GCSE Physics: Required practical Student Sheets

Contents

Introduction

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

In this guide, AQA suggest methods and activities for carrying out the required practical activities to help you plan the best experience for your students. AQA also write your exams so it is worth looking at their methods.

Why do practical work?

Practical work is at the heart of science – that's why AQA have placed it at the heart of each of their 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.

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

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.

	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).

Lab equipment

This is the equipment that the exam board says you should be familiar with. Can you come up with a use for each or link it to the AT above?

Equipment	Use or AT (from above)
• 1 kg copper, iron and aluminium metal blocks	
• 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(slot cards) 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)	

Required Practicals – Paper 1

Specific heat capacity

Required practical activity
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.

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.

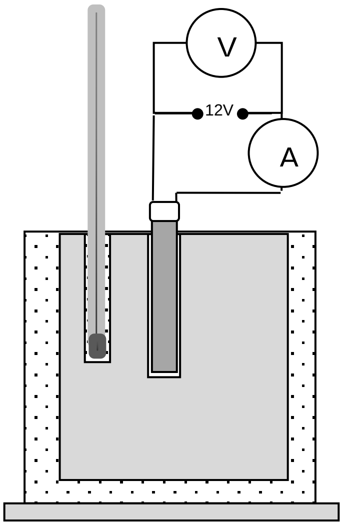
Method

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.

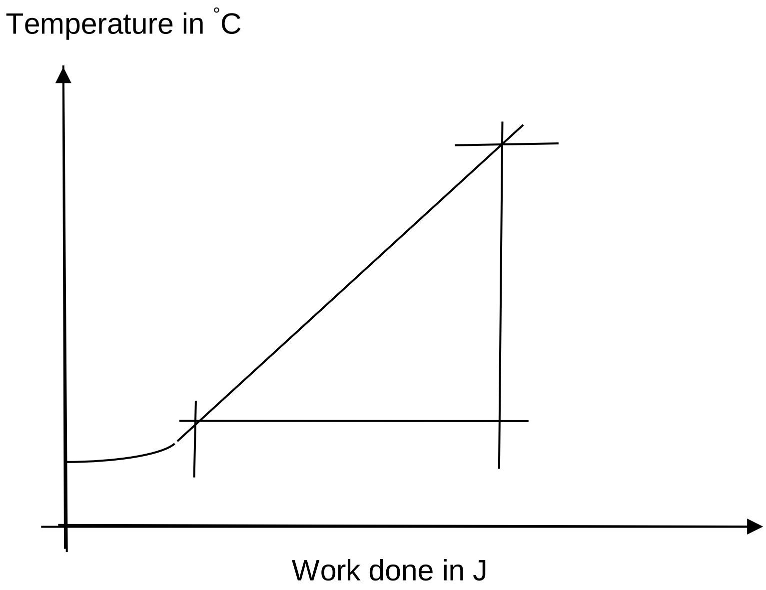
Time in seconds	Work done in J	Temperature in ˚C
0		
60		
120		
180		
240		
300		
360		
420		
480		
540		
600		

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?

Thermal insulation - Separates only

Required practical activity
Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material.

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.

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.

Resistance

Required practical activity
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.

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.

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.

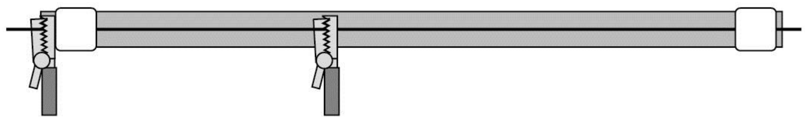
Read these instructions carefully before you start work.

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.

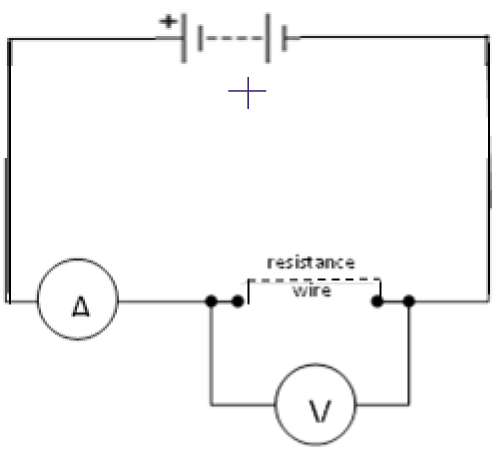


4. Connect a lead from the other crocodile clip to the negative side of the battery.

   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:

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

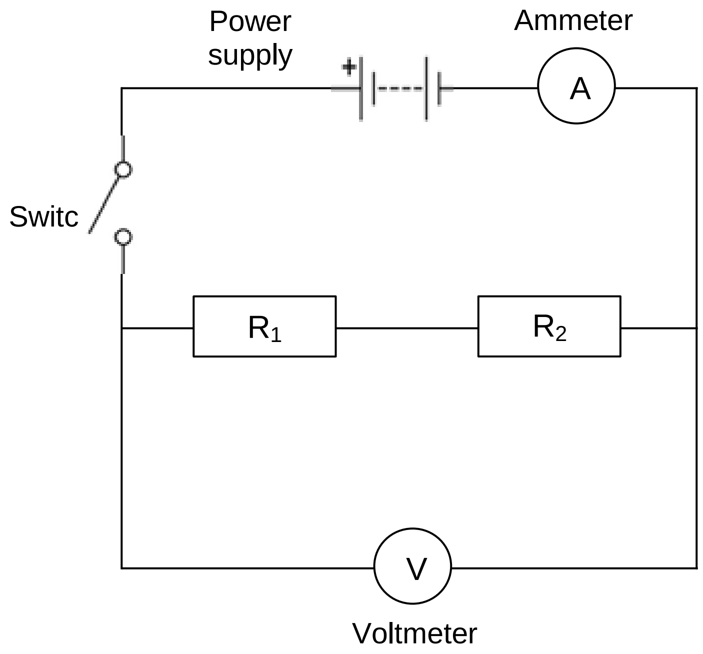
10. Plot a graph with:
    - 'Resistance in Ω' on the y-axis
    - 'Length of wire in cm' on the x-axis.

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.

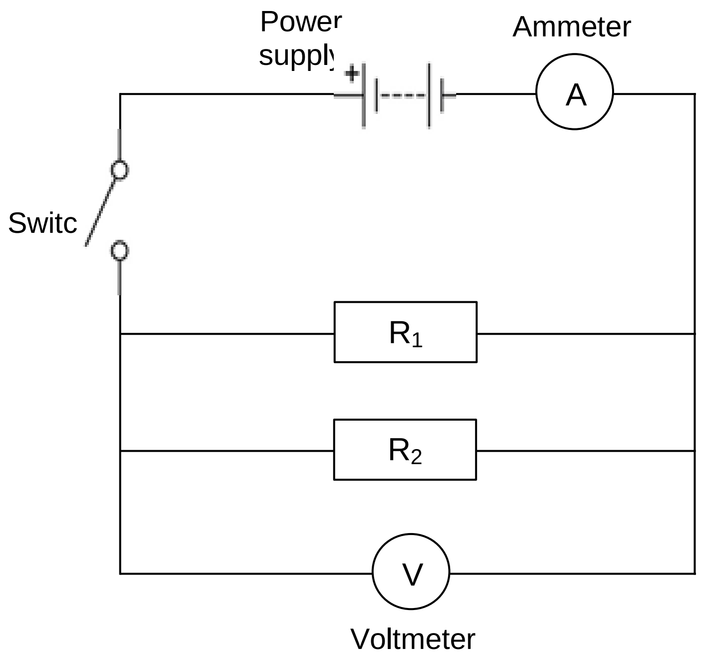
You are provided with the following:

- 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.

I-V Characteristics

Required practical activity
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.

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.

Method

You are provided with the following:

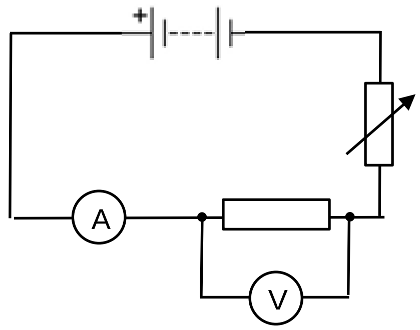
- ammeter and milliammeter, or multimeter
- voltmeter or multimeter
- component holders
- 12 V, 24 W lamp eg a ray box lamp
- resistor
- diode and protective resistor (eg 10 Ω)
- rheostat eg 10 Ω, 5 A
- connecting leads.

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.

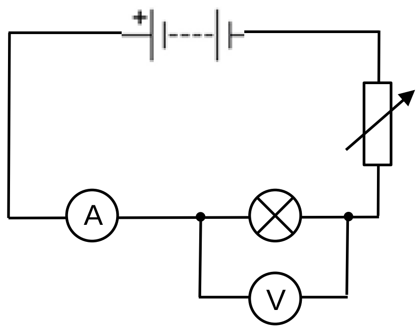
Read these instructions carefully before you start work.

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.

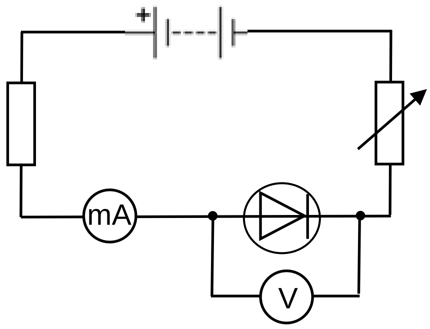
3. Remove the lead from the positive side of the battery. Connect it to the extra resistor labelled **P**.

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.

Required Practicals – Paper 2

Density

Required practical activity
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.

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.

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.

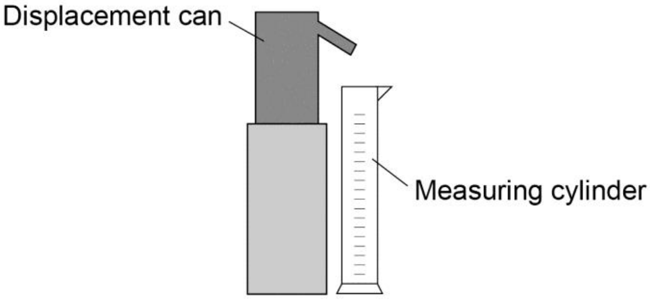
1. Measure the mass of one of the irregular shaped objects.

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.

Light – Separates only

Required practical activity
Investigate the reflection of light by different types of surface and the refraction of light by different substances.

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.

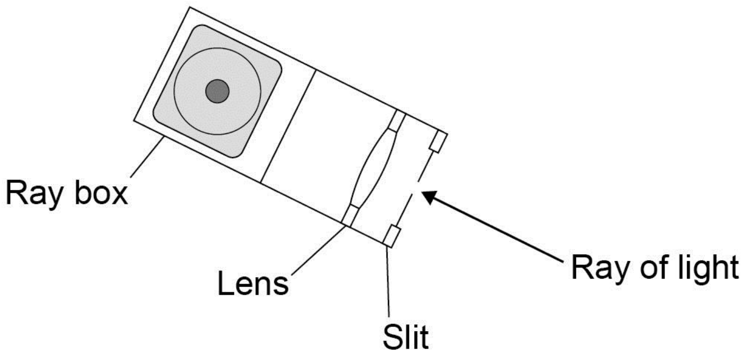
The ray box needs to produce a narrow ray of light. The experiment needs to be performed in a darkened room. This is so that the paths of the rays can be marked precisely.

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

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.

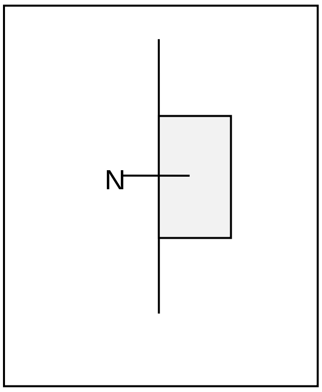


Read these instructions carefully before you start work .

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.

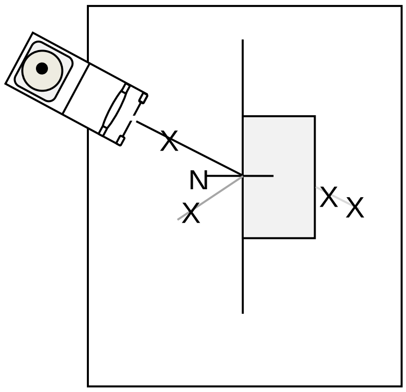
   This is called the '**incident ray**'.

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.

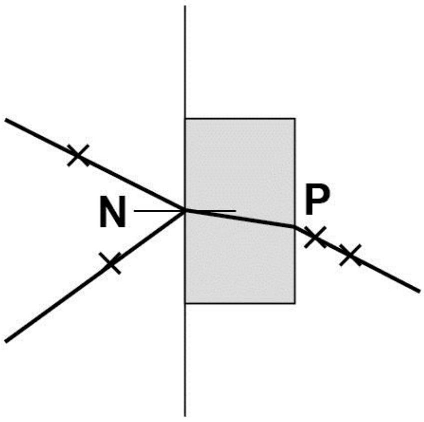
13. Draw the incident ray by drawing a line through your first cross to the point where the normal meets the block.

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

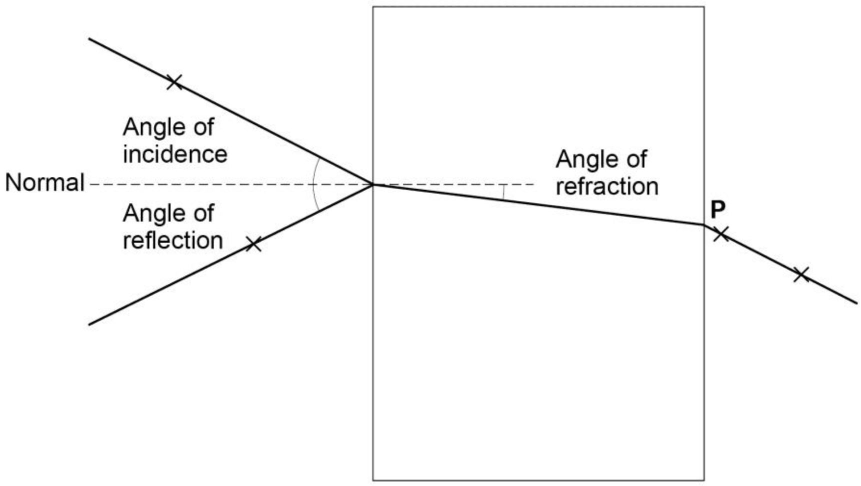
15. Draw the transmitted ray by drawing a line through the two crosses on the other side of the block to that side of the block. Label this point with a ‘**P**’.

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?

Force and extension

Required practical activity
Investigate the relationship between force and extension for a spring.

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.

Method

You are provided with the following:

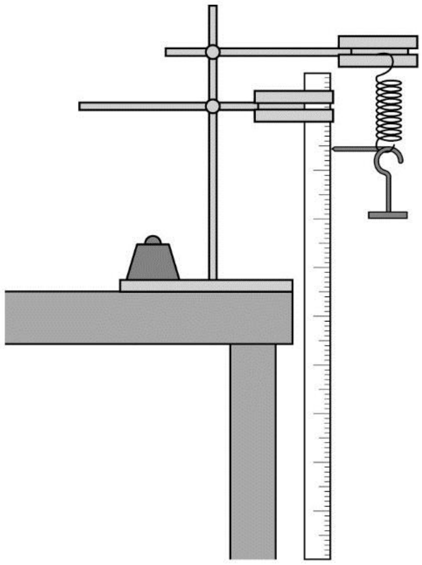
- a spring
- a metre ruler
- a splint and tape to act as a pointer
- a 10 N weight stack
- a clamp stand, with two clamps and bosses
- a heavy weight to prevent the apparatus tipping over
- a mystery object to weigh.

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.

Acceleration

Required practical activity
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.

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.

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 × 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.

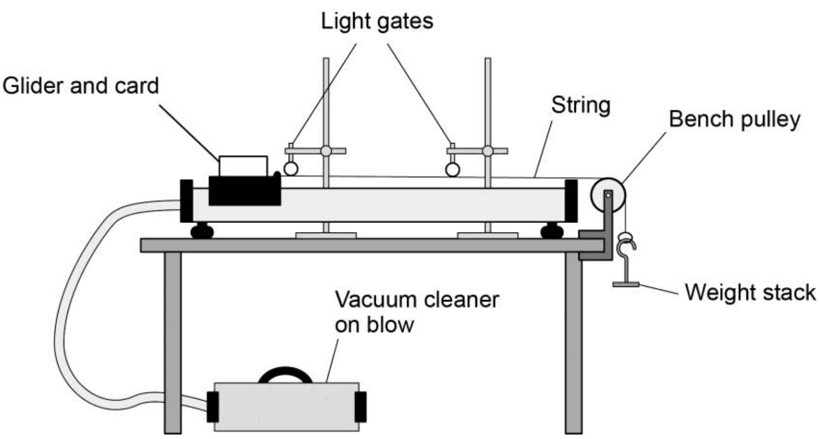
8. Attach the bench pulley to the end of the air track away from the vacuum cleaner.

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.

Waves

Required practical activity
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.

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

Method

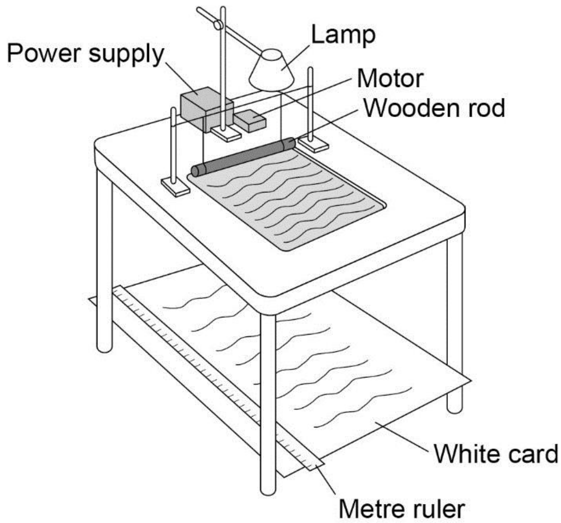
You are provided with the following:

- 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.

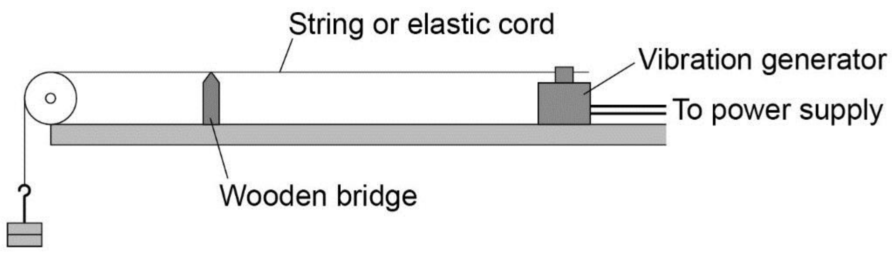
Method

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

Radiation and absorption

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.

Method

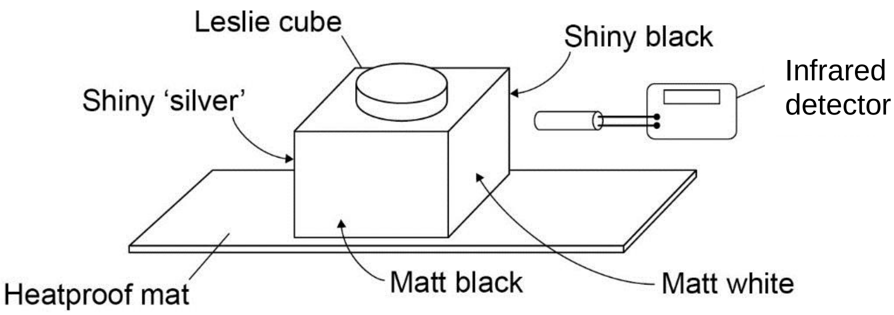
You are provided with the following:

- 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.