

FOR OFFICIAL USE



National
Qualifications
2016

Mark

X757/75/01

**Physics
Section 1 — Answer Grid
and Section 2**

TUESDAY, 24 MAY

1:00 PM – 3:00 PM



* X 7 5 7 7 5 0 1 *

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day

Month

Year

Scottish candidate number

Total marks — 110

SECTION 1 — 20 marks

Attempt ALL questions.

Instructions for completion of Section 1 are given on *Page 02*.

SECTION 2 — 90 marks

Attempt ALL questions.

Reference may be made to the Data Sheet on *Page 02* of the question paper X757/75/02 and to the Relationships Sheet X757/75/11.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. You should score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.



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The questions for Section 1 are contained in the question paper X757/75/02.

Read these and record your answers on the answer grid on *Page 03* opposite.

Use **blue** or **black** ink. Do NOT use gel pens or pencil.

1. The answer to each question is **either** A, B, C, D or E. Decide what your answer is, then fill in the appropriate bubble (see sample question below).
2. There is **only one correct** answer to each question.
3. Any rough work must be written in the additional space for answers and rough work at the end of this booklet.

Sample Question

The energy unit measured by the electricity meter in your home is the:

- A ampere
- B kilowatt-hour
- C watt
- D coulomb
- E volt.

The correct answer is **B** — kilowatt-hour. The answer **B** bubble has been clearly filled in (see below).

| | | | | |
|-----------------------|----------------------------------|-----------------------|-----------------------|-----------------------|
| A | B | C | D | E |
| <input type="radio"/> | <input checked="" type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.

| | | | | |
|-----------------------|----------------------------------|-----------------------|----------------------------------|-----------------------|
| A | B | C | D | E |
| <input type="radio"/> | <input checked="" type="radio"/> | <input type="radio"/> | <input checked="" type="radio"/> | <input type="radio"/> |

If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:

| | | | | | | | | | | |
|-----------------------|----------------------------------|-----------------------|----------------------------------|-----------------------|----|-----------------------|----------------------------------|-----------------------|-----------------------|-----------------------|
| A | B | C | D | E | or | A | B | C | D | E |
| <input type="radio"/> | <input checked="" type="radio"/> | <input type="radio"/> | <input checked="" type="radio"/> | <input type="radio"/> | | <input type="radio"/> | <input checked="" type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |



SECTION 1 — Answer Grid



| | A | B | C | D | E |
|----|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 2 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 3 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 4 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 5 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 6 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 7 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 8 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 9 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 10 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 11 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 12 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 13 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 14 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 15 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 16 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 17 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 18 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 19 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 20 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |



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SECTION 2 — 90 marks
Attempt ALL questions

1. Electrical storms occur throughout the world.



During one lightning strike 24 C of charge is transferred to the ground in 0.0012 s .

- (a) Calculate the average current during the lightning strike.

3

Space for working and answer

- (b) The charge on an electron is $-1.6 \times 10^{-19}\text{ C}$.

Determine the number of electrons transferred during the lightning strike.

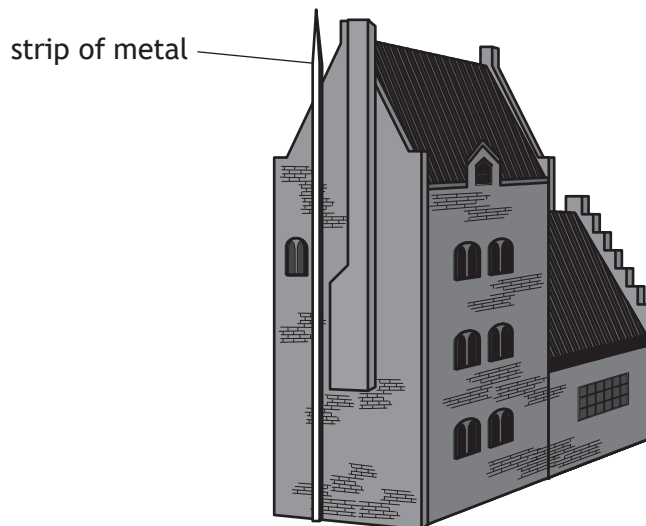
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Space for working and answer



1. (continued)

- (c) Many tall buildings have a thick strip of metal attached to the side of the building.



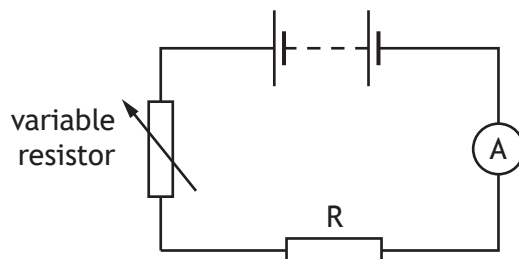
This strip is used to protect the building from damage during electrical storms.

Explain how this strip protects the building from damage.

2



2. A student investigates the resistance of a resistor using the circuit shown.



- (a) Complete the circuit diagram to show where a voltmeter must be connected to measure the voltage across resistor R. 1
 (An additional diagram, if required, can be found on Page 33.)
- (b) Describe how the student obtains a range of values of voltage and current. 1



2. (continued)

(c) The results of the student's investigation are shown.

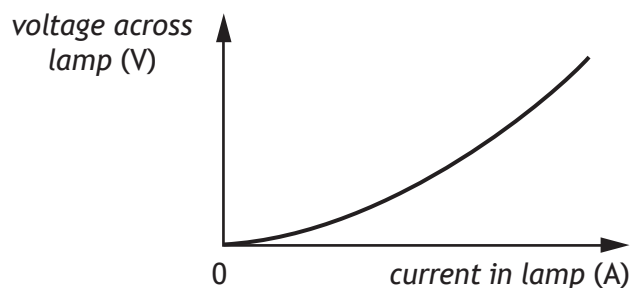
| <i>Voltage across resistor R (V)</i> | <i>Current in resistor R (A)</i> |
|--------------------------------------|----------------------------------|
| 1.0 | 0.20 |
| 2.5 | 0.50 |
| 3.2 | 0.64 |
| 6.2 | 1.24 |

Use all these results to determine the resistance of resistor R.

4

Space for working and answer

(d) The student now replaces resistor R with a filament lamp and repeats the investigation. A sketch graph of the student's results is shown.

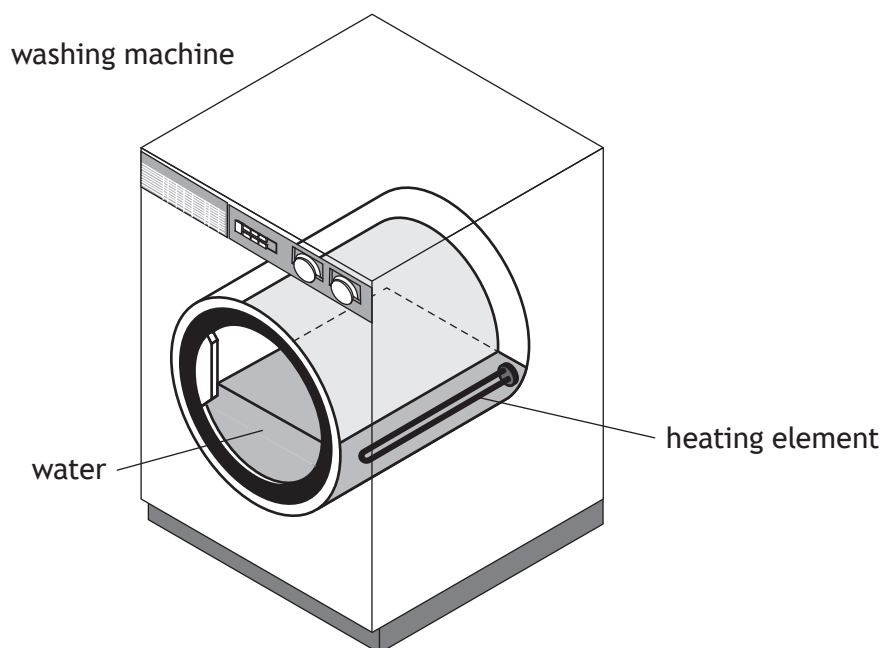


State a conclusion that can be made about the resistance of the filament lamp.

1



3. A washing machine fills with water at a temperature of 15.0°C .
The water is heated by a heating element.



- (a) The mass of the water in the washing machine is 6.00 kg .

Show that the minimum energy required to increase the temperature of the water from 15.0°C to 40.0°C is $627\,000\text{ J}$.

2

Space for working and answer



3. (continued)

(b) The heating element has a power rating of 1800 W.

(i) Calculate the time taken for the heating element to supply the energy calculated in (a).

3

Space for working and answer

(ii) Explain why, in practice, it takes longer to heat the water from 15 °C to 40 °C than calculated in (b)(i).

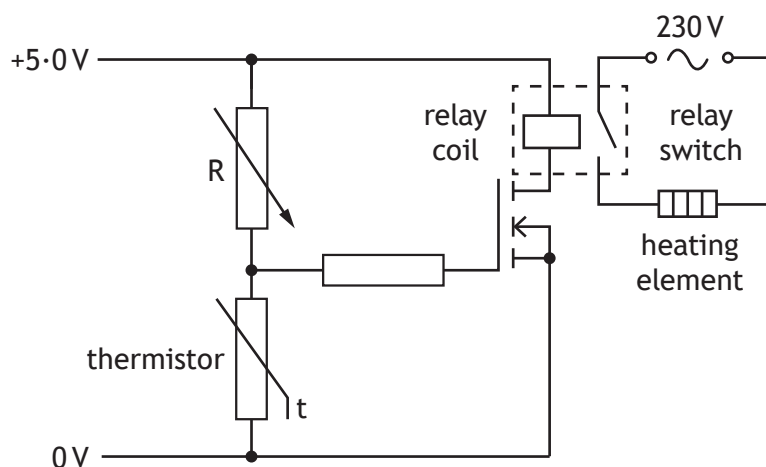
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3. (continued)

- (c) The temperature of the water in the washing machine is monitored by a circuit containing a thermistor.



As the temperature of the water increases, the resistance of the thermistor decreases.

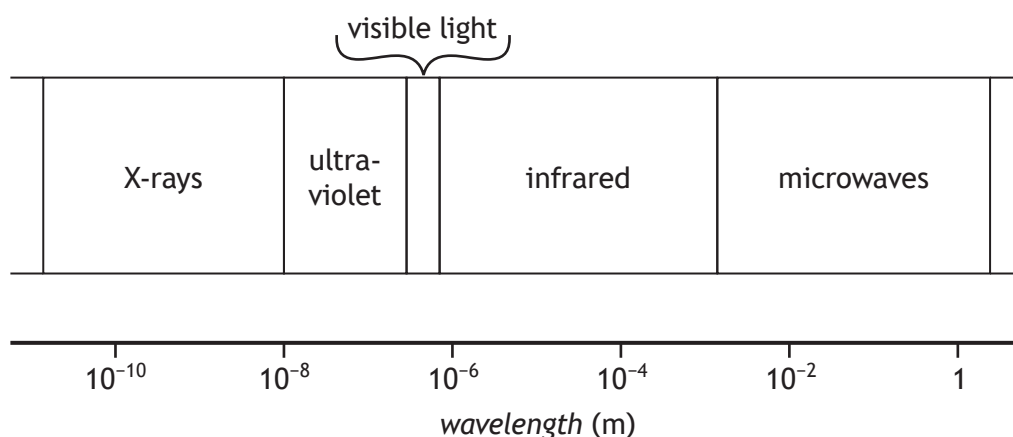
The heating element is switched off when the temperature of the water reaches 40°C.

Explain how the circuit operates to **switch off** the heating element.

3



4. The diagram shows some parts of the electromagnetic spectrum in order of increasing wavelength.



- (a) State a detector of infrared radiation. 1
- (b) State which radiation in the electromagnetic spectrum has a wavelength shorter than X-rays. 1
- (c) (i) An electromagnetic wave has a frequency of 1.2 GHz.
Show that the wavelength of this wave is 0.25 m. 2
Space for working and answer
- (ii) Identify the part of the spectrum that this wave belongs to. 1



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5. A Physics textbook contains the following statement.

“Electromagnetic waves can be sent out like ripples on a pond.”

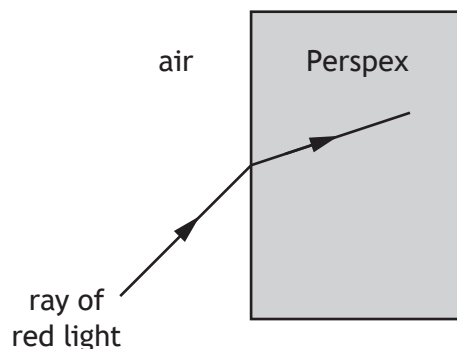
Using your knowledge of physics, comment on the similarities and/or differences between electromagnetic waves and the ripples on a pond.

3

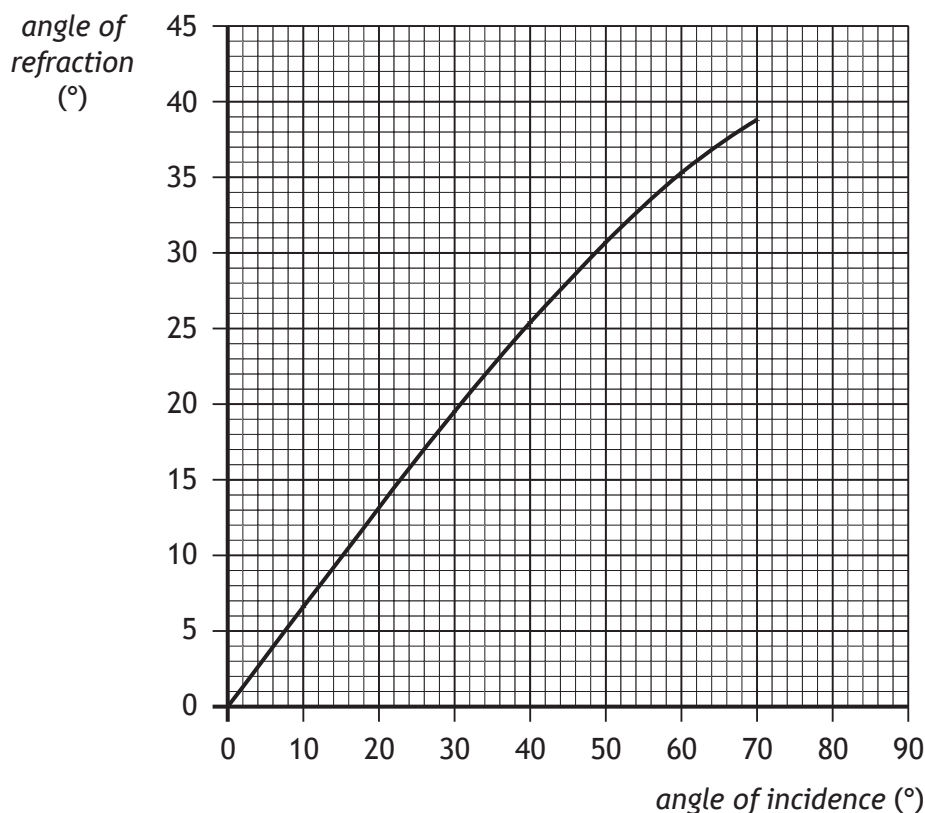


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6. A student directs a ray of red light into a Perspex block to investigate refraction.



- (a) On the diagram, draw and label:
- (i) the normal; 1
 - (ii) the angle of incidence i and the angle of refraction r . 1
- (An additional diagram, if required, can be found on *Page 33*)
- (b) The student varies the angle of incidence and measures the corresponding angles of refraction. The results are plotted on a graph.



MARKS

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6. (b) (continued)

(i) Determine the angle of refraction when the angle of incidence is 12° .

1

(ii) Use the graph to predict the angle of refraction the student would obtain for an angle of incidence of 80° .

1

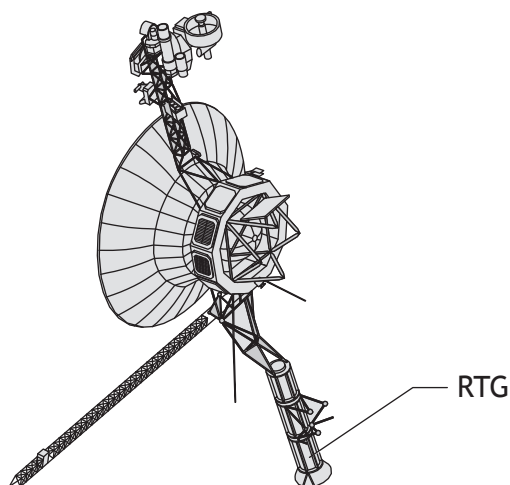
(c) Suggest why it would be good practice for the student to repeat the investigation a further three or four times.

1



* X 7 5 7 7 5 0 1 1 7 *

7. A spacecraft uses a radioisotope thermoelectric generator (RTG) as a power source.



The RTG transforms the heat released by the radioactive decay of plutonium-238 into electrical energy.

- (a) In 15 minutes, 7.92×10^{18} nuclei of plutonium-238 decay.

Calculate the activity of the plutonium-238.

3

Space for working and answer

- (b) Each decay produces heat that is transformed into 4.49×10^{-14} J of electrical energy.

Determine the power output of the RTG.

2

Space for working and answer



7. (continued)

- (c) Plutonium-238 emits alpha radiation.

Explain why a source that emits alpha radiation requires less shielding than a source that emits gamma radiation.

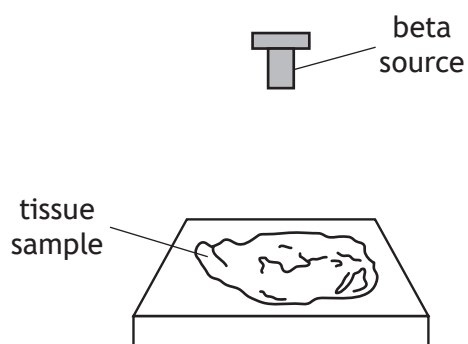
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8. During medical testing a beta source is used to irradiate a sample of tissue of mass 0.50 kg from a distance of 0.10 m .

The sample absorbs $9.6 \times 10^{-5} \text{ J}$ of energy from the beta source.



- (a) (i) Calculate the absorbed dose received by the sample.

3

Space for working and answer

- (ii) Calculate the equivalent dose received by the sample.

3

Space for working and answer



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8. (continued)

(b) The beta source used during testing has a half-life of 36 hours.

The initial activity of the beta source is 12 kBq.

Determine the activity of the source 144 hours later.

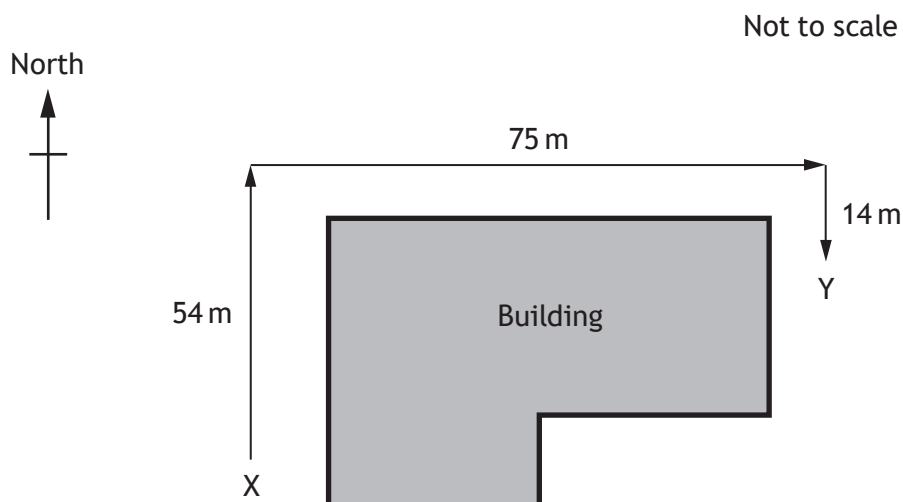
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3



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9. A student walks around a building from point X to point Y.



(a) By scale diagram, or otherwise, determine:

- (i) the magnitude of the displacement of the student from point X to point Y;

2

Space for working and answer

- (ii) the direction of displacement of the student from point X to point Y.

2

Space for working and answer



9. (continued)

(b) The student takes 68 s to travel from point X to point Y.

- (i) Determine the average velocity of the student from point X to point Y.

3

Space for working and answer

- (ii) The student states that their average speed between point X and point Y is greater than the magnitude of their average velocity between point X and point Y.

Explain why the student is correct.

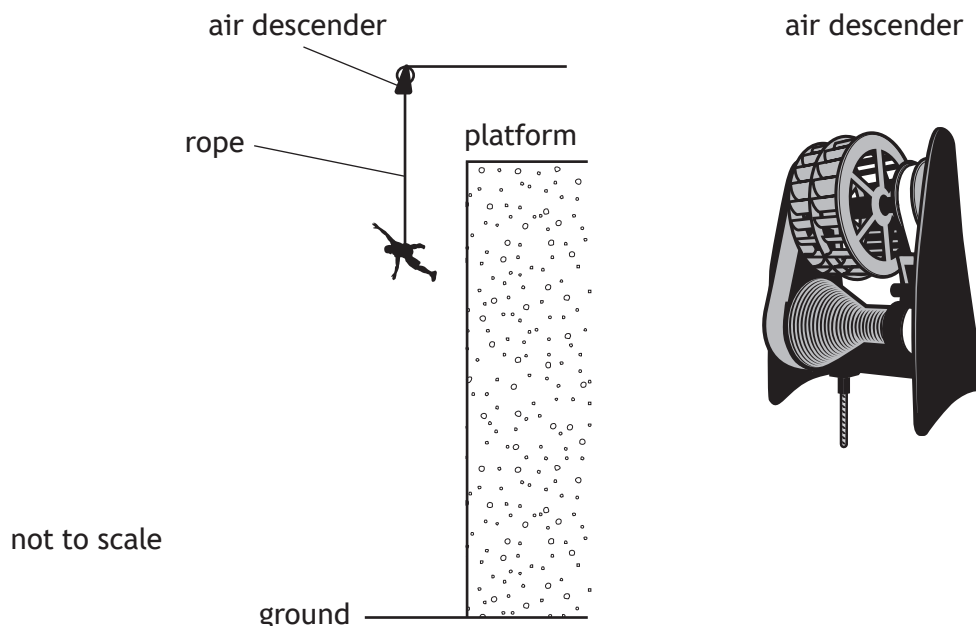
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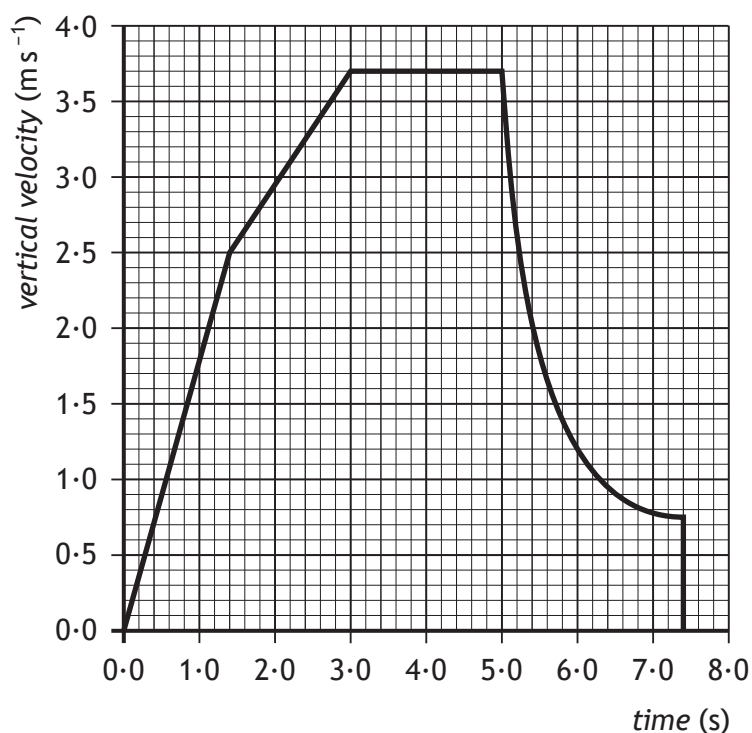
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10. An air descender is a machine that controls the rate at which a climber drops from a platform at the top of a climbing wall.

A climber, attached to the air descender by a rope, steps off the platform and drops towards the ground and lands safely.



The graph shows how the vertical velocity of the climber varies with time from the instant the climber leaves the platform until landing.



10. (continued)

- (a) Calculate the acceleration of the climber during the first 1.4 s of the drop.

3

Space for working and answer

- (b) Calculate the distance the climber drops during the first 3.0 s.

3

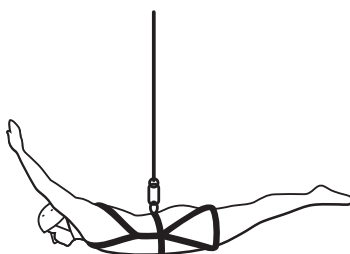
Space for working and answer

- (c) During part of the drop the forces on the climber are balanced.

On the diagram below show all the forces acting vertically on the climber during this part of the drop.

You must name these forces **and** show their directions.

3



(An additional diagram, if required, can be found on Page 33)



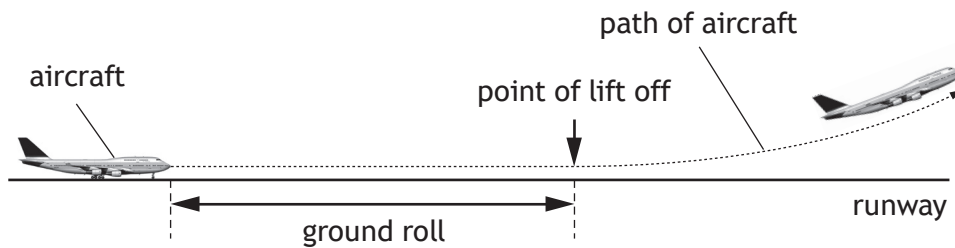
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11. The length of runway required for aircraft to lift off the ground into the air is known as the ground roll.



The ground roll of an aircraft varies for each take-off.

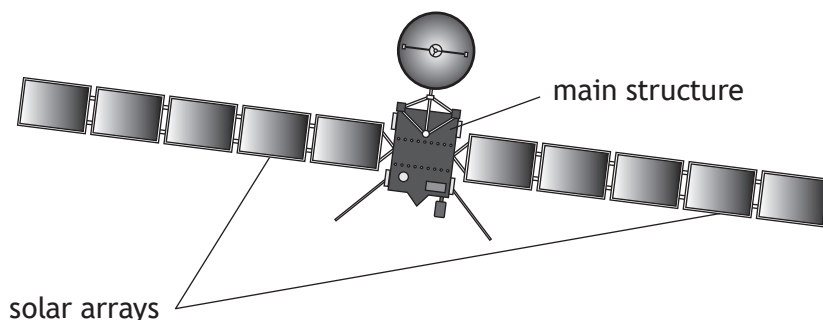
Use your knowledge of physics to comment on why the ground roll of an aircraft varies for each take-off.

3



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12. On 12th November 2014, on a mission known as Rosetta, the European Space Agency successfully landed a probe on the surface of a comet.



The main structure of the Rosetta spacecraft consists of an orbiter, a lander and propellant.

| Rosetta spacecraft data | | |
|-------------------------|--------------------|-----------------------|
| Launch mass | Orbiter | 1.23×10^3 kg |
| | Lander | 0.10×10^3 kg |
| | Propellant | 1.67×10^3 kg |
| | Total | 3.00×10^3 kg |
| Energy source | Solar array output | 850 W at 3.4 AU |
| | | 395 W at 5.25 AU |
| Trajectory control | 24 Thrusters | 10 N of force each |

- (a) Calculate the total weight of the spacecraft on Earth. 3
Space for working and answer
- (b) The solar arrays contain photovoltaic cells.
- (i) State the energy change in a photovoltaic cell. 1
- (ii) Suggest why the solar arrays were designed so that they can rotate. 1



12. (b) (continued)

- (iii) Calculate the total energy output of the solar arrays when operating at 5.25 AU for 2 hours.

3

Space for working and answer

- (c) At a point on its journey between Earth and the comet, the spacecraft was travelling at a constant velocity.

- (i) The spacecraft switched on four of its thrusters to accelerate it in the direction of travel.

The four thrusters exerted a force on the spacecraft in the same direction.

Determine the total force produced by these thrusters.

1

Space for working and answer

- (ii) At this point, the spacecraft had used 1.00×10^3 kg of propellant.

Calculate the acceleration of the spacecraft.

4

Space for working and answer



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13. Read the passage and answer the questions that follow.

Supernova explosion



The average temperature of the surface of the Sun is 5778 K. In the core of the Sun energy is produced by nuclear fusion. Once the Sun has used all its nuclear fuel it will collapse to form a white dwarf.

A star with a mass much larger than that of the Sun will end its life in an enormous explosion called a supernova. The energy released in a supernova explosion is more than a hundred times the energy that the Sun will radiate over its entire 10 billion year lifetime.

In our galaxy, the star Betelgeuse is predicted to explode in a supernova. Betelgeuse has a mass of around 8 times the mass of the Sun. Even though Betelgeuse is 640 light-years from Earth, the supernova will be as bright as a full moon at night in our sky.

(a) State what is meant by the term *nuclear fusion*. 1

(b) Determine the average temperature of the surface of the Sun in degrees Celsius. 1

Space for working and answer



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13. (continued)

(c) Show that the distance from Earth to Betelgeuse is 6.1×10^{18} m.

3

Space for working and answer

(d) Betelgeuse may have already exploded in a supernova.

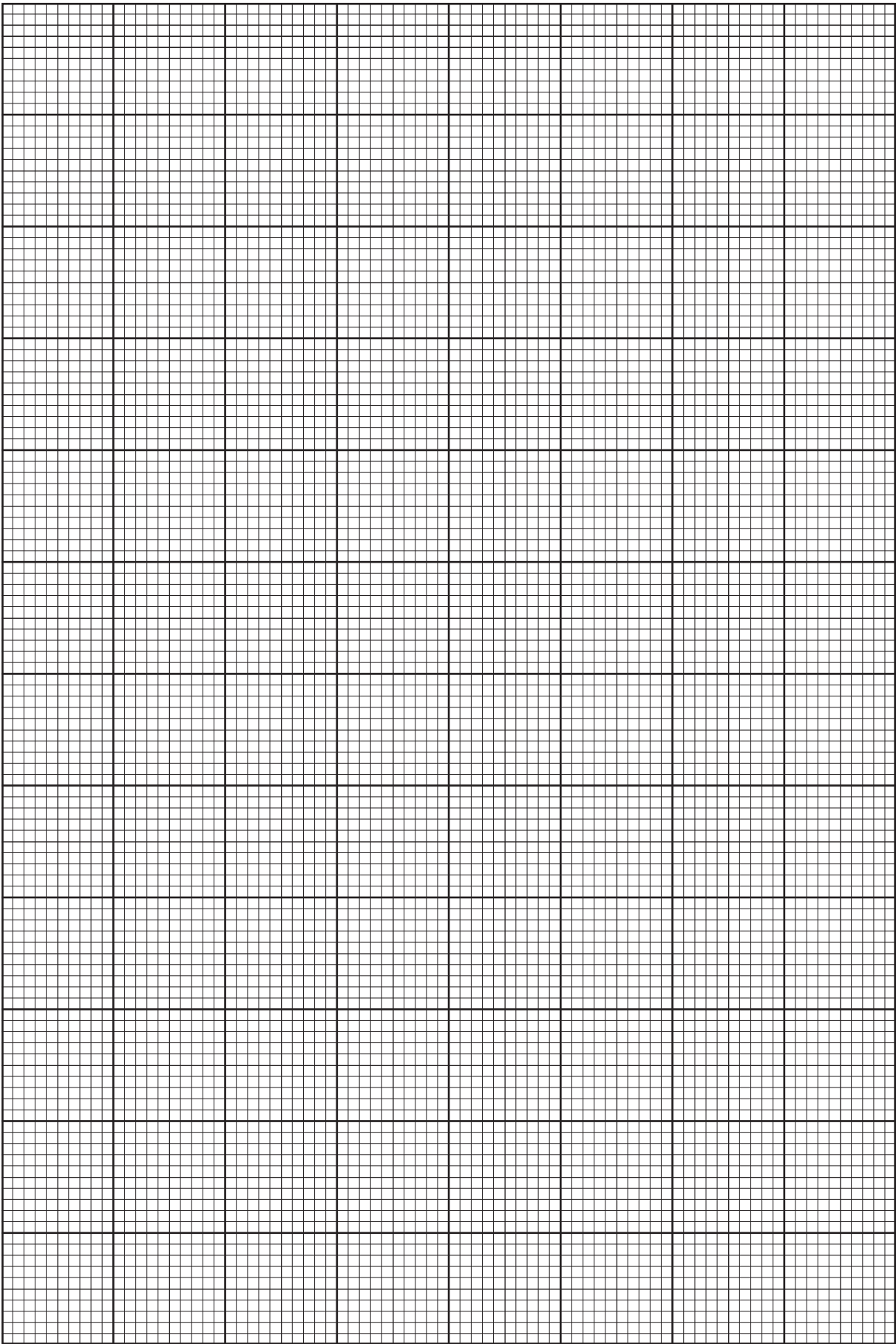
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Explain this statement.

[END OF QUESTION PAPER]



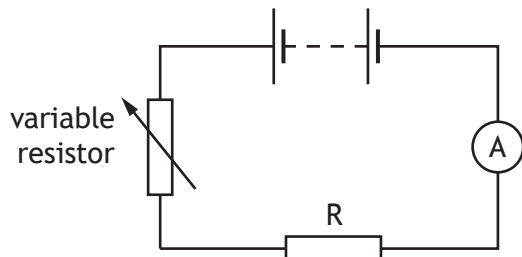
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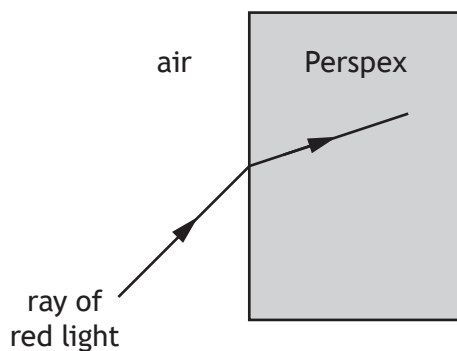
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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORKING

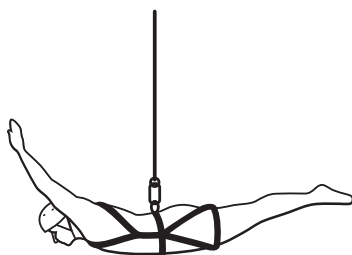
Additional diagram for Q2 (a)



Additional diagram for Q6 (a)



Additional diagram for Q10 (c)



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORKING

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ACKNOWLEDGEMENTS

Section 2 Question 1 – Piotr Krzeslak/shutterstock.com

Section 2 Question 13 - AstroStar/shutterstock.com



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