National
Qualifications
2017

X757/76/02

Physics
Section 1 — Questions

WEDNESDAY, 17 MAY

9:00 AM – 11:30 AM

Instructions for the completion of Section 1 are given on *Page 02* of your question and answer booklet X757/76/01.

Record your answers on the answer grid on *Page 03* of your question and answer booklet.

Reference may be made to the Data Sheet on *Page 02* of this booklet and to the Relationships Sheet X757/76/11.

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

DATA SHEET

COMMON PHYSICAL QUANTITIES

Quantity	*Symbol*	*Value*	*Quantity*	*Symbol*	*Value*
Speed of light in vacuum	c	$3{\cdot}00 \times 10^{8}\ \text{m s}^{-1}$	Planck's constant	h	$6{\cdot}63 \times 10^{-34}\ \text{J s}$
Magnitude of the charge on an electron	e	$1{\cdot}60 \times 10^{-19}\ \text{C}$	Mass of electron	m_e	$9{\cdot}11 \times 10^{-31}\ \text{kg}$
Universal Constant of Gravitation	G	$6{\cdot}67 \times 10^{-11}\ \text{m}^3\ \text{kg}^{-1}\ \text{s}^{-2}$	Mass of neutron	m_n	$1{\cdot}675 \times 10^{-27}\ \text{kg}$
Gravitational acceleration on Earth	g	$9{\cdot}8\ \text{m s}^{-2}$	Mass of proton	m_p	$1{\cdot}673 \times 10^{-27}\ \text{kg}$
Hubble's constant	H_0	$2{\cdot}3 \times 10^{-18}\ \text{s}^{-1}$			

REFRACTIVE INDICES

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

Substance	*Refractive index*	*Substance*	*Refractive index*
Diamond	2·42	Water	1·33
Crown glass	1·50	Air	1·00

SPECTRAL LINES

Element	*Wavelength*/nm	*Colour*
Hydrogen	656	Red
	486	Blue-green
	434	Blue-violet
	410	Violet
	397	Ultraviolet
	389	Ultraviolet
Sodium	589	Yellow

Element	*Wavelength*/nm	*Colour*
Cadmium	644	Red
	509	Green
	480	Blue

Lasers

Element	*Wavelength*/nm	*Colour*
Carbon dioxide	9550 }	Infrared
	10590 }	
Helium-neon	633	Red

PROPERTIES OF SELECTED MATERIALS

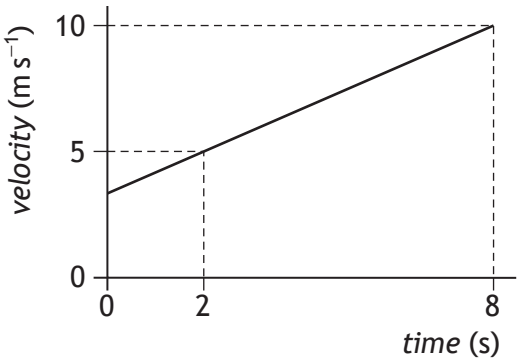
Substance	*Density*/kg m^{-3}	*Melting Point*/K	*Boiling Point*/K
Aluminium	$2{\cdot}70 \times 10^{3}$	933	2623
Copper	$8{\cdot}96 \times 10^{3}$	1357	2853
Ice	$9{\cdot}20 \times 10^{2}$	273	. . . .
Sea Water	$1{\cdot}02 \times 10^{3}$	264	377
Water	$1{\cdot}00 \times 10^{3}$	273	373
Air	1·29	. . . .	. . . .
Hydrogen	$9{\cdot}0 \times 10^{-2}$	14	20

The gas densities refer to a temperature of 273 K and a pressure of $1{\cdot}01 \times 10^{5}$ Pa.

SECTION 1 — 20 marks

Attempt ALL questions

1. The graph shows how the velocity of an object varies with time.



The acceleration of the object is

A $0{\cdot}83\,m\,s^{-2}$

B $1{\cdot}2\,m\,s^{-2}$

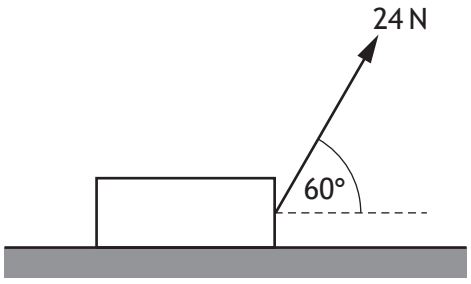
C $2{\cdot}5\,m\,s^{-2}$

D $5{\cdot}0\,m\,s^{-2}$

E $6{\cdot}0\,m\,s^{-2}$.

2. A block is resting on a horizontal surface.

A force of 24 N is now applied as shown and the block slides along the surface.



The mass of the block is 20 kg.

The acceleration of the block is $0{\cdot}20\,m\,s^{-2}$.

The force of friction acting on the block is

A 4·0 N

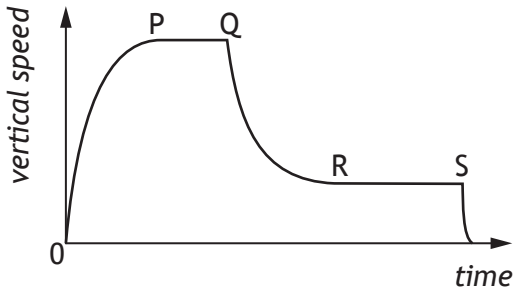
B 8·0 N

C 12 N

D 16 N

E 25 N.

3. The graph shows how the vertical speed of a skydiver varies with time.



A student uses information from the graph to make the following statements.

I The acceleration of the skydiver is greatest between P and Q.

II The air resistance acting on the skydiver between Q and R is less than the weight of the skydiver.

III The forces acting on the skydiver are balanced between R and S.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and II only

E I , II and III

4. A spacecraft is travelling at a constant speed of $2{\cdot}75 \times 10^8\,\text{m}\,\text{s}^{-1}$ relative to a planet.

A technician on the spacecraft measures the length of the spacecraft as 125 m.

An observer on the planet measures the length of the spacecraft as

A 36 m

B 50 m

C 124 m

D 314 m

E 433 m.

5. A galaxy has a recessional velocity of $0{\cdot}30c$.

Hubble's Law predicts that the distance between Earth and this galaxy is

A $1{\cdot}3 \times 10^{17}$ m

B $3{\cdot}9 \times 10^{25}$ m

C $1{\cdot}3 \times 10^{26}$ m

D $1{\cdot}4 \times 10^{41}$ m

E $4{\cdot}5 \times 10^{42}$ m.

6. Measurements of the expansion rate of the Universe lead to the conclusion that the rate of expansion is increasing.

Present theory proposes that this is due to

A redshift

B dark matter

C dark energy

D the gravitational force

E cosmic microwave background radiation.

7. A student makes the following statements about the radiation emitted by stellar objects.

I Stellar objects emit radiation over a wide range of frequencies.

II The peak wavelength of radiation is longer for hotter objects than for cooler objects.

III At all frequencies, hotter objects emit more radiation per unit surface area per unit time than cooler objects.

Which of these statements is/are correct?

A I only

B III only

C I and II only

D I and III only

E I, II and III

[Turn over

8. The following statement represents a nuclear reaction.

$$^{256}_{103}\mathrm{Lr} \rightarrow \mathrm{Z} + {}^{4}_{2}\mathrm{He}$$

Nucleus Z is

A $^{252}_{101}\mathrm{Md}$

B $^{252}_{101}\mathrm{No}$

C $^{256}_{101}\mathrm{Md}$

D $^{260}_{105}\mathrm{Db}$

E $^{252}_{103}\mathrm{Lr}$.

9. Radiation is incident on a clean zinc plate causing photoelectrons to be emitted.

The source of radiation is replaced with one emitting radiation of a higher frequency.

The irradiance of the radiation incident on the plate remains unchanged.

Which row in the table shows the effect of this change on the maximum kinetic energy of a photoelectron and the number of photoelectrons emitted per second?

	Maximum kinetic energy of a photoelectron	*Number of photoelectrons emitted per second*
A	no change	no change
B	no change	increases
C	increases	no change
D	increases	decreases
E	decreases	increases

10. Ultraviolet radiation of frequency $7{\cdot}70 \times 10^{14}$ Hz is incident on the surface of a metal.

Photoelectrons are emitted from the surface of the metal.

The maximum kinetic energy of an emitted photoelectron is $2{\cdot}67 \times 10^{-19}$ J.

The work function of the metal is

A $1{\cdot}07 \times 10^{-19}$ J

B $2{\cdot}44 \times 10^{-19}$ J

C $2{\cdot}67 \times 10^{-19}$ J

D $5{\cdot}11 \times 10^{-19}$ J

E $7{\cdot}78 \times 10^{-19}$ J.

11. A student makes the following statements about waves from coherent sources.

I Waves from coherent sources have the same velocity.

II Waves from coherent sources have the same wavelength.

III Waves from coherent sources have a constant phase relationship.

Which of these statements is/are correct?

A I only

B II only

C I and II only

D I and III only

E I, II and III

[Turn over

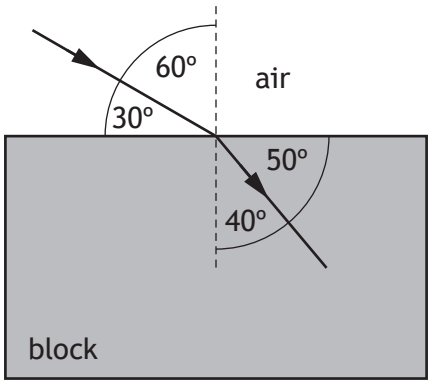
12. A ray of red light passes from a liquid to a transparent solid.

The solid and the liquid have the same refractive index for this light.

Which row in the table shows what happens to the speed and wavelength of the light as it passes from the liquid into the solid?

	Speed	*Wavelength*
A	decreases	decreases
B	decreases	increases
C	no change	increases
D	increases	no change
E	no change	no change

13. A ray of blue light passes from air into a transparent block as shown.



The speed of this light in the block is

A $1{\cdot}80 \times 10^8\ \text{m s}^{-1}$

B $1{\cdot}96 \times 10^8\ \text{m s}^{-1}$

C $2{\cdot}00 \times 10^8\ \text{m s}^{-1}$

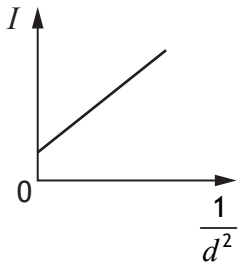
D $2{\cdot}23 \times 10^8\ \text{m s}^{-1}$

E $2{\cdot}65 \times 10^8\ \text{m s}^{-1}$.

14. A student carries out an experiment to investigate how irradiance varies with distance.

A small lamp is placed at a distance d away from a light meter. The irradiance I at this distance is displayed on the meter. This measurement is repeated for a range of different distances.

The student uses these results to produce the graph shown.



The graph indicates that there is a systematic uncertainty in this experiment.

Which of the following would be most likely to reduce the systematic uncertainty in this experiment?

A Repeating the readings and calculating mean values.

B Replacing the small lamp with a larger lamp.

C Decreasing the brightness of the lamp.

D Repeating the experiment in a darkened room.

E Increasing the range of distances.

15. A point source of light is 8·00 m away from a surface. The irradiance, due to the point source, at the surface is 50·0 mW m^{-2}. The point source is now moved to a distance of 12·0 m from the surface.

The irradiance, due to the point source, at the surface is now

A 22·2 mW m^{-2}

B 26·0 mW m^{-2}

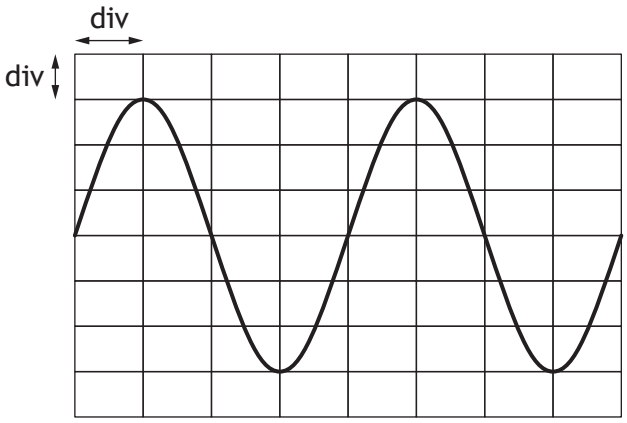
C 33·3 mW m^{-2}

D 75·0 mW m^{-2}

E 267 mW m^{-2}.

[Turn over

16. The output from an a.c. power supply is connected to an oscilloscope. The trace seen on the oscilloscope screen is shown.



The Y-gain setting on the oscilloscope is 1·0 V/div.

The r.m.s. voltage of the power supply is

A 2·1 V

B 3·0 V

C 4·0 V

D 4·2 V

E 6·0 V.

17. A 20 μF capacitor is connected to a 12 V d.c. supply.

The maximum charge stored on the capacitor is

A $1{\cdot}4 \times 10^{-3}$ C

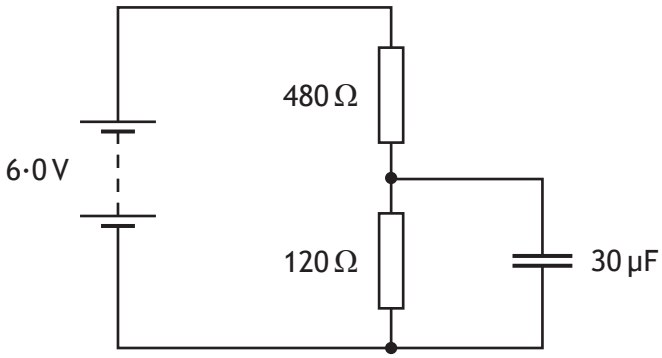
B $2{\cdot}4 \times 10^{-4}$ C

C $1{\cdot}4 \times 10^{-4}$ C

D $1{\cdot}7 \times 10^{-6}$ C

E $6{\cdot}0 \times 10^{-7}$ C.

18. A circuit containing a capacitor is set up as shown.



The supply has negligible internal resistance.

The maximum energy stored in the capacitor is

A $5{\cdot}4 \times 10^{-4}$ J

B $3{\cdot}5 \times 10^{-4}$ J

C $1{\cdot}4 \times 10^{-4}$ J

D $3{\cdot}4 \times 10^{-5}$ J

E $2{\cdot}2 \times 10^{-5}$ J.

19. A student makes the following statements about conductors, insulators and semiconductors.

I In conductors, the conduction band is completely filled with electrons.

II In insulators, the gap between the valence band and the conduction band is large.

III In semiconductors, increasing the temperature increases the conductivity.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

[Turn over for next question

20. Astronomers use the following relationship to determine the distance, d, to a star.

$$F = \frac{L}{4\pi d^2}$$

For a particular star the following measurements are recorded:

apparent brightness, $F = 4{\cdot}4 \times 10^{-10}\,\text{W m}^{-2}$

luminosity, $L = 6{\cdot}1 \times 10^{30}\,\text{W}$

Based on this information, the distance to this star is

A $3{\cdot}3 \times 10^{19}\,\text{m}$

B $1{\cdot}5 \times 10^{21}\,\text{m}$

C $3{\cdot}7 \times 10^{36}\,\text{m}$

D $1{\cdot}1 \times 10^{39}\,\text{m}$

E $3{\cdot}9 \times 10^{39}\,\text{m}$.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

FOR OFFICIAL USE

National Qualifications 2017

Mark

X757/76/01

Physics
Section 1 — Answer Grid and Section 2

WEDNESDAY, 17 MAY
9:00 AM – 11:30 AM

X7577601

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 02*.

SECTION 2 — 110 marks
Attempt ALL questions.

Reference may be made to the Data Sheet on *Page 02* 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.

SQA ©

X7577601 01

SECTION 1 — 20 marks

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 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

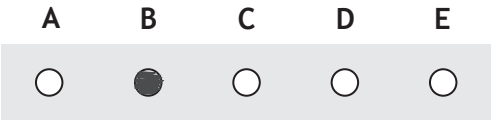
B kilowatt-hour

C watt

D coulomb

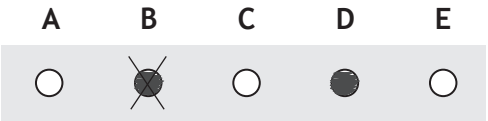
E volt.

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

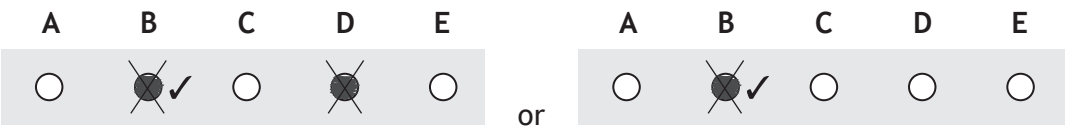


Changing an answer

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:



SECTION 1 — Answer Grid

0BJ20AE1

	A	B	C	D	E
1	○	○	○	○	○
2	○	○	○	○	○
3	○	○	○	○	○
4	○	○	○	○	○
5	○	○	○	○	○
6	○	○	○	○	○
7	○	○	○	○	○
8	○	○	○	○	○
9	○	○	○	○	○
10	○	○	○	○	○
11	○	○	○	○	○
12	○	○	○	○	○
13	○	○	○	○	○
14	○	○	○	○	○
15	○	○	○	○	○
16	○	○	○	○	○
17	○	○	○	○	○
18	○	○	○	○	○
19	○	○	○	○	○
20	○	○	○	○	○

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[Turn over for SECTION 2

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SECTION 2 — 110 marks

Attempt ALL questions

1. A student is on a stationary train.

The train now accelerates along a straight level track.

The student uses an app on a phone to measure the acceleration of the train.

(a) The train accelerates uniformly at $0{\cdot}32\ m\ s^{-2}$ for 25 seconds.

(i) State what is meant by *an acceleration of $0{\cdot}32\ m\ s^{-2}$*. **1**

(ii) Calculate the distance travelled by the train in the 25 seconds. **3**

Space for working and answer

MARKS

DO NOT WRITE IN THIS MARGIN

(b) Later in the journey, the train is travelling at a constant speed as it approaches a bridge.

A horn on the train emits sound of frequency 270 Hz.

The frequency of the sound heard by a person standing on the bridge is 290 Hz.

The speed of sound in air is 340 m s^{-1}.

(i) Calculate the speed of the train. **3**

Space for working and answer

(ii) The train continues to sound its horn as it passes under the bridge.

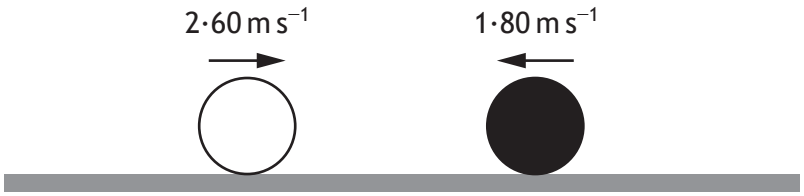
Explain why the frequency of the sound heard by the person standing on the bridge decreases as the train passes under the bridge and then moves away.

You may wish to use a diagram. **1**

2. A white snooker ball and a black snooker ball travel towards each other in a straight line.

The white ball and the black ball each have a mass of 0·180 kg.

Just before the balls collide head-on, the white ball is travelling at $2{\cdot}60\,m\,s^{-1}$ to the right and the black ball is travelling at $1{\cdot}80\,m\,s^{-1}$ to the left.



After the collision, the black ball rebounds with a velocity of $2{\cdot}38\,m\,s^{-1}$ to the right.

(a) (i) Determine the velocity of the white ball immediately after the collision. **3**

Space for working and answer

(ii) The collision between the balls is inelastic.

State what is meant by an *inelastic collision*. **1**

MARKS

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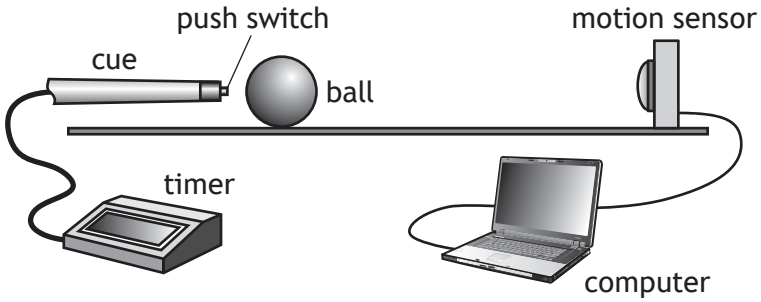
(b) A student carries out an experiment to measure the average force exerted by a cue on a ball.



The cue hits the stationary ball.

The timer records the time the cue is in contact with the ball.

The computer displays the speed of the ball.

The results are shown.

Time of contact between the cue and the ball = $(0{\cdot}040 \pm 0{\cdot}001)$ s

Speed of the ball immediately after contact = $(0{\cdot}84 \pm 0{\cdot}01)$ m s^{-1}

Mass of the ball = $(0{\cdot}180 \pm 0{\cdot}001)$ kg

(i) Calculate the average force exerted on the ball by the cue. An uncertainty in this value is not required. **3**

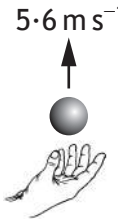
Space for working and answer

(ii) Determine the percentage uncertainty in the value for the average force on the ball. **2**

Space for working and answer

3. A ball is thrown vertically upwards.

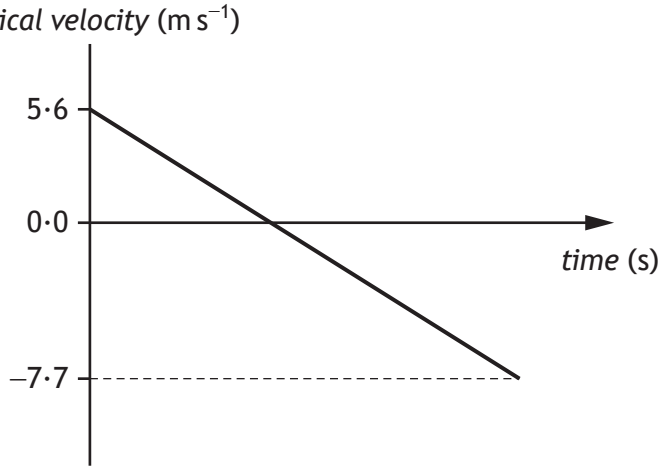
The ball is above the ground when released.



not to scale

ground

The graph shows how the vertical velocity of the ball varies with time from the instant it is released until just before it hits the ground.



The effects of air resistance can be ignored.

(a) (i) Calculate the time taken for the ball to reach its maximum height. **3**

Space for working and answer

3. (a) (continued)

(ii) Calculate the distance the ball falls from its maximum height to the ground. **3**

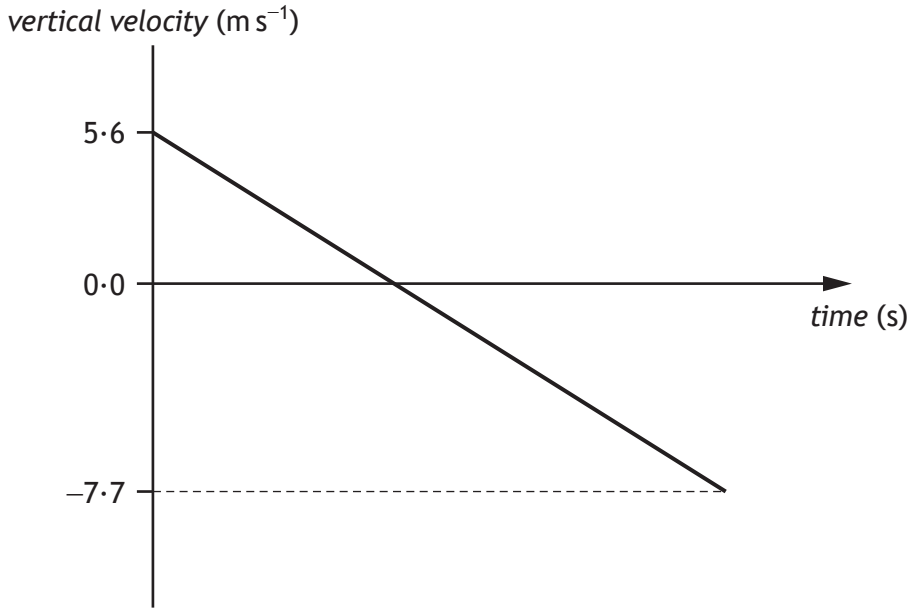
Space for working and answer

(b) The ball is now thrown vertically upwards from the same height with a greater initial vertical velocity.

Add a line to the graph below to show how the vertical velocity of the ball varies with time from the instant it is released until just before it hits the ground.

The effects of air resistance can be ignored.

Additional numerical values on the axes are not required. **3**



(An additional graph, if required, can be found on *Page 39*.)

4. Some motorways have variable speed limits, with overhead information boards displaying the maximum speed allowed. This system is designed to keep the traffic flowing and to avoid congestion.

In this system, the flow of traffic is observed and the maximum speed to be displayed is determined using

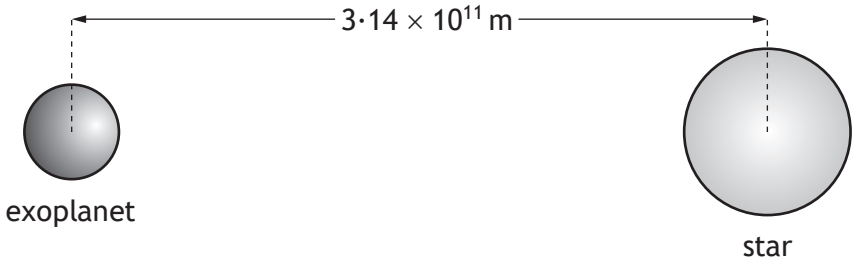
$$speed = frequency \times wavelength$$

Use your knowledge of physics to comment on this system for determining the maximum speed to be displayed. **3**

4. (continued)

5. Planets outside our solar system are called exoplanets.

An exoplanet of mass $5{\cdot}69 \times 10^{27}$ kg orbits a star of mass $3{\cdot}83 \times 10^{30}$ kg.



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(a) (i) Compare the mass of the star with the mass of the exoplanet in terms of orders of magnitude. **2**

Space for working and answer

(ii) The distance between the exoplanet and the star is $3{\cdot}14 \times 10^{11}$ m.

Calculate the gravitational force between the star and the exoplanet. **3**

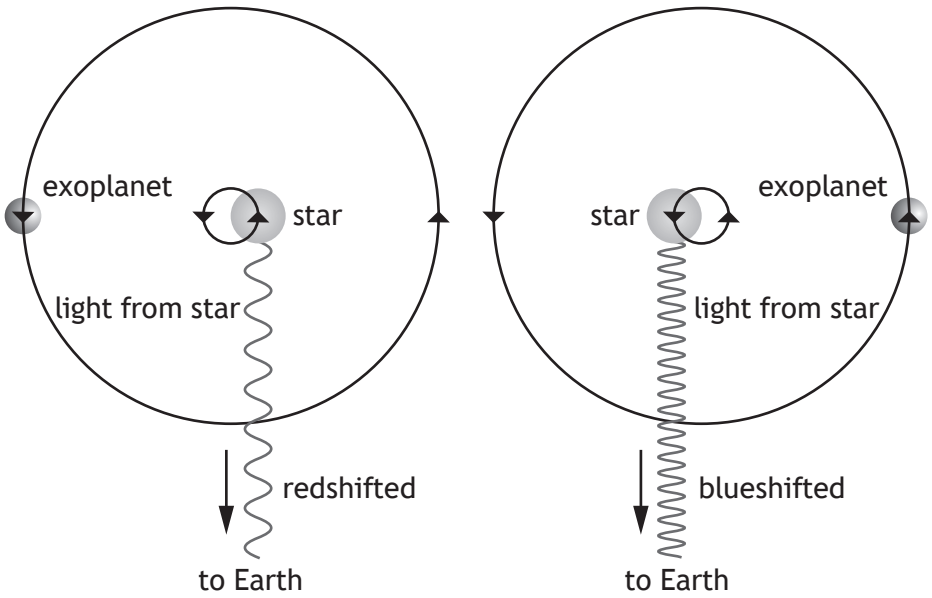
Space for working and answer

5. (continued)

(b) The gravitational force between the star and the exoplanet causes the star to follow a circular path as the exoplanet orbits the star. Small differences in the wavelength of the light from the star are observed on Earth.

Light from the star is redshifted when the star moves away from the Earth and blueshifted when the star moves towards the Earth.

not to scale



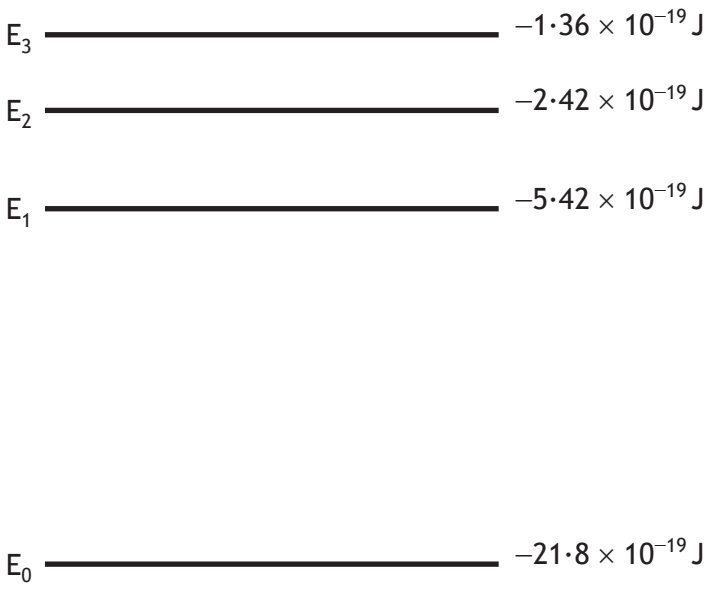
(i) Calculate the redshift of light from the star observed on Earth when the star is moving away from the Earth at $6{\cdot}60 \times 10^3\ m\ s^{-1}$. **3**

Space for working and answer

(ii) For an exoplanet of greater mass at the same distance from the star, suggest whether the radius of the circular path followed by the star would be greater than, less than, or the same as that for an exoplanet of smaller mass. **1**

6. The visible spectrum of light emitted by a star is observed to contain a number of dark lines. The dark lines occur because certain wavelengths of light are absorbed when light passes through atoms in the star's outer atmosphere.

The diagram shows some of the energy levels for a hydrogen atom.



(a) For the energy levels shown in the diagram, identify the electron transition that would lead to the absorption of a photon with the highest frequency. **1**

(b) An electron makes the transition from energy level E_1 to E_3.

Determine the frequency of the photon absorbed. **3**

Space for working and answer

[Turn over for next question

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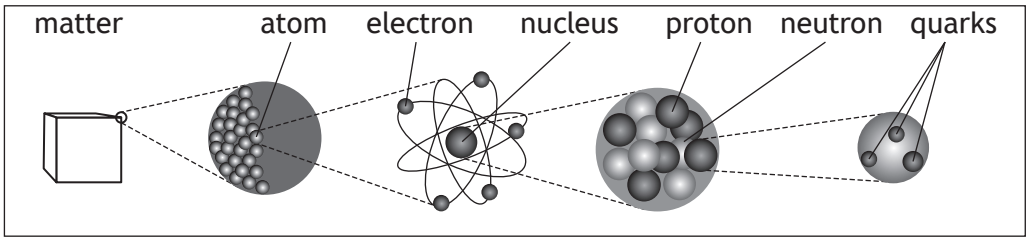
7. The following diagram gives information on the Standard Model of fundamental particles.



(a) Explain why the proton and the neutron are **not** fundamental particles. **1**

(b) An extract from a data book contains the following information about three types of sigma (Σ) particles. Sigma particles are made up of three quarks.

Particle	*Symbol*	*Quark Content*	*Charge*	*Mean lifetime* (s)
sigma plus	Σ^+	up up strange	$+1e$	$8{\cdot}0 \times 10^{-11}$
neutral sigma	Σ^0	up down strange	0	$7{\cdot}4 \times 10^{-20}$
sigma minus	Σ^-	down down strange	$-1e$	$1{\cdot}5 \times 10^{-10}$

(i) A student makes the following statement.

All baryons are hadrons, but not all hadrons are baryons.

Explain why this statement is correct. **2**

(ii) The charge on an up quark is $+\frac{2}{3}e$.

Determine the charge on a strange quark. **1**

Space for working and answer

7. (continued)

(c) (i) State the name of the force that holds the quarks together in the sigma (Σ) particle. **1**

(ii) State the name of the boson associated with this force. **1**

(d) Sigma minus (Σ^-) particles have a mean lifetime of $1{\cdot}5 \times 10^{-10}$ s in their frame of reference.

Σ^- are produced in a particle accelerator and travel at a speed of $0{\cdot}9c$ relative to a stationary observer.

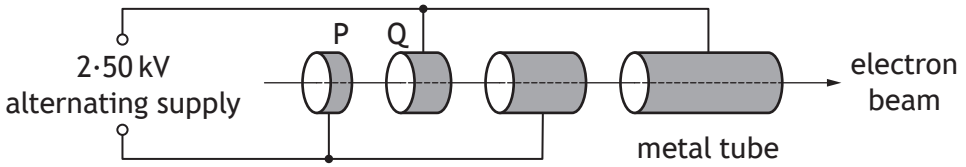
Calculate the mean lifetime of the Σ^- particle as measured by this observer. **3**

Space for working and answer

8. X-ray machines are used in hospitals.

An X-ray machine contains a linear accelerator that is used to accelerate electrons towards a metal target.

The linear accelerator consists of hollow metal tubes placed in a vacuum.



Electrons are accelerated across the gaps between the tubes by an alternating supply.

(a) (i) Calculate the work done on an electron as it accelerates from P to Q. **3**

Space for working and answer

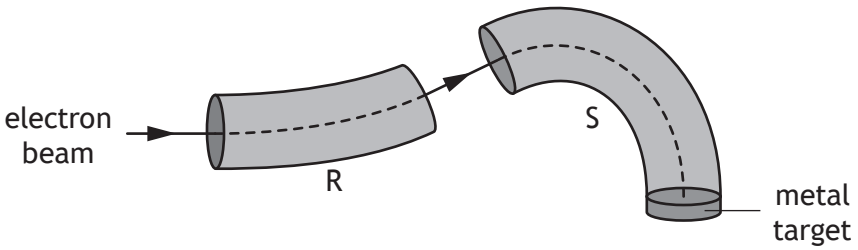
(ii) Explain why an alternating supply is used in the linear accelerator. **1**

8. (continued)

(b) The electron beam is then passed into a "slalom magnet" beam guide. The function of the beam guide is to direct the electrons towards a metal target.

Inside the beam guides R and S, two different magnetic fields act on the electrons.

Electrons strike the metal target to produce high energy photons of radiation.



(i) Determine the direction of the magnetic field inside beam guide R. **1**

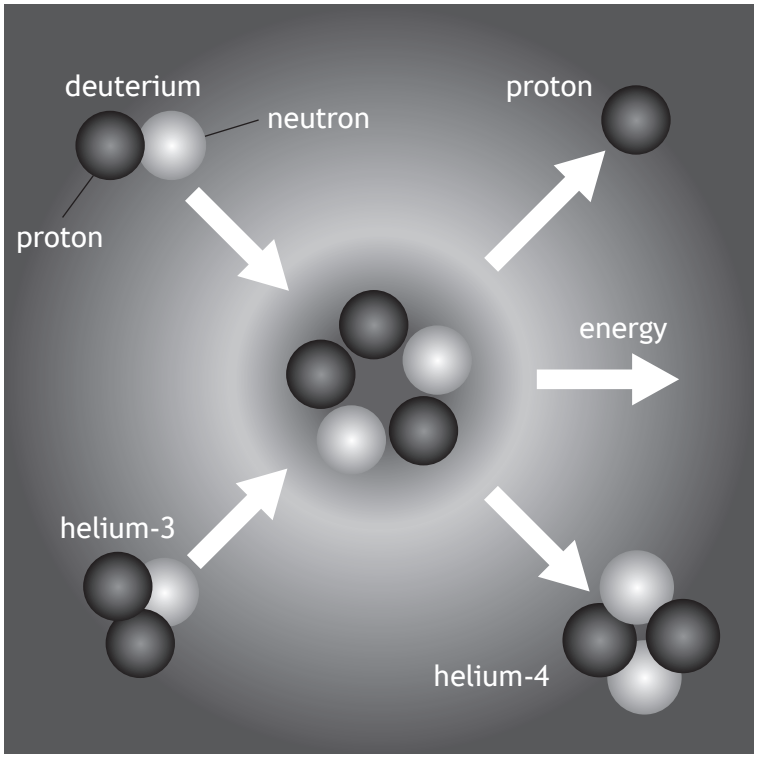
(ii) State **two** differences between the magnetic fields inside beam guides R and S. **2**

(c) Calculate the minimum speed of an electron that will produce a photon of energy $4{\cdot}16 \times 10^{-17}$ J. **3**

Space for working and answer

9. A diagram from a 'How Things Work' website contains information about a nuclear fusion reaction.

Reaction of helium-3 with deuterium



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

9. (continued)

(b) The following statement represents this fusion reaction.

$$^{3}_{2}\text{He} + {}^{2}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + {}^{1}_{1}\text{p}$$

The mass of the particles involved in the reaction are shown in the table.

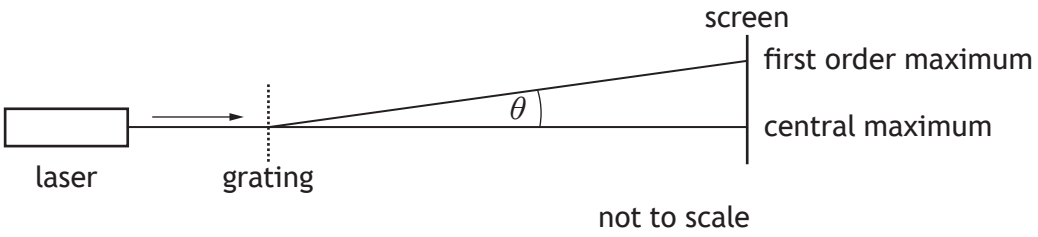
Particle	*Mass* (kg)
$^{3}_{2}\text{He}$	$5{\cdot}008 \times 10^{-27}$
$^{2}_{1}\text{H}$	$3{\cdot}344 \times 10^{-27}$
$^{4}_{2}\text{He}$	$6{\cdot}646 \times 10^{-27}$
$^{1}_{1}\text{p}$	$1{\cdot}673 \times 10^{-27}$

(i) Explain why energy is released in this reaction. **1**

(ii) Determine the energy released in this reaction. **4**

Space for working and answer

10. An experiment is carried out to determine the wavelength of light from a laser.



not to scale

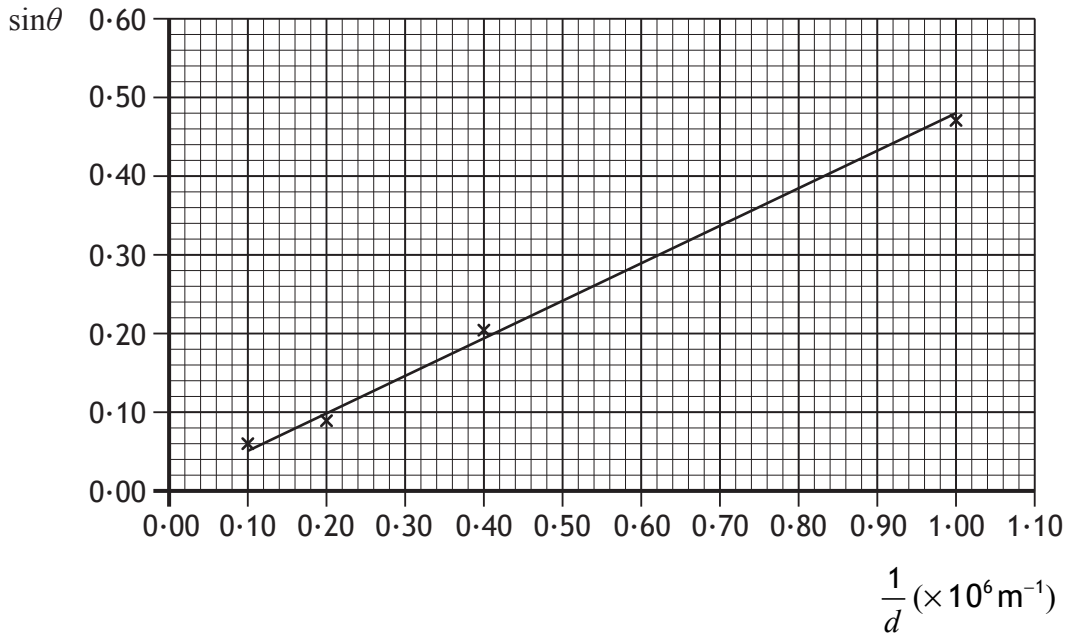
(a) Explain, in terms of waves, how a maximum is formed. **1**

(b) The experiment is carried out with four gratings.

The separation of the slits d is different for each grating.

The angle between the central maximum and the first order maximum θ, produced by each grating, is measured.

The results are used to produce a graph of $\sin\theta$ against $\frac{1}{d}$.



10. (b) (continued)

(i) Determine the wavelength of the light from the laser used in this experiment. **3**

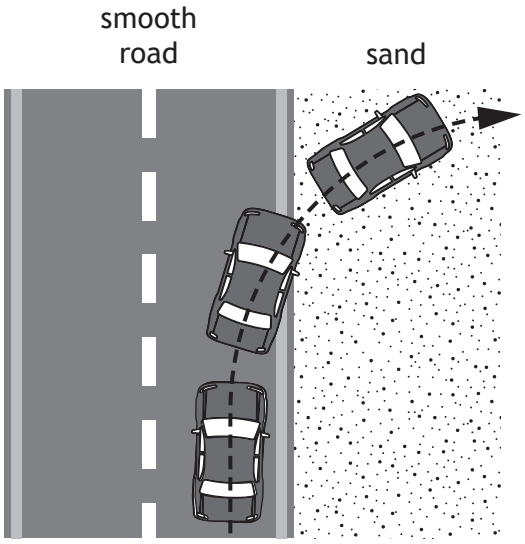
Space for working and answer

(ii) Determine the angle θ produced when a grating with a spacing d of $2{\cdot}0 \times 10^{-6}$ m is used with this laser. **3**

Space for working and answer

(c) Suggest **two** improvements that could be made to the experiment to improve reliability. **2**

11. The use of analogies from everyday life can help better understanding of physics concepts. A car moving from a smooth surface to a rough surface, eg from a road to sand, can be used as an analogy for the refraction of light.



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

[Turn over for next question

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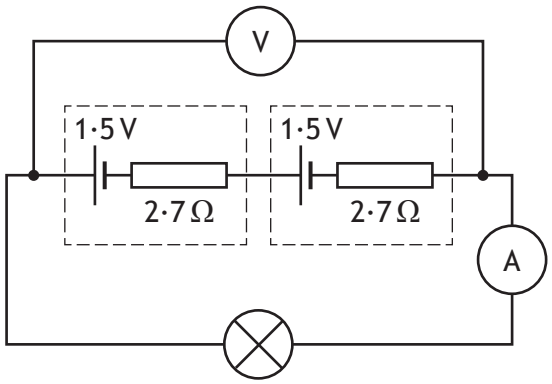
12. A lamp is connected to a battery containing two cells as shown.



The e.m.f. of each cell is 1·5 V and the internal resistance of each cell is 2·7 Ω.
The reading on the ammeter is 64 mA.

(a) State what is meant by *an e.m.f. of 1·5 V.* **1**

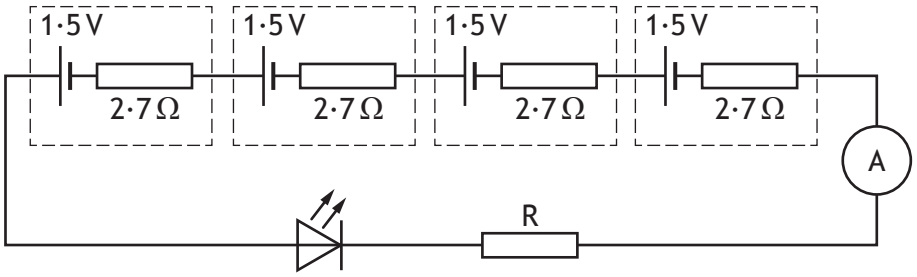
(b) (i) Show that the lost volts in the battery is 0·35 V. **2**
Space for working and answer

(ii) Determine the reading on the voltmeter. **1**
Space for working and answer

(iii) Calculate the power dissipated by the lamp. **3**
Space for working and answer

12. (continued)

(c) In a different circuit, an LED is connected to a battery containing four cells.



The potential difference across the LED is 3·6 V when the current is 26 mA.

Determine the resistance of resistor R. **4**

Space for working and answer

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13. An uncharged 220 μF capacitor is connected in a circuit as shown.

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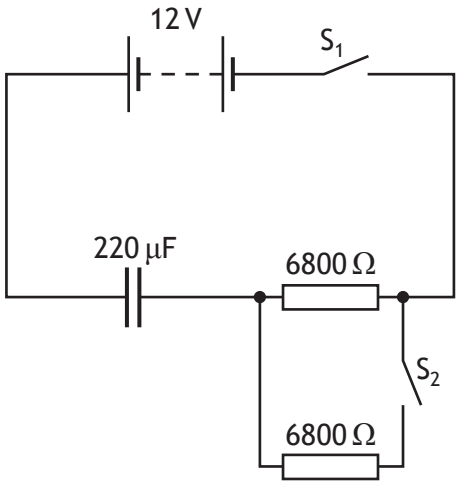


The 12 V battery has negligible internal resistance.

(a) Switch S_1 is closed and the capacitor charges in a time of 7·5 s.

Calculate the initial charging current. **3**

Space for working and answer

(b) Switch S_1 is opened.

The capacitor is discharged.

Switch S_2 is now closed and then switch S_1 is closed.

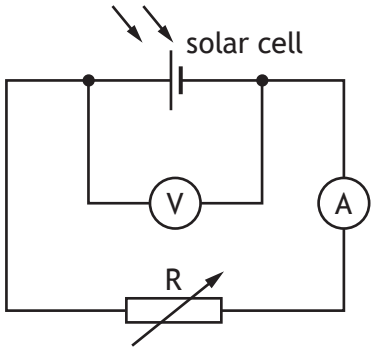
Explain why the time for the capacitor to fully charge is less than in part (a). **2**

14. Solar cells are made by joining n-type and p-type semiconductor materials. A layer is formed at the junction between the materials.

(a) A potential difference is produced when photons enter the layer between the p-type and n-type materials.

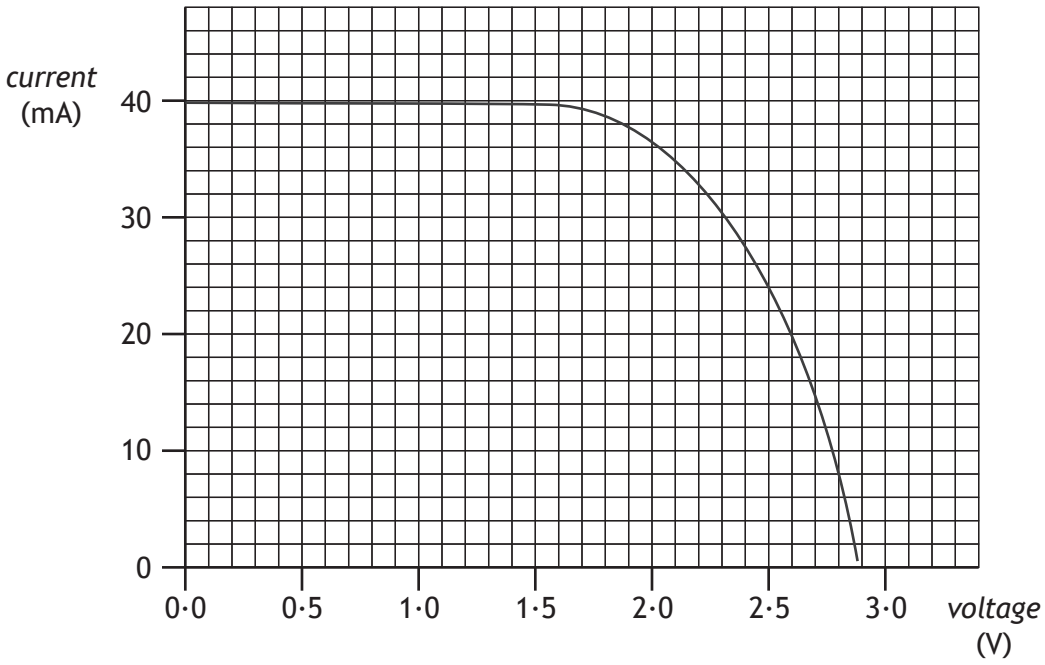
State the name of this effect. **1**

(b) A student carries out an experiment using a solar cell connected to a variable resistor R as shown.



A lamp is placed above the solar cell and switched on.

The variable resistor is altered and readings of current and voltage are taken. These readings are used to produce the following graph.



14. (b) (continued)

(i) Solar cells have a maximum power output for a particular irradiance of light.

In this experiment, the maximum power output occurs when the voltage is 2·1 V.

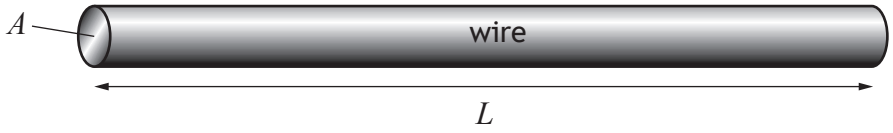
Use information from the graph to estimate a value for the maximum power output from the solar cell. **3**

Space for working and answer

(ii) The lamp is now moved closer to the solar cell.

Explain, in terms of photons, why the maximum output power from the solar cell increases. **1**

15. A wire of length L and cross-sectional area A is shown.



The resistance R of the wire is given by the relationship

$$R = \frac{\rho L}{A}$$

where ρ is the resistivity of the wire in Ω m.

(a) The resistivity of aluminium is $2{\cdot}8 \times 10^{-8}\,\Omega$ m.

Calculate the resistance of an aluminium wire of length 0·82 m and cross-sectional area $4{\cdot}0 \times 10^{-6}$ m^2. **2**

Space for working and answer

15. (continued)

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(b) A student carries out an investigation to determine the resistivity of a cylindrical metal wire of cross-sectional area $4{\cdot}52 \times 10^{-6}\,m^2$.

The student varies the length L of the wire and measures the corresponding resistance R of the wire.

The results are shown in the table.

Length of wire L (m)	*Resistance of wire* R ($\times 10^{-3}\,\Omega$)
1·5	5·6
2·0	7·5
2·5	9·4
3·0	11·2
3·5	13·2

(i) Using the square-ruled paper on *Page 36*, draw a graph of R against L. **3**

(ii) Calculate the gradient of your graph. **2**

Space for working and answer

(iii) Determine the resistivity of the metal wire. **3**

Space for working and answer

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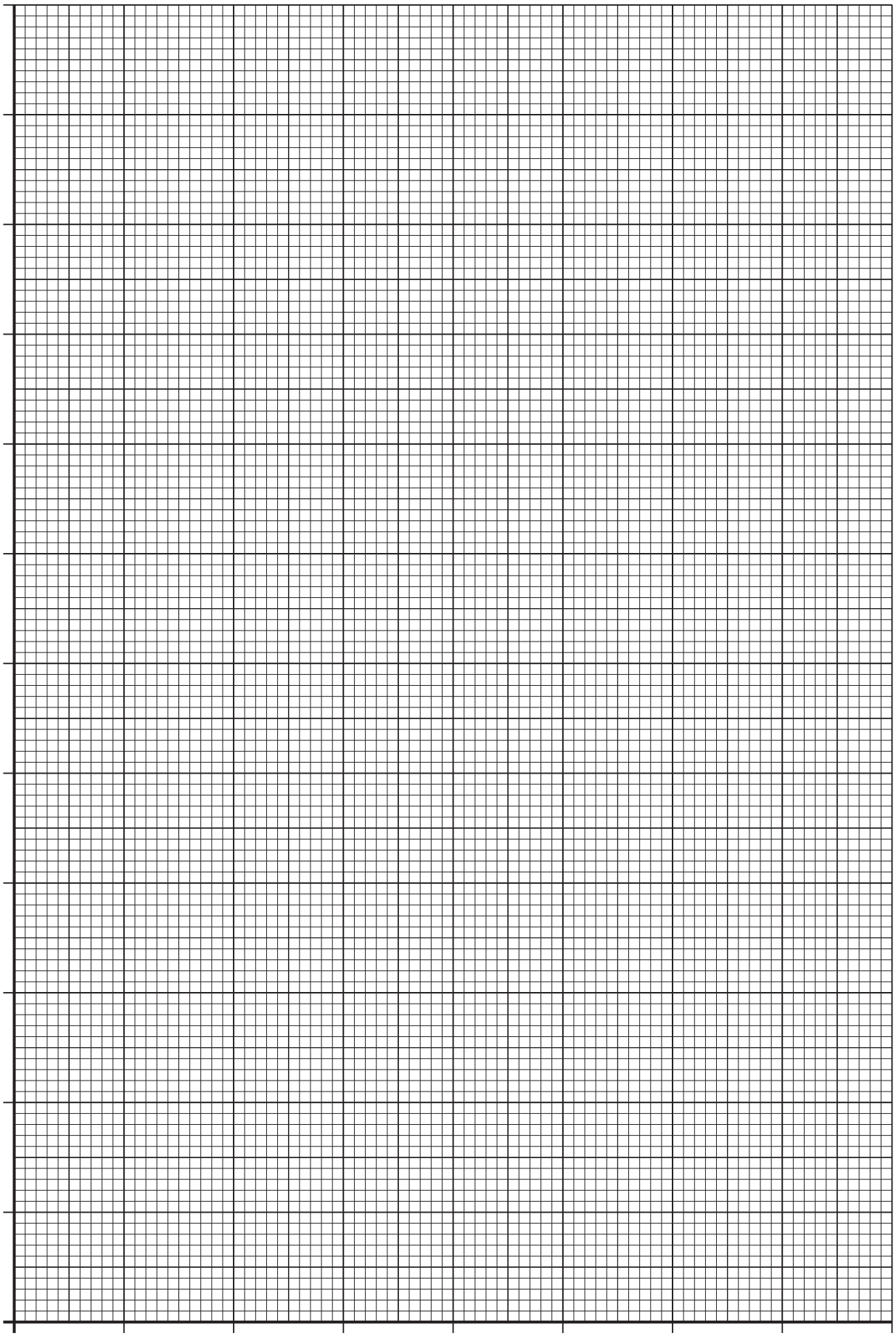
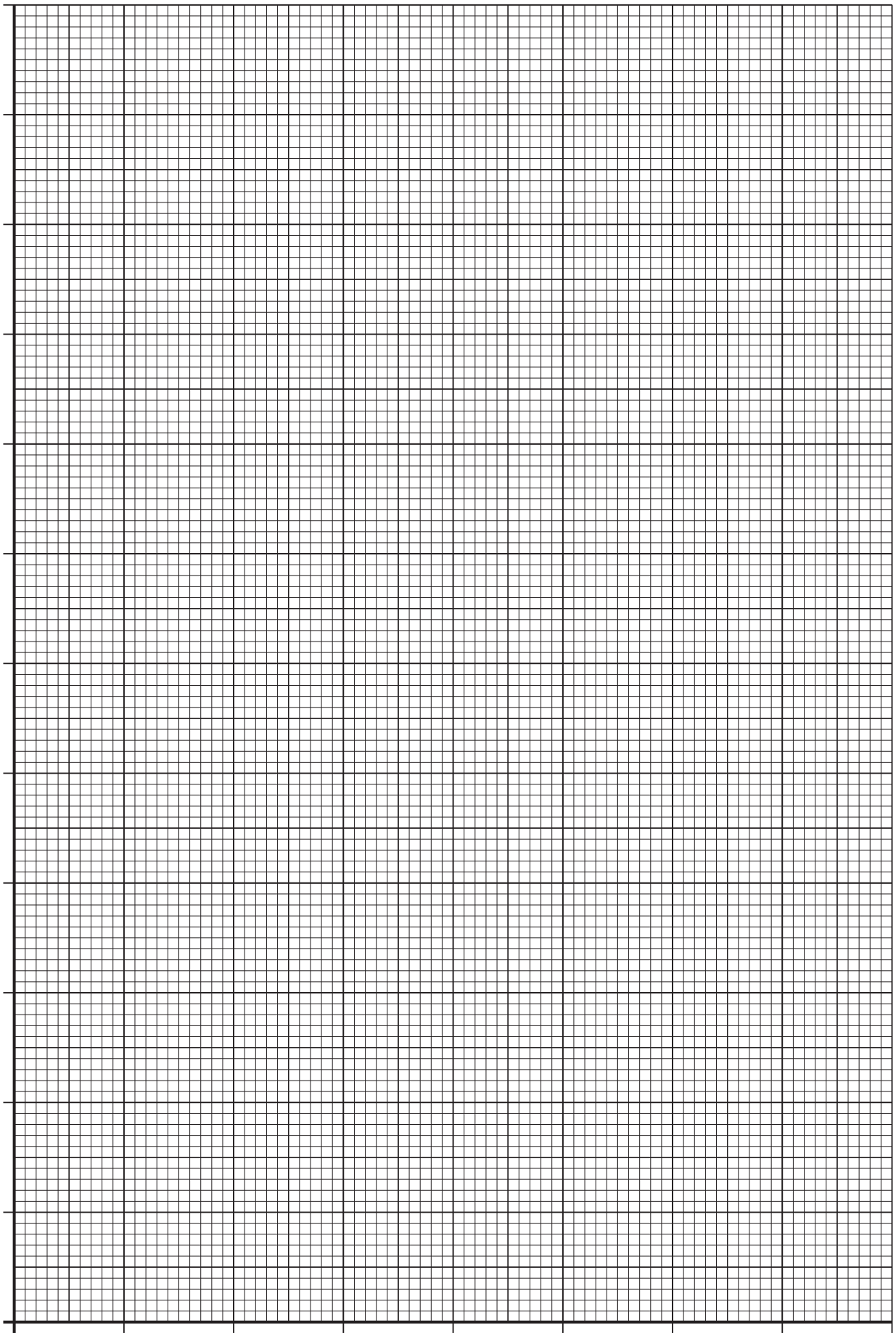
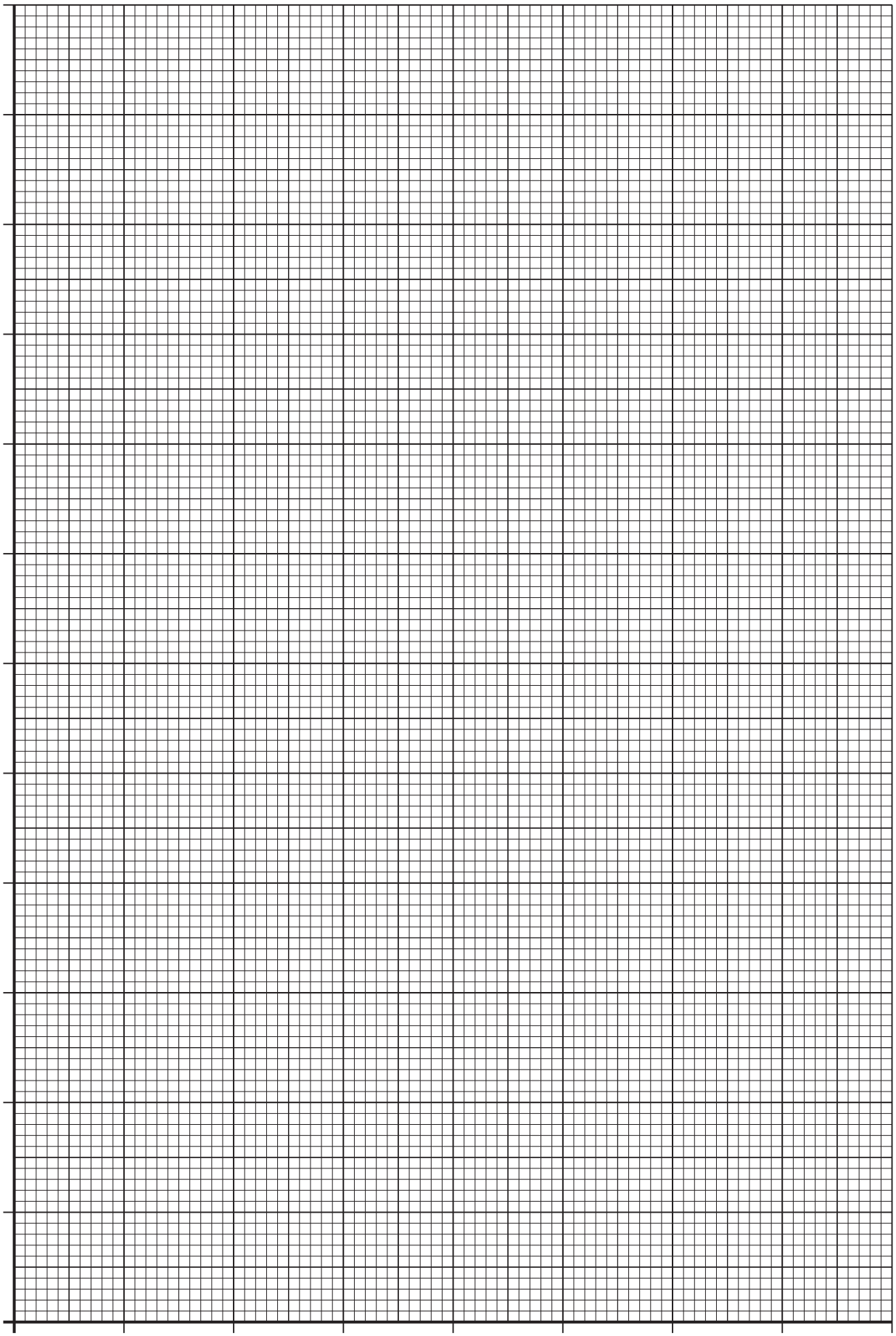
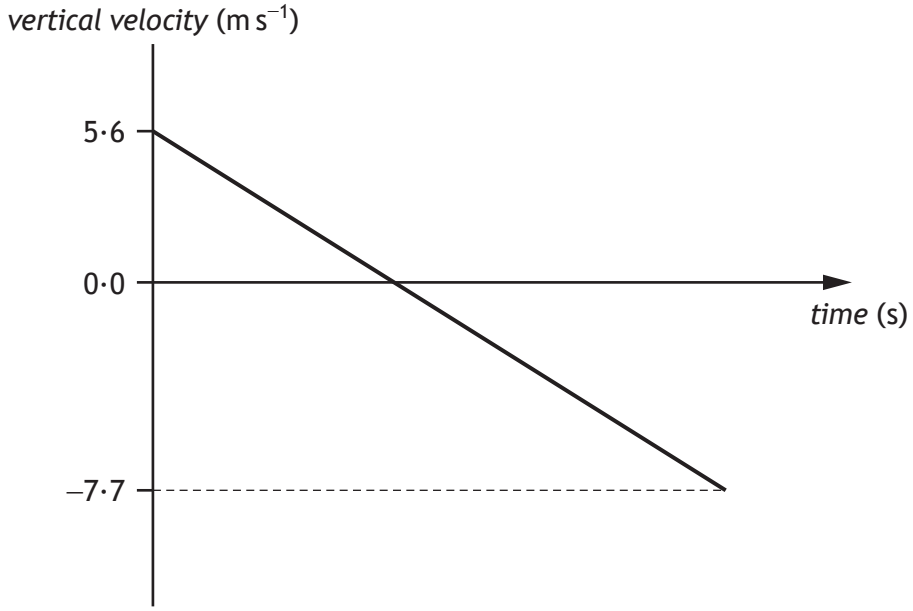






ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

Additional graph for use with Question 3 (b)



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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National
Qualifications
2017

X757/76/11

Physics
Relationships Sheet

WEDNESDAY, 17 MAY
9:00 AM – 11:30 AM

X7577611

A/PB

Relationships required for Physics Higher

$d = \bar{v}t$

$s = \bar{v}t$

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

$s = \frac{1}{2}(u + v)t$

$W = mg$

$F = ma$

$E_W = Fd$

$E_p = mgh$

$E_k = \frac{1}{2}mv^2$

$P = \dfrac{E}{t}$

$p = mv$

$Ft = mv - mu$

$F = G\dfrac{m_1 m_2}{r^2}$

$t' = \dfrac{t}{\sqrt{1-\left(v/c\right)^2}}$

$l' = l\sqrt{1-\left(v/c\right)^2}$

$f_o = f_s\left(\dfrac{v}{v \pm v_s}\right)$

$z = \dfrac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}}$

$z = \dfrac{v}{c}$

$v = H_0 d$

$W = QV$

$E = mc^2$

$E = hf$

$E_k = hf - hf_0$

$E_2 - E_1 = hf$

$T = \dfrac{1}{f}$

$v = f\lambda$

$d\sin\theta = m\lambda$

$n = \dfrac{\sin\theta_1}{\sin\theta_2}$

$\dfrac{\sin\theta_1}{\sin\theta_2} = \dfrac{\lambda_1}{\lambda_2} = \dfrac{v_1}{v_2}$

$\sin\theta_c = \dfrac{1}{n}$

$I = \dfrac{k}{d^2}$

$I = \dfrac{P}{A}$

$V_{peak} = \sqrt{2}V_{rms}$

$I_{peak} = \sqrt{2}I_{rms}$

$Q = It$

$V = IR$

$P = IV = I^2R = \dfrac{V^2}{R}$

$R_T = R_1 + R_2 + ...$

$\dfrac{1}{R_T} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + ...$

$E = V + Ir$

$V_1 = \left(\dfrac{R_1}{R_1 + R_2}\right)V_s$

$\dfrac{V_1}{V_2} = \dfrac{R_1}{R_2}$

$C = \dfrac{Q}{V}$

$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\dfrac{Q^2}{C}$

path difference $= m\lambda$ or $\left(m + \frac{1}{2}\right)\lambda$ where $m = 0, 1, 2...$

random uncertainty $= \dfrac{\text{max. value} - \text{min. value}}{\text{number of values}}$

Additional Relationships

Circle

circumference $= 2\pi r$

area $= \pi r^2$

Sphere

area $= 4\pi r^2$

volume $= \frac{4}{3}\pi r^3$

Trigonometry

$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$$

$$\sin^2\theta + \cos^2\theta = 1$$

Electron Arrangements of Elements

Key

Atomic number
Symbol
Electron arrangement
Name

Group 1 (1)	Group 2 (2)	Transition Elements (3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Group 3 (13)	Group 4 (14)	Group 5 (15)	Group 6 (16)	Group 7 (17)	Group 0 (18)
1 **H** 1 Hydrogen																	2 **He** 2 Helium
3 **Li** 2,1 Lithium	4 **Be** 2,2 Beryllium											5 **B** 2,3 Boron	6 **C** 2,4 Carbon	7 **N** 2,5 Nitrogen	8 **O** 2,6 Oxygen	9 **F** 2,7 Fluorine	10 **Ne** 2,8 Neon
11 **Na** 2,8,1 Sodium	12 **Mg** 2,8,2 Magnesium											13 **Al** 2,8,3 Aluminium	14 **Si** 2,8,4 Silicon	15 **P** 2,8,5 Phosphorus	16 **S** 2,8,6 Sulfur	17 **Cl** 2,8,7 Chlorine	18 **Ar** 2,8,8 Argon
19 **K** 2,8,8,1 Potassium	20 **Ca** 2,8,8,2 Calcium	21 **Sc** 2,8,9,2 Scandium	22 **Ti** 2,8,10,2 Titanium	23 **V** 2,8,11,2 Vanadium	24 **Cr** 2,8,13,1 Chromium	25 **Mn** 2,8,13,2 Manganese	26 **Fe** 2,8,14,2 Iron	27 **Co** 2,8,15,2 Cobalt	28 **Ni** 2,8,16,2 Nickel	29 **Cu** 2,8,18,1 Copper	30 **Zn** 2,8,18,2 Zinc	31 **Ga** 2,8,18,3 Gallium	32 **Ge** 2,8,18,4 Germanium	33 **As** 2,8,18,5 Arsenic	34 **Se** 2,8,18,6 Selenium	35 **Br** 2,8,18,7 Bromine	36 **Kr** 2,8,18,8 Krypton
37 **Rb** 2,8,18,8,1 Rubidium	38 **Sr** 2,8,18,8,2 Strontium	39 **Y** 2,8,18,9,2 Yttrium	40 **Zr** 2,8,18,10,2 Zirconium	41 **Nb** 2,8,18,12,1 Niobium	42 **Mo** 2,8,18,13,1 Molybdenum	43 **Tc** 2,8,18,13,2 Technetium	44 **Ru** 2,8,18,15,1 Ruthenium	45 **Rh** 2,8,18,16,1 Rhodium	46 **Pd** 2,8,18,18,0 Palladium	47 **Ag** 2,8,18,18,1 Silver	48 **Cd** 2,8,18,18,2 Cadmium	49 **In** 2,8,18,18,3 Indium	50 **Sn** 2,8,18,18,4 Tin	51 **Sb** 2,8,18,18,5 Antimony	52 **Te** 2,8,18,18,6 Tellurium	53 **I** 2,8,18,18,7 Iodine	54 **Xe** 2,8,18,18,8 Xenon
55 **Cs** 2,8,18,18,8,1 Caesium	56 **Ba** 2,8,18,18,8,2 Barium	57 **La** 2,8,18,18,9,2 Lanthanum	72 **Hf** 2,8,18,32,10,2 Hafnium	73 **Ta** 2,8,18,32,11,2 Tantalum	74 **W** 2,8,18,32,12,2 Tungsten	75 **Re** 2,8,18,32,13,2 Rhenium	76 **Os** 2,8,18,32,14,2 Osmium	77 **Ir** 2,8,18,32,15,2 Iridium	78 **Pt** 2,8,18,32,17,1 Platinum	79 **Au** 2,8,18,32,18,1 Gold	80 **Hg** 2,8,18,32,18,2 Mercury	81 **Tl** 2,8,18,32,18,3 Thallium	82 **Pb** 2,8,18,32,18,4 Lead	83 **Bi** 2,8,18,32,18,5 Bismuth	84 **Po** 2,8,18,32,18,6 Polonium	85 **At** 2,8,18,32,18,7 Astatine	86 **Rn** 2,8,18,32,18,8 Radon
87 **Fr** 2,8,18,32,18,8,1 Francium	88 **Ra** 2,8,18,32,18,8,2 Radium	89 **Ac** 2,8,18,32,18,9,2 Actinium	104 **Rf** 2,8,18,32,32,10,2 Rutherfordium	105 **Db** 2,8,18,32,32,11,2 Dubnium	106 **Sg** 2,8,18,32,32,12,2 Seaborgium	107 **Bh** 2,8,18,32,32,13,2 Bohrium	108 **Hs** 2,8,18,32,32,14,2 Hassium	109 **Mt** 2,8,18,32,32,15,2 Meitnerium	110 **Ds** 2,8,18,32,32,17,1 Darmstadtium	111 **Rg** 2,8,18,32,32,18,1 Roentgenium	112 **Cn** 2,8,18,32,32,18,2 Copernicium						

Lanthanides	57 **La** 2,8,18,18,9,2 Lanthanum	58 **Ce** 2,8,18,20,8,2 Cerium	59 **Pr** 2,8,18,21,8,2 Praseodymium	60 **Nd** 2,8,18,22,8,2 Neodymium	61 **Pm** 2,8,18,23,8,2 Promethium	62 **Sm** 2,8,18,24,8,2 Samarium	63 **Eu** 2,8,18,25,8,2 Europium	64 **Gd** 2,8,18,25,9,2 Gadolinium	65 **Tb** 2,8,18,27,8,2 Terbium	66 **Dy** 2,8,18,28,8,2 Dysprosium	67 **Ho** 2,8,18,29,8,2 Holmium	68 **Er** 2,8,18,30,8,2 Erbium	69 **Tm** 2,8,18,31,8,2 Thulium	70 **Yb** 2,8,18,32,8,2 Ytterbium	71 **Lu** 2,8,18,32,9,2 Lutetium
Actinides	89 **Ac** 2,8,18,32,18,9,2 Actinium	90 **Th** 2,8,18,32,18,10,2 Thorium	91 **Pa** 2,8,18,32,20,9,2 Protactinium	92 **U** 2,8,18,32,21,9,2 Uranium	93 **Np** 2,8,18,32,22,9,2 Neptunium	94 **Pu** 2,8,18,32,24,8,2 Plutonium	95 **Am** 2,8,18,32,25,8,2 Americium	96 **Cm** 2,8,18,32,25,9,2 Curium	97 **Bk** 2,8,18,32,27,8,2 Berkelium	98 **Cf** 2,8,18,32,28,8,2 Californium	99 **Es** 2,8,18,32,29,8,2 Einsteinium	100 **Fm** 2,8,18,32,30,8,2 Fermium	101 **Md** 2,8,18,32,31,8,2 Mendelevium	102 **No** 2,8,18,32,32,8,2 Nobelium	103 **Lr** 2,8,18,32,32,9,2 Lawrencium