AQA GCSE Physics

GCSE Physics
Required Practicals

Name: ______________________________

Class: ______________________________

  

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Contents Page

Learning Objectives -

- Heat up blocks of different metals using an electric heater
- Measure the mass and temperature of the block
- Calculate the work done by the heater
- Plot a graph of temperature change against work done and use the gradient to calculate specific heat capacity of the metal.

Links the decrease of the metal energy store (work done) to the increase in temperature and subsequent thermal energy stored.

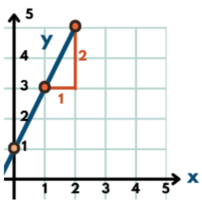
Equipment & Apparatus

Method:

1) Measure the mass of the **copper block** in kg.
2) Wrap the **insulation** around the block.
3) Place the **immersion heater** into the **larger hole** of the block.

4) Connect **ammeter**, **power pack** and heater in **series**.
5) Connect the **voltmeter** across the heater.
6) Use the **pipette** to put a small amount of **water** in the other hole.

7) Put the **thermometer** in the same hole.
8) Set the **power** back to **12V**. Switch it on. — This will turn on the heater
9) Record the **ammeter** and **voltmeter readings**.
10) Take the **starting temperature** reading and start the **stopwatch**. — These shouldn't change
11) Record the temperature every **minute** for **10 minutes**.
12) Calculate the **power** of the heater in **watts**. — Power (watts) = potential difference (V) x current (I)
13) Calculate **energy transferred** (work done, J) by the heater.
   - Work done (joules, J) = Time (seconds, S) x Power (watts, W)
14) Plot a **graph** of **temperature** (˚C) against **work done** (J).
15) Draw a **line of best fit**. — The beginning of the graph may be curved
16) Calculate the **gradient** of the straight part of the graph.
   - $$\text{Gradient} = \frac{\text{change in temperature rise (°C)}}{\text{work done (J)}}$$
   - $\frac{\text{change in y}}{\text{change in x}}$



17) Calculate the **heat capacity** of the copper block.
   - Heat capacity = 1 / gradient — The amount of heat energy (J) needed to increase the temperature by 1°C
18) Calculate the **specific heat capacity** of the copper block.
   - The amount of heat energy (J) needed to increase the temperature of 1kg copper by 1°C
   - $$\text{Specific heat capacity} = \frac{\text{Energy transferred (J)}}{\text{mass (kg) x temperature change (°C)}}$$
19) Repeat steps 1-18 with aluminium and iron blocks.

Type of metal block	Specific heat capacity (J/Kg/°C)
Copper	385
Aluminium	913
Iron	500

REQUIRED PRACTICAL 1
SPECIFIC HEAT CAPACITY

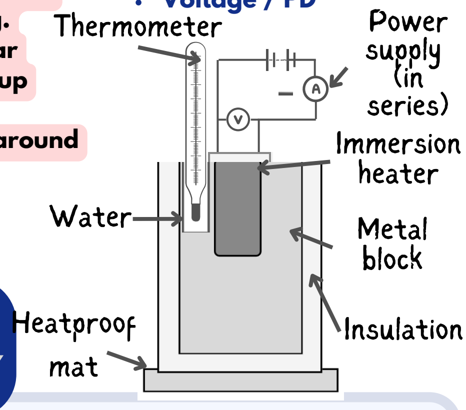
Safety:

- Do not touch the block or heater when hot - if burnt, run area under cold water for at least five minutes.
- Keep the block on the heatproof mat and allow time for equipment to cool before deconstructing.
- Avoid water spills near power supply - clean up spills.
- Wear eye protection around hot water

Independent variable
- Time

Dependent variable
- Change in temperature

Control variables:
- Block materials
- Current
- Voltage / PD



Conclusion

From AQA:"'William thinks that denser materials have higher specific heat capacities. Using the density values of the metals below and the values of specific heat capacity that you have calculated, do you agree with him?'

Type of metal block	Density (g/cm^3)
Copper	8.96
Aluminium	2.70
Iron	7.87

Example: No - copper has the highest density of 8.96g/cm^3 but the lowest specific heat capacity of 385J/Kg/˚C. Also, aluminium has the lowest density of 2.70g/cm^3 but the lowest specific heat capacity of 913 J/Kg/˚C. So, this hypothesis would be rejected as results suggest the less dense materials have a higher specific heat capacities.

Evaluation

Random errors
- Some **heat will dissipate** into the surroundings
  - Insulation minimises loss,
  - Actual specific heat capacity is likely higher
- **Errors** in **measurements** from ammeter, voltmeter and stopwatch
  - Use a joulemeter to calculate energy directly
- **Human error** of temperature reading

Systematic errors
- **Zero error** - could occur if the ammeter and voltmeter are not initially set to zero.

Exam Style Questions - Specific Heat Capacity

1. What is the independent variable in this experiment? (1 mark)

2. State two control variables in this experiment. (2 marks)

3. Why is the block wrapped in insulation? (1 mark)

4. What measurements are needed to calculate power? (2 marks)

5. Describe how to calculate the energy transferred by the heater. (2 marks)

6. A student records a voltage of 12 V, a current of 2.0 A, and heats for 600 seconds. Calculate the energy transferred. (2 marks)

7. A graph is plotted with temperature (˚C) on the y-axis and energy transferred (J) on the x-axis. What is the gradient of the straight-line section used for? (1 mark)

8. Give one source of random error in this experiment and how it can be reduced. (2 marks)

9. A student wants to compare the specific heat capacity of copper and aluminium using the same method. Describe the method they would use and explain how they would ensure the comparison is valid. Include how they would use the results to calculate the specific heat capacity. (6 marks)

Learning Objectives -

- Measure the rate of cooling of a beaker of hot water that is insulated with different materials.
- Use your results to plot cooling curves to determine which is the best thermal insulator.

Method:

1) Put the small beaker **inside** the larger beaker.

2) Use the **kettle** to boil water.
Put 80 cm^3 of this hot water into the small beaker.

3) Use a piece of **cardboard** as a lid for the large beaker - there must be a **hole** for the thermometer.

4) Put 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 **15 minutes**.

7) Record your results in a table.

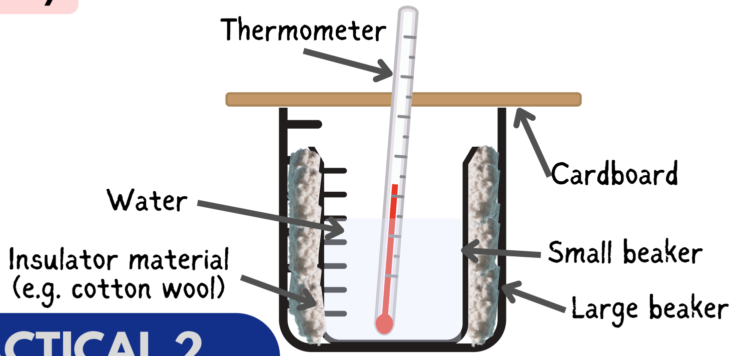
8) Repeat steps 1–6 using **different materials** each time to **fill the space** between the small and large beaker.

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

You might find it easier to set up your beakers at the start.

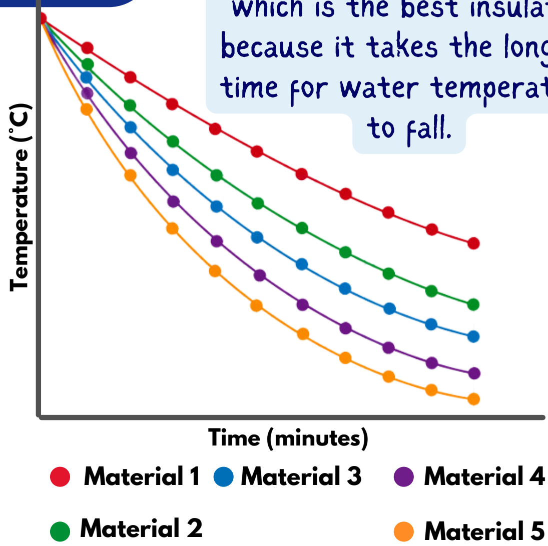
Safety:

- Do not touch the beakers when **hot** - if skin is scalded, run area under cold water for at least five - ten minutes.
- Keep the beakers on the **heatproof mat** and allow time for equipment to cool before deconstructing.
- Wear **eye protection** around hot water.
- If there is cracked or **broken glass**, inform a **supervisor** immediately.



REQUIRED PRACTICAL 2
THERMAL INSULATION P1 - DIFFERENT MATERIALS

Time (mins)	Material used for insulation			
	No insulation	Bubblewrap	Cottonwool	Newspaper
	Temperature (°C)			
0				
3				
6				
9				
12				
15				
Change in temperature (°C)				



The shallowest curve (material 1) is the material which is the best insulator because it takes the longest time for water temperature to fall.

Temperature fall is quicker at higher temperatures than lower temperatures
- When water temperature is high, there is a greater temperature difference between it and room temperature, so there is a higher rate of energy transfer.

Random errors

- Some **heat will dissipate** into the surroundings
  - Make sure the hole in cardboard is a small as possible.
- **Errors** in **measurements** from thermometer
  - Use a joulemeter to calculate energy directly
- **Human error** of temperature reading
  - Take repeated readings and obtain a mean.
  - Read values at eye level.

Independent variable - type of material
Dependent variable - temperature, T (°C)
Control variables - volume of water, temperature at the start, thickness of each material

Systematic errors

- If the **starting temperature** of the water is **different** for each material, this will affect the rate of heat loss - work in **pairs to coordinate** the starting of the stopwatch and point at which the temperature gets to the starting point used in the control.
- Make sure only the top of the beaker is covered so **energy is transferred** through the **glass**.
- A thermometer has a resolution of 1°C, a **data logger** connected to a **digital thermometer** would get more accurate readings.

Exam Style Questions - Thermal Insulation P1

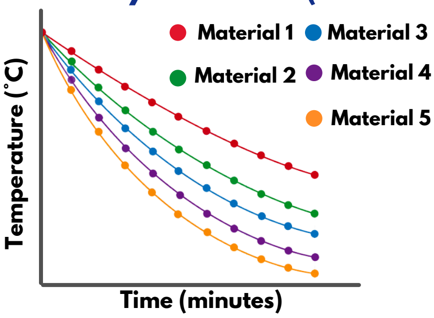
1. What is the independent variable in this experiment? (1 mark)

2. Why is a lid with a hole used during the experiment? (1 mark)

3. Describe how you would compare the effectiveness of five insulating materials using this setup. (3 marks)

4. A student finds that the temperature of the water drops fastest with newspaper and slowest with bubble wrap. What conclusion can they make about the effectiveness of these two materials? (2 marks)

5. Look at the graph. Which line shows the best insulator and how do you know? (2 marks)



6. Explain why it is important to use the same starting temperature of water in each beaker. (2 marks)

7. The student notices the thermometer readings vary slightly each time they insert it. Suggest one reason why this happens and how it could be reduced. (2 marks)

8. A student finds that the temperature of the water drops quickly in the first 3 minutes, then more slowly afterwards. Explain why this happens using ideas about temperature difference and energy transfer. (3 marks)

Learning Objectives -

- Measure the rate of cooling of a beaker of hot water that is insulated with different thicknesses of the same material
- Use your results to plot cooling curves to determine the effect of changing the thickness of the insulator.

Equipment & Apparatus

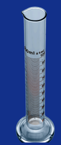

100cm


5x Thermometers


Scissors


Piece of cardboard with a hole in (lid)


Rubber bands


Measuring cylinder


Kettle (to heat water)


Insulation material e.g. cotton wool, bubblewrap, sawdust, polystyrene balls, newspaper


Stopclock

Method:

1) Wrap two layers of insulating material around the beaker, holding it in place with a rubber band. Do not add insulating material to the bottom of the beaker.

2) Put 80 cm^3 of this hot water into the beaker.

3) Use a piece of cardboard as a lid for the large beaker - there must be a hole for the thermometer.

4) Put 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 15 minutes.

7) Record your results in a table.

8) Repeat steps 2–6 using adding 2 more layers of insulation each time.

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

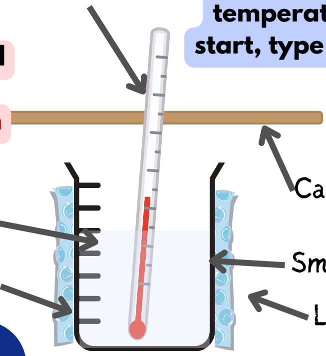
Safety:

- Do not touch the beakers when hot - if skin is scalded, run area under cold water for at least five - ten minutes.
- Keep the beakers on the heatproof mat and allow time for equipment to cool before deconstructing.
- Wear eye protection around hot water.
- If there is cracked or broken glass, inform a supervisor immediately.

Independent variable - thickness of material

Dependent variable - temperature, T (˚C)

Control variables - volume of water, temperature at the start, type of material

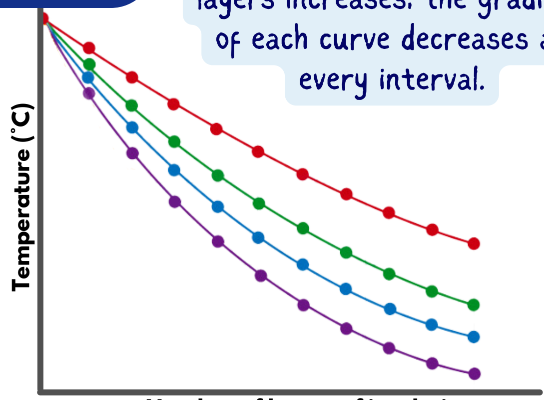


You can use the 'no insulation' results from P1 for '0 layer' to save time.

REQUIRED PRACTICAL 2 THERMAL INSULATION P2 - DIFFERENT THICKNESS

Time (mins)	Material used for insulation (layers of bubblewrap)			
	0 layers	2 layers	4 layers	6 layers
	Temperature (°C)			
0				
3				
6				
9				
12				
15				
Change in temperature (°C)				

The curve for zero layers of insulation has the steepest gradient. As the number of layers increases, the gradient of each curve decreases at every interval.



● 6 layers ● 2 layers ● 4 layers ● 0 layers

More layers of bubble wrap increases, insulation increases which means the temperature falls more slowly.
Also, similarly to part 1, the temperature falls faster at higher temperatures than at lower temperatures.

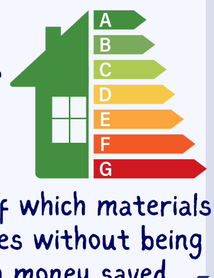
Random errors

- Make sure the hole in cardboard is a small as possible to minimise heat dissipation
- Human error of temperature reading
  - Take repeated readings and obtain a mean.
  - Read values at eye level.

Systematic errors

- Make sure the starting temperature is the same every time.
- Make sure only the top of the beaker is covered so energy is transferred through the glass.
- A data logger connected to a digital thermometer would get more accurate readings.

Energy is transmitted by conduction, convection or radiation. Comparing the time taken to transfer energy from the inside from the house to the environment by conduction helps us decide the most energy efficient materials which are suitable and affordable for different parts of a house.



It is essential to combine the knowledge of which materials and thickness create energy efficient homes without being so expensive to install it doesn't outweigh money saved from energy loss.

Exam Style Questions - Thermal Insulation P2

1. What is the independent variable in this experiment? (1 mark)

2. A student finds that the temperature change over 15 minutes is 16˚C with 0 layers and 6˚C with 6 layers. What does this suggest about the effect of thickness? (2 marks)

3. Explain why energy is transferred more slowly with more layers of insulation. (3 marks)

4. What is the purpose of using the same lid and beaker type each time? (1 mark)

5. Suggest one way to improve the accuracy of this experiment. (1 mark)

6. Why does the temperature drop more slowly when more layers of insulation are used? (2 marks)

7. The experiment is repeated using water at 100˚C instead of 80˚C. Explain how this might affect the results. (3 marks)

8. The student is told to repeat each test three times. Why is this good experimental practice? (2 marks)

9. A student finds that the temperature drop between 0 and 15 minutes was 17˚C with 0 layers, 12˚C with 2 layers, and 8˚C with 4 layers. They then add a 6th layer but find the temperature only drops by 7˚C. Explain why adding more layers becomes less effective at reducing heat loss. (3 marks)

Learning Objectives -

- Set up a circuit which can measure the potential difference and current across a wire at different lengths along the wire.
- Calculate the resistance of different lengths of the wire and state the relationship between resistance and length.

Equipment & Apparatus

Voltmeter - measure potential difference through the resistors

Ammeter - measure current through the circuit

Connecting leads

Metre ruler

Resistance wire

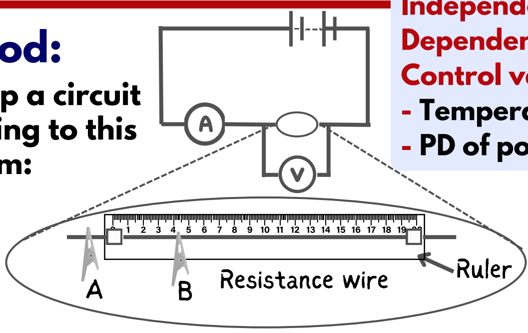
Crocodile clips

12V power supply - source of potential difference

Independent variable - length of wire (cm)
Dependent variable - resistance (Ω)
Control variables
- Temperature of the wire
- PD of power supply

Method:

1) Set up a circuit according to this diagram:



2) Connect a lead from the negative side of the ammeter to the crocodile clip (A) at the zero end of the ruler.

Connect a lead from the other crocodile clip (B) to the negative side of the battery.

Use this lead as a switch to disconnect the battery between readings.

3) Decide the interval distance (e.g. 10cm) you will investigate and connect the first distance to be tested between crocodile clips A and B.

4) Measure the readings on the voltmeter and ammeter at this distance.

Record in a table.

Length of wire in cm	Potential difference in volts	Current in amps	Resistance in ohms
e.g. 100	1.20	0.16	7.5
e.g. 90	1.18	0.17	6.8
e.g. 10	0.41	0.63	0.7

Safety Tips:
- Avoid touching the resistance wire when connected or hot; run any burns under cold water for 5-10 minutes.
- Keep liquids away from equipment to prevent electrical damage if spilled.

R= $\frac{V}{I}$

REQUIRED PRACTICAL 3
RESISTANCE P1 - LENGTH OF WIRE

5) Move crocodile clip B and record the readings for the different lengths of wire e.g. 20cm, 30cm etc.

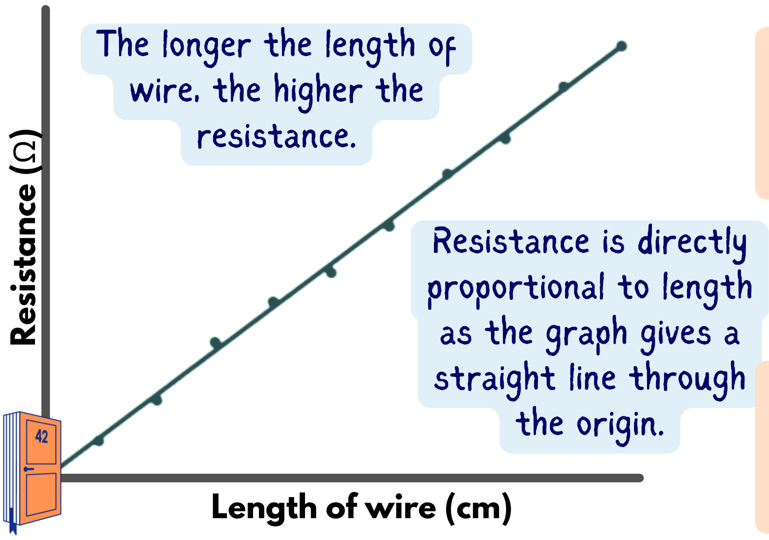
6) Calculate the resistance for each length of wire using the equation:

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

7) Plot a graph of resistance against length of wire and draw a line of best fit.
Describe the relationship between resistance and length.

Random Errors
- Limit current flow to maintain consistent wire temperature and resistance.
- Turn off current between readings to prevent temperature-related resistance changes.

Systematic Errors
- Ensure the first crocodile clip is at 0 on the ruler to avoid zero error in length measurements.
- Check that both the ammeter and voltmeter start from 0.



The graph may not pass through the origin due to confounding variables that impact both the independent and dependent variables, such as temperature affecting resistance.
- Increased temperature raises resistance as the wire heats up.
- Longer wire lengths lead to higher resistance and more heating.

To minimize confounding variables, it's best to take readings quickly and allow the wire to cool before measuring again, though time constraints in class often make this difficult.

Exam Style Questions - Resistance P1

1. What is the independent variable in this experiment? (1 mark)

2. State the equation used to calculate resistance. (1 mark)

3. A student tests 50 cm and 100 cm of wire. The current is 0.3 A and the voltages are 0.90 V and 1.80 V respectively. Calculate the resistance for both lengths. (2 marks)

4. Explain why the wire should be left to cool between measurements. (2 marks)

5. What is the relationship between length of wire and resistance? (2 marks)

6. A student plots a graph of resistance against length of wire. The line does not pass through the origin, as expected. Suggest two reasons why. (2 marks)

7. Why should the wire used be the same thickness throughout the experiment? (1 mark)

8. A student finds that resistance is higher at longer lengths.
Explain this using particle theory. (3 marks)

9. Suggest one way to reduce random error when measuring current and voltage. (1 mark)

REQUIRED PRACTICAL 3
RESISTANCE - SERIES AND PARALLEL

Learning Objectives -

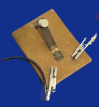
- Use circuit diagrams to construct circuits with resistors in series and in parallel
- Measure the potential difference and current in circuits with resistors in series and then in parallel.

Equipment & Apparatus

Voltmeter - measure potential difference through the resistors

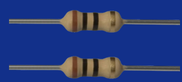
Ammeter - measure current through the circuit

Connecting leads



Switch

Crocodile clips



2 10Ω resistor

12V power supply (battery) - source of potential difference

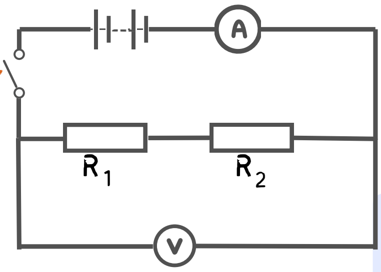
Independent variable - number of resistors

Dependent variable - total resistance (Ω)

Control variables - Temperature of the resistors and potential difference of the power supply

Method:

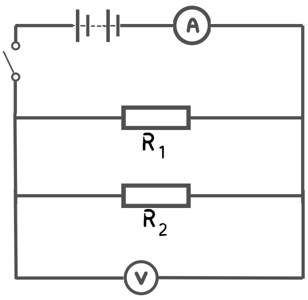
1) Set up a circuit according to this diagram in order to connect the circuit for two resistors in series.



2) Switch on and record the reading of the ammeter and the voltmeter.

3) Calculate the total resistance of the series circuit.

4) Set up a circuit according to this diagram in order to connect the circuit for two resistors in parallel.



5) Switch on and record the reading of the ammeter and the voltmeter.

6) Calculate the total resistance of the parallel circuit.

7) Write a conclusion about the effect of adding resistors
i) In series
i) In parallel

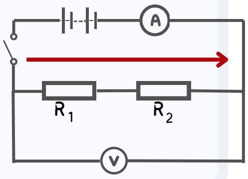
$$R = \frac{V}{I}$$

You can check the value of the resistance of R_1 and R_2 in either circuit by putting each resistor in the circuit on its own and recording the ammeter and voltmeter. The calculation R = V / I should = 10Ω.

You can continue this experiment by adding additional resistors in series and parallel to determine the effect.

i. In series:

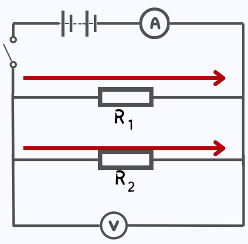
- Resistance of combined resistors = sum of two individual resistances
- Electrons, therefore the current, flowthrough one path
- The potential difference is split across the two resistors.



Combined resistance in series (R) = $R_1 + R_2 + R_3$
Therefore, increasing the number of resistors increases the overall resistance.

ii. In parallel

- Combined resistance of resistors in parallel is less than if they were in series because there is an extra path for the electrons (therefore current) to flow.
- Therefore, current is split and more charge can flow at once, giving a reduced resistance.
- The potential difference across each resistor will be the same as the power supply or battery pd.



A circuit in parallel is advantageous because it allows components to be individually switched on and off and if one component stops working, they others can continue to work.

$$R = \frac{V}{I}$$

With the current (I) increasing but potential difference (V) staying the same, the denominator in this equation is being split into larger parts, therefore the calculation results in a smaller number.

Systematic errors

- Check that the ammeter and voltmeter are calibrated to zero before taking any recordings.

Random errors

- Temperature of the wire can increase when current is applied which can affect resistance
  - Minimise current size through wire
  - Switch off circuit between readings of temperature reading

Resistor	Potential difference in volts	Current in amps	Resistance in ohms
Series	4.45V	0.22A	20.2
Parallel	3.94V	0.79A	4.9

Exam Style Questions - Resistance P2

1. What is the independent variable in this practical? (1 mark)

2. Describe the difference in current between a series and parallel circuit. (2 marks)

3. A student sets up two circuits: one in series, one in parallel. The voltage is the same in both. Explain why the total resistance is lower in the parallel circuit. (3 marks)

4. What is the equation to calculate resistance, and how can it be applied in this practical? (2 marks)

5. A student finds the total resistance in a series circuit is 9.0 Ω and in a parallel circuit is 4.9 Ω. What conclusion can they make about adding resistors in parallel vs series? (2 marks)

6. Why is it important to use identical resistors in this practical? (1 mark)

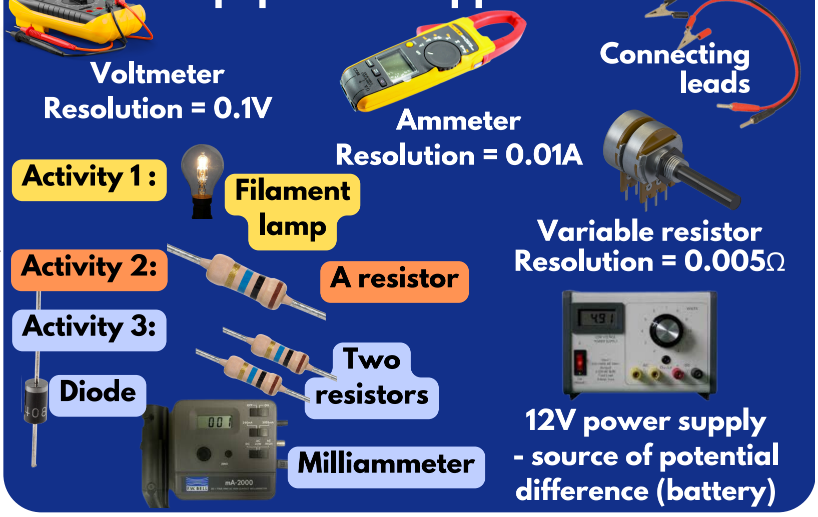
7. In a parallel circuit, the voltage across each resistor is the same. Explain why this means the total current is higher than in a series circuit. (3 marks)

8. A student adds a third identical resistor to a parallel circuit. Predict what happens to the total resistance and explain why. (2 marks)

Learning Objectives -

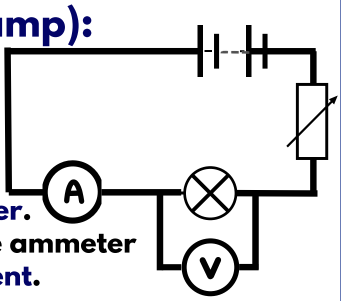
→ Use circuit diagrams to construct appropriate circuits to investigate the I-V characteristics of a variety of circuit elements: 1. a filament lamp, 2. resistor, 3. a diode, at a constant temperature.

Equipment & Apparatus



REQUIRED PRACTICAL 4
I-V CHARACTERISTICS

Activity 1 (Filament lamp):



1) Set up a circuit according to this diagram:

2) Record the readings on the ammeter and voltmeter. Take three readings from the ammeter to calculate an average current.

3) Adjust the variable resistor and record new readings on the ammeter and voltmeter.

The variable resistor varies the potential difference

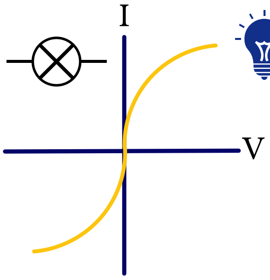
4) Repeat this to obtain of readings for 8 voltages.

5) Swap the connections on the battery/power supply so that the ammeter is connected to the negative terminal and the variable resistor to the positive terminal.

6) Repeat steps 2-4 with the battery reversed. Readings on the voltmeter and ammeter should now be negative.

7) Plot a graph of current against potential difference.

8) Draw a line of best fit through the origin - this is the characteristics of a filament lamp.



The origin of the graph is in the middle of the paper because there are negative values.

Note: the resistance at any point on the graph is the inverse of the gradient of a line from that point of origin (not the gradient of the graph!)

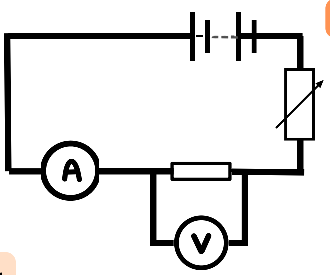
Voltage (V)	Current I_1 (A)	Current I_2 (A)	Current I_3 (A)	Average Current I (A)
0.5				
...				

Safety Tips:
- Avoid touching the resistance wire when connected or hot, especially under high voltages; run any burns under cold water for 5-10 minutes.
- Keep liquids away from equipment to prevent electrical damage if spilled.
- Switch off the circuit between readings to prevent the circuit heating unnecessarily

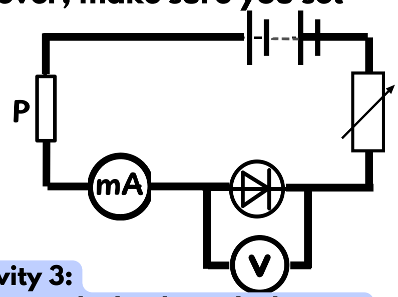
Independent variable - Potential difference, V
Dependent variable - Current, I
Control variables - Using the same wires and components

Activity 2 (Resistor) & Activity 3 (Diode):

The method for taking readings (steps 2 - 8) is the same as activity 1 and should be completed in succession. However, make sure you set up each circuit correctly:



Activity 2:
- Swap the leads on the battery back to their original positions.
- Replace the filament lamp with the resistor.



Activity 3:
- Swap the leads on the battery back to their original positions.
- Reduce the battery P.D to <5 V.

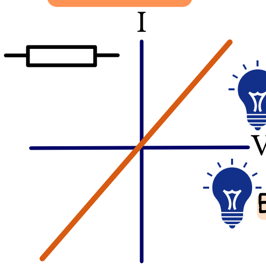
Minimises the current through the diode.

- Swap ammeter for the milliammeter

Enable us to obtain a low current reading.

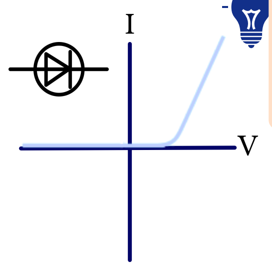
- Replace the resistor with a diode
- Connect the extra resistor, P.

A 'protective' resistor to protect the diode.



Reduce systematic errors by checking that both the ammeter and voltmeter start from 0.

Variable Resistor
- The variable resistor varies the potential difference.
- If using a battery or power pack with a single setting, the variable resistor allows you to change the p.d. from the fixed voltage.
- If you are using a power pack with a dial, you can simply change the p.d. on the dial



The diode behaves different depending on the polarity of the power supply.

Random Errors
- Limit current flow to maintain consistent wire temperature and resistance.
- Turn off current between readings to prevent temperature-related resistance changes.
- You cannot completely have zero resistance through the ammeter and voltmeter, therefore readings will have some inaccuracies.
- Take three readings for each voltage to reduce anomalous results

Exam Style Questions - I-V Characteristics

1. What is the independent variable in this experiment? (1 mark)

2. What component is used to vary the potential difference across a circuit? (1 mark)

3. Describe the shape of the I-V graph for a filament lamp. (2 marks)

4. Explain why the filament lamp's resistance increases as the current increases. (3 marks)

5. What would a graph of current against potential difference look like for a resistor at constant temperature? (1 mark)

6. Explain why the resistance of the resistor remains constant during the experiment. (2 marks)

7. The student plots a straight-line graph through the origin.
What does this show about the relationship between current and voltage? (2 marks)

8. Why is there no current when the potential difference is negative in a diode circuit? (2 marks)

9. A student says, "The resistance of a filament lamp increases as current increases, but the resistor's resistance stays constant." Use the I-V graphs to explain why the student is correct. (4 marks)

Learning Objectives -

- **Activity 1:** Use a ruler and a balance to determine the density of a regularly shaped object
- **Activity 2:** Use a displacement method to determine the density of an irregularly shaped object
- **Activity 3:** Use measurements of volume and mass to determine the density of a liquid.

Evaluation

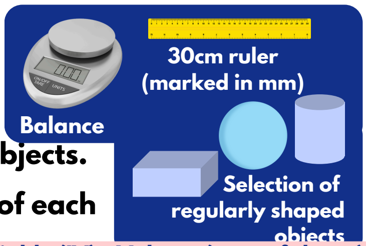
Random errors

- Errors in measurements of length of objects (incorrect volume)
  - Take multiple readings to calculate an average
- Dropping irregular objects from too high a height may cause water to splash out, therefore the volume is incorrectly determined.

Systematic errors

- Zero error - could occur if the digital balance is not initially set to zero.
- Different balances may not be identically calibrated
- Rounding errors
- Resolution of measuring cylinders may be different

Activity 1:



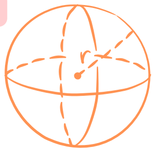
1) Measure and record the length, width and height of your selected objects.

2) Calculate the volume of each object.

Independent variable (IV) - Volume (type of shape)
Dependent variable (DV) - Mass of object

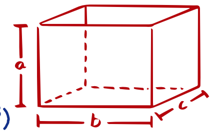
3) Measure the mass of each object using the digital balance.

$V = \frac{4}{3}\pi r^3$



4) Calculate and record the density of each object using the formula:

$\rho = \frac{m}{V}$ density $(kg/m^3) = \frac{\text{mass (kg)}}{\text{volume } (m^3)}$



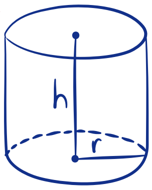
$V = abc$

5) Convert g/m^3 to kg/m^3.

Shaped object	Length (cm)	Height (cm)	Width (cm)	Volume (cm^3)	Mass (g)	Density (g/cm^3)
Sphere						
Cylinder						
Cuboid						

1cm = 0.01m
50cm = 0.5m

Record results as you go!



$V = \pi r^2 h$

Analysis - Explain the differences in density between solids and liquids

E.g.'The density of a substance depends on how closely its particles are packed. In solids, particles are tightly packed in a fixed structure, making them denser. In liquids, particles are still close but can move around, creating small gaps and lowering density. For example, ice is less dense than liquid water because its particles form an open structure.'

REQUIRED PRACTICAL 5 DENSITY

Activity 2:

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

2) Record in a table.

3) Put the displacement can on your desk. Put an empty beaker under the spout and fill the can with water. Water should be dripping from the spout and you should wait until you see this stop.

4) Put a measuring cylinder that you think will give the most accurate reading under the spout instead of the beaker.

5) Very carefully lower the object 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 the volume of the collected water. This volume is equal to the volume of the object.

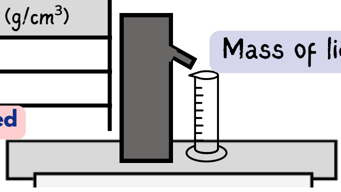
Make sure the can is full before adding the object, otherwise the can will continue to fill, before it can spill out!

7) Calculate and record the density of the object.

8) Repeat the activity for some other objects. Remember to refill the can with water each time.

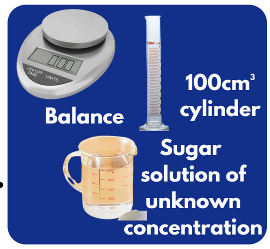
Shape	Mass (g)	Volume of liquid collected (cm^3)	Density of irregular shape (g/cm^3)
Egg			
Doorstop			
Stone			

IV - Irregular shape / mass
DV - Volume of water displaced



Independent variable (IV) - Volume of water added
Dependent variable (DV)- Mass of cylinder

Activity 3:



1) Measure the mass of the empty measuring cylinder.

2) Record in a table.

3) Pour about 100cm^3 of the sugar solution into the measuring cylinder. Record the volume accurately

4) Measure and record the mass of the measuring cylinder and liquid. From this calculate and record the mass of just the liquid.

5) Calculate the density of the liquid.

6) Standard units of density are kg/m^3. Use the data above to calculate the density of the liquid in these units.

Mass of empty cylinder (g)	Volume of liquid (cm^3)	Mass of cylinder + liquid (g)	Mass of liquid (g)	Density of liquid (g/cm^3)

Mass of liquid = Mass of cylinder with water − mass of empty cylinder

Exam Style Questions - Density

1. What equipment is needed to measure the volume of a cube or cuboid? (1 mark)

2. A metal block has a mass of 540 g and measures 5.0 cm × 3.0 cm × 2.0 cm. Calculate the density in g/cm^3. (3 marks)

3. Give one reason why it is important to take repeat readings of length when measuring a solid. (1 mark)

4. A student places a stone in a displacement can and collects 120 cm^3 of water. The mass of the stone is 300 g. Calculate the density of the stone. (2 marks)

5. When using a displacement can, explain why it's important to wait until water stops dripping from the spout before taking a reading. (2 marks)

6. A student pours 100 cm^3 of liquid into a measuring cylinder. The mass of the cylinder is 50 g. The total mass of the cylinder and liquid is 130 g. Calculate the density of the liquid in g/cm^3. (3 marks)

7. Explain why solids usually have a higher density than liquids, using ideas about particle arrangement. (3 marks)

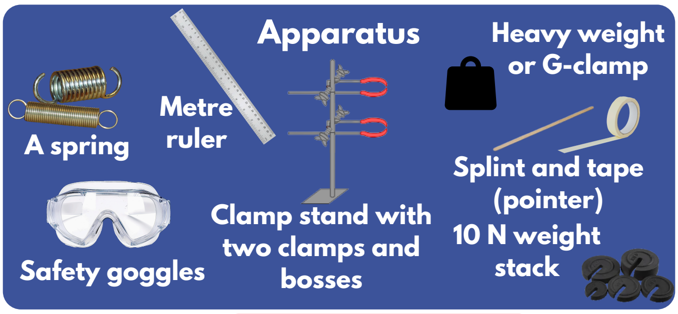
8. A student records the following data:

- **Mass of empty measuring cylinder = 60 g**
- **Mass of cylinder + unknown liquid = 180 g**
- **Volume of liquid = 150 cm^3**

a) Calculate the mass of the liquid
b) Calculate the density in g/cm^3
c) Suggest one source of error in this method and how it could be reduced (4 marks)

Learning Objectives - Investigate the relationship between force and extension of a spring.

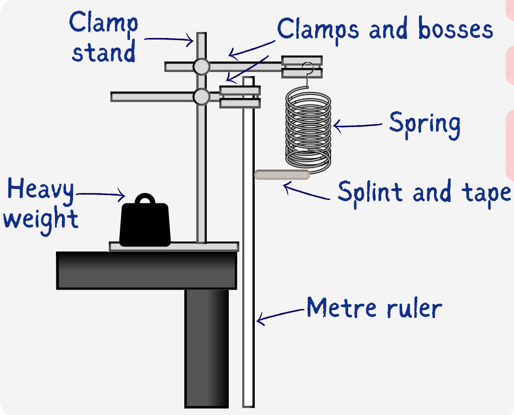
- Hang different masses from a spring and measure the extension of the spring for each mass used.
- Convert mass into weight.
- Use your results to plot a graph of extension against weight.



Method:

1) Set up your apparatus as in the diagram making sure that:

- The ruler is vertical.
  - The zero on the scale needs to be at the same height as the top of the spring
- The splint is attached securely to the bottom of the spring.
  - Make sure that the splint is horizontal and that it rests against the scale of the ruler.



Independent Variable:
- Force, F (N)

Dependent Variable:
- Extension of the spring, e (m or cm)

Control Variables:
- Spring used (spring constant, k)
- Ruler alignment
- Initial length of spring
- Environment (e.g. no air movement, stable temperature)

2) Take a reading on the ruler – this is the length of the unstretched spring. Record this reading in your results table:

Weight in N	Length of spring in cm	Extension of spring in cm
0.0 (No weight stack added)	220	0
1.0 (weight stack added)	250	30
2.0	280	0
...	...	

A force that stretches or compresses a spring does work, storing elastic potential energy. If the spring is not inelastically deformed, the work done equals the stored energy.

Safety precautions for the experiment include:
- Wearing goggles protects eyes if the spring snaps springs.
- Placing some soft material below the apparatus catch falling weights
- Using a G clamp to secure the clamp stand to the desk.
- Avoiding excessive pulling on the spring.

REQUIRED PRACTICAL 6
FORCE AND EXTENSION

3) Carefully hook the base of a 1.0 newton (1.0N) weight stack onto the bottom of the spring.

4) Take a reading on the ruler.

This is the length of the spring when a force of 1.0 N is applied to it.

5) Add further weights. Measure and record the length of the spring each time.

The force, F added to the spring is the weight of the mass. F = mg

6) Calculate the extension for each weight and record it on the table.

Don't forget that the mass added will have to be converted to newtons.

Extension = Stretched length − Original length

Hang an object on the spring to measure its extension, then use the graph to find its weight and verify with a newton meter!

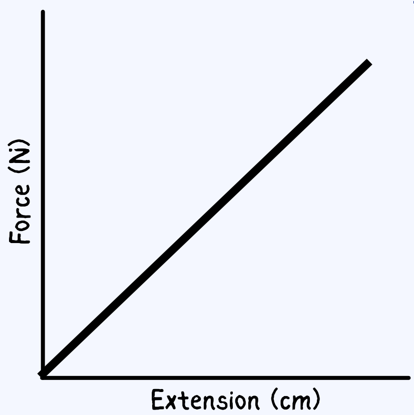
Evaluation

Random Errors
- Use a pointer, such as a fiducial marker to increase the accuracy of the experiment.
- Repeat the measurements for each force three times and calculate an average extension.

Systematic Errors
- Ensure that measurements on the ruler are taken at eye level to prevent parallax error.
- Before starting, check for a zero error on the ruler to ensure it starts at true zero.

A digital displacement sensor or video analysis tool can enhance precision and eliminate human error in measurements compared to using a ruler.

Analysis of Results



a) State the relationship between force and extension of a wire.

The force applied to a spring or wire is directly proportional to its extension. (– provided the material is not stretched beyond its limit of proportionality.)

b) Calculate the spring constant (force = spring constant x extension).

$$k = \frac{F}{e}$$

Example: If a force of 2.0 N causes a spring to extend by 0.04 m: k = 2.0 / 0.04 = 50 N/m

c) Calculate the work done in stretching your spring using the equation: Elastic potential energy = 0.5 x spring constant x $(\text{extension})^2$

Example: Using k = 50 N/m and e = 0.04 m:

$E = 0.5 \times 50 \times (0.04)^2 = 0.5 \times 50 \times 0.0016 = 0.04$ J

So, the work done (energy stored) is 0.04 joules.

Go further: Observe the point where the spring doesn't return to its original length to identify the limit of proportionality and determine if inelastic deformation has occurred.

Exam Style Questions - Force and Extension

1. What is the independent variable in this experiment? (1 mark)

2. What is meant by the "extension" of the spring? (1 mark)

3. A student hangs a 2.0 N weight and the spring extends from 200 mm to 250 mm. Calculate the extension in cm. (2 marks)

4. What does it mean if the graph of force vs extension curves upwards? (2 marks)

5. A spring stretches 0.04 m when a force of 2.0 N is applied. Calculate the spring constant. Give units. (2 marks)

7. A student plots a graph of force (N) against extension (cm). The points lie on a straight line until the last two values, which begin to curve.
a) What does the straight section of the graph show?
b) What does the curve at the end indicate? (3 marks)

8. A student investigates how the extension of a spring changes when different forces are applied. Describe how they should carry out this experiment and explain how they could ensure their results are valid and reliable.

Learning Objectives -

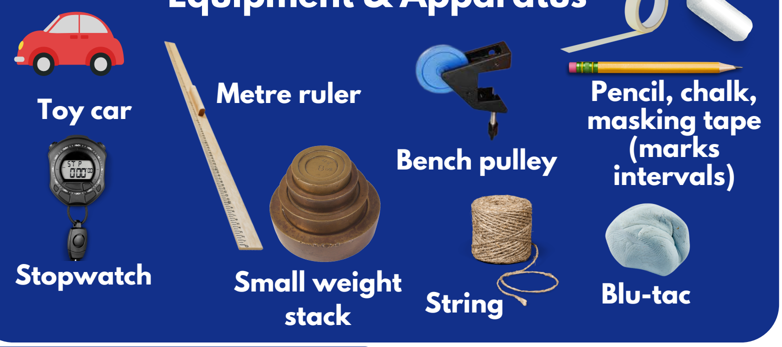
To determine how the force applied to a trolley affects its acceleration, while keeping the total mass of the system constant.

This links directly to Newton's Second Law of Motion:

F = ma

This law tells us that the acceleration of an object is directly proportional to the force applied to it, provided the mass remains unchanged.

Equipment & Apparatus



REQUIRED PRACTICAL 7
FORCE AND ACCELERATION

Activity 1:

1. Marking the bench: Use the ruler to measure 0.2m intervals on the bench and draw straight lines or place tape across the bench at these intervals.

2. Setting Up the Pulley System: Attach the bench pulley to the end of the bench.

> Make sure it is stable and will not shift during the experiment

3. Tie a length of string to the toy car or trolley. Pass the string over the pulley and attach the weight stack to the other end of the string.

> Misalignment can cause extra friction or skew the direction of the force, affecting results.

4. Aligning the System: Make sure the string is taut and runs horizontally and is in line with the toy car or trolley.

5. Preparing for Release: Hold the toy car or trolley at the start point (0cm) and make sure stationary.

6. Attach the full weight stack (1.0 N) to the end of the string.

> Recording a video of the sequence will provide more reliable data

7. Release the toy car or trolley at the same time as you start the stopwatch, press the stop watch (lap mode) at each measured interval on the bench and for the final time at 100 cm.

8. Record the results in the table.

9. Repeating with Lower Forces: Repeat steps 5–8 for decreasing weights on the stack for example, 0.8 N, 0.6 N, 0.4 N, 0.2 N. Make sure you place the masses that you remove from the weight stack onto the top of the car each time you decrease the weight.

> To keep the mass of the system constant, each time you remove a mass from the hanger, attach it to the car using Blu-tac

> For each force level, repeat the entire timing process at least 3 times to reduce the effect of random errors.

10. Calculate average velocity and acceleration between intervals using the formulas:

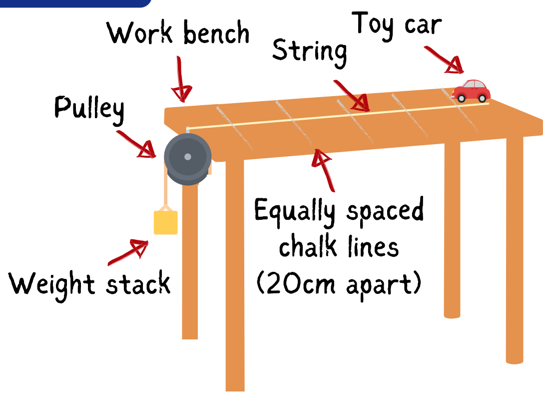
- Velocity (v) = Distance ÷ Time
- Acceleration (a) = (Final velocity - Initial velocity) ÷ Time interval

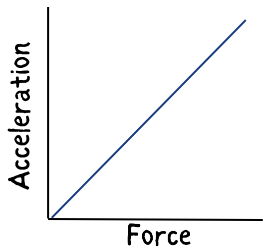
Independent variable
- Force (N), changed by adjusting the mass hanging from the pulley

Dependent variable
- Acceleration of the trolley

Control variables:
- Mass of the system (trolley + weights)
- Surface of the bench
- Starting position
- String length and alignment
- Method of timing

Safety Considerations:
- Secure weights to prevent falls and injuries.
- Stand beside the pulley system, avoiding direct alignment with falling masses.
- Use a soft buffer or sandbag to safely stop the car and prevent damage or injury.





Expected Results

You should observe that:
- When the force increases, the acceleration of the trolley increases.
- A graph of Force (N) on the x-axis and Acceleration (m/s^2) on the y-axis should show a straight line through the origin - a linear relationship.

This is because: Acceleration ∝ Force (when mass is constant), in line with Newton's Second Law, F = m*a

Distance (cm)	Time (s) for 1.0 N	Time (s) for 0.8 N	Time (s) for 0.6 N	Time (s) for 0.4 N	Time (s) for 0.2 N
20					
40					
60					
80					
100					

Exam Style Questions - Force and Acceleration

1. What is the independent variable in this experiment? (1 mark)

2. Describe how you would use the setup to determine the acceleration of the trolley. (3 marks)

3. A student times the trolley over two 20 cm intervals. The first time is 1.20 s and the second time is 0.80 s. Calculate the change in velocity and the acceleration. (3 marks)

4. What relationship should the graph of force against acceleration show? (1 mark)

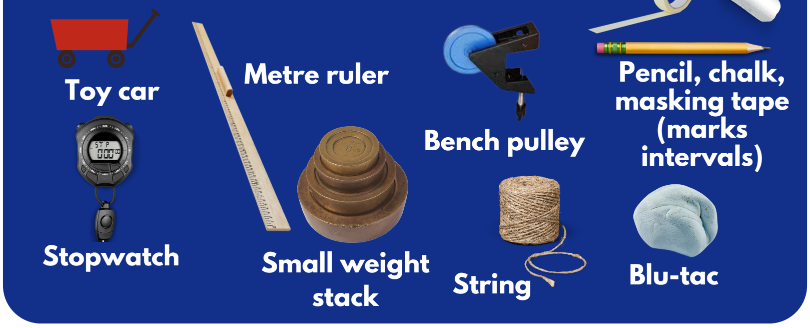
5. Suggest one way to reduce random errors in the timing of the trolley. (1 mark)

6. A trolley is pulled with different weights while keeping the total mass constant. What type of graph should be plotted with the results and what does the shape show? (2 marks)

7. A student investigates how the force applied to a trolley affects its acceleration. Describe how the student should carry out the experiment and explain how they would use their data to reach a valid conclusion. (6 marks)

Learning Objectives -
Measuring the effect of mass on acceleration with a constant force

Equipment & Apparatus



This links directly to Newton's Second Law of Motion:
m = F/a

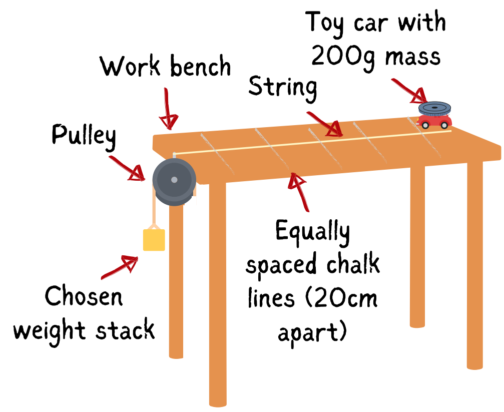
This law tells us that the acceleration of an object is directly proportional to the force applied to it, provided the mass remains unchanged.

Activity 2:

1. **Setup the bench**, pulley, weight stack and car as in steps 1-5 of activity 1.

In Activity 1, we increased the force (F) with weights. This time, we are increasing mass of car (m)

2. Use your **results from activity 1 to select a weight** for the weight stack that will just accelerate the car along the bench.



3. Starting with Minimum Mass: Place the trolley at the starting line with its base mass (e.g. 200 g).

4. Hold the car at the **start** point.

5. Attach your **chosen weight stack** to the end of the string. Attach the hanging weight and make sure the string is straight and taut.

6. Release the car at the same time as you start the stopwatch, press the stopwatch (lap mode) at each measured interval on the bench and for the final time at 100 cm.

7. Record the results in the table outline below.

8. Increasing the Mass: Repeat the test multiple times, each time increasing the trolley mass by 200 g (e.g. 400 g, 600 g, 800 g, 1000 g). Use Blu-tack to securely attach extra masses.

	Change in mass of the toy car				
Distance (cm)					
20					
40					
60					
80					
100					

9. Calculate average velocity and acceleration at each interval:
- Velocity (v) = Distance ÷ Time
- Acceleration (a) = (Final velocity - Initial velocity) ÷ Time interval

Independent variable
- Mass of the trolley (changed by adding weights)

Dependent variable
- Acceleration of the trolley

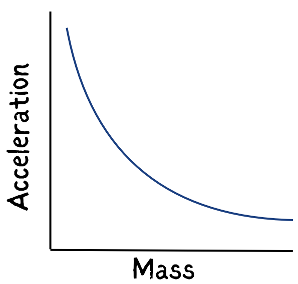
Control variables:
- Pulling force (hanging weight stays the same throughout)
- Surface and friction
- Distance travelled
- Surface of the bench
- Starting position
- String length and alignment
- Trolley and pulley system
- Method of Timing

REQUIRED PRACTICAL 7
FORCE AND ACCELERATION

Expected Results

You should observe that:
- As mass increases, the acceleration decreases.
- A graph of Mass (kg) on the x-axis vs Acceleration (m/s^2) on the y-axis will produce a curve, showing that the relationship is inversely proportional.

This is consistent with the rearranged version of Newton's Second Law:
a = F ÷ m
If F stays the same and m increases, a must decrease



Evaluation and Reducting Errors (Activities 1 and 2)

Systematic Errors:
- Forgetting to **transfer removed weights to the car** changes the systems mass, invalidating results. (Activity 1)

Random Errors:
- **Human reaction time** with the stopwatch introduces errors.
- **Pulling force** may not remain perfectly constant if the string snags or if the pulley sticks.

Human Errors:
- **Not securing masses properly** – they may shift or fall during movement.
- **Inconsistent release** technique may affect timing.

Improvements:
- Use **light gates** and a **data logger** for more accurate timing.
- **Repeat** the experiment and use mean values to minimize anomalies.
- Ensure the string is **straight** and **horizontal** before each release.

Exam Style Questions - Force and Acceleration

1. What is the independent variable in this experiment? (1 mark)

2. How is the force kept constant during this part of the investigation? (1 mark)

3. A student measures the time for the trolley to travel 1.0 m for five different masses. They notice that the trolley travels more slowly as the mass increases. Explain this result using Newton's Second Law. (3 marks)

4. Describe how to ensure this investigation is a fair test. (2 marks)

5. A student plots a graph of mass against acceleration. What would the shape of the graph be and why? (2 marks)

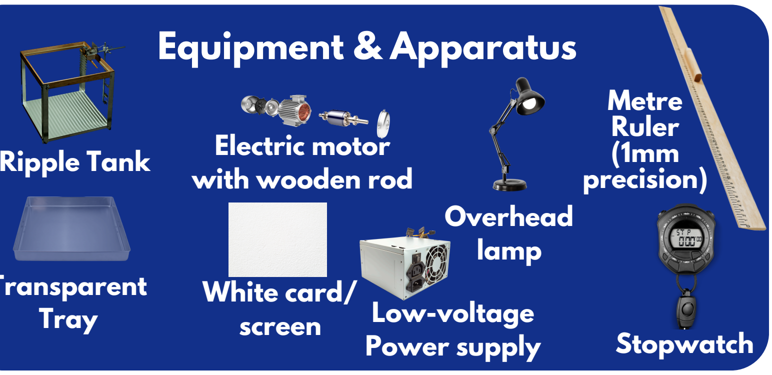
6. Explain why increasing the mass of the trolley reduces its acceleration. (2 marks)

7. A student wants to investigate how the mass of a trolley affects its acceleration when pulled by a constant force. Describe the steps they should take to collect valid results and explain what conclusion they could draw from their graph. (6 marks)

Learning Objectives -

To investigate the relationship between frequency, wavelength, and wave speed in water waves, using a ripple tank to produce and observe the waves.

Equipment & Apparatus



Waves equation:

$v = f\lambda$ Where:

v = wave speed (m/s)
f = frequency (Hz)
λ = wavelength (m)

REQUIRED PRACTICAL 8
WATER WAVES IN A RIPPLE TANK

Activity:

1) Setting Up the Ripple Tank - Assemble the ripple tank and position a large white card or screen underneath it.

This makes the wave patterns easier to observe by projecting shadows of the wave crests.

2) Adding Water - Pour water into the tank to a depth of approximately 5 mm.

Keep water depth consistent throughout the experiment to maintain uniform wave properties.

3) Positioning the Wooden Rod - Adjust the wooden rod on the motor so it just touches the surface of the water. When activated, it will produce regular waves across the water's surface.

4) Turning on the Motor and Lamp- Switch on the overhead lamp and the motor. The lamp should shine directly onto the tank so that shadows of the ripples are clearly seen on the white screen or card.

5) Producing Low-Frequency Waves - Adjust the motor via the signal generator to produce low-frequency waves that are easy to observe and count.

6) Measuring the Wavelength (λ) - Place the metre ruler at right angles to the wavefronts (across the ripples) on the screen. Measure the across as many waves as you can and divide that length by the number of waves to give you the wavelength.

7) Measuring the Frequency (f) - Count the number of waves passing a point in the pattern over a given time (say 10 seconds). Then the divide by the number of waves by 10 to give you the frequency.

- **Calculate wave speed:**

wave speed (v)= frequency (f) x wavelength (λ)

8) Record results in the table.

Repeat steps 6–8 multiple times and calculate average values to reduce random errors.

Waves in a liquid		
Frequency (Hz)	Wavelength (m)	Speed (m/s)
2	0.025	0.050

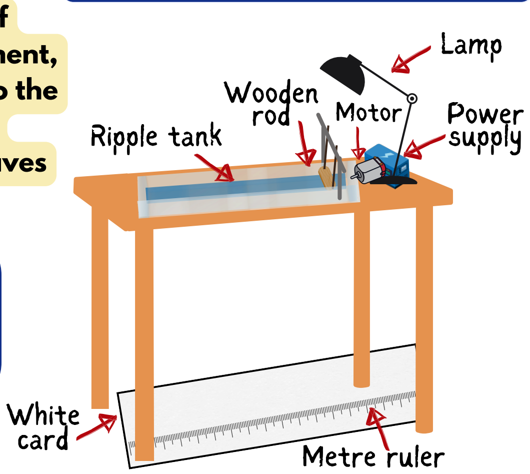
Independent variable
- Frequency of the waves (controlled by the motor/signal generator)

Dependent variable
- Wavelength of the water waves

Control variables:
- Depth of water
- Temperature of water
- Equipment and environment (lamp height, ruler placement)

Systematic Errors

Moving wavefronts are difficult to measure. To improve accuracy of wavelength measurement, ise a stroboscope set to the same frequency as the waves - this makes waves appear stationary.



Random Errors
- Wavelength: Use multiple wave crests to increase measurement accuracy.
- Frequency: Count waves over longer periods then divide by time to calculate frequency more accurately.
- Minimise disturbances (air movement, table vibrations).

Expected Results

You should observe that:
- As frequency increases, the wavelength should decrease (for a constant wave speed).
- A graph of Frequency (Hz) vs Wavelength (m) should show an inverse relationship.
- A graph of Frequency (Hz) vs Wave Speed (m/s) (if varied) may show direct proportionality if all measurements are accurate.

Safety Considerations:
- Keep electrical equipment away from water; ensure all components are elevated or sealed.
- Stand up throughout the experiment to react quickly to water spills.
- Do not consume food or drink near the apparatus.
- Avoid using strobe lighting if anyone present has photosensitive epilepsy.

Exam Style Questions - Water Waves in a Ripple Tank

1. What is the purpose of placing a white screen or card under the ripple tank? (1 mark)

2. Give the wave equation and state what each symbol represent? (2 marks)

3. A student measures 10 wavelengths across a total distance of 25 cm. Calculate the wavelength. (2 marks)

3. The student counts 20 waves passing a point in 10 seconds. Calculate the frequency. (2 marks)

4. Describe how the ripple tank should be setup to ensure a fair test and explain why each of the control variables must be kept constant. (4 marks)

5. What safety precaution should be followed when using electrical equipment near the ripple tank? (1 mark)

6. Explain why it is often difficult to measure the wavelength accurately in the ripple tank and suggest two ways the experiment can be improved to reduce this problem. (4 marks)

Learning Objectives -

To observe stationary waves in a solid (string or elastic cord), measure their wavelength and frequency, and use these values to calculate wave speed using the wave equation.

Equipment & Apparatus


Vibration generator


String or elastic cord


Wooden bridge (adjusts spring length)


Metre Ruler (1mm precision)


5/6 W signal generator (power supply)


Pulley with clamp


Safety goggles


Set of 100g & 10g masses and hangers

Waves equation:

$v = f\lambda$ Where:

- v = wave speed (m/s)
- f = frequency (Hz)
- λ = wavelength (m)

This practical helps us understand how waves behave in solids and how the frequency and tension in a string affect the wave pattern.

REQUIRED PRACTICAL 8
MEASURING WAVES IN A SOLID

Activity:

1) Setting Up the Apparatus - Attach one end of the string to the vibration generator. Pass the other end over a pulley, then attach a mass hanger with weights to create tension in the string.

Place a wooden bridge between the generator and pulley to fix the string's vibrating length.

2) Switching On and Tuning - Switch on the vibration generator. The string should begin to vibrate. Slowly increase or decrease the frequency using the signal generator until a standing wave pattern forms.

3) Adjusting for Clarity - If the wave is not clearly visible, adjust either:

- The length of the string using the bridge
- The tension (by changing the mass on the hanger) until a stable wave pattern forms.

The clearest standing wave has nodes (points that don't move) and antinodes (points of maximum vibration) that appear stationary.

4) Measuring Wavelength (λ) - Each complete "loop" of the stationary wave represents half a wavelength (½λ). Measure the total length across as many half wavelengths as possible using a metre ruler (e.g. 5 loops = 2.5 wavelengths).

- Calculate the full wavelength:

λ = (Total length ÷ Number of loops) × 2

5) Recording the Frequency (f) - Read the frequency directly from the signal generator. This is the same as the frequency of the wave on the string.

6) Calculate wave speed - wave speed (v)= frequency (f) x wavelength (λ)

7) Repeats and Reliability - Repeat the entire measurement for different frequencies (by adjusting the signal generator). For each frequency, record the wavelength and calculate wave speed. Take three readings and calculate the average for each.

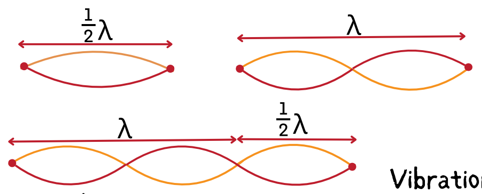
Waves in a solid		
Frequency (Hz)	Wavelength (m)	Speed (m/s)
60	0.60	36.0

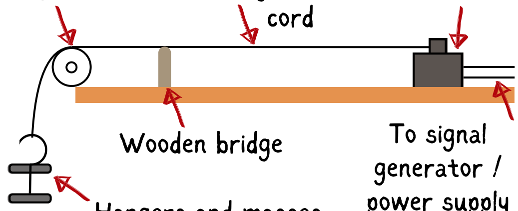
If No. loops = 3
and Measured length = 0.90m
Wavelength = (3 x 0.9) x 2 = 0.60m

Independent variable
- Frequency of the waves (adjusted by signal generator)

Dependent variable
- Wavelength (wave pattern)

Control variables:
- Type and length of string
- Mass and tension (unless deliberately altered)
- Position of the wooden bridge





Expected Results - You should observe that:
- As frequency increases, the wavelength of the wave generally decreases (assuming constant string tension).
- A graph of frequency vs wavelength will show an inverse relationship.
- A graph of frequency vs wave speed (if tension remains constant) should show wave speed remaining relatively constant for a given string under tension.

Systematic Errors:
- Stable string tension is crucial; changes in mass or pulley friction affect accuracy.
- Poor wave visibility occurs if frequency is not properly tuned.
- Use the frequency that yields the most visible wave (largest amplitude) and record it accurately.

Random Errors:
- Measure wavelength across multiple loops for accuracy.
- Repeatability can vary due to slight changes in wave visibility or string tension between trials.

Safety Considerations:
- Wear safety goggles to protect against snapping strings.
- Use rubber string or cord to minimize injury risk.
- Stand clear of hanging masses to avoid falling objects.
- Use a crash mat or soft surface beneath weights.
- Avoid damp areas for signal generators and wires to prevent electric shock.

Exam Style Questions - Water Waves in a Solid

1. What is meant by a "loop" in a standing wave on a string? (1 mark)

2. A student observes 5 loops across a string measuring 1.2 m. Calculate the wavelength. (2 marks)

3. Suggest one reason the wave pattern may not appear clearly on the string and how to fix it. (2 marks)

4. What is the dependent variable in this experiment? (1 mark)

5. Why is it better to measure the wavelength across multiple loops instead of just one? (2 marks)

6. A student increases the frequency and observes more loops form on the string. Explain why this happens. (2 marks)

7. Compare how wave speed is measured in the ripple tank and on the vibrating string. Include how wavelength and frequency are measured in each setup and how to improve accuracy. (6 marks)

Evaluation of Waves Practicals

1. State the relationship between the variables measured in activities 1 and 2.

2. Comment on the accuracy of your results in both Activity 1 and 2

3. How suitable was the apparatus that you used in both activities? How might you change the apparatus to provide more accurate results?

Learning Objectives -

Investigate the reflection of light by different types of surface and the refraction of light by different substances

- Reflection – how light behaves when it bounces off a surface.

Law of Reflection:
Angle of incidence = Angle of reflection
Applies to smooth surfaces, including transparent blocks.

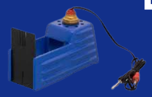
- Refraction – how light bends when it passes from one material into another (e.g. from air into glass or Perspex).

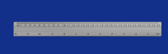
When light passes into a denser medium (e.g. from air into glass):
- It bends towards the normal (i > r)

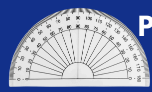
When light exits a denser medium into air:
- It bends away from the normal (i < r)

At 90˚ incidence (along the normal), there is no refraction
- The ray passes straight through.

Equipment & Apparatus

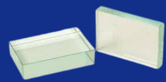

Ray optics box (ray box) & narrow slits


30cm ruler


Protractor


Sharp pencil


Bench power supply


Rectangular blocks - glass and Perspex

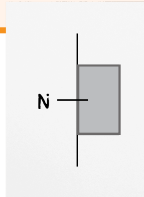

Plain A3 paper

Independent variable
- Angle of incidence (˚)

Dependent variable
- Angle of reflection (˚) / refraction (˚)

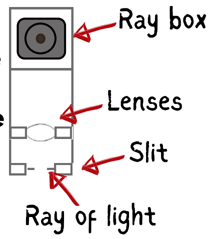
Control variables:
- Type of surface (e.g., smooth, flat mirror or transparent block surface)
- Distance from ray box to the surface
- Width of the light beam (use same slit for consistency)
- Frequency/wavelength of light (use the same light source throughout)
- Ambient lighting conditions (preferably low light)

Activity:



1) **Prepare the Setup**
- Use a ruler to draw a straight horizontal line across the centre of the A3 paper.
- Use a protractor to draw a second line at right angles to this line. This is the normal. Label it 'N'.

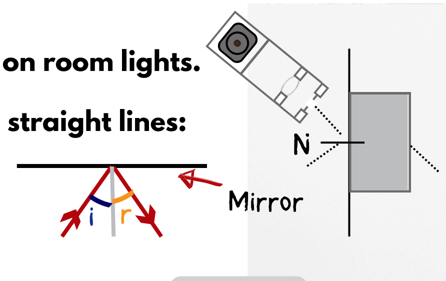
2) **Outline the Block**
- Place the transparent block (glass) so it lines up with the horizontal line.
- Carefully trace around the block using a pencil to ensure accurate repositioning after removal.



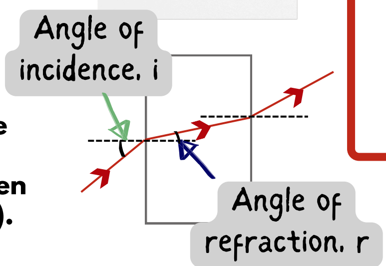
3) **Set Up the Ray Box and Switch Room Lights Off**
- Turn on the ray box and use the slit to produce a single narrow ray.
- Direct the ray so it strikes the block at the point where the normal meets the block's surface

4) **Trace the Incoming and Outgoing Ray Paths**
- Incoming ray - before it hits the block.
- Refracted ray - passes through the block.
- Emerging ray - the opposite side as it exits.
- If visible, also mark any reflected ray that bounces off the surface.

5) **Complete the Diagram**
- Switch off the ray box and switch on room lights.
- Remove the block.
- Use a ruler to join the dashes with straight lines:
  - Incident ray
  - Refracted ray
  - Emergent ray
  - Reflected ray (if applicable)
- Label all rays appropriately.



6) **Take Measurements**
- Angle of incidence (i): The angle between the incident ray and the normal.
- Angle of refraction (r): The angle between the refracted ray and the normal.
- Angle of reflection: Measure the angle between the reflected ray and the normal (if observed).



7) **Repeat with a Second Material (e.g. Perspex)**
- Flip the sheet over or use a new sheet.
- Repeat the experiment using the second transparent block

Material	Angle of incidence (°)	Angle of reflection (°)	Angle of refraction (°)
Glass			
Perspex			

Random Errors
- Pencil marking errors: Inaccurate dot placements can distort angles.
  - Solution: Use a sharpened pencil and place crosses at the beam's center.
- Reading errors: Protractor resolution (±1˚) limits precision.
  - Solution: Take multiple measurements and calculate an average.

Systematic Errors:
- Incorrect normal line: A misaligned normal affects angle readings.
  - Solution: Use a set square or a checked protractor.
- Misalignment of ray box: A wide or off-centred ray obscures the light path.
  - Solution: Use a narrow slit and mark the beam's centre.
- Misplaced block: Moving the block can distort ray paths.
  - Solution: Draw around the block and reposition it accurately.

REQUIRED PRACTICAL 9
LIGHT: REFLECTION & REFRACTION

Expected Results

You should observe that:
- The angle of reflection = angle of incidence (law of reflection).
- The angle of refraction should be smaller than the angle of incidence when light enters the block.
- Different materials have different refractive indices, so:
  - The angle of refraction will vary between glass and Perspex, even if the angle of incidence stays the same.

The glass should refract more than the perspex

Safety Considerations:
- Ray boxes get hot; switch off when not in use and avoid direct bulb contact.
- Do not look directly at the light beam.
- Keep liquids away from electrical components.
- Handle blocks and mirrors carefully to avoid cracks or sharp edges.

Exam Style Questions - Light

1. What is meant by the 'angle of incidence'? (1 mark)

2. What does the law of reflection state? (1 mark)

3. What piece of equipment is used to measure the angle of incidence and angle of refraction? (1 mark)

4. Describe the path of a light ray as it passes from air into a glass block at an angle. (2 marks)

5. A student measures the angle of incidence as 30˚ and the angle of refraction as 19˚. Did the light speed up or slow down as it passed into the new material? Explain your answer. (3 marks)

6. Why is it important to switch off room lights during this practical? (1 mark)

7. Suggest one reason why the angle of refraction might not appear to follow the expected pattern. (1 mark)

8. Describe how to carry out the refraction part of this practical using a glass block and a ray box. Include how you would improve the accuracy of your results. (4 marks)

9. Explain why light refracts when it passes from air into glass and describe how this affects the path of the ray. (3 marks)

Learning Objectives -

To investigate how the nature of a surface (its colour and texture) affects the amount of infrared radiation it emits or absorbs.

Infrared radiation is a type of electromagnetic wave that transfers heat energy. All objects emit infrared radiation, and the amount depends on their temperature and surface properties.

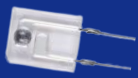
Equipment & Apparatus

Leslie cube

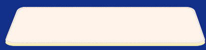
Kettle

Safety goggles

Stopwatch



Infrared detector



Heatproof mat

Graph paper

REQUIRED PRACTICAL 10
RADIATION AND ABSORPTION

Method:

1) Place the Leslie cube on a heat-proof mat to protect the bench surface.

2) Fill the cube almost to the top with boiling water. Use a funnel to avoid spills and burns.

3) Place the lid on top of the cube to reduce heat loss through convection.

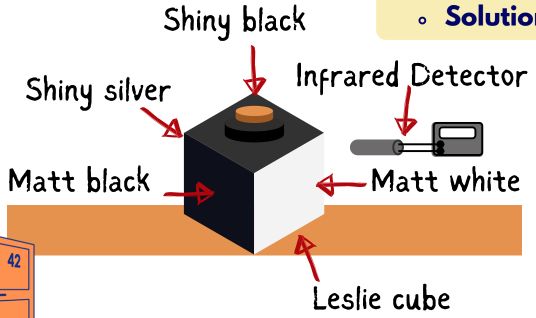
4) Wait for one minute to allow the surfaces of the cube to reach the same temperature as the water inside.

5) Use the infrared detector to measure the infrared radiation emitted by each side of the cube:
- Position the detector at the same distance (e.g. 5 cm) from each face.
- Avoid touching or moving the cube.
- Record the infrared radiated from each surface.

6) Repeat the measurement for the following surfaces of the Leslie cube:
- Matt black
- Shiny black
- Matt white
- Shiny silver

7) Record the results in a suitable table.
- Allow the cube to cool before moving.

Surface Type	Infrared Intensity (W/m^2)
Matt Black	19.5
Shiny Black	14.2
Matt White	5.1
Shiny Silver	3.8



Independent variable
- Surface type/colour (matt black, shiny silver, etc.)

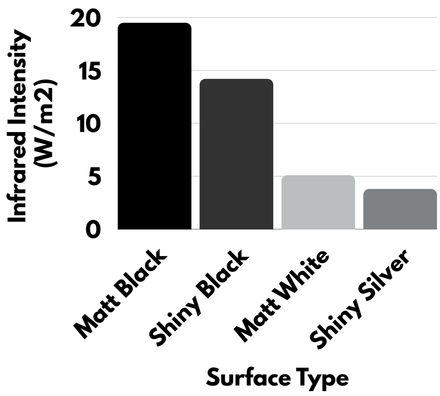
Dependent variable
- Infrared intensity (from detector)

Control variables:
- Volume of hot water in cube/flasks
- Starting temperature of water
- Distance between detector and cube surface
- Ambient room conditions (avoid drafts or direct sunlight)
- Time intervals for readings
- Same material and shape of flask (for Method 2)

Analysis and Interpretation

Plot a bar chart of infrared intensity against surface type.

This helps identify which surface emits the most infrared radiation.



Expected Results - You should observe that:
- Matt black surface: emits and absorbs the most infrared radiation
- Shiny silver surface: emits and absorbs the least
- The order of emission (best to worst):
  - ➤ Matt black → Shiny black → Matt white → Shiny silver

This practical shows that surface type influences infrared radiation emission. Darker, duller surfaces are more efficient at emitting and absorbing thermal radiation than lighter, shinier ones. This helps explain why radiators are often painted black and why survival blankets are silver to reflect body heat.

Systematic Errors:
- Distance from the detector to each cube face must be identical.
  - Solution: Use a measured spacer or block to keep the distance consistent.
- Starting temperatures must be the same.
  - Solution: Use a digital thermometer or temperature probe for precision.
- Infrared detector calibration may drift.
  - Solution: Check baseline readings before starting the test.

Random Errors:
- Readings may vary due to reflections or background heat.

Solution: Take multiple readings and average them.

Safety Considerations:
- Boiling water can cause scalds; pour slowly, use a funnel, and avoid moving hot cubes.
- Infrared sensors become hot; do not touch the bulb/lens
- Keep electrical equipment away from water.
- Work standing up with a clear workspace to prevent spills.
- Rinse burns under cold water for at least 5 minutes immediately.

Exam Style Questions - Radiation & Absorption

1. What is the independent variable in this practical? (1 mark)

2. Why is it important to wait before taking measurements after pouring the hot water into the Leslie cube? (1 mark)

3. What piece of equipment is used to detect the amount of infrared radiation emitted? (1 mark)

4. A student records the following infrared intensities:
Matt black = 19.5 units
Shiny silver = 3.5 units
What conclusion can they draw? (2 marks)

5. Suggest one control variable in this practical and explain why it should be kept the same. (2 marks)

6. Why must the detector be pointed at the same angle and distance for each reading? (2 marks)

7. Explain why a matt black surface is better for both emitting and absorbing infrared radiation than a shiny white surface. Use ideas about radiation, reflection and absorption. (4 marks)

8. Suggest three ways you could improve the accuracy or reliability of your results in this practical. (3 marks)

Exam Style Questions - Specific Heat Capacity

1. What is the independent variable in this experiment? (1 mark)

Mark One - The type of metal used

2. State two control variables in this experiment. (2 marks)

Mark One - Starting temperature
Mark Two - Voltage or current / mass of the block

3. Why is the block wrapped in insulation? (1 mark)

Mark One - To reduce heat loss to the surroundings

4. What measurements are needed to calculate power? (2 marks)

Mark One - Current
Mark Two - Potential difference (voltage)

5. Describe how to calculate the energy transferred by the heater. (2 marks)

Mark One - Use the equation: Energy transferred = Power × time
Mark Two - Power = Voltage × current

6. A student records a voltage of 12 V, a current of 2.0 A, and heats for 600 seconds. Calculate the energy transferred. (2 marks)

Mark One - Power = 12 × 2 = 24 W
Mark Two - Energy = 24 × 600 = 14,400 J

7. A graph is plotted with temperature (˚C) on the y-axis and energy transferred (J) on the x-axis. What is the gradient of the straight-line section used for? (1 mark)

Mark One - To calculate the specific heat capacity

8. Give one source of random error in this experiment and how it can be reduced. (2 marks)

Mark One - Heat lost to the surroundings
Mark Two - Use better insulation or a lid on the block

9. A student wants to compare the specific heat capacity of copper and aluminium using the same method. Describe the method they would use and explain how they would ensure the comparison is valid. Include how they would use the results to calculate the specific heat capacity. (6 marks)

Level 3 (5–6 marks)
- Describes a full valid method including: measuring mass, wrapping in insulation, inserting heater and thermometer, recording voltage and current, and logging temperature over time
- Explains how to calculate energy transferred and plot a graph
- Compares results fairly by controlling variables (same power/time/starting temp etc.)

Level 2 (3–4 marks)
- Describes a mostly complete method
- Includes how to calculate energy or how to use a graph
- Some mention of fair testing, may miss detail

Level 1 (1–2 marks)
- Describes basic idea (e.g. heat metal and measure temperature)
- Limited or no explanation of calculations or fair testing

0 marks
- No relevant content

Exam Style Questions - Thermal Insulation P1

1. What is the independent variable in this experiment? (1 mark)

Mark One - Type of insulating material

2. Why is a lid with a hole used during the experiment? (1 mark)

Mark One - To reduce heat loss while still allowing the thermometer to be inserted

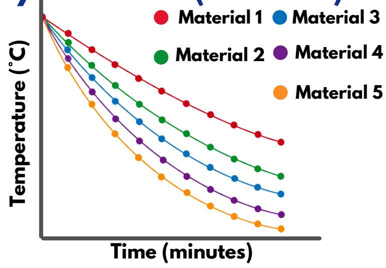
**3. Describe how you would compare the effectiveness of five insulating materials using this setup.
(3 marks)**

Mark One - Use the same volume and temperature of hot water in each beaker
Mark Two - Wrap each beaker in a different insulating material
Mark Three - Record the temperature every 3 minutes for 15 minutes and compare the results

**4. A student finds that the temperature of the water drops fastest with newspaper and slowest with bubble wrap. What conclusion can they make about the effectiveness of these two materials?
(2 marks)**

Mark One - Bubble wrap is a better insulator
Mark Two - Because it slows down energy transfer more than newspaper

5. Look at the graph. Which line shows the best insulator and how do you know? (2 marks)



Mark One - The line with the shallowest gradient (temperature drops slowest)
Mark Two - Because the temperature stays highest for longest

**6. Explain why it is important to use the same starting temperature of water in each beaker.
(2 marks)**

Mark One - So the results are comparable
Mark Two - Different starting temperatures could affect the rate of cooling

7. The student notices the thermometer readings vary slightly each time they insert it. Suggest one reason why this happens and how it could be reduced. (2 marks)

Mark One - The thermometer may not be in the same position each time
Mark Two - Use a fixed lid or clamp to keep the thermometer in place

8. A student finds that the temperature of the water drops quickly in the first 3 minutes, then more slowly afterwards. Explain why this happens using ideas about temperature difference and energy transfer. (3 marks)

Mark One - At the start, the temperature difference between the water and surroundings is greatest
Mark Two - This causes faster energy transfer to the surroundings
Mark Three - As the water cools, the temperature difference decreases, so heat is lost more slowly

Exam Style Questions - Thermal Insulation P2

1. What is the independent variable in this experiment? (1 mark)

Mark One - Number of layers of insulation

2. A student finds that the temperature change over 15 minutes is 16˚C with 0 layers and 6˚C with 6 layers. What does this suggest about the effect of thickness? (2 marks)

Mark One - More layers reduce heat loss
Mark Two - Thicker insulation slows the temperature decrease more

3. Explain why energy is transferred more slowly with more layers of insulation. (3 marks)

Mark One - More layers trap more air
Mark Two - Air is a poor conductor of heat
Mark Three - This reduces energy loss through conduction

4. What is the purpose of using the same lid and beaker type each time? (1 mark)

Mark One - To ensure the test is fair / reduce uncontrolled variables

5. Suggest one way to improve the accuracy of this experiment. (1 mark)

Mark One - Use a digital data logger / measure temperature more frequently / repeat and calculate a mean

6. Why does the temperature drop more slowly when more layers of insulation are used? (2 marks)

Mark One - More layers trap more air
Mark Two - Air is a good insulator and reduces heat loss

7. The experiment is repeated using water at 100˚C instead of 80˚C. Explain how this might affect the results. (3 marks)

Mark One - There is a greater temperature difference between the water and air
Mark Two - This causes faster heat transfer
Mark Three - The temperature may drop more quickly overall

8. The student is told to repeat each test three times. Why is this good experimental practice? (2 marks)

Mark One - To identify any anomalies
Mark Two - To calculate a more reliable average result

9. A student finds that the temperature drop between 0 and 15 minutes was 17˚C with 0 layers, 12˚C with 2 layers, and 8˚C with 4 layers. They then add a 6th layer but find the temperature only drops by 7˚C. Explain why adding more layers becomes less effective at reducing heat loss. (3 marks)

Mark One - Each extra layer still reduces heat loss
Mark Two - But the biggest temperature differences occur with fewer layers
Mark Three - The effect becomes smaller because most heat loss is already prevented

Exam Style Questions - Resistance P1

1. What is the independent variable in this experiment? (1 mark)

Mark One - Length of wire

2. State the equation used to calculate resistance. (1 mark)

Mark One - Resistance = potential difference ÷ current ($R = V \div I$)

3. A student tests 50 cm and 100 cm of wire. The current is 0.3 A and the voltages are 0.90 V and 1.80 V respectively. Calculate the resistance for both lengths. (2 marks)

Mark One - $0.90 \div 0.3 = 3.0\ \Omega$
Mark Two - $1.80 \div 0.3 = 6.0\ \Omega$

4. Explain why the wire should be left to cool between measurements. (2 marks)

Mark One - Heating increases the temperature of the wire
Mark Two - This affects the resistance and makes results less accurate

5. What is the relationship between length of wire and resistance? (2 marks)

Mark One - Resistance increases with length
Mark Two - The relationship is directly proportional (if the graph is a straight line through the origin)

6. A student plots a graph of resistance against length of wire. The line does not pass through the origin, as expected. Suggest two reasons why. (2 marks)

Mark One - The first crocodile clip might not have been placed at 0 cm
Mark Two - The wire may have warmed up during testing, increasing resistance

7. Why should the wire used be the same thickness throughout the experiment? (1 mark)

Mark One - Because thickness affects resistance

8. A student finds that resistance is higher at longer lengths. Explain this using particle theory. (3 marks)

Mark One - Electrons move through the metal and collide with atoms
Mark Two - A longer wire has more atoms
Mark Three - More collisions increase resistance

9. Suggest one way to reduce random error when measuring current and voltage. (1 mark)

Mark One - Take multiple readings and calculate a mean / allow wire to cool between readings

Exam Style Questions - Resistance P2

1. What is the independent variable in this practical? (1 mark)

Mark One - The number or arrangement of resistors (series or parallel)

2. Describe the difference in current between a series and parallel circuit. (2 marks)

Mark One - In a series circuit, current is the same throughout
Mark Two - In a parallel circuit, current splits between branches

3. A student sets up two circuits: one in series, one in parallel. The voltage is the same in both. Explain why the total resistance is lower in the parallel circuit. (3 marks)

Mark One - In parallel, there are multiple paths for current to flow
Mark Two - More current can flow overall
Mark Three - So the total resistance is reduced

4. What is the equation to calculate resistance, and how can it be applied in this practical? (2 marks)

Mark One - R = V ÷ I
Mark Two - Measure voltage and current in each circuit, then calculate total resistance

5. A student finds the total resistance in a series circuit is 9.0 Ω and in a parallel circuit is 4.9 Ω. What conclusion can they make about adding resistors in parallel vs series? (2 marks)

Mark One - Adding resistors in parallel reduces the total resistance
Mark Two - Adding resistors in series increases total resistance

6. Why is it important to use identical resistors in this practical? (1 mark)

Mark One - So any changes in resistance are only due to the circuit arrangement, not the resistor values

7. In a parallel circuit, the voltage across each resistor is the same. Explain why this means the total current is higher than in a series circuit. (3 marks)

Mark One - Each resistor gets the full voltage
Mark Two - Each branch draws current independently
Mark Three - Total current is the sum of current in each branch

8. A student adds a third identical resistor to a parallel circuit. Predict what happens to the total resistance and explain why. (2 marks)

Mark One - The total resistance decreases
Mark Two - Because more paths allow current to flow more easily

Exam Style Questions - I-V Characteristics

1. What is the independent variable in this experiment? (1 mark)

Mark One - Potential difference (voltage)

2. What component is used to vary the potential difference across a circuit? (1 mark)

Mark One - Variable resistor

3. Describe the shape of the I-V graph for a filament lamp. (2 marks)

Mark One - It curves
Mark Two - The current increases more slowly at higher voltages

4. Explain why the filament lamp's resistance increases as the current increases. (3 marks)

Mark One - More current flows through the filament
Mark Two - The filament gets hotter
Mark Three - Resistance increases with temperature

5. What would a graph of current against potential difference look like for a resistor at constant temperature? (1 mark)

Mark One - A straight line through the origin

6. Explain why the resistance of the resistor remains constant during the experiment. (2 marks)

Mark One - The temperature of the resistor stays constant
Mark Two - So resistance doesn't change with increasing current

**7. The student plots a straight-line graph through the origin.
What does this show about the relationship between current and voltage? (2 marks)**

Mark One - They are directly proportional
Mark Two - Resistance is constant

8. Why is there no current when the potential difference is negative in a diode circuit? (2 marks)

Mark One - Diodes only allow current in one direction
Mark Two - A reverse potential difference blocks the flow of current

9. A student says, "The resistance of a filament lamp increases as current increases, but the resistor's resistance stays constant." Use the I-V graphs to explain why the student is correct. (4 marks)

Mark One - The I-V graph for the filament lamp is a curve
Mark Two - This shows current increases more slowly as voltage increases
Mark Three - This means resistance is increasing ($R = V \div I$)
Mark Four - The resistor has a straight-line graph through the origin, showing constant resistance

Exam Style Questions - Density

1. What equipment is needed to measure the volume of a cube or cuboid? (1 mark)

Mark One - Ruler

2. A metal block has a mass of 540 g and measures 5.0 cm × 3.0 cm × 2.0 cm. Calculate the density in g/cm³. (3 marks)

Mark One - Volume = 5 × 3 × 2 = 30 cm³
Mark Two - Density = 540 ÷ 30 = 18
Mark Three - Final answer = 18 g/cm³

3. Give one reason why it is important to take repeat readings of length when measuring a solid. (1 mark)

Mark One - To reduce random error / improve accuracy

4. A student places a stone in a displacement can and collects 120 cm³ of water. The mass of the stone is 300 g. Calculate the density of the stone. (2 marks)

Mark One - Density = 300 ÷ 120
Mark Two - Final answer = 2.5 g/cm³

5. When using a displacement can, explain why it's important to wait until water stops dripping from the spout before taking a reading. (2 marks)

Mark One - To ensure all the displaced water has been collected
Mark Two - So the volume measured is accurate

6. A student pours 100 cm³ of liquid into a measuring cylinder. The mass of the cylinder is 50 g. The total mass of the cylinder and liquid is 130 g. Calculate the density of the liquid in g/cm³. (3 marks)

Mark One - Mass of liquid = 130 − 50 = 80 g
Mark Two - Volume = 100 cm³
Mark Three - Density = 80 ÷ 100 = 0.8 g/cm³

7. Explain why solids usually have a higher density than liquids, using ideas about particle arrangement. (3 marks)

Mark One – In solids, particles are tightly packed in a fixed, regular pattern
Mark Two – In liquids, particles are still close but have small gaps between them
Mark Three – This means more mass is packed into the same volume in solids, so the density is higher

8. A student records the following data:
- **Mass of empty measuring cylinder = 60 g**
- **Mass of cylinder + unknown liquid = 180 g**
- **Volume of liquid = 150 cm³**

a) Calculate the mass of the liquid
b) Calculate the density in g/cm³
c) Suggest one source of error in this method and how it could be reduced (4 marks)

Mark One – Mass of liquid = 180 − 60 = 120 g
Mark Two – Density = 120 ÷ 150 = 0.8 g/cm³
Mark Three – Source of error: parallax error when reading scale / liquid sticking to the sides
Mark Four – Use a digital balance / ensure consistent measuring technique

Exam Style Questions - Force and Extension

1. What is the independent variable in this experiment? (1 mark)

Mark One - Force applied to the spring

2. What is meant by the "extension" of the spring? (1 mark)

Mark One - The increase in length of the spring from its original length

3. A student hangs a 2.0 N weight and the spring extends from 200 mm to 250 mm. Calculate the extension in cm. (2 marks)

Mark One - Extension = 250 − 200 = 50 mm
Mark Two - Convert to cm = 5.0 cm

4. What does it mean if the graph of force vs extension curves upwards? (2 marks)

Mark One - The spring has passed its limit of proportionality
Mark Two - It will no longer return to its original shape

5. A spring stretches 0.04 m when a force of 2.0 N is applied. Calculate the spring constant. Give units. (2 marks)

Mark One - k = F ÷ e = 2.0 ÷ 0.04 = 50
Mark Two - Final answer: 50 N/m

6. A student plots a graph of force (N) against extension (cm). The points lie on a straight line until the last two values, which begin to curve.
a) What does the straight section of the graph show?
b) What does the curve at the end indicate? (3 marks)

Mark One – The spring obeys Hooke's Law in the straight-line section
Mark Two – Force is directly proportional to extension in this region
Mark Three – The curve shows the spring has passed its limit of proportionality

7. A student investigates how the extension of a spring changes when different forces are applied. Describe how they should carry out this experiment and explain how they could ensure their results are valid and reliable.

Level 3 (5–6 marks)

- Describes the method clearly, including setting up apparatus, measuring original and stretched length, and calculating extension
- Explains how to ensure accuracy (e.g. using a pointer, reading at eye level, avoiding parallax)
- Describes reliability improvements such as repeating readings and checking proportionality
- Example:
- Use a clamp stand with spring and ruler
- Add weights one at a time, measure extension
- Use a pointer for accuracy, take repeat readings
- Plot force vs extension graph to check proportional relationship

Level 2 (3–4 marks)

- Gives a mostly complete method
- Some valid points on accuracy or reliability
- May lack clarity or miss one key element

Level 1 (1–2 marks)

- Describes a basic method or mentions taking measurements
- Limited mention of accuracy or checks

0 marks

- No relevant content

Exam Style Questions - Force and Acceleration

1. What is the independent variable in this experiment? (1 mark)

Mark One – The total mass of the system (car + weights)
Mark Two – To isolate the effect of force on acceleration

2. Describe how you would use the setup to determine the acceleration of the trolley. (3 marks)

Mark One – Use a stopwatch to time the trolley as it passes distance markers (e.g. every 20 cm)
Mark Two – Calculate velocity at each interval
Mark Three – Use acceleration = (final velocity – initial velocity) ÷ time

3. A student times the trolley over two 20 cm intervals. The first time is 1.20 s and the second time is 0.80 s. Calculate the change in velocity and the acceleration. (3 marks)

Mark One – $v_1 = 0.20 \div 1.20 = 0.167$ m/s; $v_2 = 0.20 \div 0.80 = 0.25$ m/s
Mark Two – Change in velocity = 0.25 − 0.167 = 0.083 m/s
Mark Three – Acceleration = 0.083 ÷ 0.80 = approx. 0.104 m/s^2

4. What relationship should the graph of force against acceleration show? (1 mark)

Mark One – A directly proportional relationship (straight line through the origin)

5. Suggest one way to reduce random errors in the timing of the trolley. (1 mark)

Mark One - Use a light gate or motion sensor instead of a manual stopwatch

6. A trolley is pulled with different weights while keeping the total mass constant. What type of graph should be plotted with the results and what does the shape show? (2 marks)

Mark One - Graph of force vs acceleration
Mark Two - The shape is a straight line through the origin (directly proportional)

7. A student investigates how the force applied to a trolley affects its acceleration. Describe how the student should carry out the experiment and explain how they would use their data to reach a valid conclusion. (6 marks)

Level 3 (5–6 marks):
- Describes full method, including use of pulley, consistent total mass, measuring acceleration, and plotting graph.
- Includes how to control variables and assess relationship.

Level 2 (3–4 marks):
- Gives method and mentions a few valid variables/steps.
- Some mention of calculating or using results.

Level 1 (1–2 marks):
- Limited or partial method.
- May mention force or acceleration vaguely.

Exam Style Questions - Force and Acceleration

1. What is the independent variable in this experiment? (1 mark)

Mark One – The mass of the trolley system

2. How is the force kept constant during this part of the investigation? (1 mark)

Mark One – By using the same weight stack to pull the trolley each time

3. A student measures the time for the trolley to travel 1.0 m for five different masses. They notice that the trolley travels more slowly as the mass increases. Explain this result using Newton's Second Law. (3 marks)

Mark One – Newton's Second Law is $F = ma$
Mark Two – If force is constant and mass increases, acceleration must decrease
Mark Three – This explains why heavier masses move more slowly

4. Describe how to ensure this investigation is a fair test. (2 marks)

Mark One – Use the same track and pulley setup each time
Mark Two – Release the trolley from the same position and use the same force

5. A student plots a graph of mass against acceleration. What would the shape of the graph be and why? (2 marks)

Mark One – $F = ma$, so if force is constant and mass increases
Mark Two – Then acceleration must decrease

6. Explain why increasing the mass of the trolley reduces its acceleration. (2 marks)

Mark One – Use the same weight or force each time
Mark Two – Do not change the pulling force

7. A student wants to investigate how the mass of a trolley affects its acceleration when pulled by a constant force. Describe the steps they should take to collect valid results and explain what conclusion they could draw from their graph. (6 marks)

Level 3 (5–6 marks):
- Describes the method (same pulley, increasing mass, timing),
- explains how to measure acceleration,
- and mentions the expected inverse relationship

Level 2 (3–4 marks):
- Reasonable method and idea of acceleration decreasing with mass

Level 1 (1–2 marks):
- Basic idea of adding mass and timing trolley;
- lacks clarity on what's measured

Exam Style Questions - Water Waves in a Ripple Tank

1. What is the purpose of placing a white screen or card under the ripple tank? (1 mark)

Mark One - To see the wave shadows more clearly

2. Give the wave equation and state what each symbol represent? (2 marks)

Mark One - $v = f \times \lambda$
Mark Two - v = wave speed, f = frequency, λ = wavelength

3. A student measures 10 wavelengths across a total distance of 25 cm. Calculate the wavelength. (2 marks)

Mark One - 25 cm ÷ 10 = 2.5 cm
Mark Two - Convert to metres = 0.025 m

3. The student counts 20 waves passing a point in 10 seconds. Calculate the frequency. (2 marks)

Mark One - $v = 3.0 \times 0.02$
Mark Two - Final answer = 0.06 m/s

4. Describe how the ripple tank should be setup to ensure a fair test and explain why each of the control variables must be kept constant. (4 marks)

Mark One - The water depth must be kept the same to maintain consistent wave properties
Mark Two - The lamp height should stay constant so shadows remain sharp and clear
Mark Three - The same section of the tank should be used for measurement to avoid distortion at the edges
Mark Four - Consistent ruler placement and camera/light angle prevent systematic errors

5. What safety precaution should be followed when using electrical equipment near the ripple tank? (1 mark)

Mark One - Keep all electrical equipment elevated and dry / avoid spills

6. Explain why it is often difficult to measure the wavelength accurately in the ripple tank and suggest two ways the experiment can be improved to reduce this problem. (4 marks)

Mark One - The wave crests are constantly moving, making it hard to line up the ruler accurately
Mark Two - Water movement or vibrations may blur the wave pattern
Mark Three - Use a stroboscope set to the same frequency to make waves appear stationary
Mark Four - Measure across multiple wavelengths and divide to get an average

Exam Style Questions - Water Waves in a Solid

1. What is meant by a "loop" in a standing wave on a string? (1 mark)

Mark One - Half of a wavelength

2. A student observes 5 loops across a string measuring 1.2 m. Calculate the wavelength. (2 marks)

Mark One - $1.2 \div 5 = 0.24$
Mark Two - Wavelength = $0.24 \times 2 = 0.48$ m

3. Suggest one reason the wave pattern may not appear clearly on the string and how to fix it. (2 marks)

Mark One - Frequency isn't set correctly / wrong tension
Mark Two - Adjust the signal generator or the masses until the wave is stable

4. What is the dependent variable in this experiment? (1 mark)

Mark One - The wavelength of the standing wave

5. Why is it better to measure the wavelength across multiple loops instead of just one? (2 marks)

Mark One - Reduces random errors
Mark Two - Gives a more accurate average wavelength

6. A student increases the frequency and observes more loops form on the string. Explain why this happens. (2 marks)

Mark One - Higher frequency = shorter wavelength
Mark Two - More half-wavelengths fit on the same length of string

7. Compare how wave speed is measured in the ripple tank and on the vibrating string. Include how wavelength and frequency are measured in each setup and how to improve accuracy. (6 marks)

Level 3 (5–6 marks):
- Clearly describes both methods for measuring wavelength and frequency
- Explains how wave speed is calculated in each case using $v = f \times \lambda$
- Identifies at least one limitation and one improvement for each setup
- (e.g. moving water in ripple tank; stroboscope; difficulty seeing loops on string; tuning frequency for stable pattern)

Level 2 (3–4 marks):
- Describes both setups with some correct detail
- Mentions how wave speed is calculated
- Includes one improvement or error source

Level 1 (1–2 marks):
- Basic statements about measurement or wave behaviour
- May confuse parts of the method

0 marks:
- No relevant content

Evaluation of Waves Practicals

1. State the relationship between the variables measured in activities 1 and 2.

In both activities, we measured the frequency (f) and the wavelength (λ) of waves to calculate the wave speed (v) using the equation: $v = f \times \lambda$.

In Activity 1 (ripple tank), the independent variable was frequency (changed using the motor), and the dependent variable was wavelength. Wave speed was calculated using the measured frequency and wavelength.

In Activity 2 (vibrating string), the independent variable was also frequency (set using the signal generator), and the dependent variable was the wavelength of the standing wave pattern.

In both cases, the wave speed was derived from the relationship between frequency and wavelength. This confirmed the direct proportionality between wave speed and frequency when wavelength is fixed, and inverse proportionality between frequency and wavelength when speed remains relatively constant.

2. Comment on the accuracy of your results in both Activity 1 and 2.

Activity 1: Ripple Tank

- **Wavelength accuracy was affected by wavefront motion, making it hard to precisely align the ruler with the peaks or troughs.**
- **Frequency accuracy depended on accurate wave counting and consistent timing over 10 seconds. Any miscount or slow reaction with the stopwatch introduced error.**
- **Accuracy could be improved by using a stroboscope to "freeze" the wave pattern, allowing easier and more reliable wavelength measurements.**
- **Measuring across multiple wavelengths (e.g., 5–10) reduced random errors.**

Activity 2: Vibrating String

- **The frequency readings were accurate, as they were taken directly from the signal generator.**
- **Wavelength measurement was more reliable than in the ripple tank, especially if measured across multiple loops.**
- **There was potential for systematic error if the string tension wasn't stable or if the standing wave wasn't fully formed.**
- **Accuracy improved when waves appeared stationary (clear antinodes), indicating resonance.**
- **Repeat readings helped ensure reliability, especially when averaging the frequency where wave patterns were most visible.**

Overall, results from Activity 2 were typically more accurate and repeatable than those from Activity 1, due to the more controlled conditions and direct digital readout of frequency.

3. How suitable was the apparatus that you used in both activities? How might you change the apparatus to provide more accurate results?

Activity 1: Ripple Tank

- **Suitability: The apparatus was functional for observing wave behaviour, but it had limitations:**
  - **Moving wavefronts made measurement difficult.**
  - **Manual counting of wave crests and use of a stopwatch introduced human error.**
- **Improvements:**
  - **Use a stroboscope to match wave frequency – this makes the wave appear stationary and simplifies wavelength measurement.**
  - **Use a high-speed camera or video capture with frame-by-frame analysis to accurately count wave crests and measure timings.**
  - **Use a calibrated digital frequency generator for more precise frequency control.**

Activity 2: Vibrating String

- **Suitability: The setup was generally more suitable and produced reliable results.**
  - **Signal generators provided accurate and adjustable frequencies.**
  - **The standing wave pattern was clear when the string was correctly tensioned.**
- **Improvements:**
  - **Use a laser measurement tool or optical sensor to more precisely measure node/antinode positions and wavelengths.**
  - **Add a tension meter to precisely monitor the string tension, ensuring constant force across trials.**
  - **Ensure consistent string material and length and reduce friction at the pulley for more controlled conditions.**

In both activities, replacing human observation and timing with digital sensors and improving environmental control (e.g., eliminating vibrations, maintaining water depth) would significantly enhance the accuracy and reliability of the results.

Exam Style Questions - Light

1. What is meant by the 'angle of incidence'? (1 mark)

Mark one - The angle between the incident ray and the normal

2. What does the law of reflection state? (1 mark)

Mark one - The angle of incidence equals the angle of reflection

3. What piece of equipment is used to measure the angle of incidence and angle of refraction? (1 mark)

Mark one - A protractor

4. Describe the path of a light ray as it passes from air into a glass block at an angle. (2 marks)

Mark one - The ray slows down
Mark two - and bends towards the normal

5. A student measures the angle of incidence as 30˚ and the angle of refraction as 19˚. Did the light speed up or slow down as it passed into the new material? Explain your answer. (3 marks)

Mark one - The light slowed down
Mark two - Because it bent towards the normal
Mark three - Meaning it entered a denser material

6. Why is it important to switch off room lights during this practical? (1 mark)

Mark one - To make the light rays from the ray box easier to see and trace clearly

7. Suggest one reason why the angle of refraction might not appear to follow the expected pattern. (1 mark)

One mark for any one of the following:
- The block may have moved/been misaligned
- Or the normal line might not have been drawn at 90˚ to the surface

8. Describe how to carry out the refraction part of this practical using a glass block and a ray box. Include how you would improve the accuracy of your results. (4 marks)

Mark one - Draw a normal line at 90˚ to the block's edge
Mark two - Shine the ray at different angles and mark the refracted ray
Mark three - Measure angles of incidence and refraction with a protractor
Mark four - Improve accuracy by using a sharp pencil, repeating measurements, and switching off lights

9. Explain why light refracts when it passes from air into glass and describe how this affects the path of the ray. (3 marks)

Mark one - Light changes speed as it enters a different medium
Mark two - It slows down when entering a denser material like glass
Mark three - This causes the ray to bend towards the normal

Exam Style Questions - Radiation & Absorption

1. What is the independent variable in this practical? (1 mark)

One mark - The type/colour of the surface

2. Why is it important to wait before taking measurements after pouring the hot water into the Leslie cube? (1 mark)

One mark - To allow all surfaces of the cube to reach the same temperature

3. What piece of equipment is used to detect the amount of infrared radiation emitted? (1 mark)

One mark - Infrared detector

4. A student records the following infrared intensities:
Matt black = 19.5 units
Shiny silver = 3.5 units
What conclusion can they draw? (2 marks)

Mark one - To make the readings consistent
Mark two - So that the amount of radiation detected only depends on the surface type

5. Suggest one control variable in this practical and explain why it should be kept the same. (2 marks)

Mark one - To make the readings consistent
Mark two - So that the amount of radiation detected only depends on the surface type

6. Why must the detector be pointed at the same angle and distance for each reading? (2 marks)

Mark one - To make the readings consistent
Mark two - So that the amount of radiation detected only depends on the surface type

7. Explain why a matt black surface is better for both emitting and absorbing infrared radiation than a shiny white surface. Use ideas about radiation, reflection and absorption. (4 marks)

Mark One - Matt black is a good emitter of infrared radiation
Mark Two - It is also a good absorber because it does not reflect much radiation
Mark Three - Shiny white reflects most radiation
Mark Four - So it emits and absorbs much less than black

8. Suggest three ways you could improve the accuracy or reliability of your results in this practical.

One mark for each of the following, and any other applicable suggestion:

- Take multiple readings and calculate an average
- Use a fixed distance and angle for all infrared measurements
- Ensure the surfaces of the cube reach the same temperature before recording data