FOR OFFICIAL USE

H

National
Qualifications
2015

Mark

X757/76/01

Physics
Section 1 – Answer Grid and Section 2

TUESDAY, 5 MAY

1:00 PM – 3:30 PM

* X 7 5 7 7 6 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 — 130

SECTION 1 — 20 marks

Attempt ALL questions.

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

SECTION 2 — 110 marks

Attempt ALL questions.

Reference may be made to the Data Sheet on *Page two* of the question paper X757/76/02 and to the Relationship Sheet X757/76/11.

Care should be taken to give an appropriate number of significant figures in the final answers to calculations.

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.

* X 7 5 7 7 6 0 1 0 1 *

The questions for Section 1 are contained in the question paper X757/76/02.
Read these and record your answers on the answer grid on *Page three* 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

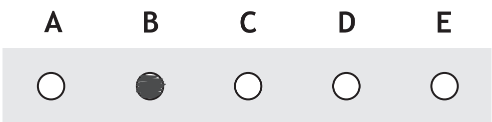
B kilowatt-hour

C watt

D coulomb

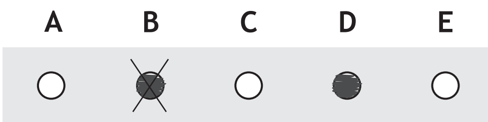
E volt.

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

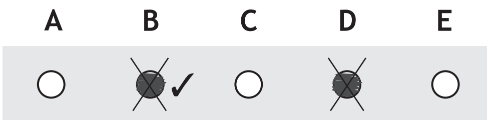


Changing an answer

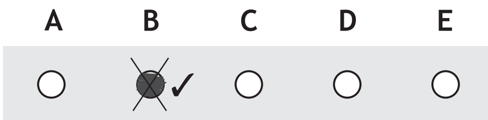
If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



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:



or



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OBJ20AE1

You must record your answers to Section 1 questions on the answer grid on **Page 3** of your **answer booklet**

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[Turn over for SECTION 2 on *Page six*

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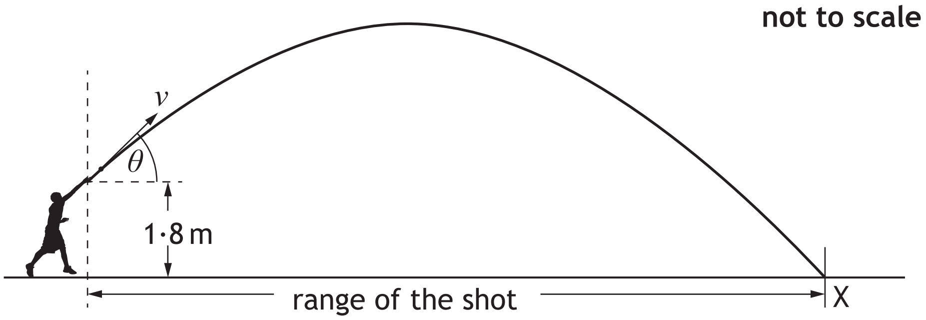
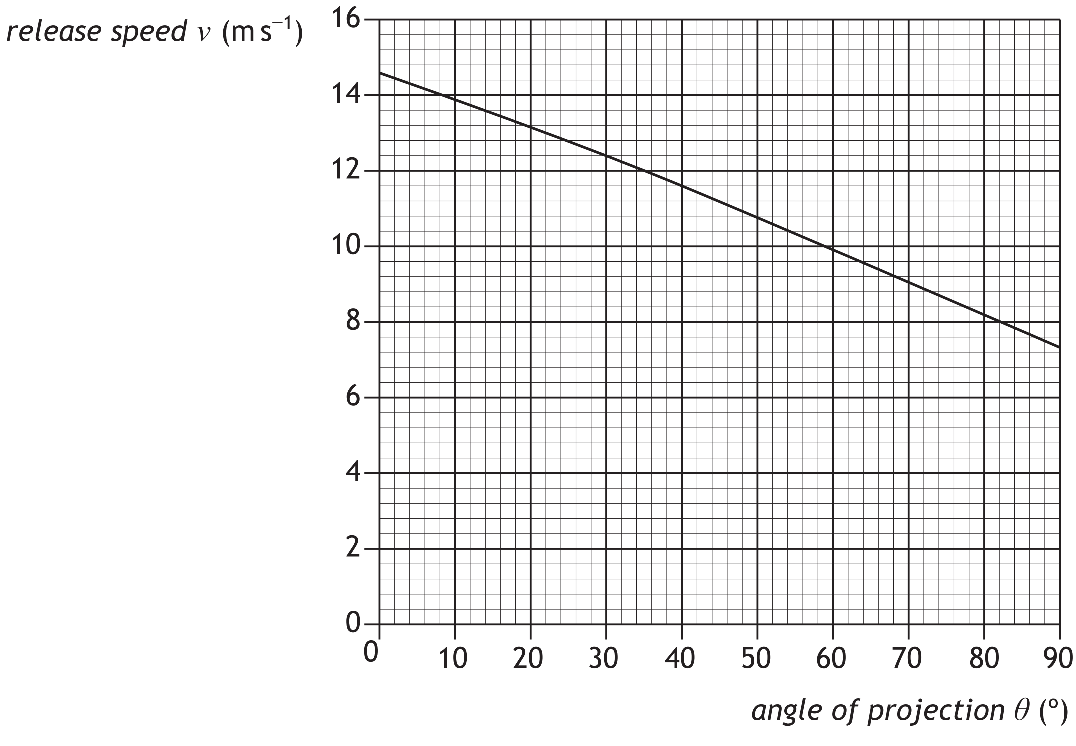
SECTION 2 — 110 marks

Attempt ALL questions

1. The shot put is an athletics event in which competitors "throw" a shot as far as possible. The shot is a metal ball of mass 4·0 kg. One of the competitors releases the shot at a height of 1·8 m above the ground and at an angle θ to the horizontal. The shot travels through the air and hits the ground at X. The effects of air resistance are negligible.



The graph shows how the release speed of the shot v varies with the angle of projection θ.



MARKS | DO NOT WRITE IN THIS MARGIN

(a) The angle of projection for a particular throw is 40°.

(i) (A) State the release speed of the shot at this angle. **1**

(B) Calculate the horizontal component of the initial velocity of the shot. **1**

Space for working and answer

(C) Calculate the vertical component of the initial velocity of the shot. **1**

Space for working and answer

(ii) The maximum height reached by the shot is 4·7 m above the ground. The time between release and reaching this height is 0·76 s.

(A) Calculate the total time between the shot being released and hitting the ground at X. **4**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

1. (a) (ii) **(continued)**

(B) Calculate the range of the shot for this throw. 3

Space for working and answer

(b) Using information from the graph, explain the effect of increasing the angle of projection on the kinetic energy of the shot at release. 2

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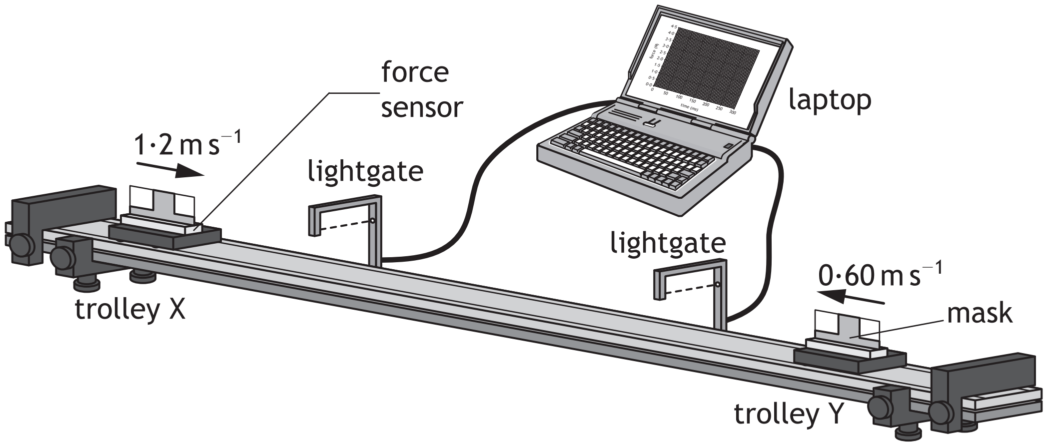
2. A student sets up an experiment to investigate collisions between two trolleys on a long, horizontal track.



The mass of trolley X is 0·25 kg and the mass of trolley Y is 0·45 kg.

The effects of friction are negligible.

In one experiment, trolley X is moving at $1\cdot2\,\text{m}\,\text{s}^{-1}$ to the right and trolley Y is moving at $0\cdot60\,\text{m}\,\text{s}^{-1}$ to the left.

The trolleys collide and do not stick together. After the collision, trolley X rebounds with a velocity of $0\cdot80\,\text{m}\,\text{s}^{-1}$ to the left.

(a) Determine the velocity of trolley Y after the collision. **3**

Space for working and answer

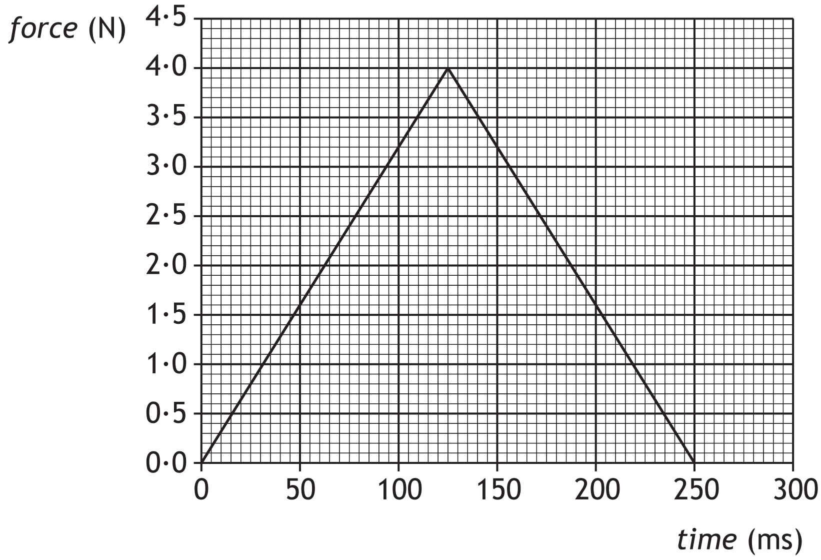
[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

2. (continued)

(b) The force sensor measures the force acting on trolley Y during the collision.

The laptop displays the following force-time graph for the collision.



(i) Determine the magnitude of the impulse on trolley Y. **3**

Space for working and answer

(ii) Determine the magnitude of the change in momentum of trolley X. **1**

2. (b) (continued)

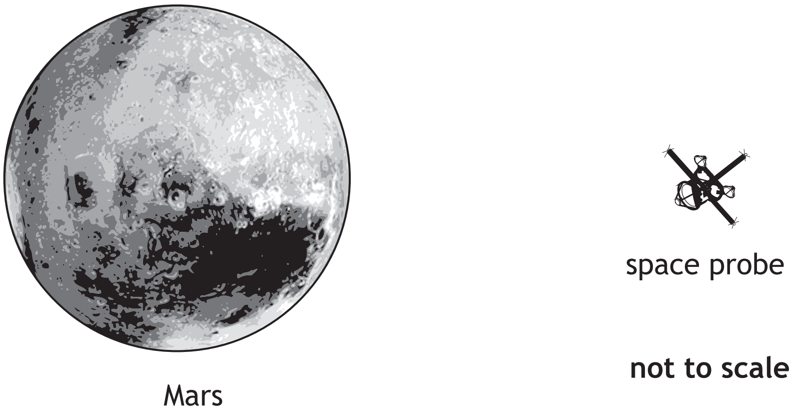
(iii) Sketch a velocity-time graph to show how the velocity of trolley X varies from 0·50 s before the collision to 0·50 s after the collision. **3**

Numerical values are required on both axes.
You may wish to use the square-ruled paper on *Page thirty-six*.

[Turn over

MARKS DO NOT WRITE IN THIS MARGIN

3. A space probe of mass $5 \cdot 60 \times 10^3$ kg is in orbit at a height of $3 \cdot 70 \times 10^6$ m above the surface of Mars.



The mass of Mars is $6 \cdot 42 \times 10^{23}$ kg.
The radius of Mars is $3 \cdot 39 \times 10^6$ m.

(a) Calculate the gravitational force between the probe and Mars. **3**

Space for working and answer

(b) Calculate the gravitational field strength of Mars at this height. **3**

Space for working and answer

[Turn over for Question 4 on *Page fourteen*

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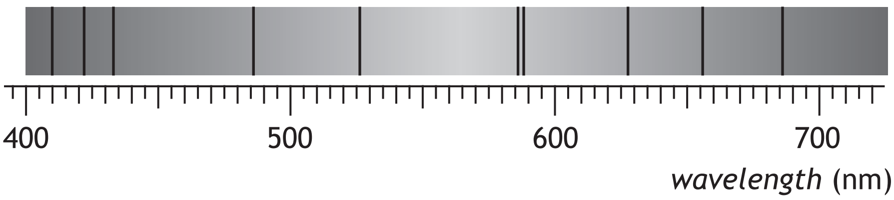
4. Light from the Sun is used to produce a visible spectrum.

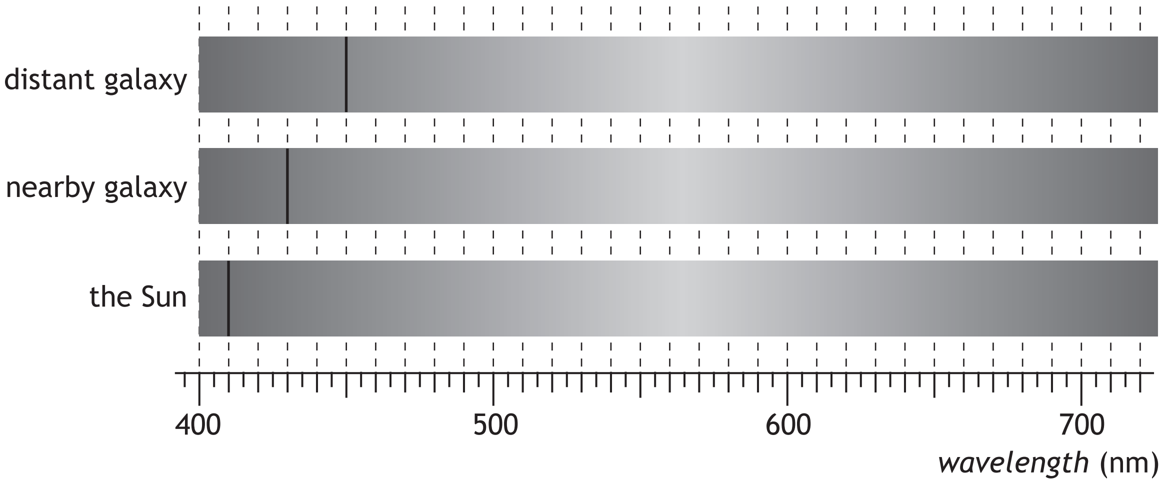
A student views this spectrum and observes a number of dark lines as shown.



(a) Explain how these dark lines in the spectrum of sunlight are produced. **2**

(b) One of the lines is due to hydrogen.

The position of this hydrogen line in the visible spectrum is shown for a distant galaxy, a nearby galaxy and the Sun.



(i) Explain why the position of the line is different in each of the spectra. **2**

MARKS | DO NOT WRITE IN THIS MARGIN

4. (b) (continued)

(ii) Show that the redshift of the light from the distant galaxy is 0·098. **2**

Space for working and answer

(iii) Calculate the approximate distance to the distant galaxy. **5**

Space for working and answer

[Turn over

MARKS DO NOT WRITE IN THIS MARGIN

5. A quote from a well-known science fiction writer states:

"In the beginning there was nothing, which exploded."

Using your knowledge of physics, comment on the above statement. **3**

* X 7 5 7 7 6 0 1 1 6 *

MARKS | DO NOT WRITE IN THIS MARGIN

6\. (a) The Standard Model classifies *force mediating particles* as bosons. Name the boson associated with the electromagnetic force. **1**

(b) In July 2012 scientists at CERN announced that they had found a particle that behaved in the way that they expected the Higgs boson to behave. Within a year this particle was confirmed to be a Higgs boson.

This Higgs boson had a mass-energy equivalence of 126 GeV.
($1\ \text{eV} = 1{\cdot}6 \times 10^{-19}\ \text{J}$)

(i) Show that the mass of the Higgs boson is $2{\cdot}2 \times 10^{-25}$ kg. **3**

Space for working and answer

(ii) Compare the mass of the Higgs boson with the mass of a proton in terms of orders of magnitude. **2**

Space for working and answer

[Turn over

* X 7 5 7 7 6 0 1 1 7 *

MARKS DO NOT WRITE IN THIS MARGIN

7. The use of analogies from everyday life can help better understanding of physics concepts. Throwing different balls at a coconut shy to dislodge a coconut is an analogy which can help understanding of the photoelectric effect.

Use your knowledge of physics to comment on this analogy. **3**

[Turn over for Question 8 on *Page twenty*

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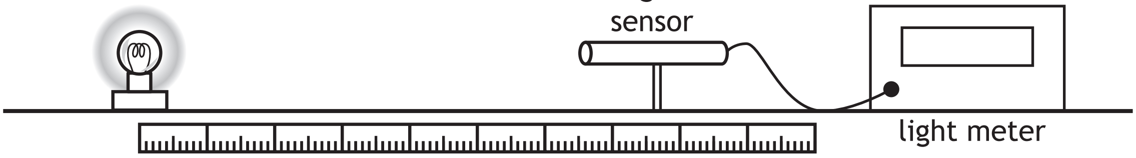
8. A student investigates how irradiance I varies with distance d from a point source of light.



The distance between a small lamp and a light sensor is measured with a metre stick. The irradiance is measured with a light meter.

The apparatus is set up as shown in a darkened laboratory.

The following results are obtained.

d (m)	0·20	0·30	0·40	0·50
I (W m^{-2})	134·0	60·5	33·6	21·8

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

(b) Use **all** the data to establish the relationship between irradiance I and distance d. **3**

MARKS DO NOT WRITE IN THIS MARGIN

8. (continued)

(c) The lamp is now moved to a distance of 0·60 m from the light sensor.

Calculate the irradiance of light from the lamp at this distance. **3**

Space for working and answer

(d) Suggest one way in which the experiment could be improved.

You **must** justify your answer. **2**

(e) The student now replaces the lamp with a different small lamp.
The power output of this lamp is 24 W.

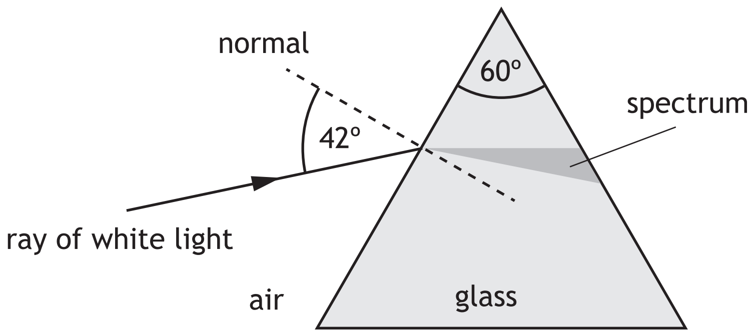
Calculate the irradiance of light from this lamp at a distance of 2·0 m. **4**

Space for working and answer

9. A student carries out two experiments to investigate the spectra produced from a ray of white light.

(a) In the first experiment, a ray of white light is incident on a glass prism as shown.

not to scale



(i) Explain why a spectrum is produced in the glass prism. **1**

(ii) The refractive index of the glass for red light is 1·54.

Calculate the speed of red light in the glass prism. **3**

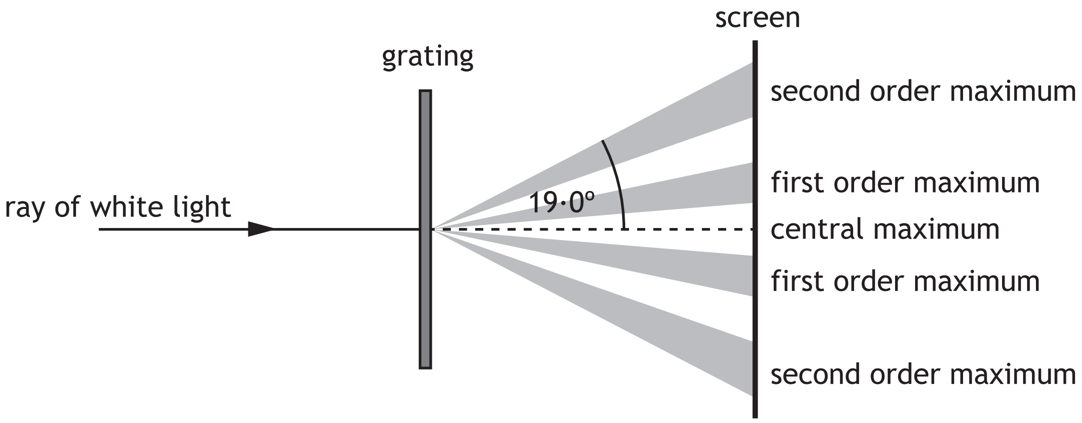
Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

9. (continued)

(b) In the second experiment, a ray of white light is incident on a grating.

not to scale



The angle between the central maximum and the second order maximum for red light is 19·0°.
The frequency of this red light is $4{\cdot}57 \times 10^{14}$ Hz.

(i) Calculate the distance between the slits on this grating. **5**

Space for working and answer

(ii) Explain why the angle to the second order maximum for blue light is different to that for red light. **3**

*X 7 5 7 7 6 0 1 2 3 *

[Turn over

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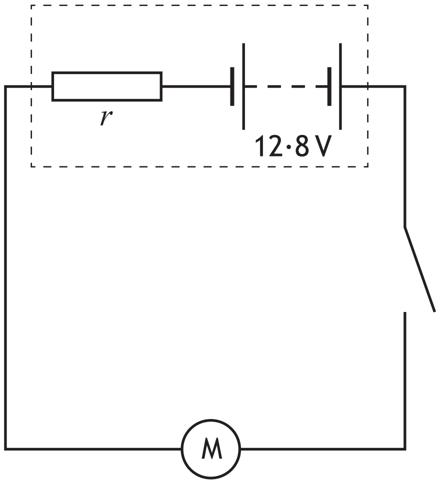
10. A car battery is connected to an electric motor as shown.



The electric motor requires a large current to operate.

(a) The car battery has an e.m.f. of 12·8 V and an internal resistance r of $6{\cdot}0 \times 10^{-3}\,\Omega$. The motor has a resistance of $0{\cdot}050\,\Omega$.

(i) State what is meant by an *e.m.f. of 12·8 V*. **1**

(ii) Calculate the current in the circuit when the motor is operating. **3**

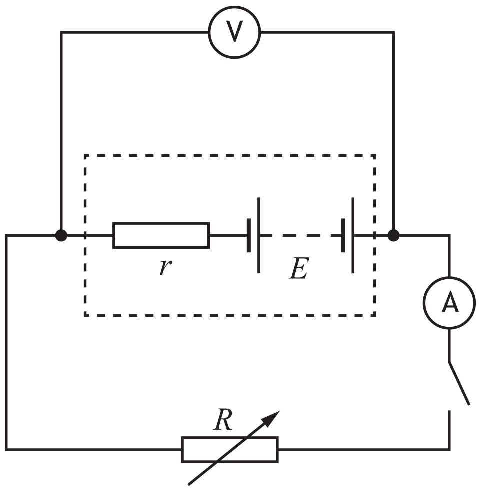
Space for working and answer

(iii) Suggest why the connecting wires used in this circuit have a large diameter. **1**

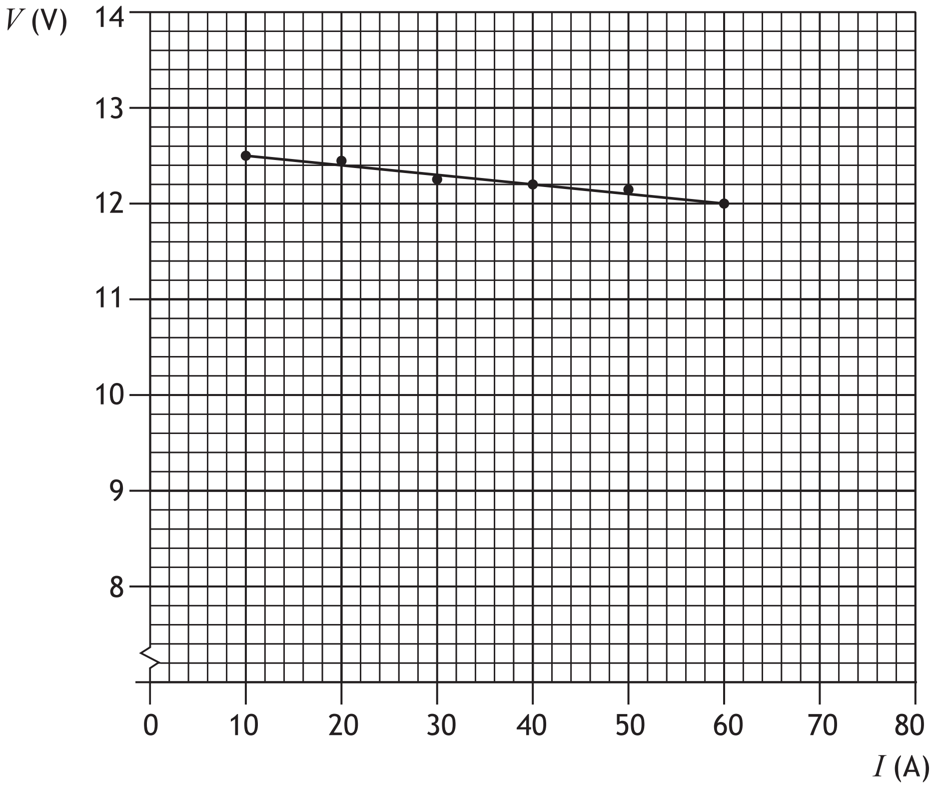
MARKS | DO NOT WRITE IN THIS MARGIN

10. (continued)

(b) A technician sets up the following circuit with a different car battery connected to a variable resistor R.



Readings of current I and terminal potential difference V from this circuit are used to produce the following graph.



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10. (b) (continued)

Use information from the graph to determine:

(i) the e.m.f. of the battery; **1**

Space for working and answer

(ii) the internal resistance of the battery; **3**

Space for working and answer

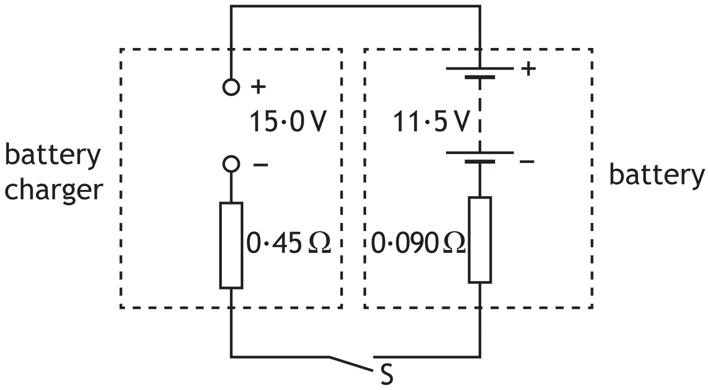
[Turn over

MARKS DO NOT WRITE IN THIS MARGIN

10. (b) (continued)

(iii) After being used for some time the e.m.f. of the battery decreases to 11·5 V and the internal resistance increases to 0·090 Ω.

The battery is connected to a battery charger of constant e.m.f. 15·0 V and internal resistance of 0·45 Ω as shown.



(A) Switch S is closed.

Calculate the initial charging current. 3

Space for working and answer

(B) Explain why the charging current decreases as the battery charges. 2

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[Turn over for Question 11 on *Page thirty*

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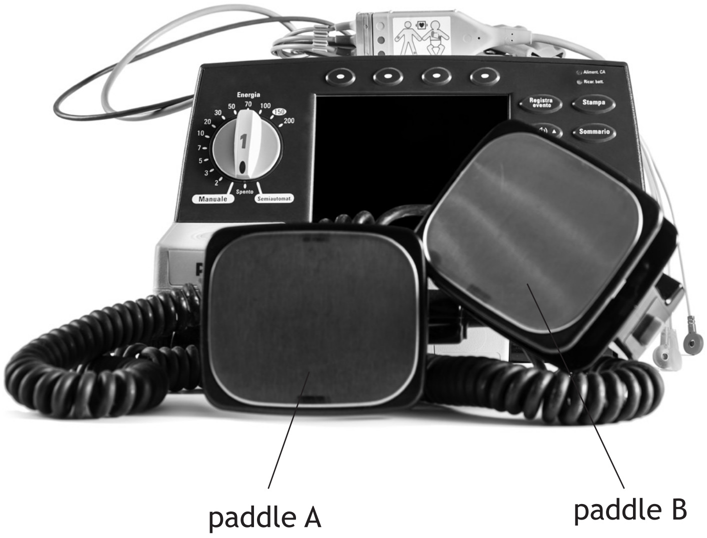
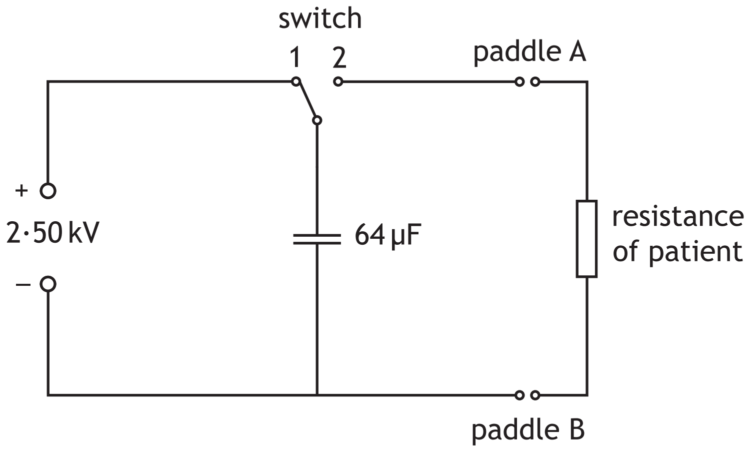
11. A defibrillator is a device that provides a high energy electrical impulse to correct abnormal heart beats.



The diagram shows a simplified version of a defibrillator circuit.



The switch is set to position 1 and the capacitor charges.

(a) Show the charge on the capacitor when it is fully charged is 0·16 C. **2**

Space for working and answer

11. (continued) **MARKS** DO NOT WRITE IN THIS MARGIN

(b) Calculate the maximum energy stored by the capacitor. **3**

Space for working and answer

(c) To provide the electrical impulse required the capacitor is discharged through the person's chest using the paddles as shown

The initial discharge current through the person is 35·0 A.

(i) Calculate the effective resistance of the part of the person's body between the paddles. **3**

Space for working and answer

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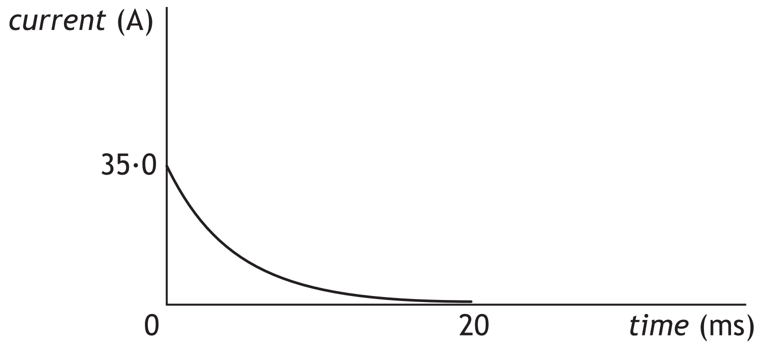
MARKS | DO NOT WRITE IN THIS MARGIN

11. (c) (continued)

(ii) The graph shows how the current between the paddles varies with time during the discharge of the capacitor.



The effective resistance of the person remains the same during this time.

Explain why the current decreases with time. **1**

(iii) The defibrillator is used on a different person with larger effective resistance. The capacitor is again charged to 2·50 kV.

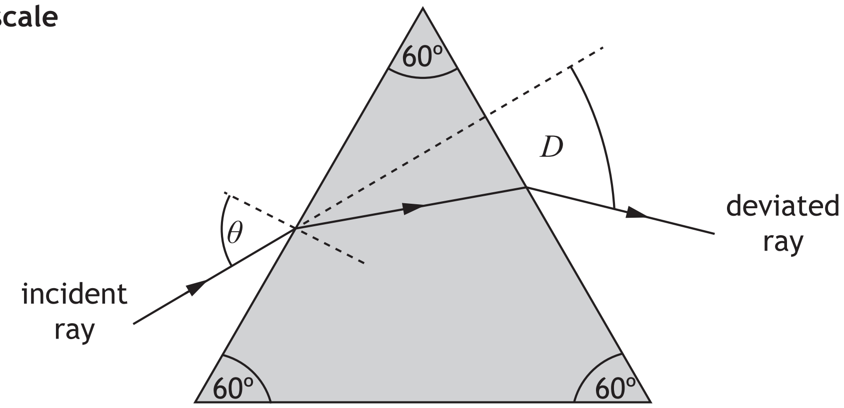
On the graph in (c)(ii) add a line to show how the current in this person varies with time.

(An additional graph, if required, can be found on *Page thirty-eight*). **2**

12. A student carries out an investigation to determine the refractive index of a prism.

A ray of monochromatic light passes through the prism as shown.

not to scale



The angle of deviation D is the angle between the direction of the incident ray and the deviated ray.

The student varies the angle of incidence θ and measures the corresponding angles of deviation D.

The results are shown in the table.

Angle of incidence θ (°)	*Angle of deviation* D (°)
30·0	47·0
40·0	38·1
50·0	37·5
60·0	38·8
70·0	42·5

(a) Using the square-ruled paper on *Page thirty-five*, draw a graph of D against θ. **3**

(b) Using your graph state the two values of θ that produce an angle of deviation of 41·0°. **1**

(c) Using your graph give an estimate of the minimum angle of deviation D_m. **1**

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12. (continued)

(d) The refractive index n of the prism can be determined using the relationship.

$$n\sin\left(\frac{A}{2}\right)=\sin\left(\frac{A+D_m}{2}\right)$$

where A is the angle at the top of the prism, and
D_m is the minimum angle of deviation.

Use this relationship and your answer to (c) to determine the refractive index of the prism. **2**

Space for working and answer

(e) Using the same apparatus, the student now wishes to determine more precisely the minimum angle of deviation.

Suggest two improvements to the experimental procedure that would achieve this. **2**

[END OF QUESTION PAPER]

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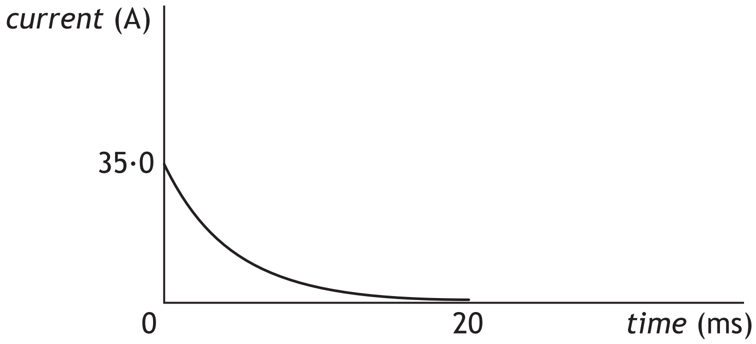
ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

Additional graph for Question 11 (c)(iii)



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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ACKNOWLEDGEMENT

Section 2, Question 7 – daseaford/shutterstock.com

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