Oxford Cambridge and RSA

Friday 16 June 2023 – Morning

GCSE (9–1) Physics B (Twenty First Century Science)

J259/02 Depth in physics (Foundation Tier)

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (cm/mm)
- the Equation Sheet for GCSE (9-1) Physics B (inside this document)

You can use:
- a scientific or graphical calculator
- an HB pencil

F

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) ______________________

Last name ______________________

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **28** pages.

ADVICE
- Read each question carefully before you start your answer.

1 Draw lines to connect each part of the electromagnetic spectrum to its use.

Electromagnetic spectrum	Use
Microwave	Sun beds
Ultraviolet	Cooking food
X-rays	Sterilising surgical instruments
Gamma rays	Looking for broken bones

[3]

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2 Sam is making measurements to calculate the density of a rubber bung.

(a) Which piece of apparatus does Sam use to measure the mass of the bung?

Tick (✓) **one** box.

Metre rule ☐

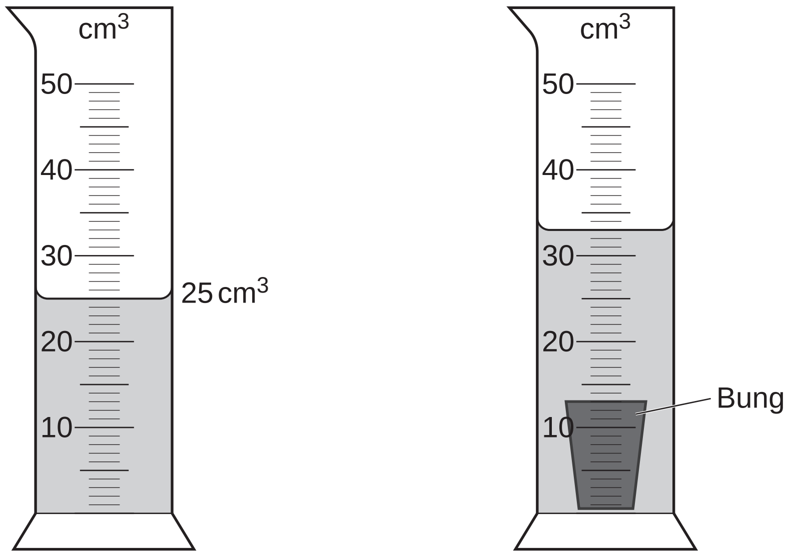
Thermometer ☐

Stopwatch ☐

Balance ☐

[1]

(b) Sam puts 25 cm^3 of water in a measuring cylinder. When the bung is placed into the measuring cylinder, the level of the water rises as shown.



Calculate the volume of the bung.

Volume = ... cm^3 **[2]**

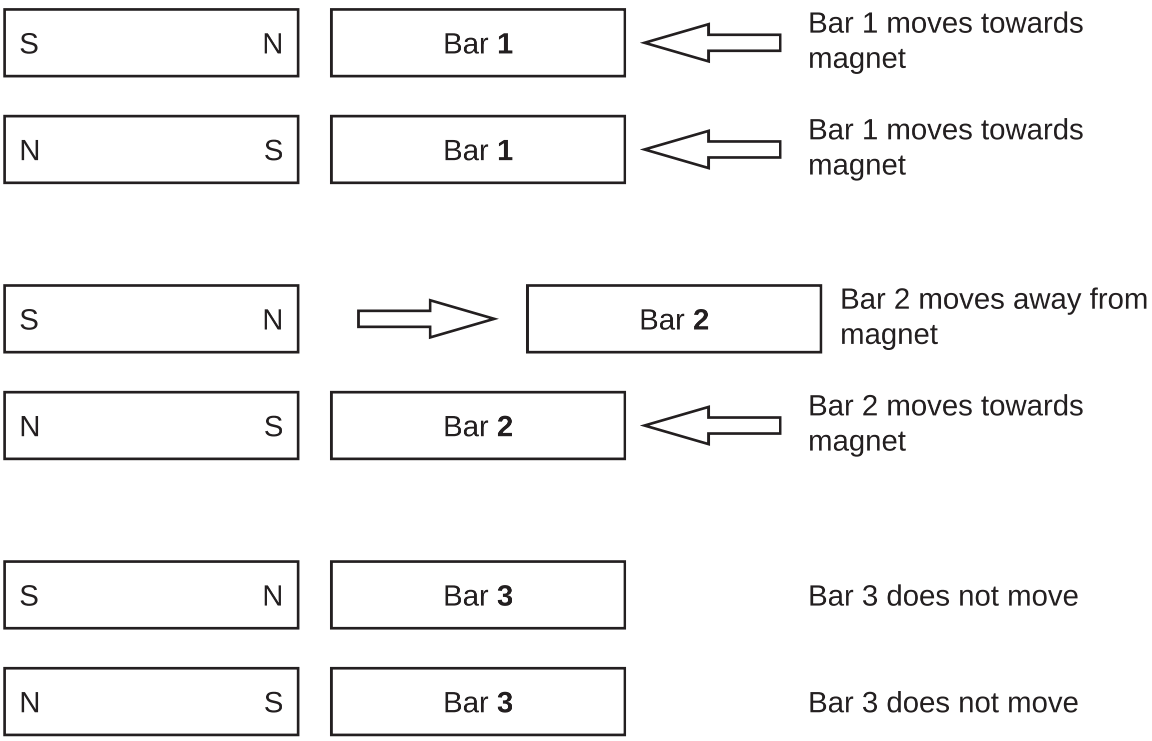
(c) Sam has a second bung which has a mass of 24 g and a volume of 12 cm^3.

Calculate the density of the second bung.

Use the equation: density = $\frac{\text{mass}}{\text{volume}}$

Density = ... g/cm^3 **[2]**

3 Anika has a magnet and three bars made of unknown metals. She places the same end of each bar next to each pole of the magnet as shown.



Complete the table by identifying if bars **1**, **2** and **3** are magnets or not magnets.

Tick (✓) **one** box in each row.

Bar	A magnet	Not a magnet
1		
2		
3		

[2]

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4 A group of scientists investigate four different materials **A**, **B**, **C** and **D**. They measure the density of each material. They also measure the electrical resistance using pieces of a similar size.

The table gives the results.

Material	**Density (g/cm^3)**	**Resistance (Ω)**
A	3.0	0.070
B	2.7	0.003
C	2.5	0.023
D	6.7	0.007

(a) State which material **A**, **B**, **C** or **D**, could be used to make the lightest bicycle frame.

Material = ... **[1]**

(b) Suggest **one** reason why material **B** is chosen to make an electrical circuit in a mobile phone.

....

.... **[1]**

(c) Scientists are developing new materials containing the substance graphene.

Why should scientists communicate new scientific data to a range of audiences?

Tick (✓) **one** box.

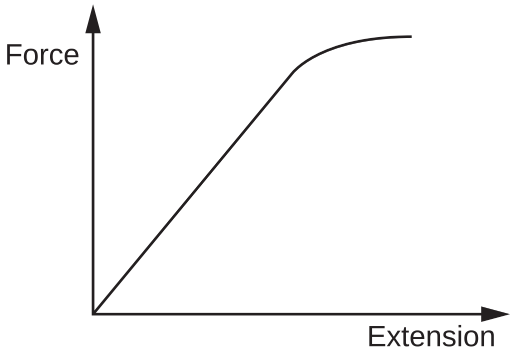
They can build a reputation and show everybody how clever they are. ☐

They can sell their work and make money. ☐

The data can be shared, used and discussed. ☐

[1]

(d) The graph shows the force-extension sketch graph for graphene.



Describe the relationship between force and extension for graphene.

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.... **[3]**

(e) When graphene is stretched, it can deform elastically or plastically depending on the size of the force.

Describe the difference between elastic and plastic deformation of graphene.

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.... **[2]**

5* In an emergency the total distance required for a car to come to a stop depends on the thinking distance and the braking distance.

The data in the table shows the thinking distance and braking distance for a car travelling at different speeds.

Speed (miles per hour)	**Thinking distance (m)**	**Braking distance (m)**	**Stopping distance (m)**
20	6	6	12
30	9	14	23
40	12	24	36
50	15	38	53
60	18	56	74
70	21	75	96

Describe the trends in the thinking distance and braking distance when the speed increases, **and** describe other factors that affect the thinking distance and the braking distance.

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.... **[6]**

6 Radon-222 is radioactive. Radon-222 decays to polonium-218 as shown by the decay equation.

$$^{222}_{86}\text{Rn} \longrightarrow ^{218}_{84}\text{Po} + \mathbf{X}$$

(a) **(i)** What is particle **X**?

Put a (ring) around the correct option.

$^{0}_{-1}\text{e}$ $\quad$ $^{4}_{2}\text{He}$ $\quad$ $^{1}_{0}\text{n}$

[1]

(ii) Complete the sentences about the decay equation.

Put a (ring) around the correct options.

1. When a nucleus of radon-222 decays the mass number reduces by **4 / 2 / 0**
2. When a nucleus of radon-222 decays the atomic number reduces by **4 / 2 / 0**

[2]

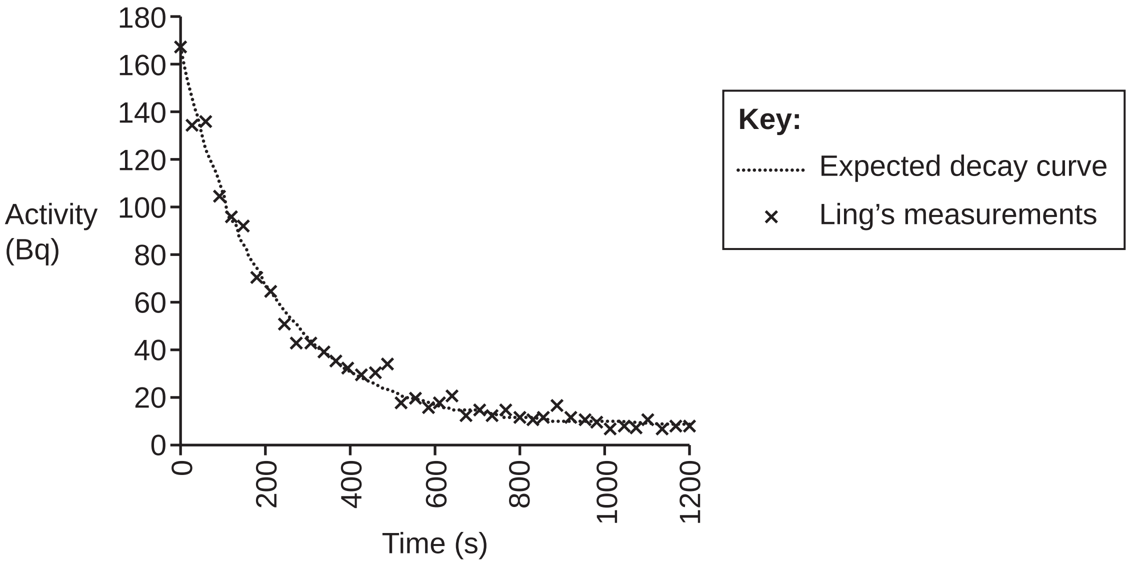
(b) Half-life is used to measure the length of time of decay.

Define the term half-life.

....

.... **[1]**

(c) Ling takes measurements of the decay of a piece of radioactive radium. The results are shown in the graph.



(i) Ling says that some of the measurements do not lie exactly on the expected decay curve because of experimental errors.

Give **one** other reason why some readings do **not** lie on the expected decay curve.

....

.... **[1]**

(ii) Suggest **two** precautions Ling should take while doing experiments with radioactive materials.

1. ....

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2. ....

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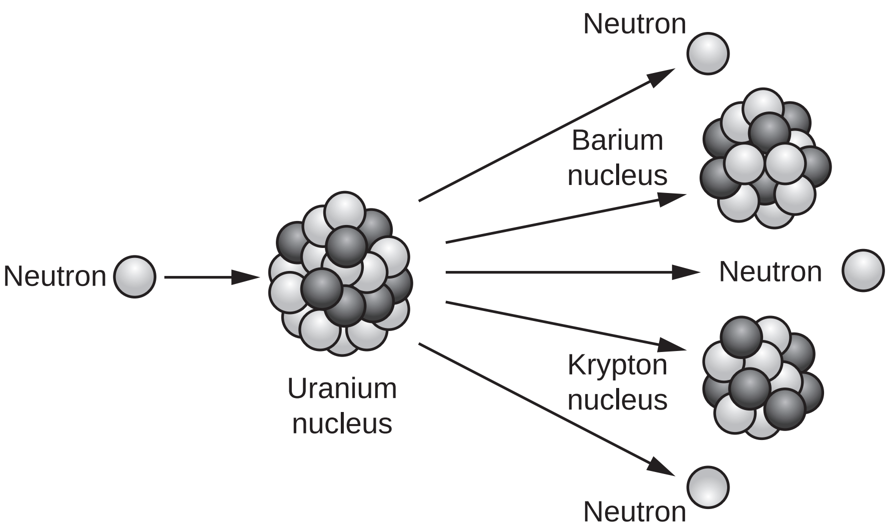
[2]

7 In a fission reaction a uranium nucleus absorbs a neutron.

The diagram shows a model of this fission reaction.



(a) State **two** ways that energy is released during this fission reaction.

1. ....

2. ....
[2]

(b) Neutrons are emitted during a fission reaction. These neutrons may collide with other uranium nuclei.

Explain how this can lead to a chain reaction.

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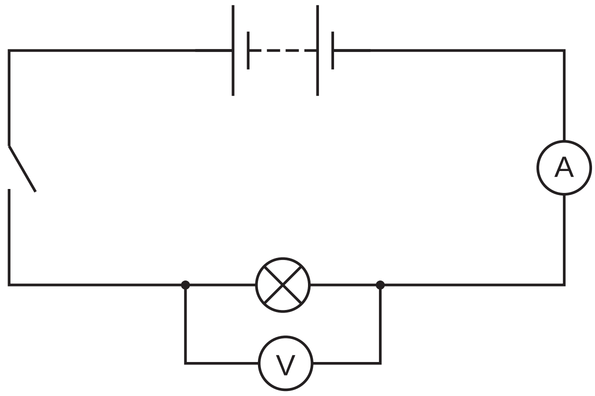
.... **[2]**

8 Taylor builds an electrical circuit as shown in **Fig. 8.1**.

Fig. 8.1



(a) Taylor closes the switch. The ammeter records a current.

(i) Give **two** reasons why there is a current.

1. ....

....

2. ....

....
[2]

(ii) Taylor records a current of 2 A flowing for a time of 120 s.

Calculate the charge that passes through the lamp in this time.

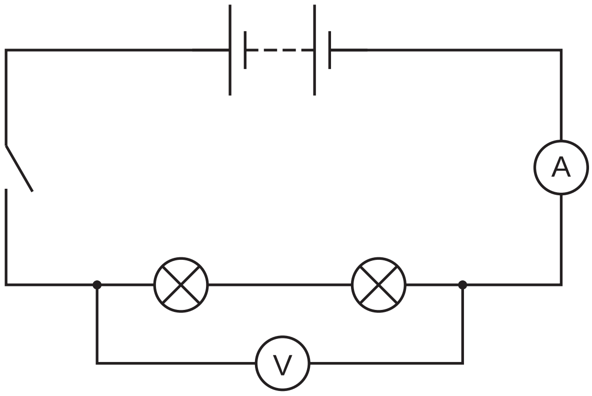
Use the equation: charge = current × time

Charge = ... C **[2]**

(b) Taylor adds a second, identical lamp to the circuit as shown in **Fig. 8.2**. He does not change the cells.

The two lamps in **Fig. 8.2** are dimmer compared to the single lamp in **Fig. 8.1**.

Fig. 8.2



(i) How do the readings on the ammeter and voltmeter change when the second lamp is added?

Put a (ring) around the correct options.

The reading on the ammeter **increases / decreases / stays the same**.

The reading on the voltmeter **increases / decreases / stays the same**.

[2]

(ii) Explain why the lamps are dimmer in **Fig. 8.2** compared to the single lamp in **Fig. 8.1**.

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.... **[3]**

(c) Taylor investigates how the brightness of lamps change when they are connected in parallel.

(i) Draw a circuit diagram of two lamps in parallel that Taylor can use in his investigation.

[1]

(ii) What happens to the brightness of each lamp when a third lamp is added in parallel?

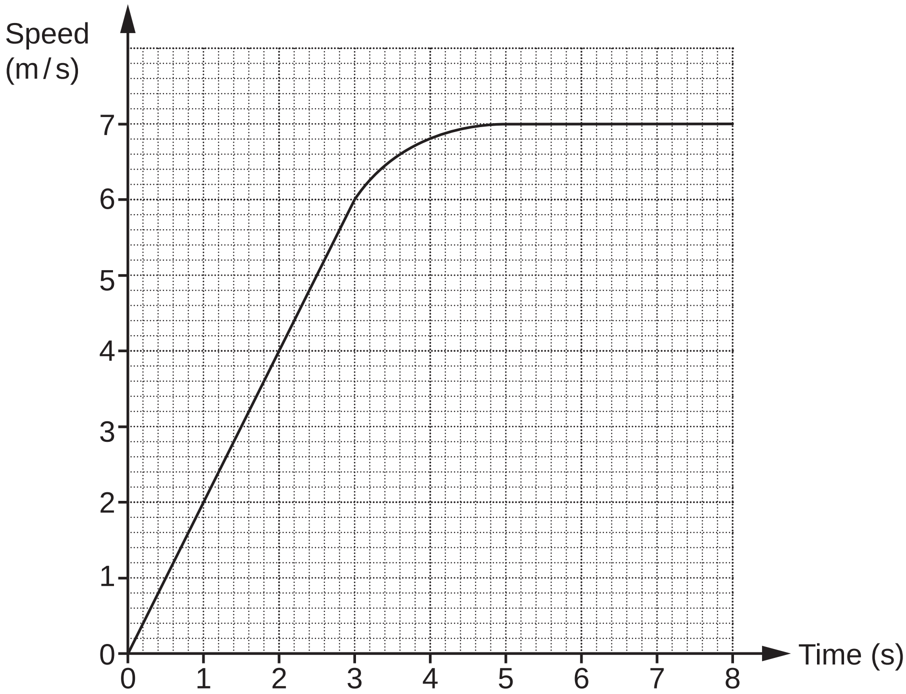
Put a (ring) around the correct option.

The brightness of each lamp **increases / decreases / stays the same**.

[1]

9 Charlie is competing in a cycling race.

The speed–time graph shows Charlie's speed during the race.



(a) State Charlie's maximum speed.

Maximum speed = ... m/s **[1]**

(b) State the time into the race that Charlie reaches a speed of 2 m/s.

Time = ... s **[1]**

(c) Calculate Charlie's acceleration in the first 3 s.

Acceleration = ... m/s^2 **[2]**

(d) In another race, Charlie starts with a greater acceleration and reaches the same maximum speed.

Sketch a line on the speed–time graph to show how Charlie's speed changes for this race.

[2]

10 The New Car Assessment Program (NCAP) tests how cars perform in crashes.

(a) NCAP tests a car travelling at 25 m/s in a head-on crash. The car comes to a stop in 0.1 s.

Calculate the deceleration of the car.

Use the equation: $\text{acceleration} = \dfrac{\text{change in speed}}{\text{time}}$

Deceleration = ... m/s^2 **[2]**

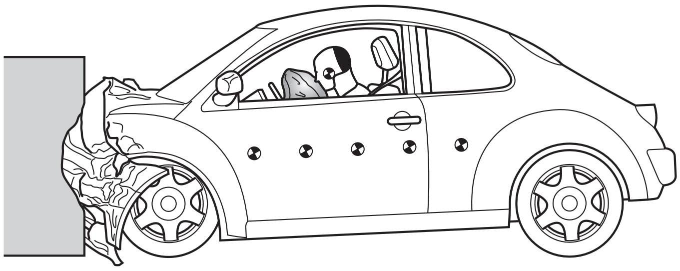
(b) In another head-on crash test, a car with a mass of 1000 kg decelerates at 150 m/s^2.

Calculate the force needed to produce this deceleration.

Use the equation: force = mass × acceleration

Force = ...N **[2]**

(c) The picture shows what happens to the crumple zone of a car in a controlled head-on crash.



Explain how the crumple zone of a car improves safety for the driver in a head-on crash.

Use ideas about acceleration and force in your answer.

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.... **[3]**

11 Li does an experiment to find the specific heat capacity of aluminium.

(a) Define the term specific heat capacity.

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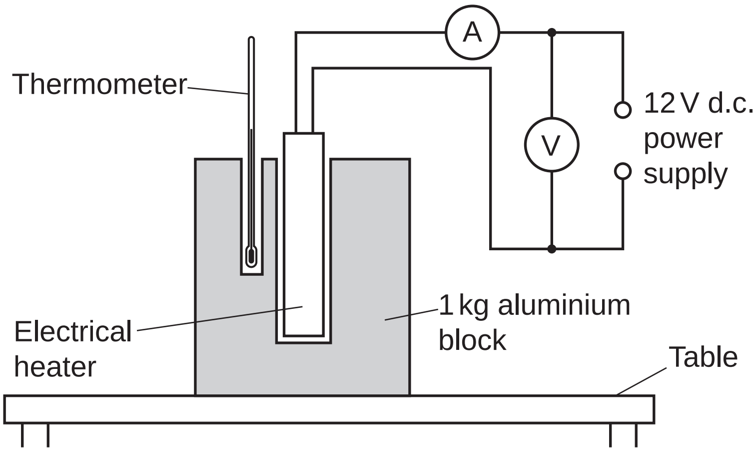
.... **[1]**

(b) Li uses this equipment:



This is the method:

- Connect an ammeter and a voltmeter in a circuit with a 12 V power supply and an electrical heater.
- Place the heater into a hole in the aluminium block.
- Place a thermometer into the other hole and record the temperature.
- Switch on the power supply.
- After 5 minutes take a reading from the thermometer, the ammeter, and the voltmeter.

(i) Describe **one** energy transfer taking place during this experiment.

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.... **[1]**

(ii) Describe how the motion of the aluminium particles changes as the block is heated.

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.... **[1]**

(c) (i) Explain improvements that can be made to the **equipment**.

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.... **[4]**

(ii) Suggest **one** improvement to the **method**.

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.... **[1]**

(d) Li records the results from the experiment in a table:

Current (A)	4.62
Final Temperature (°C)	32
Initial Temperature (°C)	18
Mass of aluminium block (kg)	1
Potential difference (V)	10.80
Time (s)	300

Calculate the specific heat capacity of aluminium using Li's results.

Use the equations:

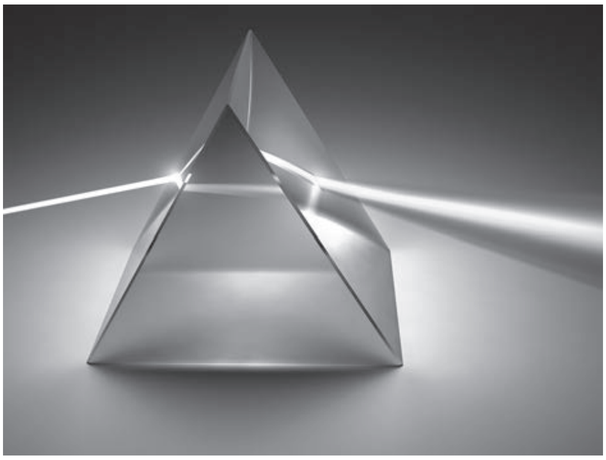
- specific heat capacity = $\frac{\text{change in internal energy}}{\text{mass} \times \text{temperature}}$
- power = potential difference × current
- energy transferred = power × time

Specific heat capacity = ... J/kg°C
[5]

12 A student investigates the path of light passing through a triangular glass prism.

A narrow beam of white light is directed at the prism with an angle of incidence equal to 40°. The student observes a spectrum of different coloured light.

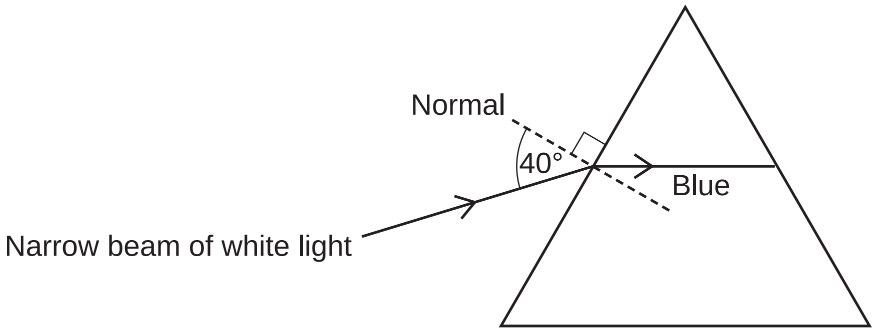
Narrow beam of white light



Spectrum of coloured light

The two-dimensional diagram shows a narrow beam of white light directed at the side of a prism.

A line showing the path of a ray of blue light passing through the prism is partially drawn.



(a) Complete the line to show the path of blue light as it passes out the other side. **[1]**

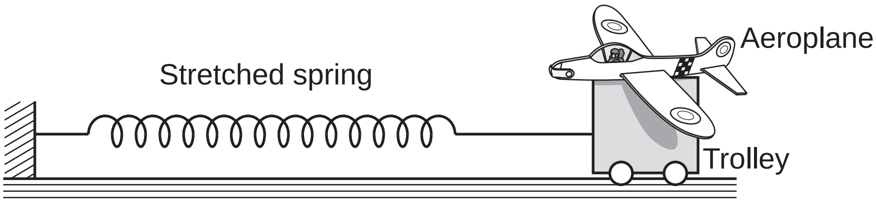
(b) Estimate the size of the angle of refraction of the ray of blue light as it enters the prism.

Angle of refraction = ...° **[1]**

(c) Add another line to the diagram to show the path of a ray of red light as it passes through the prism and out the other side. **[2]**

13 Jamal is making a model aeroplane that can be launched from a moving trolley.

One end of a spring is connected to the trolley. The other end of the spring is held stationary.



The aeroplane is placed on the trolley. Jamal pulls the trolley and the aeroplane to the right so that the spring stretches. When Jamal lets go, the trolley and the aeroplane accelerate to the left.

(a) Explain how Jamal can make the trolley and aeroplane accelerate more quickly using the same apparatus.

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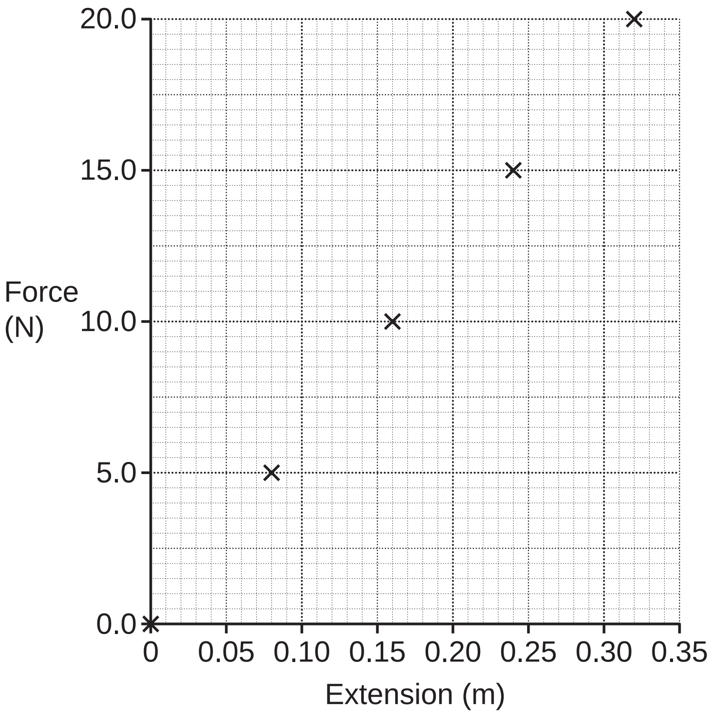
.... **[3]**

(b) Jamal investigates the relationship between force and extension for the spring. The results of the investigation are shown in the table and the graph.

Force (N)	Extension (m)
0.0	0
5.0	0.08
10.0	0.16
15.0	0.24
20.0	0.32



(i)* Describe how Jamal gets these results safely **and** how he uses the results to calculate the work done in stretching the spring.

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.... **[6]**

(ii) The kinetic energy of the trolley must be at least 1 J for the aeroplane to launch from the trolley.

Jamal concludes that the aeroplane can launch from the trolley when the spring has an extension of 0.16 m.

Use the graph to explain why Jamal's conclusion is **wrong**.

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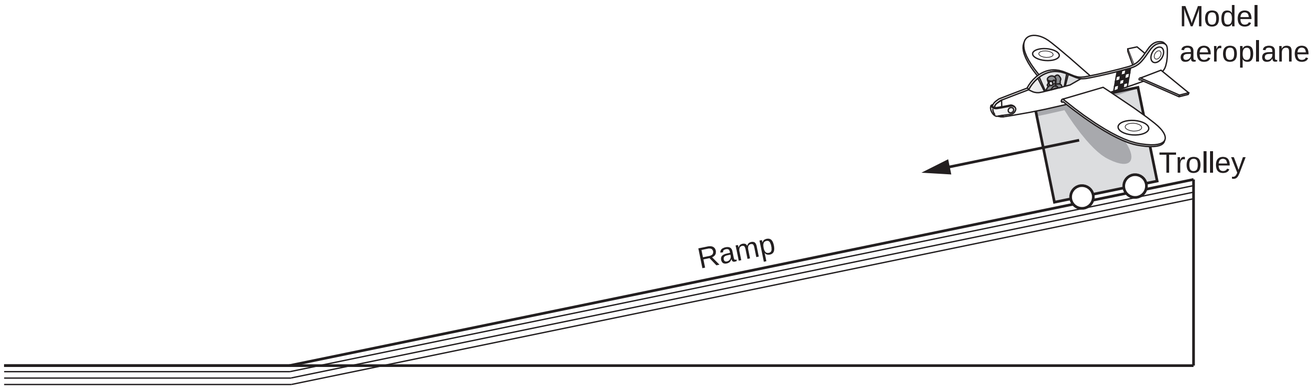
.... **[2]**

(c) Jamal investigates using a ramp instead of a spring to launch the aeroplane.



Jamal releases the trolley and the trolley accelerates down the ramp. The aeroplane is launched when the trolley reaches the bottom of the ramp.

Describe how Jamal can accurately measure the speed of the trolley at the bottom of the ramp.

You should include the equipment Jamal uses.

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.... **[3]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).