GCSE Double Award Science Physics

Unit 7 Practical Manual

This practical manual was created to support students with their revision for Double Award Science, Physics Unit 7 Booklet A, which assesses practical skills. The practical manual covers the six prescribed physics practicals listed in the Double Award Science specification. The physics practical tasks in booklet A will be based on the six prescribed practical tasks but not identical to these. Students may also be asked questions about physics practical work in units 3, 6 and 7B.

Unit 7: Double Award Science Physics Practical Manual

Content/Specification Section Page

1.1 Motion, prescribed practical activity P1: Investigating the motion of an object on inclined runway

Introduction

This material is on prescribed practical activity. That means that **you can be asked to do practical assessment** in Unit 7A or in "ordinary" examination questions based on it in Units 3, 6 or 7B.

Aim

- to investigate how the average speed of an object moving down a runway depends on the slope of the runway measured as the height of one end of the runway.

Variables

- The **independent** variable is the height of the ramp.
- The **dependent** variable is the average speed of the marble down the ramp.
- The **controlled** variable is the surface of the ramp.

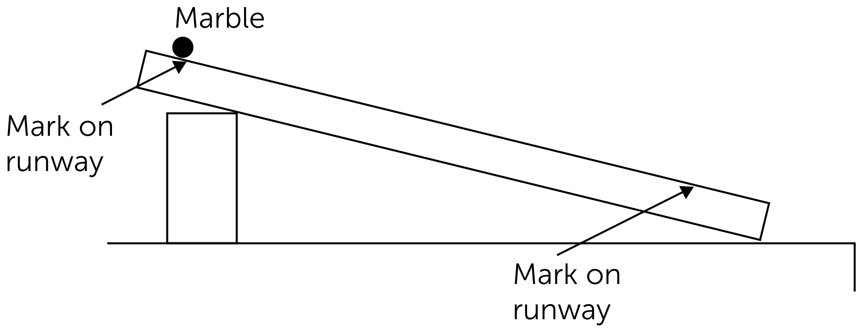
Note that using marbles of different mass would produce a detectable difference in the time taken to for the marbles to roll down the ramp. But that is not the focus of this experiment as can be seen from the aim identified above.

Apparatus

- Wooden ramp about 120 cm long
- Blocks of wood from about 5 cm high to about 15 cm high
- Metre stick – to measure height of block and distance on runway
- Pencil
- Stopwatch
- Marble

Method

1. Set up a ramp against a wooden block.
2. With a ruler draw two pencil lines in the ramp, one at the top and the other at the bottom, approximately 1.0 m apart.
3. Measure the distance, x between these two lines.
4. Measure the height of the ramp, h.
5. Allow a marble to roll down the ramp, starting from rest at the upper pencil line and finishing at the lower pencil line.
6. For each height h, ranging from about 5 cm to about 15 cm, time this motion a total of three times using a stop watch and record the results in a table (such as shown below.)
7. Calculate the average time, t.
8. The average speed is equal to x/t.



Source: Line Diagram – Author

Results					
Height h /cm					
Time t_1 /s					
Time t_2 /s					
Time t_3 /s					
Average time t / s					
Average speed, v / cm/s					

Treatment of Results

- Plot the graph of average speed (y-axis) against height, h (x –axis).
- The line of best fit is a curve through the origin of decreasing gradient.
- The graph shows that the average speed is NOT proportional to h, but it increases with h in some (unknown) non-linear way.

Other Approaches

There are also other ways this practical could be conducted. For example, the timing may be done with light gates and a data-logger and the data analysis and graph plotting might be done using suitable computer software. **Note** that while the use of light gates is encouraged, it would not be part of an experiment in GCSE DAS Physics Unit 7A.

1.2 Force, prescribed practical activity P2: (Hooke's Law) Investigating the relationship between the extension of a spring and applied force

Aim

- to investigate experimentally the extension of a spring and how it is related to the applied force, provided the extension is within the limit of proportionality.

Variables

- The independent variable is the force applied to the free end of the spring.
- The dependent variable is the extension of the spring.
- The controlled variable is the spring constant.

Apparatus

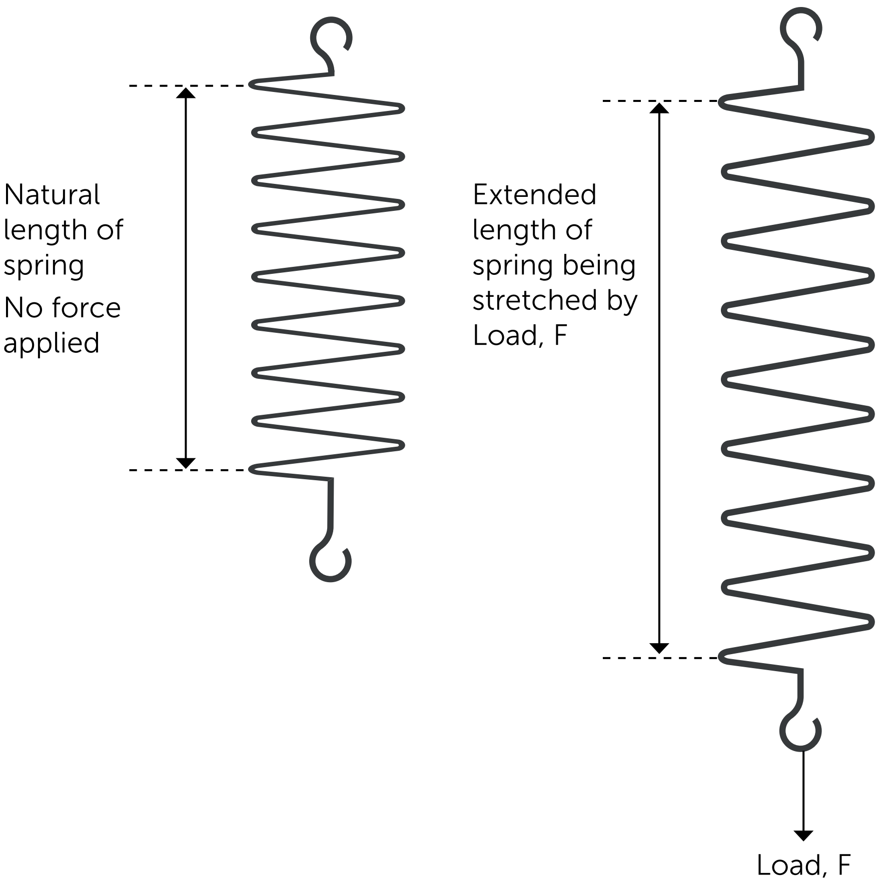
- Safety spectacles – one pair for each learner
- Helical spring
- Retort stand, boss-head and clamp
- G-clamp to clamp iron stand to bench
- Mass hanger and slotted masses up to about 500 grams
- Ruler

Safety

While the centre must carry out its own risk assessment, this is an experiment where safety glasses should be worn by everyone in the lab.

Method

1. Clamp a retort stand with boss-head and clamp to a bench.
2. Attach a helical spring to the clamp and secure it.
3. Measure the natural length of the spring with a metre stick.
2. Add 100 g (weight = 1.0 N) mass hanger.
3. Measure the extended length of the spring.
4. Calculate and record the extension.
5. Add a second 100 g slotted mass.
6. Repeat measurements and record results in a table, as shown on following page.
7. Plot a graph of Force (load) / N) on the x-axis versus extension / cm on the y-axis.



Remember: a mass of 100 g produces o force of 1 N

Results			
Load (force), F / N	**Total length of spring / cm**	**Extension of spring e / cm**	**Ratio Force : extension N /cm**

Treatment of Results

- Plot the graph of Force / N (y-axis) against extension / cm h (x –axis).
- Calculate the ratio Force to extension.

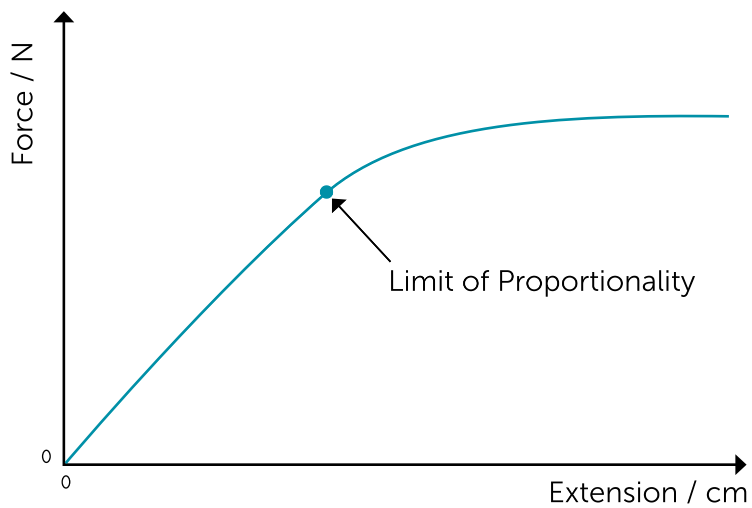
Conclusion

- The line of best fit is a straight line through the origin up to a particular point, known as the limit of proportionality.
- The graph shows that the extension of the spring is directly proportional to the applied force up to the limit of proportionality.
- Beyond that point (in his case around 5 N) the force is **NOT** proportional to the extension, and the extension increases significantly.
- The gradient of the force, F, against extension, e, graph up to the limit of proportionality is known as the spring constant (or Hooke's Law constant), that is **F = ke** where k is the spring constant.

Conclusion

The experiment demonstrates Hooke's Law, which states that for many materials the extension is directly proportional to the applied load, up to a limit known as the limit of proportionality.

The straight line graph through the (0,0) origin is the mathematical proof that the extension is directly proportional to the load.



Graph illustrating Hooke's Law

1.3 Force, prescribed practical activity P3: Investigating the Principle of Moments

Aim

- to verify experimentally the Principle of Moments using a suspended metre rule and attached weights.

Variables

- The independent variables is the forces applied to the suspended metre rule.
- The dependent variables is the distances from the attached masses to the pivot.
- The controlled variable is the distance between the point of suspension and the centre of gravity of the metre rule.

Apparatus

- Retort stand, boss-head and clamp
- G-clamp to clamp iron stand to bench
- 2 mass hangers and slotted masses up to about 600 grams
- Uniform wooden metre rule
- Fine string

Safety

While the centre must carry out its own risk assessment, this is an experiment where safety glasses should be worn by everyone in the lab. It is also recommended that precautions are taken to minimise the hazard due to falling masses.

Method

1. Suspend and balance a metre rule at the 50 cm mark by passing an optical pin through a hole in the rule at the 50 cm mark. The sharp end of the pin enters a cork on the other side. The cork is held in a clamp on the far side of the rule.
2. If necessary, attach a small piece of plasticine to the rule so that it comes to rest in the horizontal position.
3. Using fine string, hang unequal masses, m_1 and m_2 (100 g slotted masses), from either side of the metre rule as illustrated in the diagram.
4. Adjust the position of the masses until the metre rule is balanced (in equilibrium) once again.
5. Gravity exerts forces F_1 and F_2 on the masses m_1 and m_2. Remember that a 100 g slotted mass is equivalent to a weight of 1 N.
6. Record the results in the table, as shown below and repeat for other loads and distances.
7. The force F_1 is trying to turn the metre stick anticlockwise and $F_1 \times d_1$ is its moment. F_2 is trying to turn the metre stick clockwise, its moment is $F_2 \times d_2$.
8. When the metre stick is balanced (i.e. in equilibrium), the results should show that the anticlockwise moment $F_1 \times d_1$ equals the clockwise moment $F_2 \times d_2$.

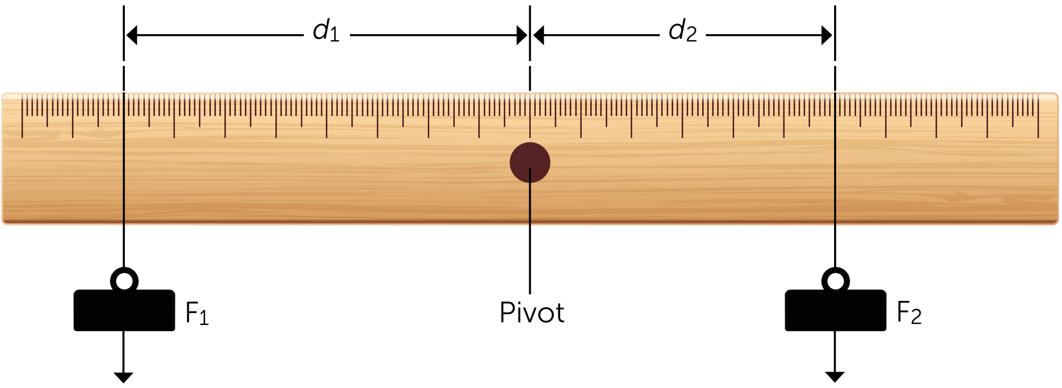


Diagram of Apparatus

Results							
Anticlockwise				Clockwise			
m_1 / g	F_1 / N	d_1 / cm	$F_1 \times d_1$ / N cm	m_2 / g	F_2 / N	d_2 / cm	$F_2 \times d_2$ / N cm

Conclusion

The experiment verifies the Principle of Moments which states:

When a body is in equilibrium, the sum of the clockwise moments about any point equals the sum of the anticlockwise moments about the same point.

The equation that arises from this principle is:

$$\mathbf{F_1 \times d_1 = F_2 \times d_2}$$

Another very important consequence of the fact that the body is in equilibrium is that the forces acting on the metre stick in any direction must balance. The upward forces must balance the downward forces. This idea is very useful when solving problems.

1.4 Energy, prescribed practical activity P4: Investigating personal power

Aim

- to measure the personal power of a student by measuring the time taken to climb a staircase.

Variables

- The independent variable is the vertical height of the staircase.
- The dependent variable is the time taken to run up the staircase.
- The controlled variable is the mass of the student.

Apparatus

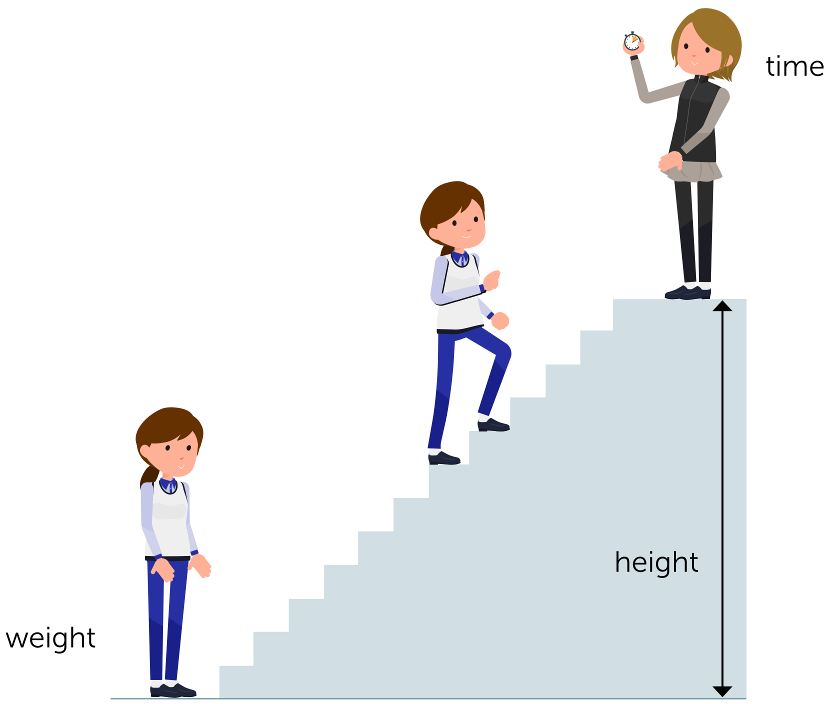
- Access to a flight of stairs (best, but not essential, if this is of around 20 steps or more)
- Bathroom (or newton) scales to measure the mass of a student
- Metre stick or 30 cm ruler
- Stopwatch or stopcock or timer

Safety

While the centre must carry out its own risk assessment, it is recommended that precautions are taken to mitigate the risk of the student falling whilst running up the stairs.

Method

1. Student A uses bathroom scales to find his/her mass in kilograms.
2. The mass of student A in kg is then multiplied by 10 to find his / her weight in N.
3. (Alternatively, the student finds his / her weight directly using bathroom scales calibrated in N.)
4. Using a metre stick or 30 cm ruler, measure the height of at least 5 risers on the staircase and determine the average height of a riser.
5. Multiply the number of risers in the staircase by the average height of a riser to find the vertical height h of the staircase in metres.
6. A second student, B, at the top of the staircase **uses a stopwatch** to measure the time taken for student A to run up the stairs.
7. For **reliability**, the experiment should be repeated several times and the average power of the student A determined.



Measuring the Personal Power of a Student

Source: Author

Typical Results

Mass of student / kg	45
Weight of student / N	450
Height of risers / cm	14.0, 13.8, 13.8, 14.0, 13.9
Average riser height in cm	13.9
Number of risers 30	
Staircase height 13.9 x 30	= 417 cm = 4.17 m
Time to run upstairs in s	5.2, 5.1, 4.9, 5.0, 4.8
Average time taken in s	5.0

Calculations

Work = force x distance	= 450 x 4.17 = 1876.5 J
Power = work/time	= 1876.5/5.0 = 375 W (approx.)

An alternative method involves a student of known mass, m, being timed to do, say 50, **"step-ups" on to a platform** such as the first step of a flight of stairs. If the time taken is t and the height of the platform is h metres, then the power, P, of the student is given by:

$P = 50 \times mgh/t$

Note typically, the time to run up a school staircase is around 5 – 10 seconds. If there are fewer stairs, this time is shorter and the error in the measured time increases to an unacceptable level. For that reason it is better for the staircase to have as many steps as possible, and certainly more than 20.

2.2 Light, prescribed practical P5: Investigating refraction of white light by a glass block

Aim

- to use ray tracing to measure the angles of incidence and refraction when light is refracted by a glass block.
- to plot a graph of angle of incidence, i, against angle of refraction, r, to show that they are related but not proportional.

Variables

- The independent variable is the angle of incidence at the air/glass boundary.
- The dependent variable is the angle of refraction in glass.
- The controlled variable is the type of glass used in the block.

Apparatus

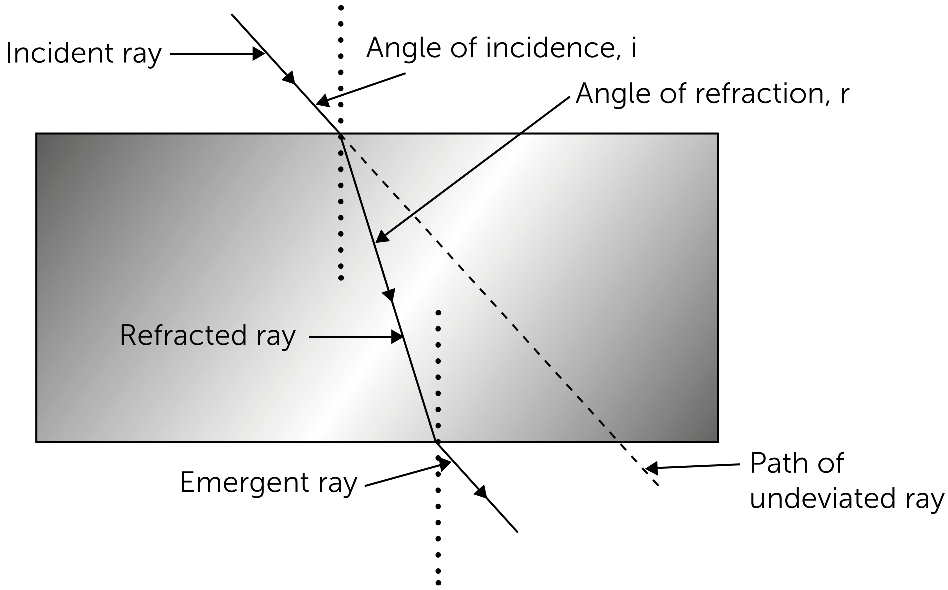
- rectangular glass block
- ray box
- low voltage power supply (PSU)
- 2 low voltage leads to connect ray box to PSU
- A4 plain white paper
- pencil
- ruler
- protractor

Safety

While the centre must carry out its own risk assessment, it is essential that the ray box and PSU have been inspected before use.

Method

1. Prepare a table for results like that shown below.
2. Place the rectangular glass block in the centre of the sheet of white paper on a drawing board and draw round its outline with a sharp pencil.
3. Switch on the PSU and direct a ray of light to enter the block near the middle of the longest side of the block, so that the angle of incidence is about 10^0.
4. Mark on the paths of both the incident ray and the emergent ray two pencil dots and remove the glass block.
5. Join the dots on the incident ray up to the point of incidence and join the dots on the emergent ray back to the point of emergence.
6. Draw a straight line between the point of incidence and the point of emergence.
7. Draw the normal at the point of incidence.
8. Measure the angle of incidence, i, and the angle of refraction, r and record the data in a table.
9. Repeat steps 1 to 8 for angles of incidence ranging from about 20^0 up to about 80^0.



Refraction in a Glass Block

Source: Author

Results								
Angle of incidence, i/⁰								
Angle of refraction, i/⁰								

Treatment of the results

Plot the graph of Angle of incidence (vertical axis) against Angle of refraction (horizontal axis).

Conclusion

- The graph of Angle of incidence against Angle of refraction is a curve through the origin of increasing gradient (the graph gets steeper as the angle of incidence increases).
- This tells us that **i is NOT directly proportional to r** (because the graph is **not** a straight line), but that i and r have a positive correlation (as i increases, r increases).

2.3 Electricity, prescribed practical P6: (Ohm's Law) Investigating the relationship between the current, voltage and resistance for a metal wire

Aim

- to pass an electric current through a wire.
- to measure the current for different values of the voltage across the wire.
- to take precautions to ensure the temperature of the wire is kept constant.
- to plot a graph of voltage across the wire (y-axis) against current in the wire (x-axis).
- to use the graph to establish an equation linking voltage and current.
- to determine the resistance of the wire.

Variables

- The independent variable is the voltage across the wire.
- The dependent variable is the current flowing through the wire.
- The controlled variables are the temperature, the area of cross section of the wire and the material from which the wire is made.

Apparatus

- low voltage power supply unit (PSU)
- rheostat
- ammeter
- voltmeter
- connecting leads
- resistance wire
- switch

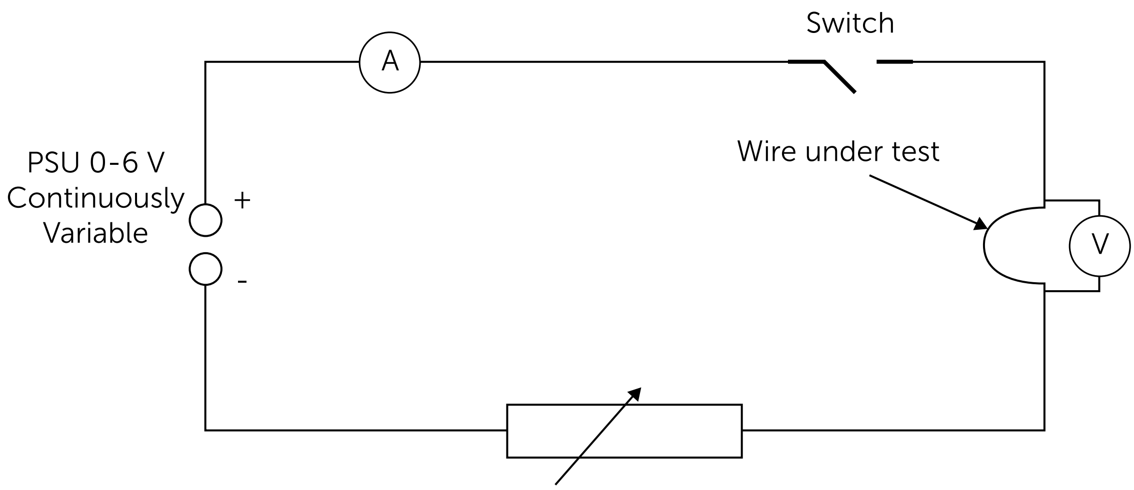
Method

1. Prepare a table for your results like that shown below.
2. Ensure that the PSU is switched off and connect it to the mains socket.
3. Set up the circuit as shown in the circuit diagram. The device marked R represents the wire being tested.
4. Adjust the PSU to supply zero volts.
5. Switch on the PSU.
6. Record the voltage on the voltmeter and the corresponding current on the ammeter.
7. Switch off the PSU immediately after recording in the table values for voltage and current.
8. Wait for about two minutes to ensure the wire cools to room temperature.
9. Switch on the PSU and adjust the voltage (or the rheostat) so that the reading on the voltmeter increases by 0.5 V.

10. Repeat steps 6 – 9 until readings have been recorded for a voltages ranging from zero to a maximum voltage of 6 V*. This is Trial 1.
11. Repeat the entire experiment to obtain a second set of current values. This is Trial 2.
12. Calculate the mean current from the two trials and enter the results in the table.
13. Plot the graph of voltage against mean current.

***Note** it is necessary to ensure the wire's temperature remains constant (close to room temperature). This can be done by:

- keeping the voltage low* (so that the current remains small)
- switching off the current between readings to allow the wire to cool



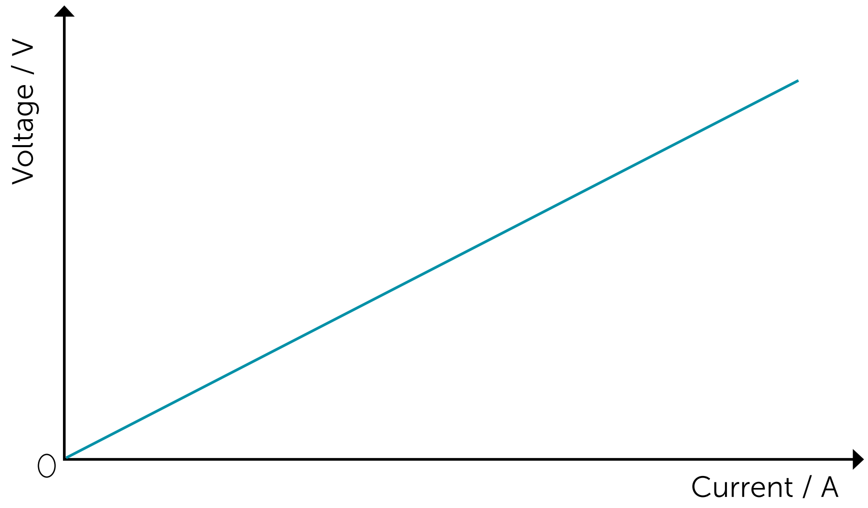
Circuit Diagram

Source: Author

Results							
Voltage across wire / V							
Trial 1 Current / A							
Trial 2 Current / A							
Mean Current / A							
Ratio of Voltage to Current / W							

Treatment of Results

The graph of *V* against *I* is a straight line through the origin. This indicates that the current in a metallic conductor is directly proportional to the voltage across its ends, provided the temperature remains constant. This result is commonly called Ohm's Law.



Graph showing Ohm's Law

Conclusion
The resistance of the wire does not change when the current and voltage change.

That is why the graph of V against I is a straight line through the origin.
The ratio V/I is constant throughout the experiment.

The experiment establishes the resistance formula and confirms:

V	=	I	×	R
voltage	=	current	×	resistance

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