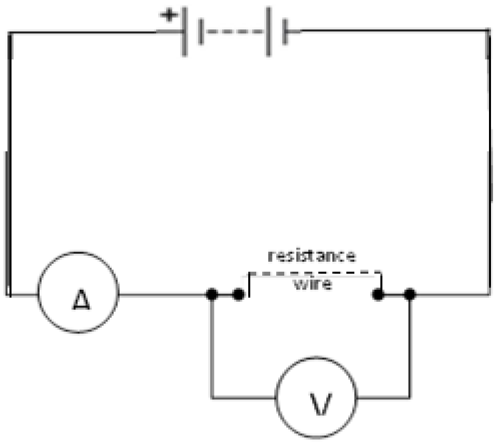
There are two parts to this practical:

1. **Investigating how the resistance of a wire varies with its length**
2. **Investigating resistance in series and parallel circuits.**

Materials

In addition to access to general laboratory equipment, each group needs access to:

- a battery or suitable power supply
- ammeter or multimeter
- voltmeter or multimeter
- crocodile clips
- resistance wire eg constantan
- metre ruler
- connecting leads
- wire-wound resistors, eg 10 Ω.



Technical information

The most straightforward way to investigate resistance is to use an ohmmeter. However, this practical requires the students to make a circuit, measure current and potential difference and calculate the resistance.

There are at least 5 different experiments that could be carried out: the circuit is the same in each case. However, this practical focuses on the variation of resistance with length.

Use a length of resistance wire (just over a metre of 22 swg constantan). Attach it to a metre ruler using tape. Attach a crocodile clip to one end (the zero end of the ruler) of the material. Attach the other crocodile clip to the wire. The students vary the length of wire by moving this crocodile clip and record the length of wire, current and potential difference.

Additional information

The resistance of the wire is proportional to its length. A graph of resistance against length should be a straight line through the origin. This experiment is a good one to use to discuss zero error as it is hard to attach the crocodile precisely to the zero end of the wire, and there will be some contact resistances. The potential difference will not vary very much during the experiment. Use a low value of potential difference, particularly for the short length of wire as the current will increase significantly and the wire can get quite hot. The wire should be fairly thin to give decent values of resistance.

Lock variable power supply unit to low voltages, if possible. Use heatproof mats.

For the second activity, any suitable value of resistors may be used, but if wire wound resistors are used, this should alleviate any potential problems with overheating. Give students two resistors of the same value and ask them to connect them into the two circuits shown below. By measuring the voltage across the resistors and the current through them (placing the meters in the positions shown in the circuit diagrams) they can calculate the total resistance of the circuit.

As an extension, you could ask them to put three identical resistors in series and then in parallel.

As a further extension you could ask them to measure the current at different points in the circuit.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Short lengths of wire are likely to get hot. Use low values of potential difference. Switch off between readings.

Trialling

The practical should be trialled before use with students.

GCSE Physics required practical activity: Resistance

Student sheet

Required practical activity	Apparatus and techniques
Use circuit diagrams to set up an appropriate circuit to investigate a factor/the factors that affect the resistance of an electrical circuit. This should include: • the length of a wire at constant temperature • combinations of resistors in series and parallel.	AT 1, AT 6, AT 7

Activity 1: Investigating how the resistance of a wire varies with its length

A dimmer switch allows you to control the brightness of a lamp.

You will investigate how the dimmer switch works. You will construct a circuit to measure the potential difference across a wire and the current in the wire. You will do this for different lengths of wire.

Learning outcomes
1
2
3
Teachers to add these with particular reference to working scientifically

Method

You are provided with the following:

- a battery or suitable power supply
- ammeter or multimeter
- voltmeter or multimeter
- crocodile clips
- resistance wire eg constantan
- connecting leads.

Read these instructions carefully before you start work.

1. Connect the circuit.

   It may be helpful to start at the positive side of the battery or power supply. This may be indicated by a red socket.

2. Connect a lead from the red socket to the positive side of the ammeter.

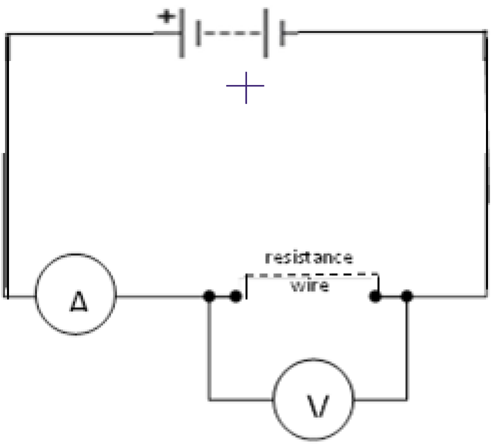
3. Connect a lead from the negative side of the ammeter (this may be black) to the crocodile clip at the zero end of the ruler.

4. Connect a lead from the other crocodile clip to the negative side of the battery.

   The main loop of the circuit is now complete. Use this lead as a switch to disconnect the battery between readings.

5. Connect a lead from the positive side of the voltmeter to the crocodile clip the ammeter is connected to.

6. Connect a lead from the negative side of the voltmeter to the other crocodile clip.



7. Record on a table the:
    - length of the wire between the crocodile clips
    - the readings on the ammeter
    - the readings on the voltmeter.

You will need four columns in total.

Length of wire in cm	Potential difference in V	Current in A	Resistance in Ω

8. Move the crocodile clip and record the new ammeter and voltmeter readings. Note that the voltmeter reading may not change.

    Repeat this to obtain several pairs of meter readings for different lengths of wire.

9. Calculate and record the resistance for each length of wire using the equation:

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

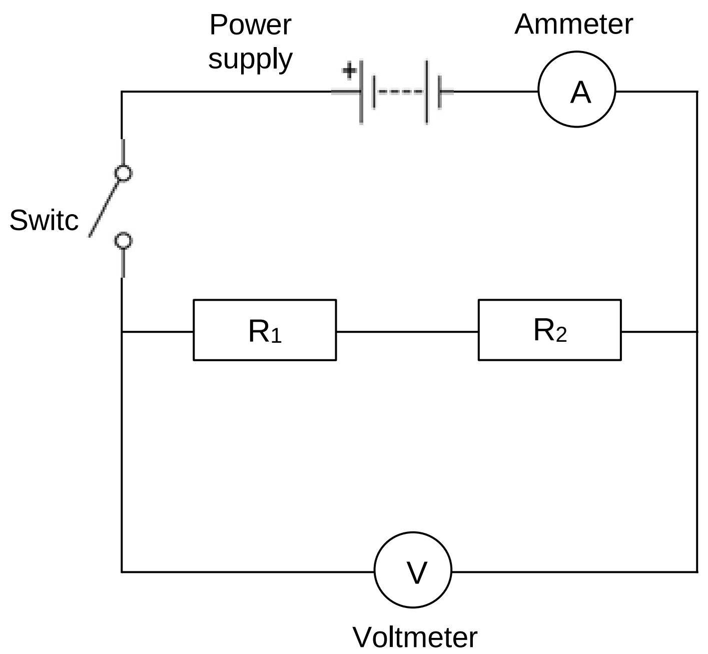
10. Plot a graph with:
    - ‘Resistance in Ω’ on the y-axis
    - ‘Length of wire in cm’ on the x-axis.

11. You should be able to draw a straight line of best fit although it may not go through the origin.

Activity 2: Investigating resistors in series and in parallel.

You are provided with the following:

- a battery or suitable power supply
- ammeter or multimeter
- voltmeter or multimeter
- crocodile clips
- two 10Ω resistors
- connecting leads.



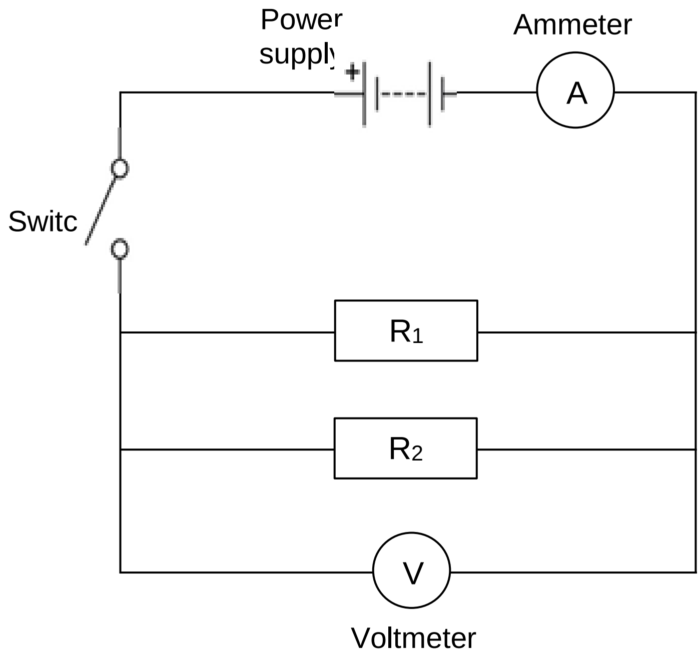
Read these instructions carefully before you start work.

1. Connect the circuit for two resistors in series, as shown in the diagram.

2. Switch on and record the readings on the ammeter and the voltmeter.

3. Use these readings to calculate the total resistance of the circuit.

4. Now set up the circuit for two resistors in parallel.



5. Switch on and record the readings on the ammeter and the voltmeter.

6. Use these readings to calculate the total resistance of the circuit.

7. With one single resistor in the circuit, the total resistance would be 10 ohms. What is the effect on the total resistance of adding:

    a. another identical resistor in series

    b. another identical resistor in parallel?

8. You could also try setting up a circuit with three resistors in series and one with three resistors in parallel.

9. What conclusions can you come to about the effect of adding resistors

    a. in series

    b. in parallel.

GCSE-Physics required practical activity: I-V Characteristics

Teachers' notes

Required practical activity	Apparatus and techniques
Use circuit diagrams to construct appropriate circuits to investigate the I-V characteristics of a variety of circuit elements including a filament lamp, a diode and a resistor at constant temperature.	AT 6, AT 7

What happens to the current when the p.d across a component changes?

Materials

In addition to access to general laboratory equipment, each group needs access to:

- ammeter and milliammeter, or multimeter
- voltmeter or multimeter
- component holders
- 12 V, 24 W lamp e.g. a ray box lamp
- resistor, for example 100 Ω, 1 W
- diode and protective resistor (eg 10 Ω)
- variable resistor eg 10 Ω, 5 A
- connecting leads.

Technical information

There are many different kits available and the students should use what is familiar to them. If using multimeters, it may be helpful to tape over the connections not in use.

When using the diode, the students will need to use a protective resistor. They should still be able to connect the voltmeter across the diode (ie the resistor and diode should not be soldered together).

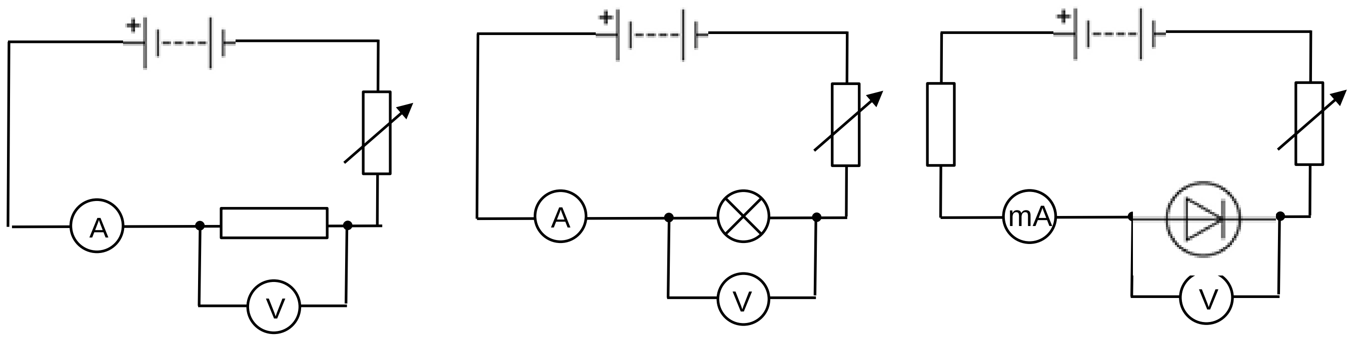
If a lab pack is used for the power supply this can remove the need for the variable resistor as the pd can be varied directly.

The pd should not be allowed to get so high as to damage the components.

Additional information

There are three separate experiments.

The students will record the current through each component for different values of pd. The pd. will be varied using a rheostat, although a variable power supply may be used.



The students will plot a graph of current against pd. This is what is meant by a characteristic.
The circuit with the diode will need to be protected to prevent the current through it getting too big. This circuit also behaves differently depending on the polarity of the supply and due to the low currents through it, a milliammeter will need to be used.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Care should be taken as components, particularly lamps, are likely to get quite hot. The mains lead should be checked for damage before a lab pack is used by a student.

Trialling

The practical should be trialled before use with students.

GCSE Physics required practical activity: I-V Characteristics

Student sheet

Required practical activity	Apparatus and techniques
Use circuit diagrams to construct appropriate circuits to investigate the I-V characteristics of variety of circuit elements including a filament lamp, a diode and a resistor at constant temperature.	AT 6, AT 7

What happens to the current when the p.d across a component changes?

There are **three** activities. In each one you are going to measure electric current in a component as you change the potential difference (Pd) across the component.

You will then plot a graph of current in an against potential difference in V. You will investigate the behaviour of a resistor, a lamp and a diode.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically.**

Method

You are provided with the following:

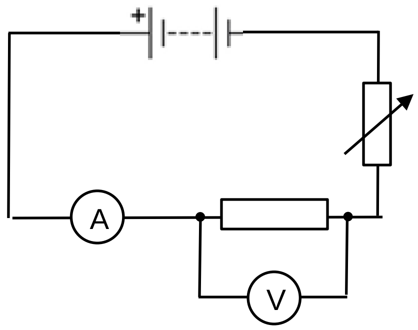
- ammeter and milliammeter, or multimeter
- voltmeter or multimeter
- component holders
- 12 V, 24 W lamp eg a ray box lamp
- resistor
- diode and protective resistor (eg 10 Ω)
- rheostat eg 10 Ω, 5 A
- connecting leads.

Read these instructions carefully before you start work.

Activity 1: The characteristic of a resistor

1. Connect the circuit. It may be helpful to start at the positive side of the battery or power supply. This may be indicated by a red socket.

2. Connect a lead from the red socket to the positive side of the ammeter.



3. Connect a lead from the negative side of the ammeter (this may be black) to one side of the resistor.

4. Connect a lead from the other side of the resistor to the variable resistor.

5. Connect a lead from the other side of the variable resistor to the negative side of the battery.

   The main loop of the circuit is now complete. Use this lead as a switch to disconnect the battery between readings.

6. Connect a lead from the positive side of the voltmeter to the side of the resistor the ammeter is connected to.

7. Connect a lead from the negative side of the voltmeter to the other side of the resistor.

8. Record the readings on the ammeter and voltmeter in a suitable table.

9. Adjust the variable resistor and record the new ammeter and voltmeter readings. Repeat this to obtain several pairs of readings.

10. Swap the connections on the battery. Now the ammeter is connected to the negative terminal and variable resistor to the positive terminal.

    The readings on the ammeter and voltmeter should now be negative.

11. Continue to record pairs of readings of current and potential difference with the battery reversed.

12. Plot a graph with:
    - 'Current in A' on the y-axis
    - 'Potential difference in V' on the x-axis.

    As the readings include negative values, the origin of your graph will be in the middle of the graph paper.

13. You should be able to draw a straight line of best fit through the origin. This is the characteristic of a resistor.

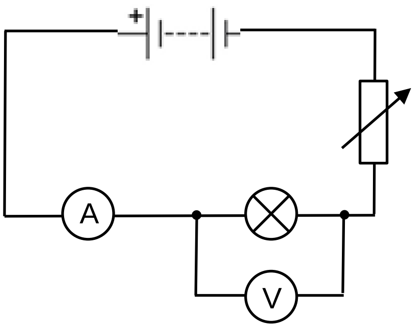
Read these instructions carefully before you start work.

Activity 2: The characteristic of a lamp

1. Swap the leads on the battery back to their original positions.

2. Replace the resistor with the lamp.

   If you are making the circuit from the beginning, follow steps 1-7 in the procedure for the resistor above. For these instructions, use a lamp in place of the resistor.



3. The lamp will get hot. Take care not to touch it.

4. Follow steps **8–11** in the procedure for the resistor above. Remember to swap the leads on the battery to obtain negative readings.

5. Plot a graph with:
   - 'Current in A' on the y-axis
   - 'Potential difference in V' on the x-axis.

   Again the origin will be in the middle of the paper.

   Draw a curved line of best fit for your points.

Read these instructions carefully before you start work.

Activity 3: The characteristic of a diode

1. Swap the leads on the battery back to their original positions.

2. If you can, reduce the battery potential difference to less than 5 V.

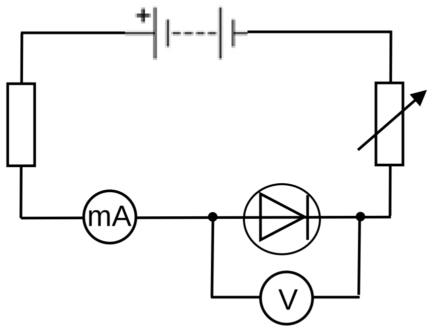
3. Remove the lead from the positive side of the battery. Connect it to the extra resistor labelled **P**.

4. Connect the other end of resistor **P** to the positive side of the battery.

5. Replace the ammeter with a milliammeter

   or

   change the setting on the multimeter.



6. Replace the lamp with the diode. Connect the positive side of the diode to the milliameter.

7. Repeat steps **1–6** above to obtain pairs of readings of potential difference and current for the diode.

8. Plot a graph with:

   - ‘Current in A’ on the y-axis
   - ‘Potential difference in V’ on the x-axis.

   The origin will probably be in the middle of the bottom of your graph paper.

   There should not be any negative values of current.

GCSE Physics required practical activity: Density

Teachers' notes

Required practical activity	Apparatus and techniques
Use appropriate apparatus to make and record the measurements needed to determine the densities of regular and irregular solid objects and liquids. Volume should be determined from the dimensions of regularly shaped objects and by a displacement technique for irregularly shaped objects. Dimensions to be measured using appropriate apparatus such as a ruler, micrometre or Vernier callipers	AT 1

Using density to identify what something is made from.

Materials

In addition to access to general laboratory equipment, each group needs access to further equipment.

For the regular shaped solid objects, each group needs:

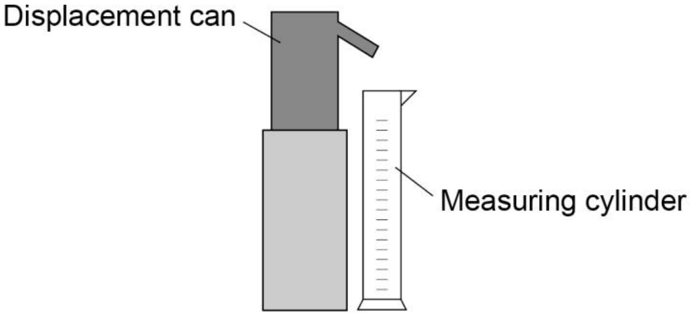
- 30 cm ruler marked off in mm
- digital balance
- materials kits ie various regular shaped objects made of iron, copper, aluminium.

For the irregular shaped solid objects, each group needs:

- digital balance
- displacement can and something to stand it on (eg a brick)
- measuring cylinders
- 250 ml beaker of water and an extra empty beaker
- paper towels
- cotton or thin string
- various irregular shaped objects.

For the liquids, each group needs:

- digital balance
- 250 ml beaker
- suitable liquid eg sugar solution.



Ideally the digital balance should have a range of 1 kg in 1 g steps.

The experiments are relatively straightforward although the measurement of the densities of the liquids and the irregular objects may create a bit of a mess.

The experiments may be best done as part of a circus – so that everyone uses the different density measuring techniques.

You may want to label the solid objects for easy identification.

The displacement can spout is likely to be too low to fit a measuring cylinder underneath it; use a brick or something similar to stand the displacement can on. Alternatively, they can tip the measuring cylinder so that it goes under the spout, but they may knock the spout when moving it.

Additional information

There are three separate experiments. The density of regular objects focuses on the use of a millimetre scale ruler and the calculations of volume and density. Students use their value of density to identify the material of the object being measured.

In the second experiment students measure the volume by displacement. This can be done by lowering the object into a sufficiently large measuring cylinder and noting the change in volume reading. However, a displacement can allows the use of narrower and therefore more precise measuring cylinders to measure the volume. The students should choose a measuring cylinder and justify their choice.

The density of liquid experiment does not make use of specific gravity bottles. It is a basic technique and students identify a liquid from its density.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- There are no serious issues related to these activities.

Trialling

The practical should be trialled before use with students.

GCSE Physics required practical activity: Density

Student sheet

Required practical activity	Apparatus and techniques
Use appropriate apparatus to make and record the measurements needed to determine the densities of regular and irregular solid objects and liquids. Volume should be determined from the dimensions of regularly shaped objects and by a displacement technique for irregularly shaped objects. Dimensions to be measured using appropriate apparatus such as a ruler, micrometre or Vernier callipers.	AT 1

Identifying a substance from its density.

There are **three** activities. In each one you are going to measure the density of an object. You will then use this value to find out what the substance is. You will be expected to work as accurately as possible.

Activity 1: you will determine the density of a regular shaped object using a ruler and balance.

Activity 2: you will measure the mass of an object in the same way as activity 1. You will also measure its volume from the amount of water it displaces.

Activity 3: you will find the density of a liquid.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically.**

Method

Activity 1: Regular shaped objects

You are provided with the following:

- 30 cm ruler marked off in mm
- digital balance
- regular shaped objects.

Read these instructions carefully before you start work.

1. For each object measure the:
    - length
    - width
    - height.
2. Record your results in a table.

    Include columns for volume, mass, density and substance.
    - volume
    - mass
    - density
    - substance.
3. Measure the mass of each object using the digital balance. Record the results.
4. Calculate and record the volumes (length × width × height).
5. Calculate and record the densities (mass ÷ volume).
6. Use the table below to identify the substance each object is made from.

Substance	**Aluminium**	**Zinc**	**Iron**	**Copper**	**Gold**
Density in g/cm^3	2.7	7.1	7.9	8.9	19.3

Activity 2: Irregular shaped objects.

You are provided with the following:

- digital balance
- displacement can and something to stand it on (eg a brick)
- various measuring cylinders
- beaker of water and an extra empty beaker
- paper towels
- cotton or thin string
- irregularly shaped objects.

Read these instructions carefully before you start work.

1. Measure the mass of one of the irregular shaped objects.

2. Record your result in a table.

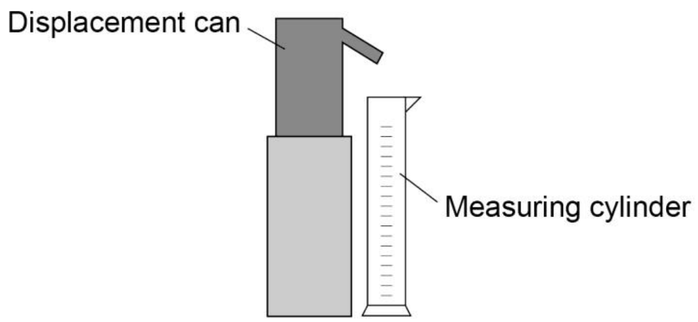
   It will need columns for:

   - volume
   - density
   - mass
   - substance.

3. Place a displacement can on a brick. Put an empty beaker under the spout and fill the can with water. Water should be dripping from the spout.

4. Wait until the water stops dripping. Then place a measuring cylinder under the spout instead of the beaker.

   Choose the measuring cylinder you think will give the most precise reading.



5. Tie the object to a piece of cotton. Very carefully lower it into the displacement can so that it is completely submerged.

   Collect all of the water that comes out of the spout in the measuring cylinder.

6. Measure and record the volume of the collected water. This volume is equal to the volume of the object.

7. Calculate and record the density of the object.

   Try to find out what substance it is made from.

8. Repeat steps **1–7** for some other objects.

   Remember to refill the can each time.

Activity 3 – liquids

You are provided with the following:

- digital balance
- 250 ml beaker
- 100 ml measuring cylinder
- suitable liquid eg sugar solution.

Read these instructions carefully before you start work.

1. Measure the mass of the empty beaker.

2. Record your results in a table.

   Your table will need columns for the:

   - mass of the empty beaker
   - mass of the beaker with the liquid in
   - mass of the liquid
   - volume of the liquid
   - density of the liquid.

3. Pour about 100 ml of liquid into the measuring cylinder.

   Measure and record the volume.

4. Pour this liquid into the beaker.

   Measure and record the mass of the beaker and liquid.

5. Calculate and record the volume of the liquid.

6. Calculate the density of the liquid.

7. The density of water is 1 g/cm^3.

8. Determine the mass of sugar per cm^3 dissolved in the water. Assume the sugar does **not** affect the volume of the water.

GCSE Physics required practical activity: Light

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the reflection of light by different types of surface and the refraction of light by different substances.	AT 4, AT 8

What happens to the direction of light after hitting the surface of different materials?

Materials

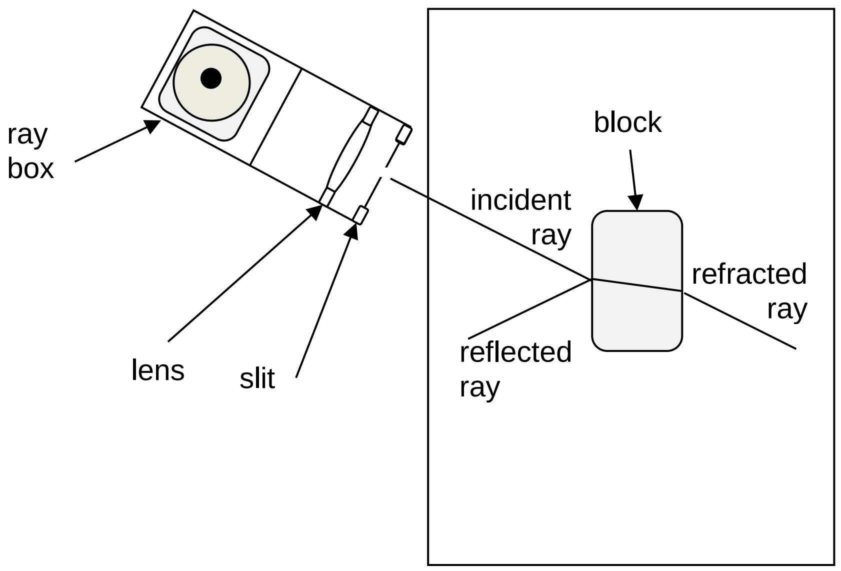
In addition to access to general laboratory equipment, each group needs:

- ray box and suitable power supply
- collimating slit and lens
- rectangular transparent blocks – preferably of different materials eg glass, Perspex
- 30 cm ruler
- protractor
- sheets of plain A3 paper.

Technical information

In this experiment, students trace the path of light refracted through and reflected from blocks of different materials. They will use a ray box to produce a narrow ray of light. They will compare the light reflected and refracted for the two materials.

The ray is produced using a single narrow slit placed in the jaws of the ray box. The ray is likely to broaden as it leaves the slit so a cylindrical convex lens can be used to help produce a narrow, bright ray. The reflected and refracted rays will be faint. The experiment will have to be carried out in low light conditions.



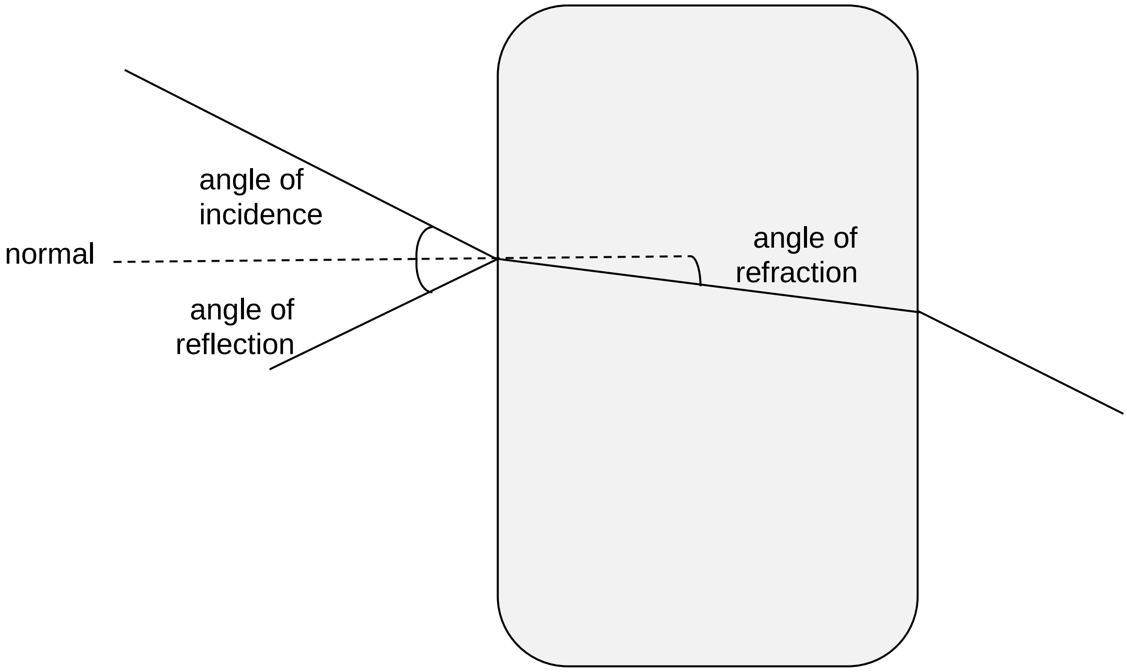
Additional information

A ray shows the path of the light wave. The angle of the ray at the surface of a material is conventionally measured to the ‘normal’. This is a line drawn at right angles to the surface.

The angle of the incident ray (the angle of incidence) and the angle of the reflected ray (the angle of reflection) are equal. This does not depend on the material.

The path of the refracted ray within the block is found by marking its path as it leaves the block and joining the start of this to the end of the path of the incident ray. The angle the ray makes to the normal (the angle of refraction) within the block depends on the material.

The investigation is designed to demonstrate the effect the material has on the angles of reflection and refraction.



Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- The ray box will get hot. It should be switched off when not in use.
- The experiment will have to be carried out in reduced lighting. Care should be taken so that students can still be supervised to minimise the risk of accidents.
- If you are opting to use a levelling laser or LED ray box, please refer to CLEAPSS PS52. Lasers must be class 2.

Trialling

The practical should be trialled before use with students.

GCSE Physics required practical activity: Light

Student sheet

Required practical activity	Apparatus and techniques
Investigate the reflection of light by different types of surface and the refraction of light by different substances.	AT 4, AT 8

What happens to the direction of light after hitting the surface of different materials?

When light hits a surface it can be reflected, transmitted and absorbed.

You will investigate what happens to light when it is reflected and transmitted. You will use two different materials.

A ray box is used to direct a ray of light onto the surface of a transparent block. You will then mark the path of the ray that is:

- reflected from the surface of the block
- that passes through the block.

The ray box needs to produce a narrow ray of light. The experiment needs to be performed in a darkened room. This is so that the paths of the rays can be marked precisely.

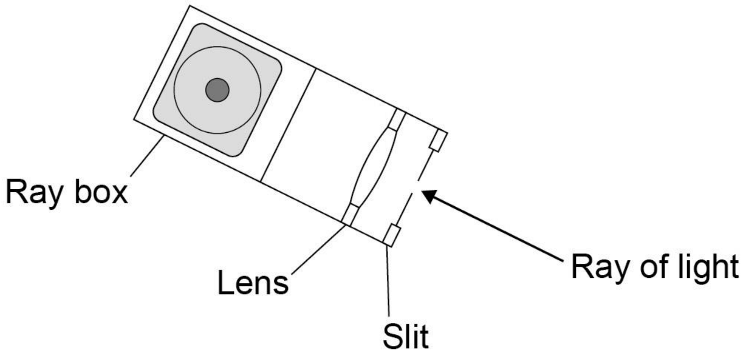
You will then repeat the experiment using a different block and compare the results.

Learning outcomes
1
2
3
Teachers to add these with particular reference to working scientifically.

Method

You are provided with the following:

- ray box
- suitable power supply
- a slit and lens that fit the ray box and can be used to make a narrow ray
- two rectangular transparent blocks of different materials eg glass, Perspex
- 30 cm ruler
- protractor
- sheets of plain A3 paper.



Read these instructions carefully before you start work .

1. Set up the ray box, slit and lens so that a narrow ray of light is produced. Then darken the room.

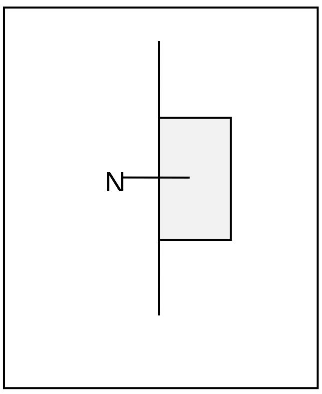
2. The ray box will get hot – be careful when you move it.

   Switch it off when you don't need it.

3. Place the ruler near the middle of the A3 paper and draw a straight line parallel to its long side.

4. Use the protractor to draw a second line at right angles to this line.

   Label this line with an '**N**' for '**normal**'.



5. Place the longest side of a transparent block against the first line, with the largest face of the block on the paper.

   The normal should be near the middle of the block.

6. Draw around the transparent block. Be careful **not** to move it.

7. Use the ray box to direct a ray of light at the point where the normal meets the block.

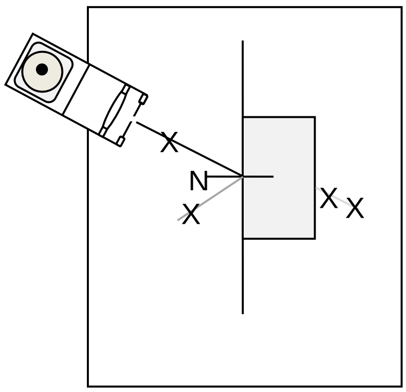
   This is called the '**incident ray**'.

8. The angle between the normal and the incident ray is called '**the angle of incidence**'.

   Move the ray box or paper to change the angle of incidence. Do this until you see;

   - a clear ray reflected from the surface of the block
   - another clear ray leaving the opposite face of the block.

   You will probably have to do this with the room darkened.



9. Mark the path of the incident ray with a cross. If the ray is wide, make sure the centre of the cross is in the centre of the ray.

10. Mark the path of the reflected ray with another cross.

11. Mark the path of the ray that leaves the block (the transmitted ray) with two crosses. One cross needs to be near the block and the other cross further away.

12. Switch on the room lights. Switch off the ray box and remove the block.

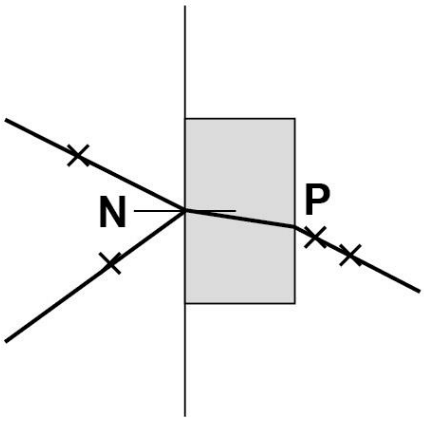
13. Draw the incident ray by drawing a line through your first cross to the point where the normal meets the block.

14. Draw the reflected ray by drawing a line through your second cross to the point where the normal meets the block.

15. Draw the transmitted ray by drawing a line through the two crosses on the other side of the block to that side of the block. Label this point with a ‘**P**’.

16. Draw a line that represents the path of the transmitted ray through the block.

    Do this by drawing a line from point **P** to the point where the normal meets the block.

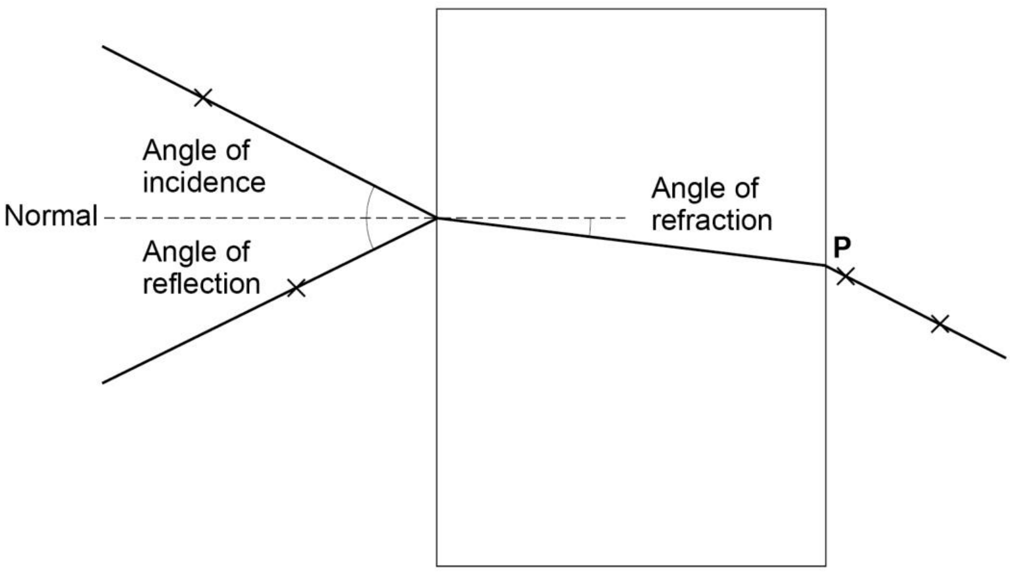


17. Use the protractor to measure:

    a. the angle between the incident ray and normal – this is the angle of incidence

    b. the angle between the reflected ray and normal – this is the angle of reflection

    c. the angle between the ray inside the block and the normal – this is the angle of refraction.



Record your measurements in a table such as the one below.

Angle of incidence in degrees	First block		Second block	
	Angle of reflection in degrees	Angle of refraction in degrees	Angle of reflection in degrees	Angle of refraction in degrees

18. Now repeat steps **3–17** for the other transparent block.

    Place the other block on the A3 paper.

19. Line up the long side of the block as before.

20. If the block is not the same size as the first one, carefully draw around it without moving it.

21. Use your ray box to send in an incident ray along the same line as before. Again you may have to work in a darkened room.

22. Look at the directions of the reflected and transmitted rays.

23. If they are not the same as before, mark their paths using crosses.

24. Remove the block, switch off the ray box, and switch on the room lights.

25. Draw in the reflected and refracted rays.

26. Measure the angle of reflection and the angle of refraction. Record them in your table.

27. Physics theory suggests that the angles of reflection should be the same, but the angles of refraction should be different.

    How well do your results support this theory?

GCSE Physics required practical activity: Force and Extension

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the relationship between force and extension for a spring.	AT 1, AT 2

Making and calibrating a spring-balance (newtonmeter).

Materials

In addition to access to general laboratory equipment, each group needs:

- a spring of a suitable stiffness (eg capable of extending more than 1 cm under a load of 1 N) with loops at each end
- metre ruler
- suitable pointer – eg splint and tape
- weight stack appropriate for the spring – eg 10 N in steps of 1 N
- clamp stand, 2 clamps and bosses
- g clamp or weight to prevent the apparatus tipping over the edge
- object, eg stone attached to string, to weigh

Technical information

If you are using new springs, you should extend them under a suitable load for a short while. The pointer should be attached so that it doesn't slip or change angle. It is probably best attached to the bottom of the spring. The students will measure the extension ie the increase in length. Many are likely to think that this is the incremental increase – in fact it is the total increase (ie from the original length). The students align the top of the ruler with the top of the spring – this isn't essential but it may help emphasise this point about the extension.

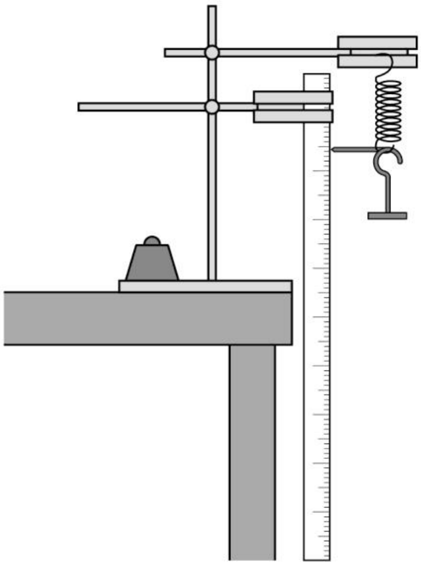
Students may need to be told how to convert the mass (in grams) written on the weight stack into a weight in newtons. (Using the equation W = mg, 100 g has a weight of 1 N). This practical can be used to emphasise the difference between mass and weight.

The weight of the stone should be within the range of weights used. The length of the spring shouldn't exceed one metre when fully stretched.

Additional information

The relationship between force and extension is given by Hooke's Law. This is an opportunity to investigate the life and work of Robert Hooke who was a contemporary of Isaac Newton.

The students will record the reading on the metre ruler (which will be the length of the spring if set up that way) as the weights are added. They will then calculate the extension (ie the increase from the original reading). The extension should increase in proportion to the weight. A graph of extension against weight will be a straight line through the origin. The gradient of the line is 1/stiffness or 1/spring constant. (ie the graph for a stiffer spring will have a lower gradient). To determine the weight of the stone, students measure the extension and either use their graphs (read off the weight directly) or use 1/gradient multiplied by the extension to give the weight.



Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- The springs should be checked so that the loops at the ends don't unravel when the greatest weight is used.
- It is likely that the spring will extend below the edge of the bench. The clamp stand should be secure so as not to tip. Put something under the spring and weight to protect the floor in case things slip.

Trialling

The practical should be trialled before use with students.

GCSE Physics required practical activity: Force and extension

Student sheet

Required practical activity	Apparatus and techniques
Investigate the relationship between force and extension for a spring.	AT 1, AT 2

Making and calibrating a spring balance (newtonmeter)

You will investigate the relationship between the weight hung from a spring and how much longer the spring gets (the extension).

You will use your results to plot a graph of extension against weight. Then you will use your graph to find the weight of a mystery object.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

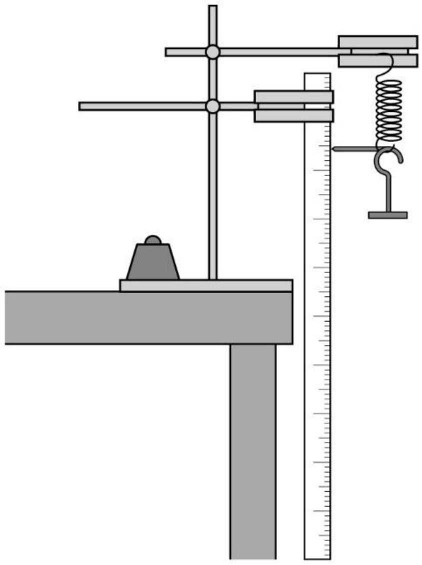
- a spring
- a metre ruler
- a splint and tape to act as a pointer
- a 10 N weight stack
- a clamp stand, with two clamps and bosses
- a heavy weight to prevent the apparatus tipping over
- a mystery object to weigh.

Read these instructions carefully before you start work.

1. Attach the two clamps to the clamp stand using the bosses. The top clamp should be further out than the lower one.

2. Place the clamp stand near the edge of a bench. The ends of the clamps need to stick out beyond the bench.

3. Place a heavy weight on the base of the clamp stand to stop the clamp stand tipping over.



4. Hang the spring from the top clamp.

5. Attach the ruler to the bottom clamp with the zero on the scale at the top of the ruler.

   If there are two scales going in opposite directions, you will have to remember to read the one that increases going down.

6. Adjust the ruler so that it is vertical. The zero on the scale needs to be at the same height as the top of the spring.

7. Attach the splint securely to the bottom of the spring. Make sure that the splint is horizontal and that it rests against the scale of the ruler.

8. Take a reading on the ruler – this is the length of the unstretched spring.

9. Carefully hook the base of the weight stack onto the bottom of the spring. This weighs 1.0 newton (1.0 N).

10. Take a reading on the ruler – this is the length of the spring when a force of 1.0 N is applied to it.

11. Add further weights. Measure the length of the spring each time.

12. Record your results in a table such as the one below.

    You will need a third column for the extension. This is the amount the string has stretched. To calculate this you subtract the length of the unstretched spring from each of your length readings.

Weight in N	**Length of spring in cm**	**Extension of spring in cm**

13. Do not put the apparatus away yet.

14. Plot a graph with:
    - 'Extension of spring in cm' on the y-axis
    - 'Weight in N' on the x-axis.

15. Hang the unknown object on the spring. Measure the extension and use your graph to determine the object's weight. Check it with a newtonmeter.

GCSE Physics required practical activity: Acceleration

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the effect of varying the force on the acceleration of an object of constant mass and the effect of varying the mass of an object on the acceleration produced by a constant force.	AT 1, AT 2, AT 3

Investigating acceleration using an air track and light gates.

Materials

In addition to access to general laboratory equipment, each student needs access to:

- linear air track and gliders
- bench pulley, string and small weight stack e.g. 1 N in steps of 0.2 N
- card 10 cm x 5 cm
- two clamp stands, clamps and bosses
- two light gates, interface and computer software
- Blu-Tack or similar to attach the weights to the glider.

Technical information

The air track provides a cushion of air for the gliders to 'float' on, thus reducing friction to almost zero. Air is often provided by a vacuum cleaner in 'blow' mode. The air track should be level. This can be achieved by adjusting the legs. There are two adjustments: one to make sure that the air track isn't leaning to one side. The other to make sure it is horizontal. Place a glider in the middle of the air track and switch on the vacuum cleaner. Adjust the legs so that the glider rests on the cushion of air without moving or touching the sides of the air track.

The card is attached to the glider. Using the clamp stands, the light gates are positioned so that the card interrupts the light beam as the glider moves along the air track. The time is measured automatically. The software usually requires you to input the length of the card (10 cm in this case). The force is provided by the weight stack, string and pulley. Attach the pulley to the bench at the far end of the air track. Hang the weight stack on the string, pass it over the pulley and attach it to the glider. Check that, when the vacuum cleaner is switched on, the weight starts to fall and the glider to accelerate. It is important that the card passes through the second light gate before the weight stack hits the ground.

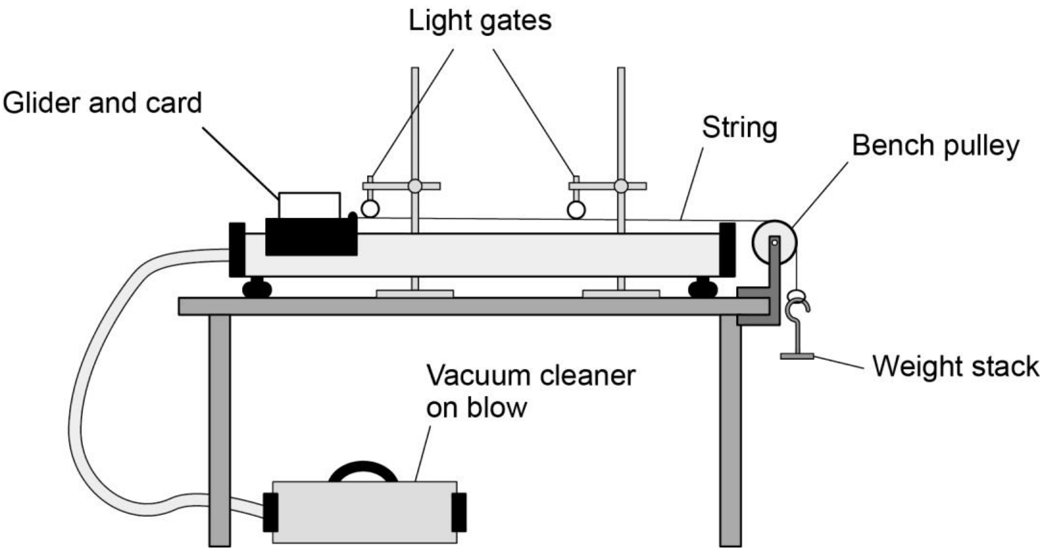
When varying the force, the total mass of the system should stay constant. The mass of the system is the mass of the glider plus the mass of the weight stack. The ‘unused’ weights should therefore be attached to the sides of the glider (with the Blu-Tack).
The experiment is best controlled with the vacuum cleaner mains switch. When everything is ready simply switch it on and the glider will go. When the weight stack hits the ground, switch it off and the glider stops.

Additional information

The relationship between force, mass and acceleration is given by Newton’s Second Law of Motion. The acceleration of the glider is usually worked out automatically by the software that comes with the light gates provided the length of the card is input into the system. Students should understand how the calculation is done:

$$\text{acceleration} = \frac{\left(\dfrac{length\ of\ card}{interrupt\ time\ 2} - \dfrac{length\ of\ card}{interrupt\ time\ 1}\right)}{time\ between\ interruptions}$$

The students will record the values of acceleration for constant mass as the force is varied. They can plot a graph of acceleration against force and get a straight line through the origin.



Alternatively this investigation can be carried out using a trolley, ramp and ticker timers. Students would use the ticker tape to make a velocity-time graph and measure the acceleration from the slope.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Check the mains cable to the vacuum cleaner.
- Do not use large weights on the weight stack. The glider can cause the air track to fall off the bench if it hits the end moving quickly.

Trialling

The practical should be trialled before use with students.

GCSE Physics required practical activity: Acceleration

Student sheet

Required practical activity	**Apparatus and techniques**
Investigate the effect of varying the force on the acceleration of an object of constant mass and the effect of varying the mass of an object on the acceleration produced by a constant force.	AT 1, AT 2, AT 3

Investigating acceleration using an air track and light gates.

You will investigate the relationship between the acceleration of an object and the size of the force acting upon it.

You will use an air track. This produces a cushion of air which allows gliders to move almost friction free.

Learning outcomes
1
2
3
Teachers to add these with particular reference to working scientifically.

Method

You are provided with the following:

- linear air track and gliders
- vacuum cleaner
- bench pulley, string and small weight stack eg 1 N in steps of 0.2 N
- card
- two clamp stands, with clamps and bosses
- two light gates, interface and computer
- Adhesive putty to attach the weights to the glider.

Read these instructions carefully before you start work.

1. Place the air track on a bench and attach it to the vacuum cleaner, set on ‘blow’.

2. Place a glider on the air track and switch on the vacuum cleaner. The glider should lift up off the air track and be free to move.

3. Adjust the legs of the air track so that the glider moves without touching and the air track is horizontal.

   There are two separate adjustments to make. With the vacuum cleaner on:

   - place the glider above the adjuster that tilts the air track from side to side. Adjust the length of the leg until the glider does not touch the sides
   - place the glider in the middle of the air track. Adjust the other leg until the glider does not move when released.

4. Cut out a piece of card measuring 5 cm $\times$ 10 cm. Put it in the groove on the glider. The long side should be horizontal.

5. Clamp the two light gates horizontally. Position them above the air track so that the card passes through them as the glider moves.

6. Connect the light gates to the interface and computer. Start the software for timing.

   You should have the opportunity to choose acceleration using two light gates.

   Type in the length of the card (10 cm) when asked by the computer.

7. Check the movement of the glider by gently pushing it along the track. The software needs to be on.

   The acceleration should be close to zero. Switch off the vacuum cleaner.

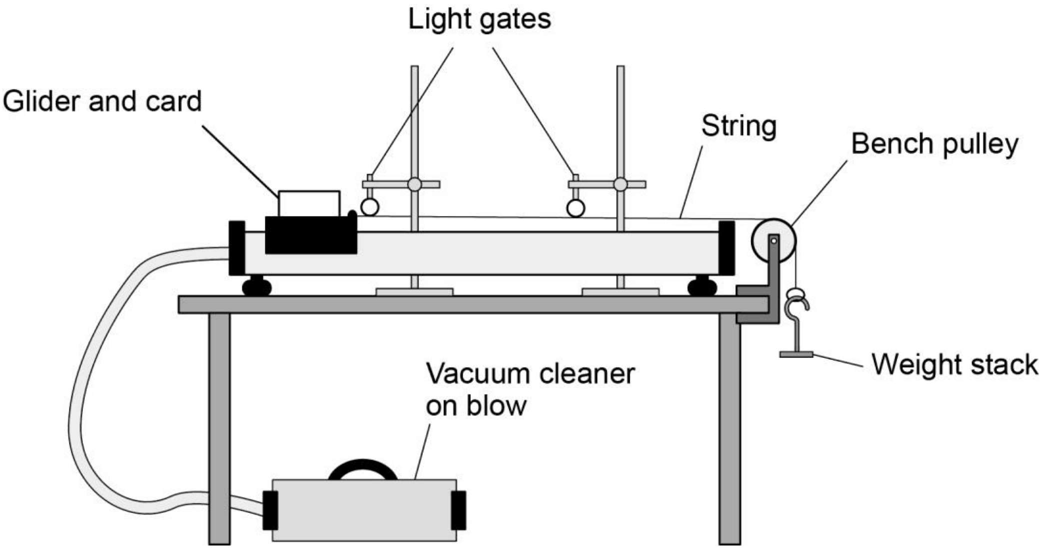
8. Attach the bench pulley to the end of the air track away from the vacuum cleaner.

9. Tie a length of string to the glider. Pass the string over the pulley and attach the weight stack to the other end of the string.

   Make sure the string is horizontal and is in line with the air track.

10. Switch on the vacuum cleaner. The glider should accelerate through the light gates as the weight falls to the ground.

11. If necessary, move the second light gate so that the glider passes through it before the weight hits the ground. If the weight hits the ground too early, the glider will stop accelerating too early.



12. The first experiment will investigate how the acceleration depends upon the force. The force is provided by the weight stack.
    - Attach the full weight stack (1 N) to the end of the string.
    - Switch on the software.
    - Make sure the glider is in position and switch on the vacuum cleaner.
    - The glider should accelerate through the light gates towards the bench pulley.
    - Record the acceleration. Repeat.
    - If the two values are not similar, repeat again.
    - Record your readings in a table such as the one below. Calculate the mean.

Force in N	**Acceleration in cm/s^2**			
	First reading	**Second reading**	**Third reading (if necessary)**	**Mean**

13. Remove one weight (0.2 N) and attach that to the glider. This will keep the total mass constant. (The weight stack is being accelerated too.)

14. Repeat the experiment for a force of:
    - 0.8 N
    - 0.6 N

- 0.4 N
- 0.2 N.

Remember to attach each weight to the glider as it is removed from the weight stack.

15. Plot a graph with:
    - ‘Acceleration in m/s^2’ on the y-axis
    - ‘Force in N’ on the x-axis.

GCSE Physics required practical activity: Waves

Teachers' notes

Required practical activity	Apparatus and techniques
Make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements.	AT 4

This activity is likely to be a teacher demonstration or form part of a 'circus' of experiments for students to perform.

The activity is split into two parts:

- observing water waves in a ripple tank
- observing waves on a stretched string or elastic cord.

Activity 1: Observing waves in a ripple tank

Materials

- ripple tank plus accessories
- suitable low voltage power supply
- metre ruler

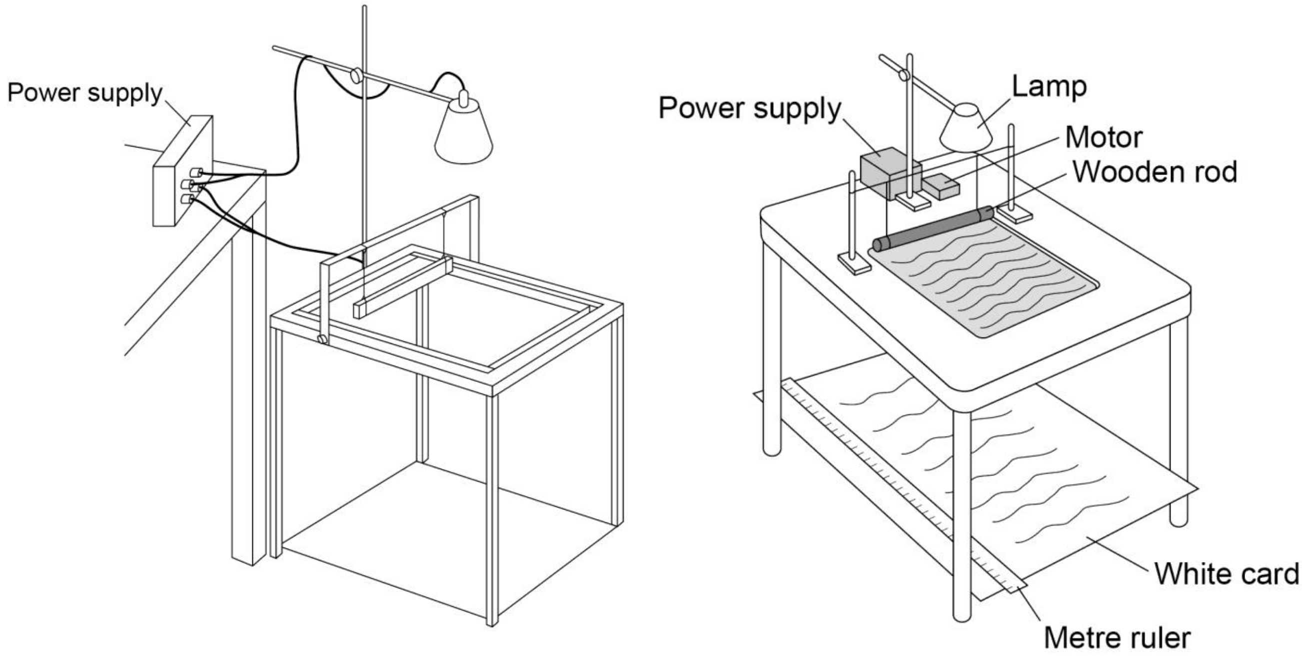
Technical information

The design of ripple tanks varies slightly from one manufacturer to another. The following is given for general guidance.

The depth of water in the ripple tank should be about 5 mm.

To produce plain (straight) waves, a wooden rod should be used (usually one of the accessories supplied with the ripple tank). When stationary the wooden rod should just touch the water surface. A single low voltage power supply may be used for both the motor attached to the wooden rod and the lamp (usually a power supply designed specifically for use with a ripple tank). Alternatively, a fixed power supply can be used for the lamp and a single 1.5 V cell with a variable resistor (in series) as a variable supply to the motor.

The ripple pattern can be viewed either on a large sheet of white card placed on the floor directly below the ripple tank or on the ceiling. To view the pattern on the floor, have the lamp above the ripple tank. To view the pattern on the ceiling, have the lamp below the ripple tank. If viewing the pattern on the floor, students should look from the side directly at the card and not look from above through the water in the ripple tank. The position of the lamp should be adjusted to give a clear image. Some ripple tanks are designed to sit on top of an overhead projector. If one of these is used, the students will be able to view a large image projected onto a wall.



Additional information

A darkened laboratory may make it easier to observe the wave pattern.

Students should observe the wave pattern and then decide how the wavelength, frequency and speed should be measured.

Wavelength – it is likely that a metre ruler positioned at right angles to the projected wave fronts will be used. Measure across as many waves as possible then divide the total length by the number of waves.

Frequency – it is likely that no apparatus will be used. If the motor is rotating slowly so the frequency is low it should be possible to count the number of waves passing a point in the pattern over a given time (say 10 seconds). Then divide the number of waves counted by 10. If this is a demonstration experiment, have several students count the waves and then calculate the mean value.

Speed – this will be calculated using the equation:

wave speed = frequency x wavelength

Risk assessment

- Water is easily spilt onto the floor. Mop up all spills straight away.
- Place any power supply used on a laboratory bench and not on the floor.
- The frequency of a stroboscope can trigger an epileptic fit (7-15 Hz). Although this method may be suggested by students, it is NOT advisable to use a stroboscope with the class.

Trialling

Obtaining a clear pattern from a ripple tank is not easy. It is advisable to trial the experiment and if possible have the ripple tank set up and ready for use before the class starts.

Activity 2: Observing waves on a stretched string or elastic cord

This method uses resonance to set up a standing wave on a vibrating string. The theory of resonance and standing waves does not need to be covered.

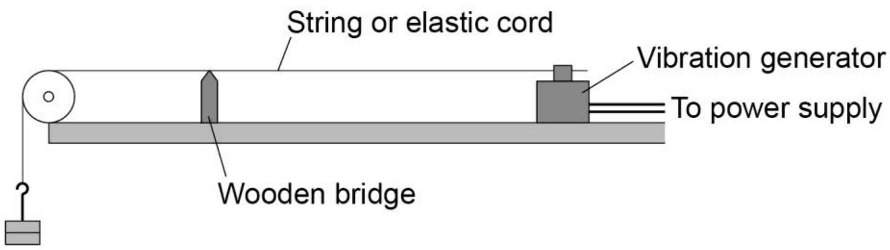
Materials:

- vibration generator
- suitable power supply (variable frequency)
- suitable string or elasticated cord
- set of 100g masses and hanger
- set of 10g masses and hanger
- wooden bridge
- pulley on a clamp.

Technical information

To achieve the conditions necessary for resonance the following can be adjusted:

- the frequency at which the generator vibrates (adjust the frequency of the power supply)
- the length of string allowed to vibrate (move the wooden bridge)
- the tension in the string (add or remove masses).



For a quick demonstration use an elasticated cord attached to the vibration generator. Then simply stretch the cord until it resonates and a standing wave pattern is seen.

Students should observe the wave pattern and then decide how the wavelength, frequency and speed should be measured.

- Wavelength – it is likely that a metre ruler will be used to measure across as many half wavelengths as possible. Then divide the total length by the number of half waves. Multiplying this number by two will give the wavelength.
- Frequency – it is likely that no apparatus will be used. The frequency will be the frequency of the power supply. It may be suggested that a stroboscope is used. This will 'freeze' the pattern to show a transverse wave. The frequency of the stroboscope is then the frequency of the waves.
- Speed – this will be calculated using the equation:

$$\text{wave speed} = \text{frequency} \times \text{wavelength}$$

Risk assessment

- Students sitting close to the vibrating string should wear safety goggles or sit behind a safety screen.
- The frequency of a stroboscope can trigger an epileptic fit. Although this method may be suggested by students it is therefore NOT advisable to use a stroboscope with the class.

Trialling

The practical should be trialled before use with students to ensure a standing wave can be set up and seen.

Extension

Using the same apparatus, the relationship between the tension in the string and speed of the wave could be investigated.

GCSE Physics required practical activity: Waves

Student sheet

Required practical activity	Apparatus and techniques
Make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements.	AT 4

The activity is split into two parts:

- observing water waves in a ripple tank
- observing waves on a stretched string or elastic cord.

Your teacher may complete both parts of this activity as a class demonstration.

Activity 1: Observing waves in a ripple tank

Learning outcomes
1
2
3
Teachers to add these with particular reference to working scientifically

Method

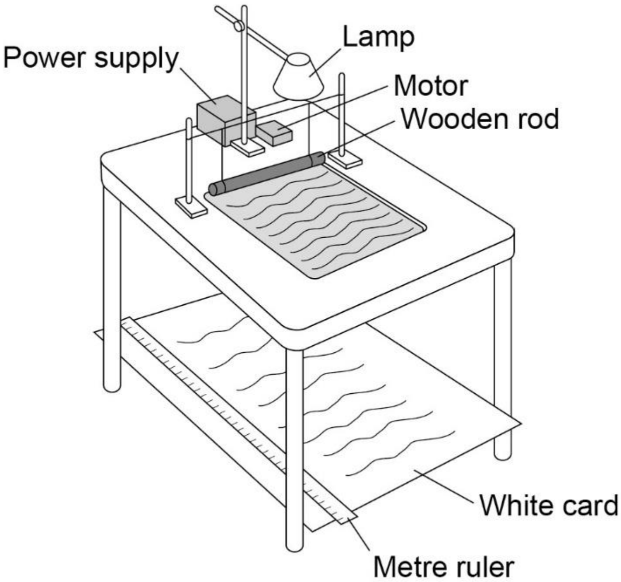
You are provided with the following:

- ripple tank plus accessories
- suitable low voltage power supply
- metre ruler.

Read these instructions carefully before you start work.

1. Set up the ripple tank.

   A large sheet of white card or paper needs to be on the floor under the tank.



2. Pour water to a depth of about 5 mm into the tank.

3. Adjust the height of the wooden rod so that it just touches the surface of the water.

4. Switch on both the overhead lamp **and** the electric motor.

5. Adjust the speed of the motor. Low frequency water waves need to be produced.

6. Adjust the height of the lamp. The pattern needs to be clearly seen on the card on the floor.

7. Place a metre ruler at right angles to the waves shown in the pattern on the card.

   Measure across as many waves as possible. Then divide that length by the number of waves. This gives the **wavelength** of the waves.

8. Count the number of waves passing a point in the pattern over a given time (say 10 seconds).

   Then divide the number of waves counted by 10. This gives the **frequency** of the waves.

9. Calculate the speed of the waves using the equation:

$$\text{wave speed} = \text{frequency} \times \text{wavelength}$$

Activity 2: Observing waves on a stretched string or elastic cord.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically**

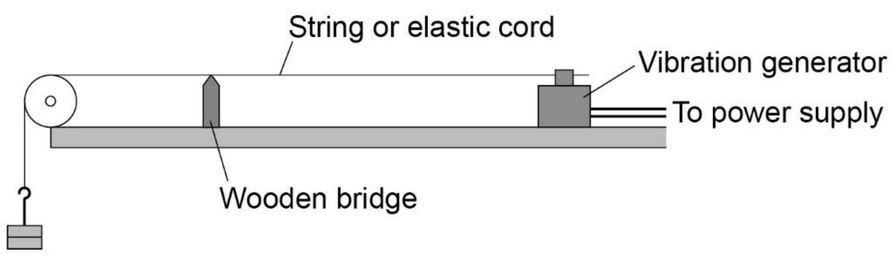
Method

You are provided with the following:

- vibration generator
- suitable power supply (variable frequency)
- suitable string or elasticated cord
- set of 100 g masses and hanger
- set of 10 g masses and hanger
- wooden bridge
- pulley on a clamp.

Read these instructions carefully before you start work

1. Set up the apparatus as shown.



2. Switch on the vibration generator. The string (or elasticated cord) should start to vibrate.

3. A clear wave pattern needs to be seen. To do this, adjust the tension in the string or move the wooden bridge to adjust the length of the string.

   The waves should look like they are stationary.

4. Use a metre ruler to measure across as many half wavelengths as possible (a half wavelength is one loop).

   Then divide the total length by the number of half waves. Multiplying this number by two will give the **wavelength**.

5. The **frequency** is the frequency of the power supply.

6. Calculate the speed of the wave using the equation:
   wave speed = frequency × wavelength

GCSE Physics required practical activity: Radiation and absorption

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.	AT 1, AT 4

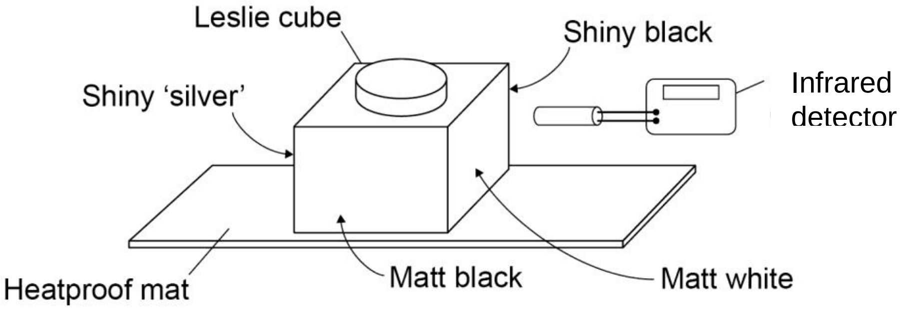
Investigate the amount of infrared radiation emitted by different surfaces

Materials:

- Leslie cube
- kettle
- infrared detector
- heatproof mat.

Technical information

If a Leslie cube is not available or a class set is required, then a simple 'home-made' version could be used. Take a large empty metal can and lid, for example a coffee tin. Remove any outside paper labels so that only the bare metal is seen. Paint one section with a matt white paint and another with a matt black paint. Leave one section as a shiny 'silver' surface.



The detector may be an infrared detector with a suitable meter, an infrared thermometer or a liquid-in-glass thermometer with the bulb painted matt black. The last option is likely to have the least resolution.

Investigate the amount of infrared radiation absorbed by different surfaces

A simple investigation showing how the type of surface affects the amount of infrared radiation absorbed involves placing two metal sheets an equal distance from an infrared source. One side of one sheet is painted black with the black surface pointing inwards. The other sheet is shiny on both sides. Use candle wax to attach a small coin to the side of the sheets that face away from the infrared source. When the infrared radiation source is turned on the coin that drops off first will have been attached to the sheet that was the better absorber of radiation.

Additional information

Before filling with boiling (or very hot) water the Leslie cube should be placed on a heatproof mat.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Care must be taken when boiling (or very hot) water is used. Students should not carry containers of hot water across the laboratory.
- Take care with black surfaces as these can reach high temperatures (~80 °C).

Trialling

The practical should be trialled before use with students.

GCSE Physics required practical activity: Radiation and absorption

Student sheet

Required practical activity	Apparatus and techniques
Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.	AT 1, AT 4

Investigating the amount of infra-red radiation emitted by different surfaces

Your teacher may complete this investigation as a class demonstration or include it in a 'circus' of experiments.

Learning outcomes
1
2
3
Teachers to add these with particular reference to working scientifically

Method

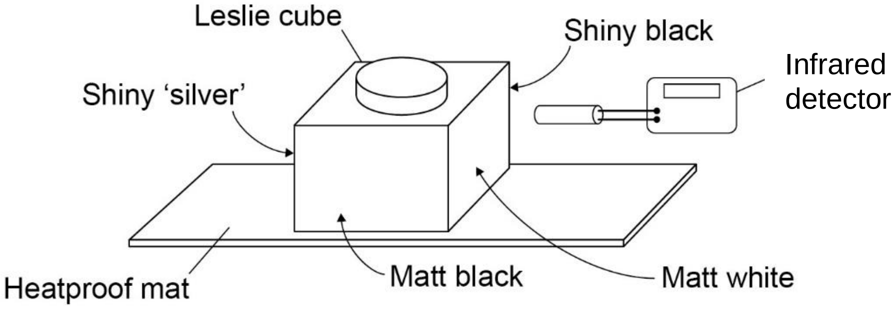
You are provided with the following:

- Leslie cube kettle
- infrared detector
- heatproof mat.

Read these instructions carefully before you start work

1. Place the Leslie cube on to a heat proof mat.

2. Fill the cube with very hot water and replace the lid of the cube.



3. Use the detector to measure the amount of infrared radiated from each surface.

   Make sure that before a reading is taken the detector is the same distance from each surface.

   Draw a bar chart to show the amount of infrared radiated against the type of surface.