

## Wednesday 1 December 2021 – Afternoon 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 Data Sheet for GCSE (9-1) Physics B (inside this document)

**You can use:**

- a scientific or graphical calculator
- an HB pencil



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

Centre number

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Candidate number

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First name(s)

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Last name

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### 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.

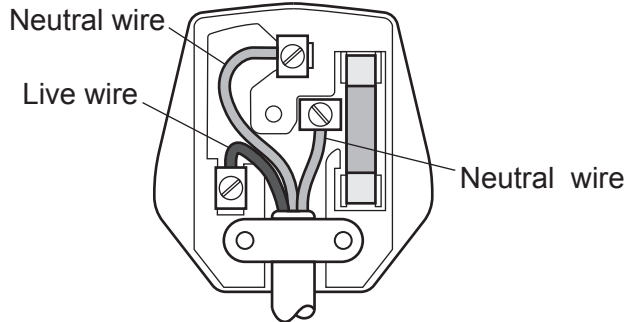
### ADVICE

- Read each question carefully before you start your answer.

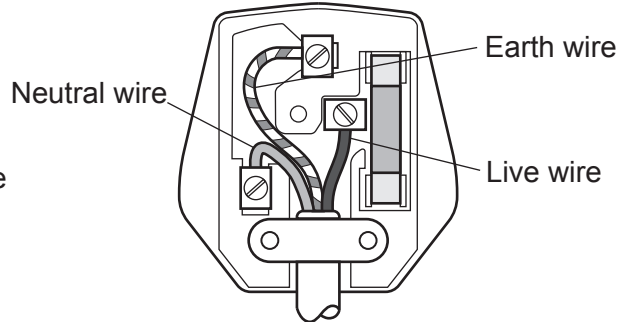
Answer **all** the questions.

1 (a) Fig. 1.1 shows the wiring of four 3-pin plugs.

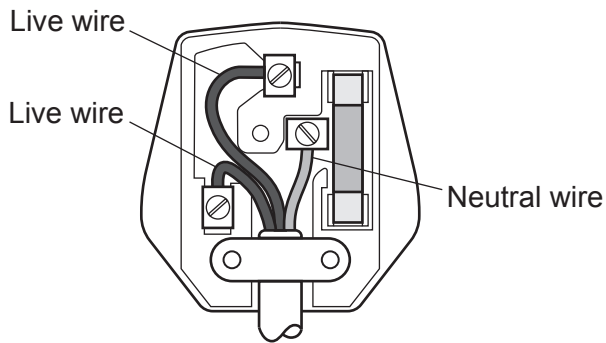
**A**



**B**



**C**



**D**

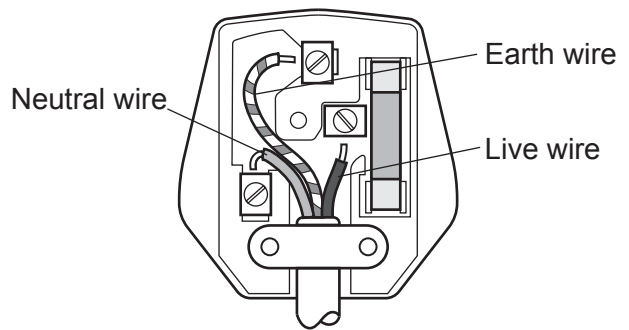


Fig. 1.1

Which diagram shows a correctly wired 3-pin plug?

Tick (✓) **one** box.

- |          |                          |
|----------|--------------------------|
| <b>A</b> | <input type="checkbox"/> |
| <b>B</b> | <input type="checkbox"/> |
| <b>C</b> | <input type="checkbox"/> |
| <b>D</b> | <input type="checkbox"/> |

[1]

(b) Fig. 1.2 shows part of the National Grid.

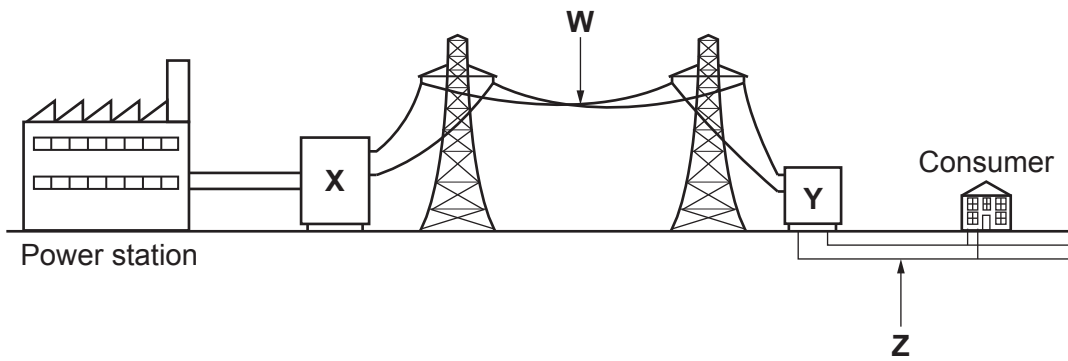


Fig. 1.2

(i) Which part of Fig. 1.2 shows a step-up transformer?

Tick (✓) **one** box.

<b>W</b>	<input type="checkbox"/>
<b>X</b>	<input type="checkbox"/>
<b>Y</b>	<input type="checkbox"/>
<b>Z</b>	<input type="checkbox"/>

[1]

(ii) Which part of Fig. 1.2 shows high voltage cables?

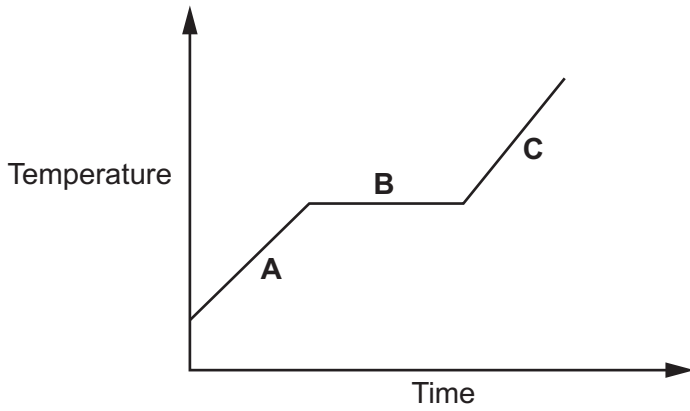
Tick (✓) **one** box.

<b>W</b>	<input type="checkbox"/>
<b>X</b>	<input type="checkbox"/>
<b>Y</b>	<input type="checkbox"/>
<b>Z</b>	<input type="checkbox"/>

[1]

- 2 Kareem heats candle wax steadily from room temperature and records its temperature over a period of time.

The graph shows a sketch of his results.



- (a) Complete the table by matching each section **A**, **B** or **C** with the correct statement.

Tick (✓) **one** box in each row.

Statement	A	B	C
The wax is melting			
The wax is a liquid			
The particles of the wax are closest together			

[3]

- (b) The specific latent heat of fusion for wax is 24 000 J/kg.

Calculate the energy needed to change 0.25 kg of wax from solid to liquid.

Use the equation: energy to cause a change of state = mass × specific latent heat

Energy to cause a change of state = ..... J [2]

3 Jamal drives a go-cart around one lap of a 500 m oval track.

(a) It takes him 125 seconds to complete one lap of the track.

Calculate Jamal's average speed for the lap.

Average Speed = ..... m/s [3]

(b) Distance is a scalar quantity.

Which statement defines a scalar quantity?

Tick (✓) **one** box.

It has both size and direction.

It has direction but not size.

It has either size or direction.

It has size but not direction.

[1]

- 4 Jane has a dimmer switch in her bedroom that allows her to change the brightness of a lamp.

She investigates how the dimmer switch changes the brightness of the lamp. She builds the circuit in Fig. 4.1.

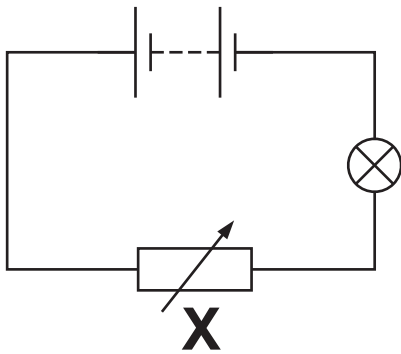


Fig. 4.1

- (a) (i) What is the name of the component labelled X in Fig. 4.1?

Tick (✓) **one** box.

Thermistor

Variable Resistor

Fixed Resistor

[1]

- (ii) The potential difference across the lamp is 3.6V. The current in the circuit is 0.75A.

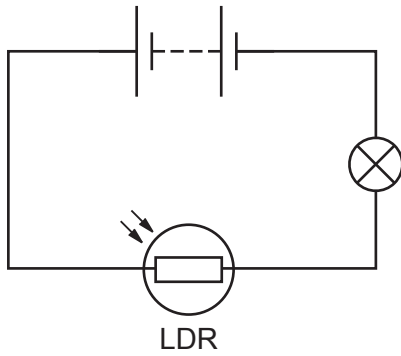
Calculate the resistance of the lamp.

Resistance = .....  $\Omega$  [3]

- (b) Jane has an electric clock with an illuminated display. The display is designed to be dimmer when the room is dark.

She replaces component **X** in **Fig. 4.1** with a Light Dependent Resistor (LDR) to investigate her electric clock.

The new circuit is shown in **Fig. 4.2**.



**Fig. 4.2**

- (i) Jane wants to make measurements to calculate the resistance of the LDR in the circuit in **Fig. 4.2**.

What **two** components does Jane need to add to the circuit in **Fig. 4.2**?

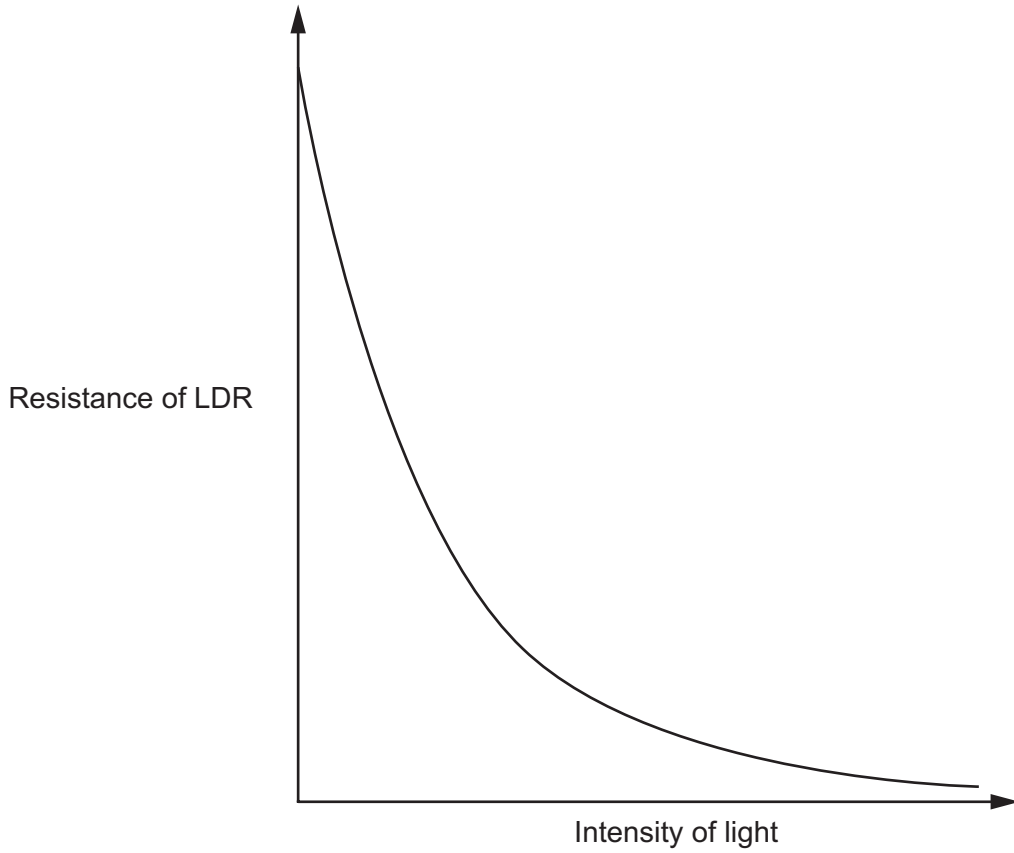
**Component 1** .....

**Component 2** .....

[2]

- (ii) Jane investigates how the resistance of the LDR varies as the intensity of the light shining on the LDR increases.

Jane sketches a graph of her results, as shown in **Fig. 4.3**.



**Fig. 4.3**

Describe how the resistance of the LDR varies with the intensity of the light.

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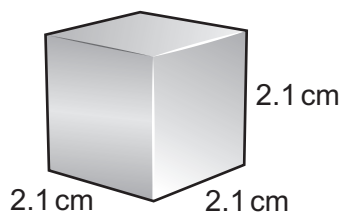
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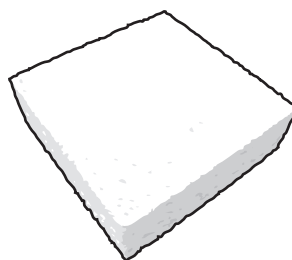
6 Beth has been asked to find the density of three substances:



**Steel**



**Water**



**Polystyrene**

(a) (i) Calculate the volume of the steel.

Give your answer to **2** significant figures.

Volume = ..... cm<sup>3</sup> [2]

(ii) Calculate the density of the steel.

The mass of the steel is 74.4 g.

Use the equation: density = mass ÷ volume

Use your answer from (a)(i).

Density = ..... g/cm<sup>3</sup> [2]

(b) Describe a method to find the density of the **water**.

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..... [4]

(c) The polystyrene and the water have the **same** mass.

The volume of the polystyrene is four times greater than the volume of the water.

The density of the water is  $1.0 \text{ g/cm}^3$ .

Calculate the density of the polystyrene.

Use the equation:

density of polystyrene  $\times$  volume of polystyrene = density of water  $\times$  volume of water

Density = .....  $\text{g/cm}^3$  [2]

- 7 The properties of some radioactive isotopes are shown in the table.

Radioactive isotope	Type of radiation emitted	Half-life
Americium-214	Alpha	432 years
Bismuth-213	Alpha	46 minutes
Cobalt-60	Gamma	5.3 years
Technetium-99m	Gamma	6 hours

- (a) A patient is injected with a medical tracer.  
A medical tracer contains a radioactive isotope that emits radiation. This radiation is detected from outside the body to produce an image.

Explain why technetium-99m is suitable for use as a medical tracer.

Use data from the table in your answer.

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..... [2]

- (b) The radioactive medical tracer, technetium-99m, is prepared in the same room as the patient.

Identify **one** precaution when preparing this medical tracer in the same room as the patient, and explain how this reduces the risk to the patient.

Precaution .....

.....

Explanation .....

..... [2]

- (c) Radiotherapy is a treatment to kill cancerous cells carried out over several weeks. The radioactive isotope needs to produce a consistent beam of radiation over several weeks.

Which radioactive isotope from the table is suitable to use for radiotherapy?

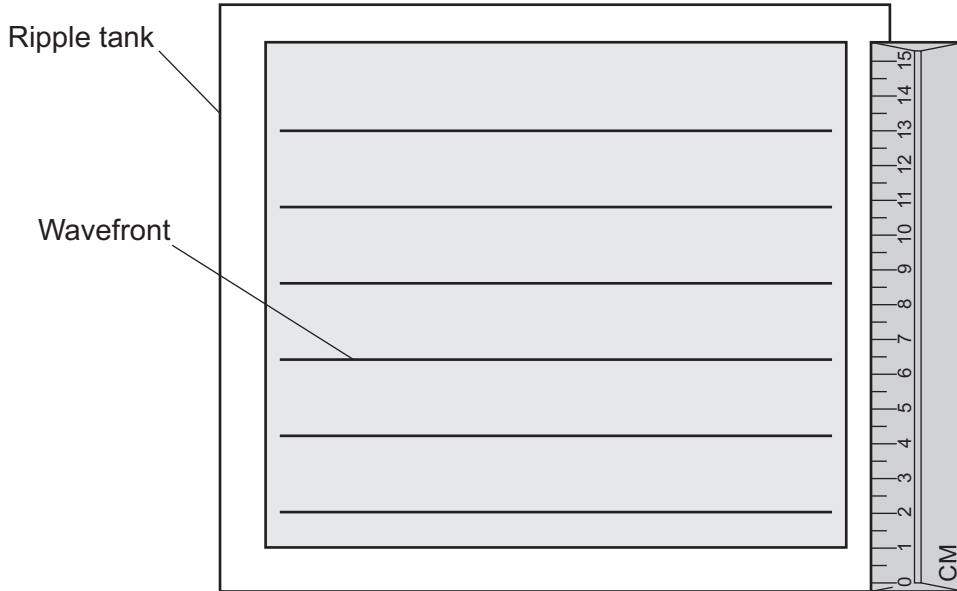
Give **one** reason for your answer.

Radioactive isotope .....

Reason .....

**[2]**

- 8 Sarah investigates how the speed of a water wave changes with the depth of water. She uses a ripple tank to produce a wave on the surface of the water. Sarah observes the wavefronts shown in the diagram. The diagram is **not** to scale.



- (a) (i) Describe how Sarah can accurately measure the wavelength of the wave.

Include an accurate measurement of the wavelength in your answer.

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[3]

(ii) Describe how Sarah can calculate the speed of the wave.

Include in your answer any equipment and equations that she would need to use.

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..... [3]

(b) Sarah measures the wavelength with different depths of water.

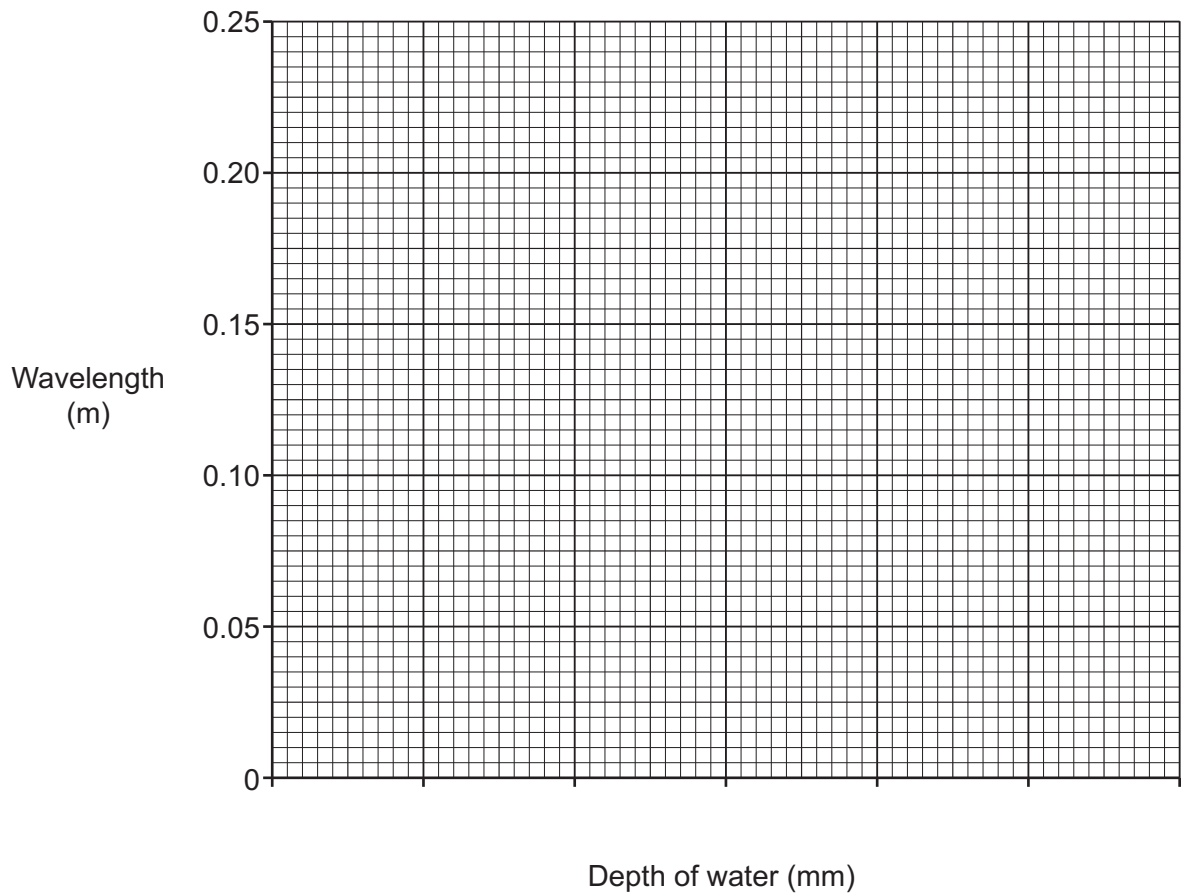
She records her results in the table.

Depth of water (mm)	Wavelength (m)
20	0.12
40	0.17
60	0.20
80	0.22
100	0.23

(i) Plot a graph of the results from the table.

Use an appropriate scale **and** draw a line of best fit.

[3]





(ii) Sarah concludes



The wavelength increases with the depth of water but the relationship is **not** proportional.

Is Sarah correct?

Yes

No

Use data from the table to explain your answer.

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..... [2]

9 Electromagnets are used in scrap metal yards to pick up and move scrap metal.

(a) Amaya builds an electromagnet in the school lab, as shown in Fig. 9.1.

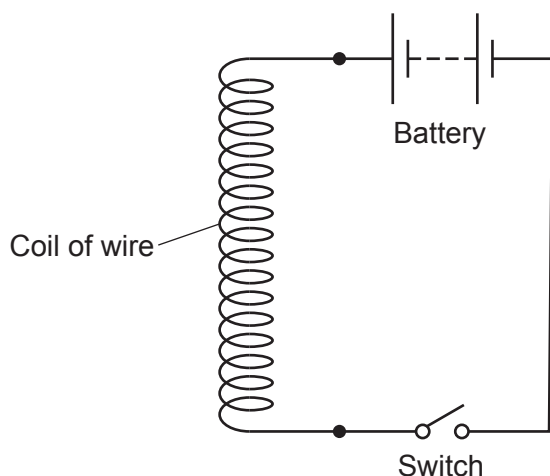


Fig. 9.1

(i) When the switch is closed a current flows in the circuit and creates a magnetic field around the coil of wire.

Describe how to investigate the pattern of the magnetic field.

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..... [2]

(ii) Amaya makes the following suggestion about the electromagnet.

I can make the electromagnet stronger by placing a cardboard cylinder inside the coil of wire.



Explain why Amaya is wrong.

Include **one** correct way of making the electromagnet stronger in your answer.

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..... [2]

- (b) Fig. 9.2 shows a crane in a scrap metal yard fitted with an electromagnet. The electromagnet can be lowered so that it can pick up and move scrap metal across the yard.

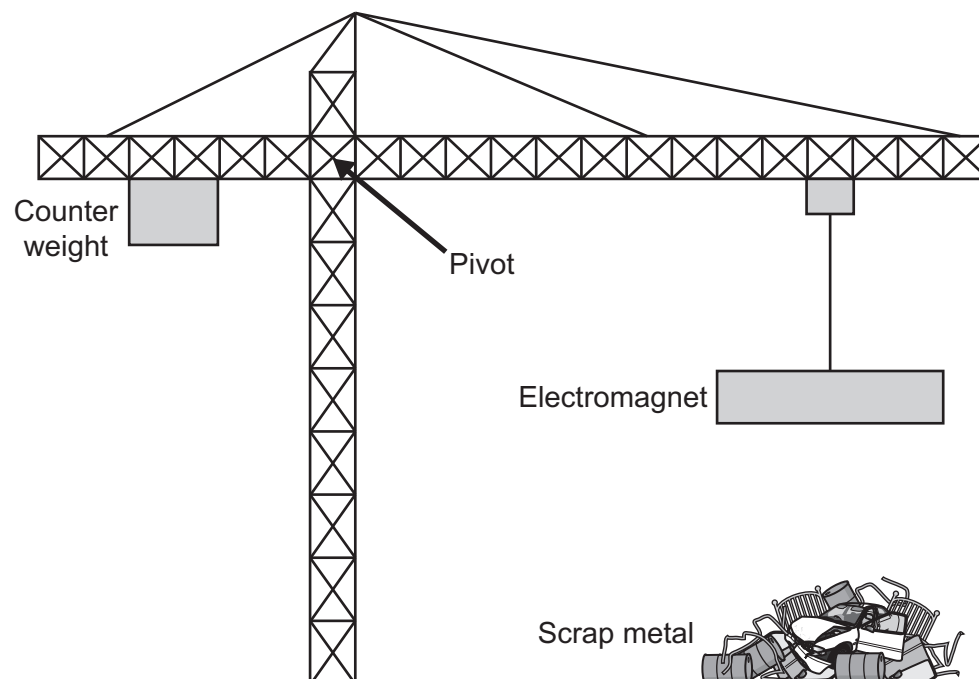


Fig. 9.2

- (i) Explain why the electromagnet needs to be brought closer to the scrap metal to pick the scrap metal up.

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 ..... [2]

- (ii) When the electromagnet picks up the scrap metal the counter weight is moved further away from the pivot.

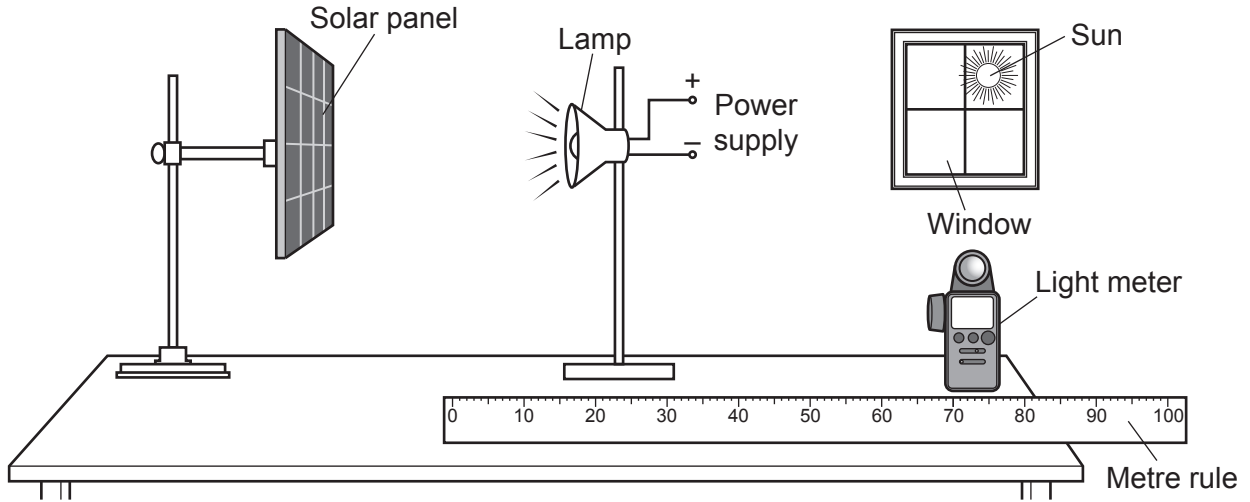
Explain how this prevents the crane from tipping over.

Use ideas about moments in your answer.

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 ..... [2]

10 Solar panels generate electricity using energy from the Sun.

Kai investigates solar panels and sets up the equipment in the diagram.



Kai wants to use the light meter to record the total power input to the solar panel from the lamp.

Kai also wants to measure the distance between the lamp and the solar panel with the metre rule.

(a) Identify **two** sources of error in Kai's experiment, and describe how each error can be reduced.

**Error 1** .....

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How to reduce **error 1** .....

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**Error 2** .....

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How to reduce **error 2** .....

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[4]

21  
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**Question 10 continues on page 22**

- (b) Kai corrects the errors in his experiment. He also records the useful power output of the solar panel, and the energy output of the solar panel in 30 seconds.

He records his results in the table.

Distance between lamp and solar panel (cm)	Total power input to the solar panel (W)	Useful power output of the solar panel (W)	Energy output of the solar panel in 30 seconds (J)
10.0	4	2.85	85.5
20.0	1	0.63	18.9
30.0	0.44	0.28	8.40
40.0	0.25	0.14	4.20
50.0	0.16	0.06	.....
60.0	0.11	0.05	1.50

- (i) Complete the table.

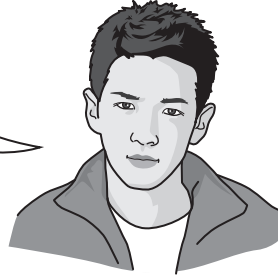
Use the equation:  $\text{power} = \text{energy} \div \text{time}$

[2]

(ii) Kai makes a hypothesis.

**Kai**

When the distance doubles the efficiency of the solar panel halves.



Explain why Kai's hypothesis is incorrect.

Use calculations to support your answer.

Use the equation:  $\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$

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..... [3]

(iii) Space probes that travel to the outer planets of the solar system do **not** use solar panels to provide electricity.

Explain why solar panels are not used by these space probes.

Use data from the table to support your answer.

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..... [2]

11 Amir has bought an electric car.

(a) (i) The electric car has a power of 80 kW.

Define power, with reference to the energy store of the car's battery.

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..... [2]

(ii) Work is done when electric current passes from the battery to the motor, but some energy is wasted.

Describe how this energy is wasted and where this energy is transferred to.

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..... [2]

(b) 42 kWh of energy is stored in the fully charged battery.

(i) 1 kWh of electricity costs 16p.

Calculate the cost of fully charging the car, in £.

Cost = £ ..... [2]

(ii) Calculate the time taken, in hours, to fully charge the battery using a 7 kW charger.

Use the equation: power = energy ÷ time

Time = ..... hours [2]



(iii) The manufacturer claims the car uses 1 kWh of energy to travel 6 km.

When the battery is fully charged Amir travels 220 km before the charge on the battery runs out.

Find out if the manufacturer's claim is correct.

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..... [2]

(c) Amir makes a hypothesis about the performance of the car's battery.

Travelling with more passengers in the car would cause the battery to discharge more quickly.



Amir has a small electrical motor and a trolley.

Outline an experiment that Amir could do in a school lab to investigate his hypothesis.

Include any additional equipment required in your answer.

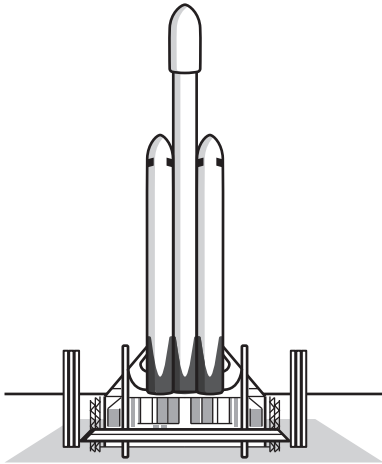
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12\* A space company is testing a rocket that may eventually take humans to Mars.



The mass of the rocket before lift-off is 1 420 000 kg including the fuel.  
During lift-off the rocket’s engines provide a maximum upward thrust of 23 000 000 N.

Explain how the forces and acceleration of the rocket change **before, during** and **after** lift-off.

Gravitational field strength = 10 N/kg

Use the equation: force = mass × acceleration

Use the equation: weight = mass × gravitational field strength

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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).

A large area of lined paper for writing, consisting of 25 horizontal dotted lines. A solid vertical line runs down the left side of the page, creating a margin. The rest of the page is open for writing.

A large rectangular area for writing, bounded by a solid vertical line on the left and horizontal dotted lines on the top, bottom, and right.



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