Neap

Trial Examination 2023

VCE Physics Units 3&4

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	18	18	110
			Total 130

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, pre-written notes (one folded A3 sheet or two A4 sheets bound together by tape) and one scientific calculator.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

Question and answer booklet of 40 pages

Formula sheet

Answer sheet for multiple-choice questions

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet.

You may keep the formula sheet.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2023 VCE Physics Units 3&4 Written Examination.

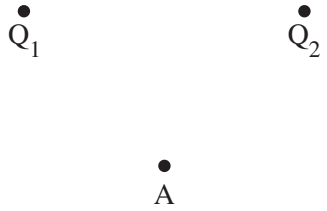
SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1; an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1

Two identical point charges, Q_1 and Q_2, of charge 1.0 μC are shown in the diagram below. Q_1, Q_2 and point A are equidistant from each other at 1.0 m.



What is the magnitude of the electric field at point A?

A. 15.6 N C^{-1}

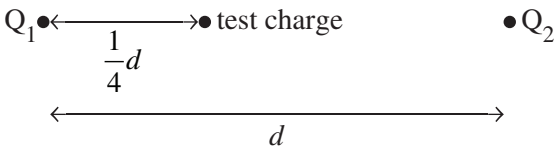
B. 18.0 N C^{-1}

C. 1.56×10^4 N C^{-1}

D. 1.80×10^4 N C^{-1}

Question 2

Two positive charges, Q_1 and Q_2, are separated by a distance of d, as shown in the diagram below. A negative test charge is placed at a distance of $\frac{1}{4}d$ from Q_1. Q_1 has a value of Q and Q_2 has a value of 4Q.



What is the direction of the resulting force acting on the test charge?

A. downwards

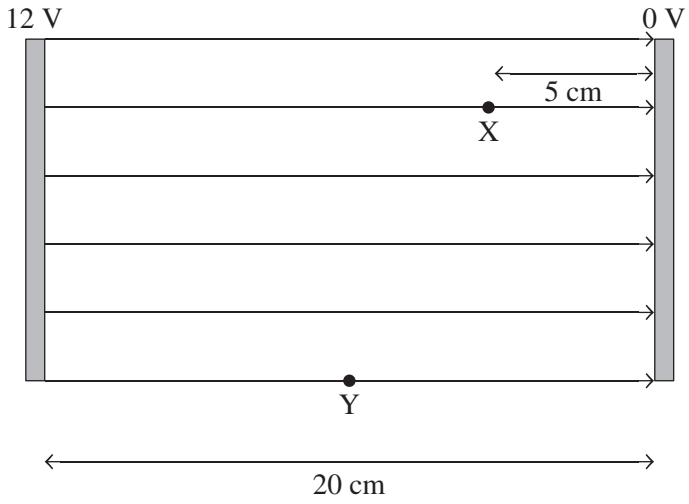
B. upwards

C. to the right

D. to the left

Question 3

The following diagram shows an electric field between two charged plates that are 20 cm apart. Points X and Y are located in the electric field. Point X is 5 cm from the 0 V plate and point Y is midway between the plates.



Which of the following identifies the potential and electric field strength at points X and Y?

	Potential at point X	Electric field strength at point X	Potential at point Y	Electric field strength at point Y
A.	12 V	60 N C^{-1}	12 V	60 N C^{-1}
B.	3.0 V	60 N C^{-1}	6.0 V	60 N C^{-1}
C.	3.0 V	15 N C^{-1}	6.0 V	30 N C^{-1}
D.	12 V	60 N C^{-1}	12 V	30 N C^{-1}

Question 4

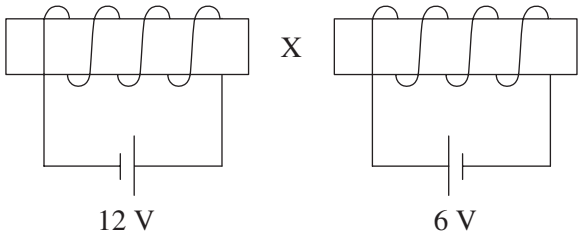
Which of the following matches the type of radiation with its use?

	Radiation	Use
A.	gamma rays	telecommunications
B.	radio waves	fiber-optic communications
C.	infrared	heating and night-vision cameras
D.	ultraviolet	medical imaging

Question 5

Two identical coils of wire are connected to batteries and oriented as shown in the diagram below.

The left coil uses a 12 V battery and the right coil uses a 6.0 V battery. Point X is equidistant from the ends of each coil.



What is the direction of the resulting magnetic field at point X?

A. to the right

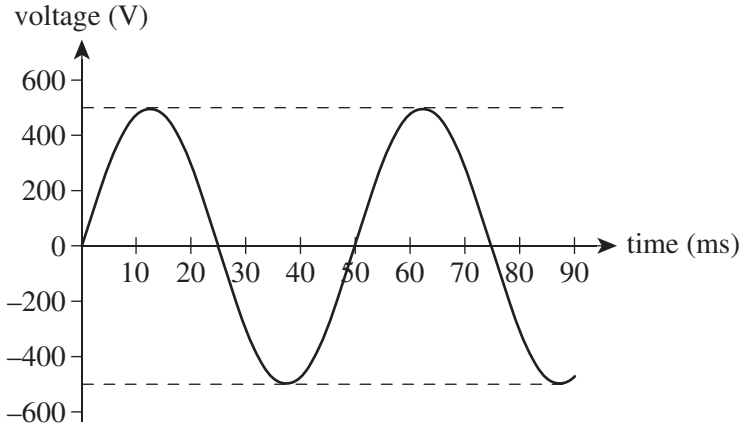
B. to the left

C. out of the page

D. into the page

Question 6

The graph below shows the output from a generator.



Which of the following represents the output in the graph?

	RMS voltage	Frequency
A.	354 V	20 Hz
B.	500 V	50 Hz
C.	707 V	20 Hz
D.	1000 V	50 Hz

Question 7

The diagram below shows Earth and its Moon.

The force and gravitational field of Earth and the Moon are represented by the following variables.

$F_{\text{E on M}}$	force of Earth on the Moon
$F_{\text{M on E}}$	force of the Moon on Earth
g_{E}	gravitational field of Earth at the position of the Moon
g_{M}	gravitational field of the Moon at the position of Earth

Which of the following correctly compares the forces and gravitational fields between Earth and the Moon?

	Force comparisons	Gravitational field comparisons
A.	$F_{\text{E on M}} > F_{\text{M on E}}$	$g_{\text{E}} = g_{\text{M}}$
B.	$F_{\text{E on M}} = F_{\text{M on E}}$	$g_{\text{E}} > g_{\text{M}}$
C.	$F_{\text{E on M}} = F_{\text{M on E}}$	$g_{\text{E}} = g_{\text{M}}$
D.	$F_{\text{E on M}} > F_{\text{M on E}}$	$g_{\text{E}} > g_{\text{M}}$

Question 8

Which two variables are explored in Heisenberg's uncertainty principle?

A. momentum and position in the same plane

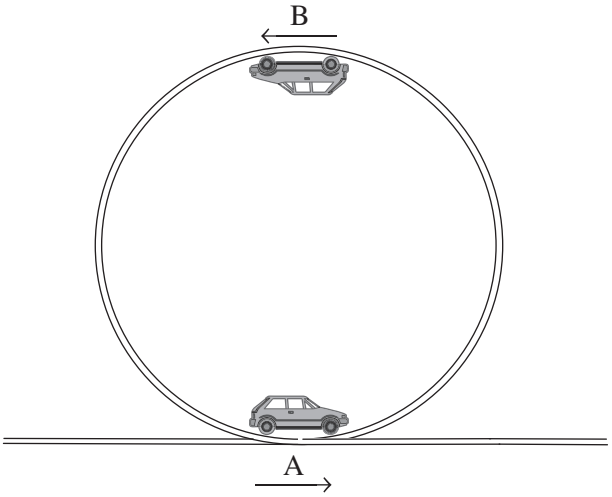
B. velocity and momentum in the same plane

C. momentum and position in two perpendicular planes

D. velocity and position in the same plane

Question 9

Two toy cars have an identical mass *m* and are undergoing a loop-the-loop motion, as shown in the diagram below. Both cars remain on the track at positions A and B, but each car experiences a different speed.



Which one of the following represents the ratio $\frac{\text{normal reaction on toy car at A}}{\text{normal reaction on toy car at B}}$?

A. $\frac{F_{\text{centripetal at A}} + mg}{F_{\text{centripetal at B}} - mg}$

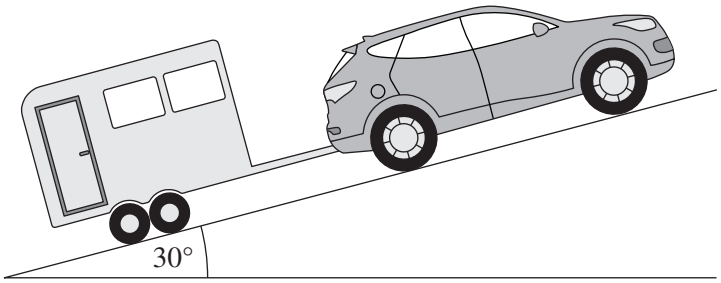
B. 1

C. $\frac{F_{\text{centripetal at A}} - mg}{mg}$

D. $\frac{F_{\text{centripetal at A}}}{mg}$

Question 10

A car is towing a trailer up an incline with an angle of 30°, as shown in the diagram below. The mass of the car is 1250 kg and the mass of the trailer is 750 kg. The car-trailer system travels at a constant speed. Friction is negligible.



The engine force is closest to

A. 2000 N.

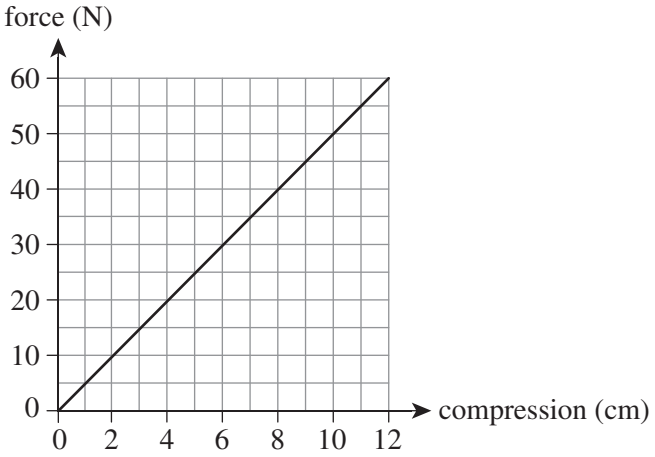
B. 6125 N.

C. 9800 N.

D. 12 250 N.

Question 11

The force versus compression graph for a spring is shown below.



The spring is compressed by 10 cm and a 100 g ball is placed on the spring in a vertical position. The spring is then released and the ball rises vertically to a maximum height. Air resistance is negligible.

Which one of the following is closest to the maximum height of the ball?

A. 0.03 m

B. 0.26 m

C. 0.39 m

D. 2.55 m

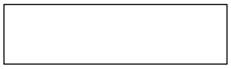
Question 12

The diagram below shows a stationary frame.

Which one of the following best represents the frame if it is travelling to the right at 0.95c?

A.

B.

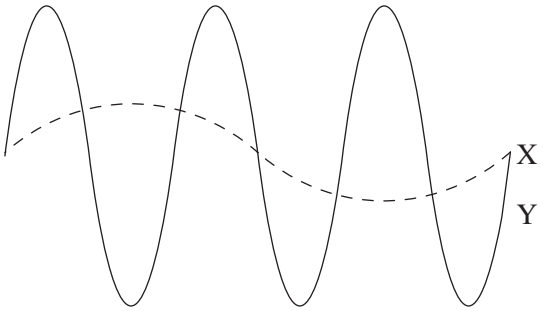


C.

D.

Question 13

The diagram below shows two waves, X and Y.



Both waves have a speed of 12 m s^{-1}. Wave X has a wavelength of 3.0 m.

Which one of the following is closest to the frequency of wave Y?

A. 1.3 Hz

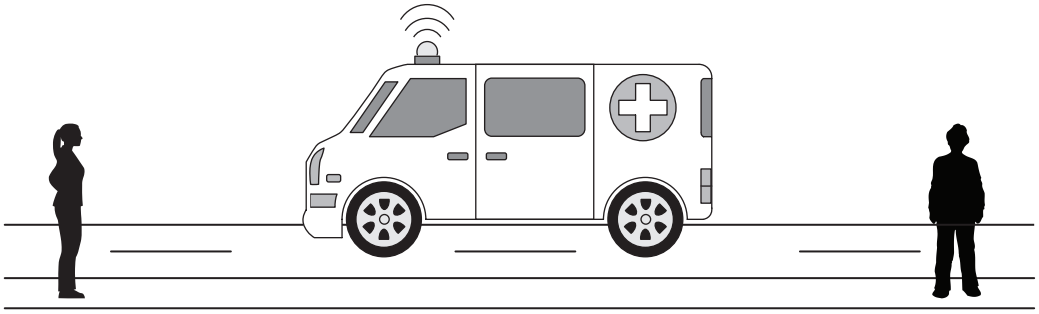
B. 3.0 Hz

C. 4.0 Hz

D. 12 Hz

Question 14

Justin and Margaret are standing on a footpath. An ambulance passes Justin and approaches Margaret with its siren playing, as shown in the diagram below. The driver of the ambulance hears the siren at a frequency of 800 Hz.

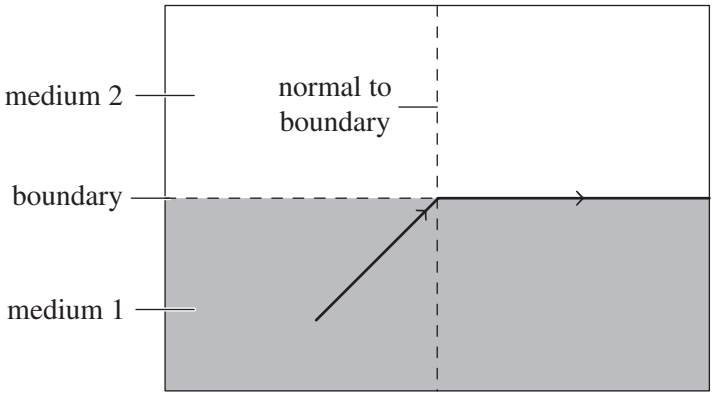


Which of the following describes the frequency of the siren as heard by Margaret and Justin?

	Siren as heard by Margaret	Siren as heard by Justin
A.	800 Hz	800 Hz
B.	< 800 Hz	< 800 Hz
C.	> 800 Hz	< 800 Hz
D.	< 800 Hz	> 800 Hz

Question 15

An experiment is conducted in which a ray of violet light travels through medium 1 towards the boundary of medium 2. The ray of violet light strikes the boundary and travels along it, as shown in the diagram below.



The experiment is conducted again using the same conditions, except that the violet light is replaced with a ray of red light.

The passage of the ray of red light

A. reflects at the boundary and remains in medium 1.

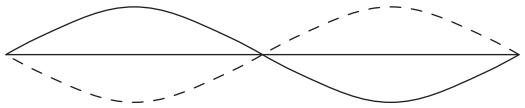
B. travels the same path as the ray of violet light along the boundary.

C. just passes into medium 2 and travels above the path of the violet light.

D. passes into medium 2, travelling close to the normal to the boundary.

Question 16

The diagram below shows a particular wave pattern in a string of fixed length. The wave has a wavelength of 2.0 m.



Which one of the following lists wavelengths of other possible wave patterns in the string?

A. 0.5 m, 1.0 m, 1.33 m

B. 0.5 m, 3.5 m, 5.0 m

C. 1.0 m, 3.0 m, 5.0 m

D. 3.0 m, 3.5 m, 4.0 m

Question 17

Which one of the following phenomena cannot be demonstrated using longitudinal waves?

A. diffraction

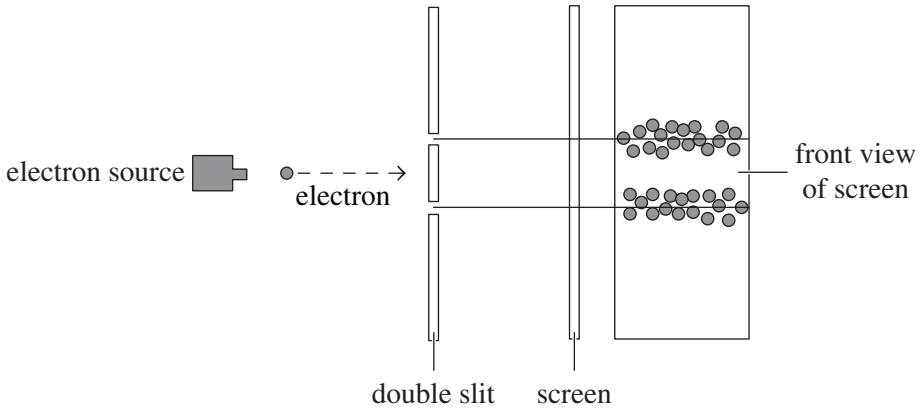
B. polarisation

C. interference

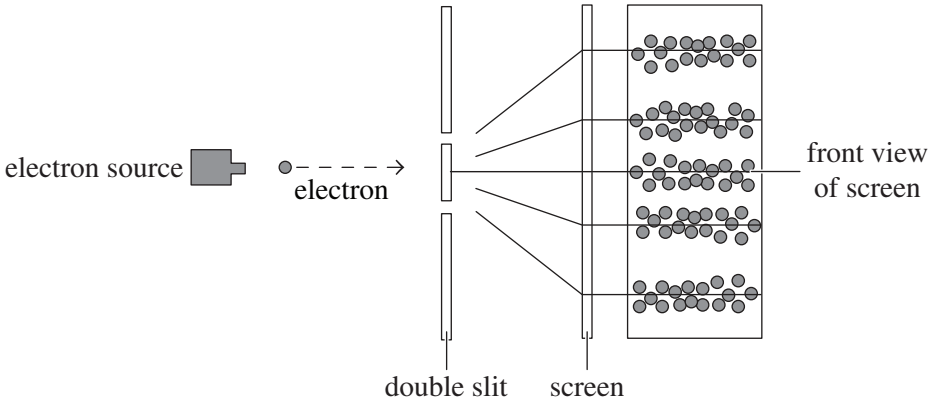
D. reflection

Question 18

The diagrams below show two experiments, X and Y, in which an electron source fires electrons one at a time towards a double slit arrangement, leading to two different screen patterns from the strikes of the electrons.



Experiment X



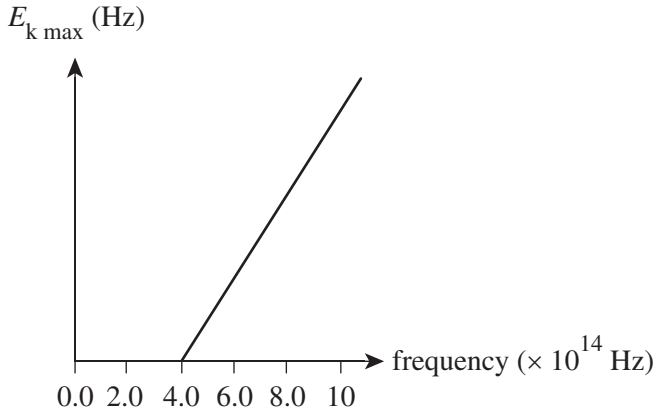
Experiment Y

Which of the following identifies the model that explains the behaviour of the electrons in experiments X and Y?

	Experiment X	Experiment Y
A.	particle model only	wave model only
B.	dual wave-particle model	wave model only
C.	dual wave-particle model	dual wave-particle model
D.	particle model only	dual wave-particle model

Question 19

An experiment is conducted to investigate the photoelectric effect. The results of the experiment are shown in the following maximum kinetic energy versus light frequency graph.



Which one of the following is closest to the maximum kinetic energy of electrons when light of frequency 6.0×10^{14} Hz is used in the experiment?

A. 0.83 eV

B. 1.66 eV

C. 2.49 eV

D. 6.0 eV

Question 20

The true value of a certain distance is 4.5 m.

Which one of the following shows the most precise set of measurements for the distance?

A. 3.9 m, 4.0 m, 3.9 m

B. 4.2 m, 4.5 m, 4.6 m

C. 4.5 m, 5.0 m, 4.0 m

D. 4.6 m, 4.5 m, 4.4 m

END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.
Where an answer box is provided, write your final answer in the box.
If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1 (7 marks)
Figure 1 shows a simple DC motor. The square coil has a side length of 0.030 m and the current flowing through the coil is 0.050 A. The coil has 10 turns and the magnetic field strength experienced by the coil is 0.10 T.

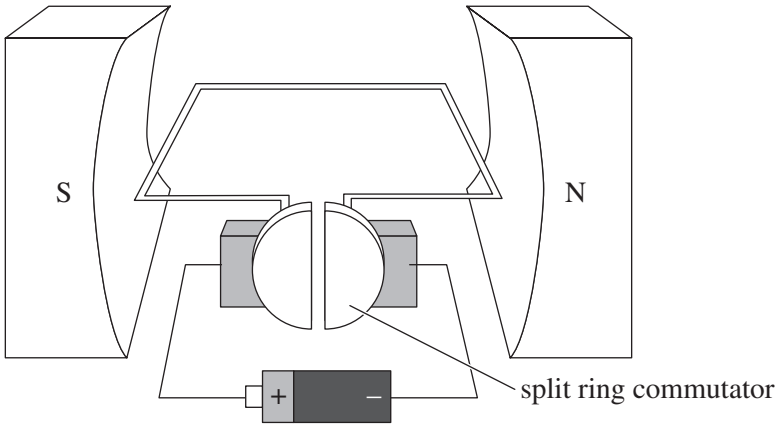


Figure 1

a. Identify the state of the coil's rotation in the instant shown in Figure 1 by circling the correct word below. 1 mark

clockwise *stationary* *anti-clockwise*

b. Determine the magnitude of the force acting on the side of the coil closest to the south pole magnet. 2 marks

N

c. Explain why the split ring commutator consists of a ring that is split into two halves. In your answer, make reference to the operation of the commutator. 3 marks

d. State the magnitude of the current in the coil when the coil is at right angles to the orientation shown in Figure 1. 1 mark

A

Question 2 (6 marks)

The ExoMars Trace Gas Orbiter (TGO) is an atmospheric research spacecraft that gathers data about the presence of methane and other trace gases in Mars's atmosphere, which can be used as evidence of possible biological activity. Mars has a mass of 6.39×10^{23} kg and a radius of 3.3895×10^{3} km. The period of the TGO's circular orbit around Mars is 2.0 hours.

a. Show that the TGO's altitude above Mars is approximately 436 km. Show your working. 4 marks

b. Determine the speed of the TGO around Mars. Show your working. 2 marks

	m s^{-1}

Question 3 (8 marks)

An ion travels from rest through a potential difference, V, and is accelerated to a speed of 2.4×10^5 m s^{-1}. The ion travels at this speed into a magnetic field. The displacement, d, of the ion as it enters the field and travels through a half-circle is shown in Figure 2.

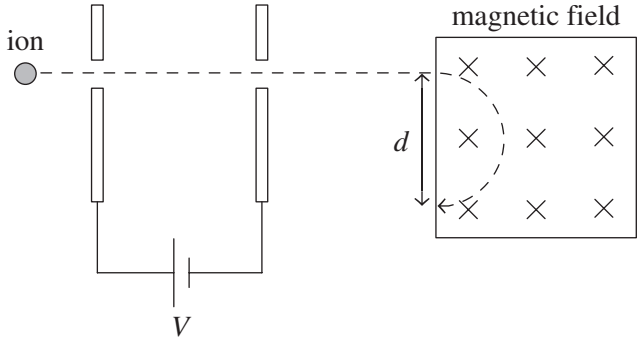


Figure 2

The ion has a mass of 1.06×10^{-25} kg and a charge of 3.2×10^{-19} C. The magnetic field strength is 1.60 T.

a. Determine the potential difference, V. Show your working. 3 marks

V

b. Determine the displacement of the ion, d. Show your working. 2 marks

m

c. The motion of the Moon around Earth and the motion of the ion in the magnetic field have one similarity and one difference in their circular motion and the cause of their motion.

Compare and contrast the circular motion of the Moon around Earth and its cause to that of the ion in the magnetic field. 3 marks

Question 4 (6 marks)

A square loop with a side length of 10 cm travels at a constant speed of 0.10 m s^{-1} through two different regions of a magnetic field. Each region has the same field strength, as shown in Figure 3.

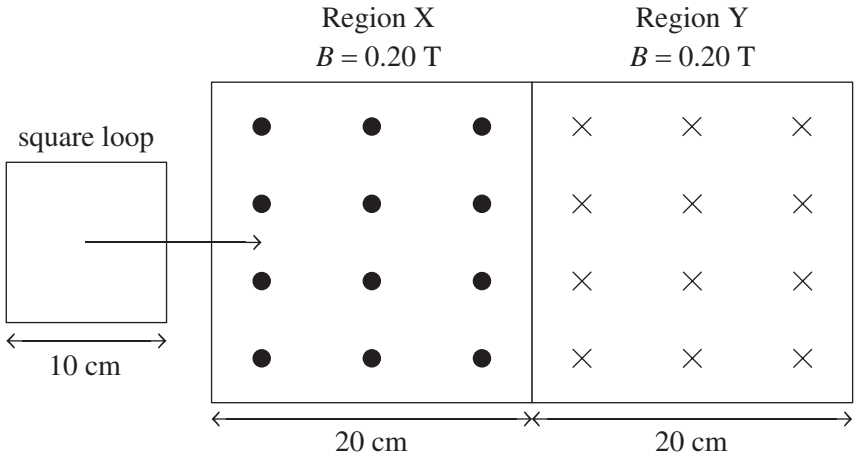
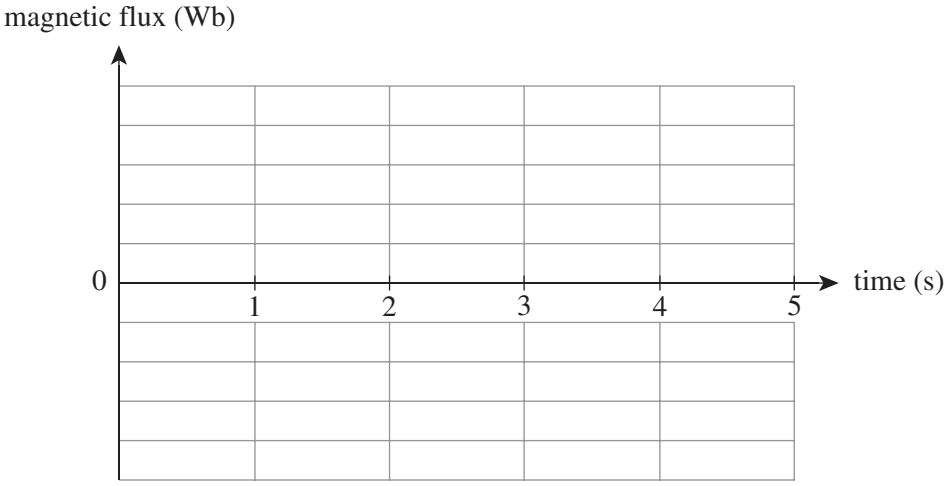
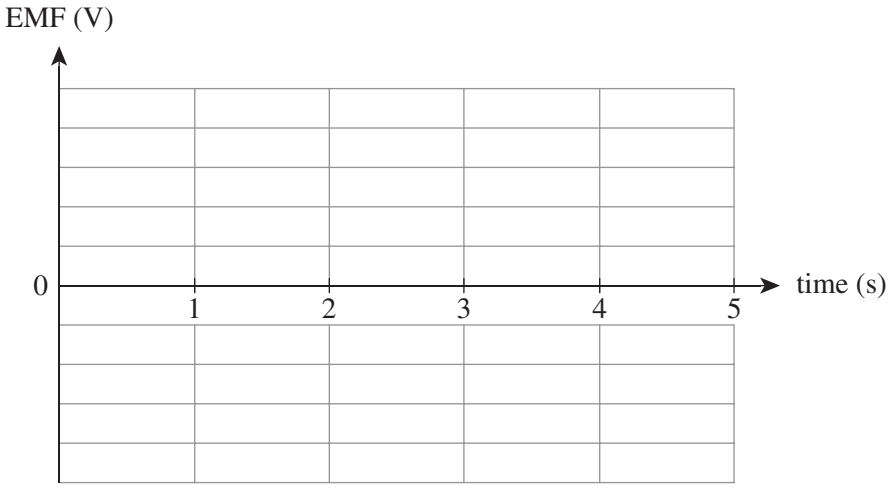


Figure 3

a. On the axes below, sketch the magnetic flux versus time graph for the period of the right side of the loop just entering region X to the left side of the loop just exiting region Y. The positive direction is represented as out of the page. (A scale on the *y*-axis is not required.) 3 marks



b. Using the graph from **part a.**, sketch the EMF versus time graph for the period of the right side of the loop just entering region X to the left side of the loop just exiting region Y. (A scale on the *y*-axis is not required.) 3 marks



Question 5 (5 marks)

An electrical power station produces 200 MW of power at 20 kV_{RMS} AC. The transmission line from the power station to the substation has two transformers, T_1 and T_2, as shown in Figure 4.

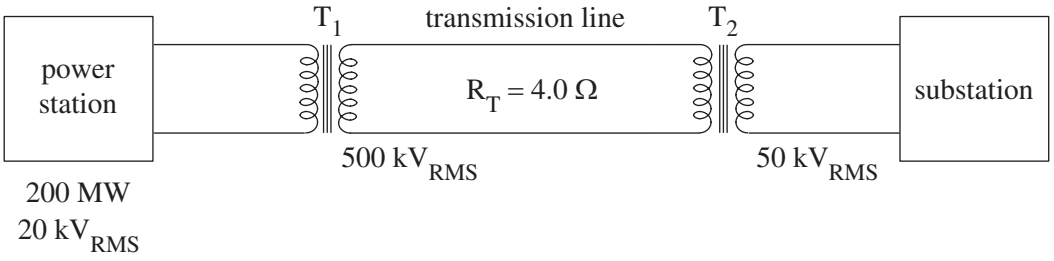


Figure 4

T_1 steps up the voltage to 500 kV_{RMS} and T_2 steps down the voltage to 50 kV_{RMS}. The current in the transmission line is 400 A_{RMS}. The transmission line has a total resistance of 4.0 Ω.

a. Calculate the power loss in the transmission line. Show your working. 2 marks

W

b. Determine the ratio $\frac{\text{substation peak current}}{\text{transmission line peak current}}$. Give your answer correct to three significant figures. 3 marks

Question 6 (4 marks)

Figure 5 shows a circular coil of 10 turns that is positioned close to the north pole of a magnet such that it experiences maximum magnetic flux.

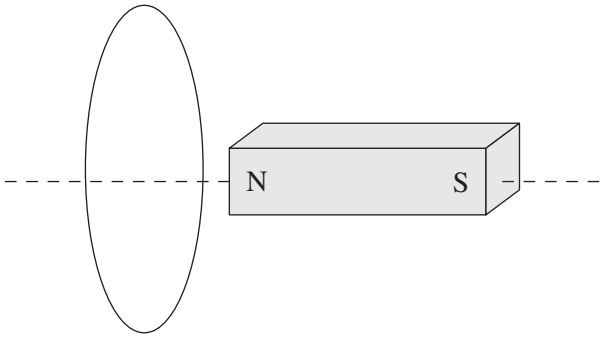


Figure 5

The coil has a diameter of 5.0 cm and it is pulled away in 0.50 seconds. The maximum magnetic field strength experienced by the coil is 0.10 T.

a. Determine the average EMF induced in the coil. Show your working. 3 marks

V

b. On Figure 5, draw an arrow to indicate the direction of the induced current in the coil as the coil is pulled away from the magnet. 1 mark

Question 7 (8 marks)

A steel ball of mass 50.0 g is connected to an inextensible string of length 1.00 m and released from a horizontal position. The steel ball then strikes another steel ball of mass 100 g that sits on a golf tee, as shown in Figure 6.

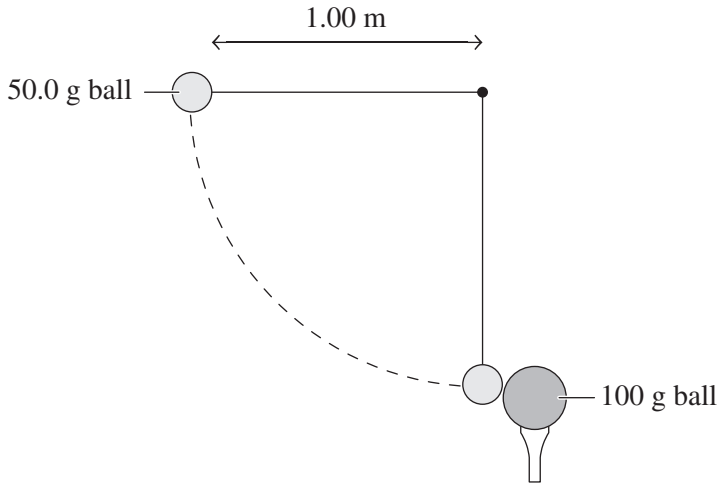


Figure 6

Upon collision, both balls initially move horizontally.

a. Show that the speed of the 50.0 g ball is 4.43 m s^{-1} when it collides with the 100 g ball. Show your working. 2 marks

Immediately after the collision, the 50.0 g ball slows to 1.0 m s^{-1} and continues to the right.

b. Determine the speed of the 100 g ball immediately after the collision. Show your working. 3 marks

m s^{-1}

c. Determine whether the collision is elastic or inelastic. Show your working. 3 marks

Question 8 (3 marks)

A van of mass 1000 kg is approaching a horizontal turn, as shown in Figure 7. The radius of the turn is 80 m.

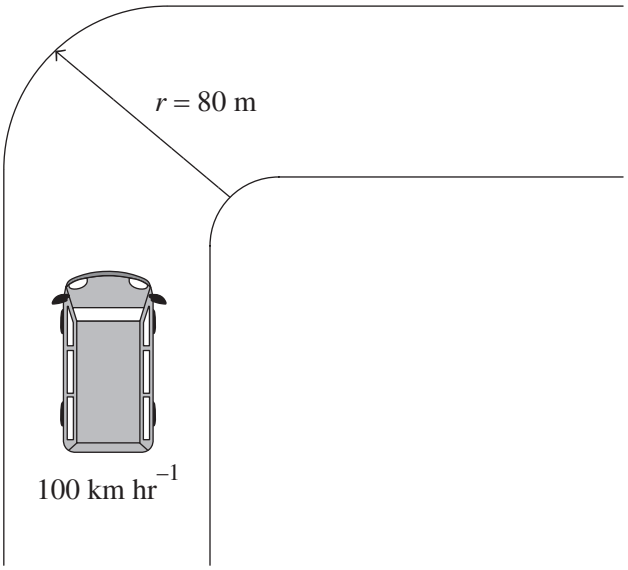


Figure 7

The maximum sideways friction that the wheels can experience before slipping is 7200 N.

The driver is approaching the turn at 100 km hr^{-1} while driving on the straight section of the road.

Determine whether the van will remain on the road or slip off the road at this speed. Provide calculations to justify your answer.

Question 9 (4 marks)

Banked turns on high-speed roads are used to assist vehicles to safely turn corners. A cross-section of a car on a banked turn is shown in Figure 8. The angle that the surface of the road subtends with the horizontal is θ.

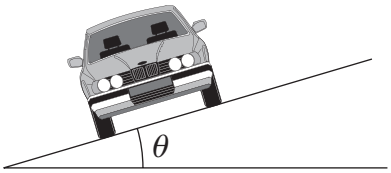


Figure 8

Explain how banked turns assist vehicles to make safe turns at high speeds when compared with road-tyre friction. Draw the relevant forces on Figure 8 to support your answer.

Question 10 (3 marks)

In the core of the Sun, four hydrogen atoms fuse to become a helium atom. The mass of one hydrogen atom is 1.674×10^{-27} kg and the mass of one helium atom is 6.646×10^{-27} kg.

Determine the amount of energy released by the fusion of four hydrogen atoms in the Sun. Show your working.

J

Question 11 (12 marks)

A student is investigating the maximum height reached by a steel ball that is launched from a launching mechanism. The launching mechanism can launch the steel ball at different speeds. The student sets the launching mechanism to project at 45° for each trial. A video camera is used to capture the maximum height of the ball against a tape measure, as shown in Figure 9.

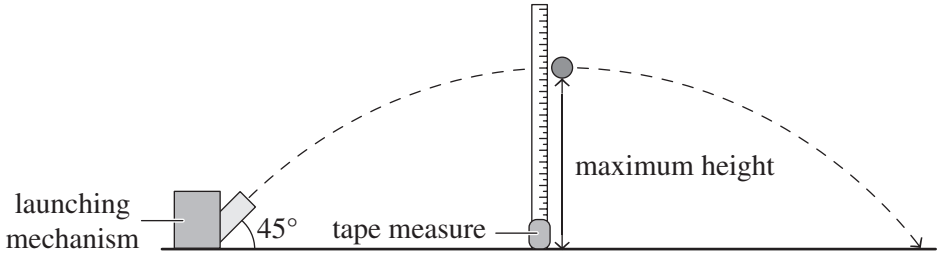


Figure 9

The student makes the following hypothesis.

'The maximum height of the ball will increase in a linear manner as the launch speed increases.'

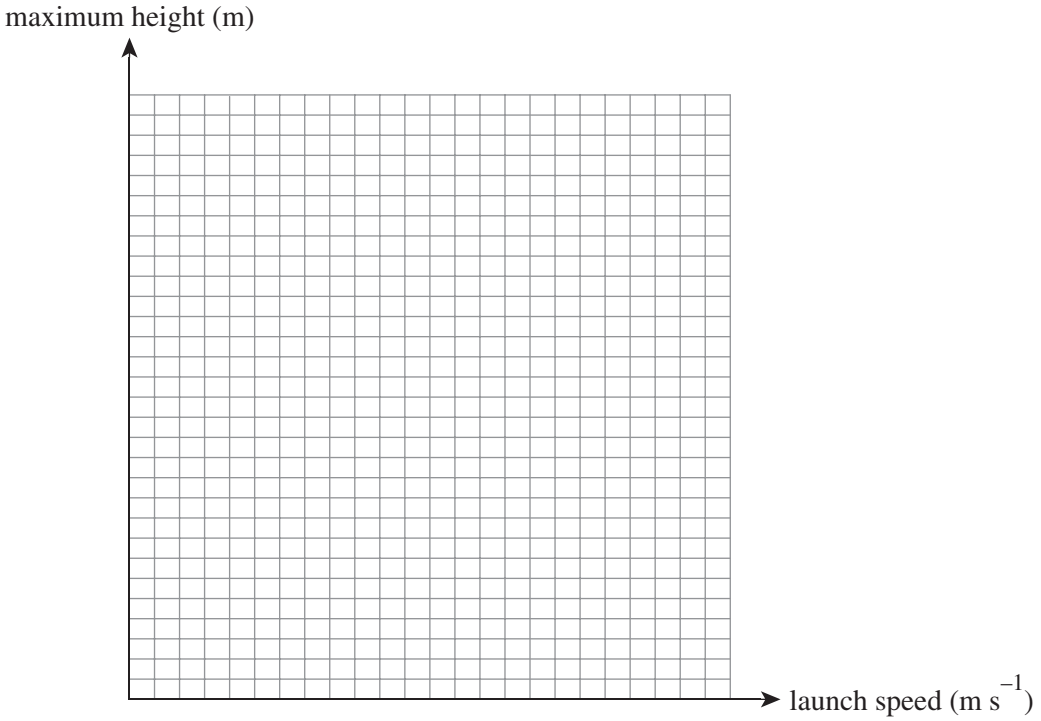
The student conducts three trials at each speed and records the greatest maximum height for each speed. The results are shown in the table below.

Launch speed (m s^{-1})	Maximum height (m)
5.0	0.61
5.5	0.79
6.0	0.90
6.5	1.10
7.0	1.23
7.5	1.45
8.0	1.61
8.5	1.86
9.0	2.10
9.5	2.28
10.0	2.55

The student determines that the uncertainty in the maximum height is ±5 cm.

a. On the axes provided below:

- plot the data from the table
- use an appropriate scale for each axis
- include uncertainty bars for the maximum height for at least three data points
- draw a line of best fit. 5 marks



b. Using the graph drawn in **part a.**, discuss whether the student's hypothesis is supported or rejected. 2 marks

The student undertakes some research and finds the following equation for the maximum height reached by a projectile.

$$\text{maximum height} = \frac{\text{launch speed}^2 \times \sin^2(\theta)}{2g},$$

where θ is the launch angle to the horizontal and $g = 9.8$ m s^{-2}.

The student realises that the data from their experiment can be used to determine the experimental value of the acceleration due to gravity. The student plots a graph of the maximum height versus the square of the launch speed, as shown in Figure 10.

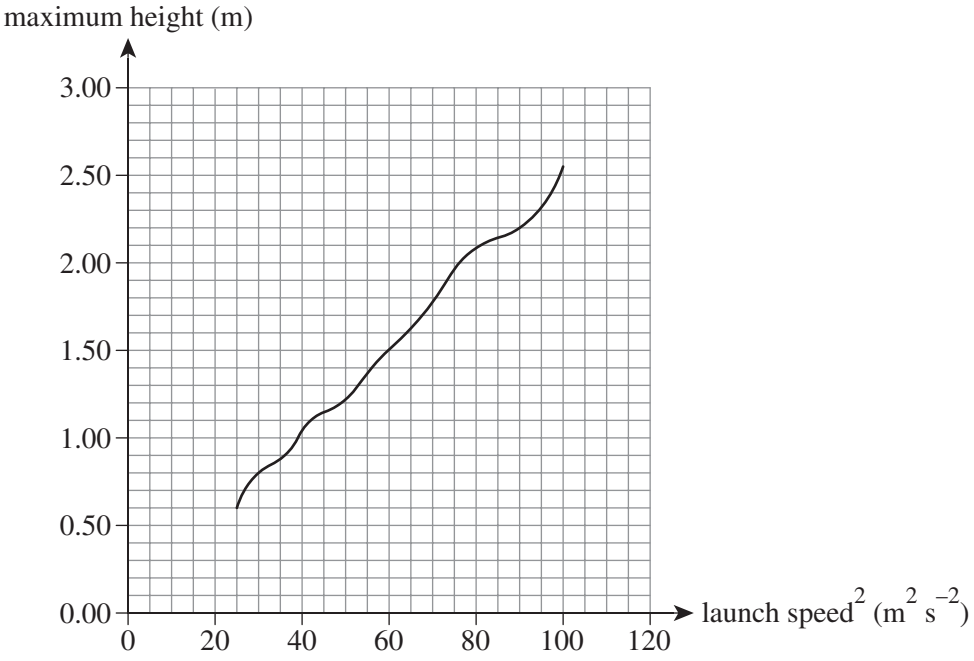


Figure 10

c. Evaluate whether the effect of external forces or inconsistencies in the use of any apparatus may have affected the integrity of the results. Justify your answer. 2 marks

d. Using the equation and the graph in Figure 10, determine the acceleration due to gravity in the student's experiment. Show your working. 3 marks

m s^{-2}

Question 12 (5 marks)

Muons are created in the upper atmosphere where they travel at $0.9999c$ ($\gamma = 70.7$). Muons have a mean lifetime of 2.2 μs in their frame of reference before they decay into other particles.

a. Show that the muons travel 660 m over their lifetime in their frame of reference. 2 marks

b. Explain how muons can be observed at ground level when they are created at 10 km above the ground. Provide calculations to justify your answer. 3 marks

Question 13 (9 marks)

A class of Physics students are investigating the effect of shining a beam of white light through two narrow slits, S_1 and S_2, and onto a screen, as shown in Figure 11.

The students observe the following on the screen.

- a white band
- dark bands symmetrically on both sides of the white band
- thin bands of seven colours of white light on either side of the dark bands

The slits are 0.10 mm apart and the plane of the slits is 4.00 m from the screen.

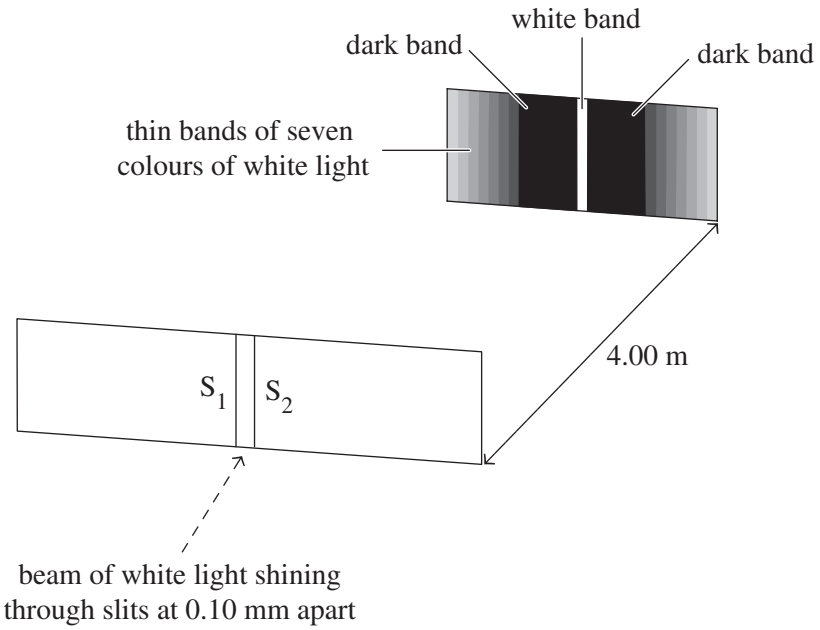


Figure 11

Figure 12 shows a section of the screen. The distance between the centre of the white and green bands is 2.2 cm.

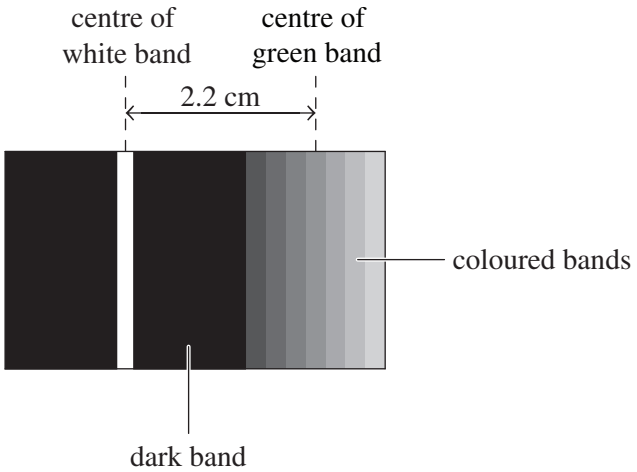


Figure 12

a. Explain why the white band exists. 2 marks

b. Explain why the bands to the right or left of the dark bands are coloured instead of being one white band. 4 marks

c. Determine the frequency of the green light. Show your working. 3 marks

Hz

Question 14 (3 marks)

A tourist is standing at the edge of a jetty and looking at a fish below the surface of a still body of water, as shown in Figure 13. Point A is the point at which a ray of light from the fish's eyes passes through the water into the air and to the tourist's eyes. The refractive index of air is 1.00.

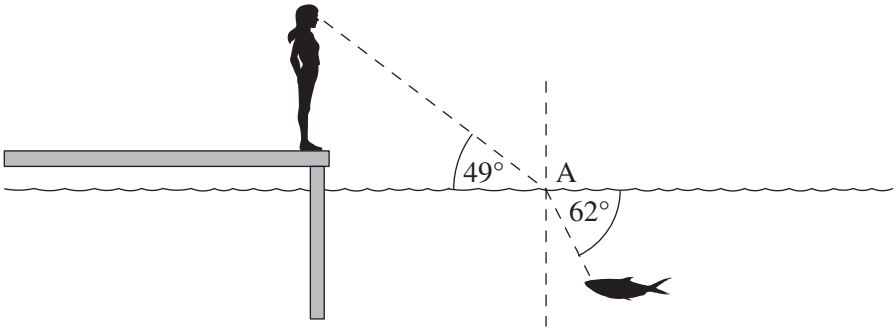


Figure 13

Determine the refractive index of the water. Show your working.

Question 15 (9 marks)

A Physics student is investigating the photoelectric effect. The student uses a photocell circuit and shines light onto the photocathode, as shown in Figure 14.

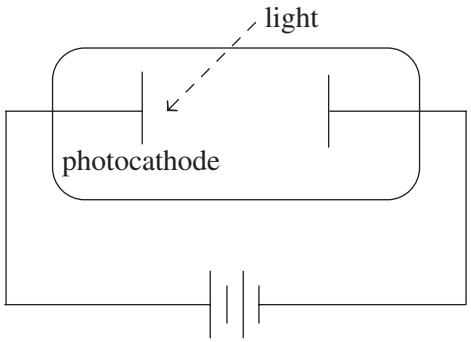


Figure 14

Figure 15 shows a graph of the photocurrent versus the applied voltage across the photocell for a particular trial of the investigation. X is the voltage intercept.

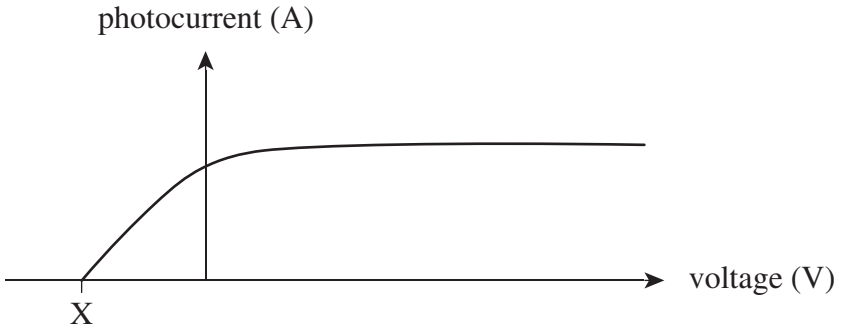


Figure 15

a. In the trial shown in Figure 15, the student uses light of wavelength 480 nm and the photocathode metal has a work function of 2.30 eV.

Determine the value of X. Show your working. 3 marks

V

b. In a second trial, the student uses light of frequency 4.0×10^{14} Hz and the work function of the photocathode metal remains the same.

i. Describe the graph result for this trial. Provide a justification for your answer. 2 marks

ii. Explain the physics principle that supports your answer to **part b.i.** In your answer, make reference to the particular model of light that underpins the explanation. 4 marks

Question 16 (7 marks)

The absorption spectrum for hydrogen is shown in Figure 16.

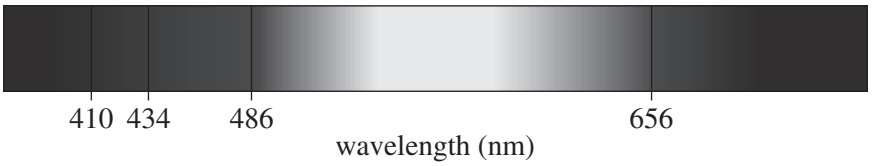


Figure 16

a. There is no absorption line at 550 nm in this spectrum.

With reference to the energy levels within the hydrogen atom, explain why this absorption line is not present. 2 marks

The energy levels for a hydrogen atom are shown in Figure 17.

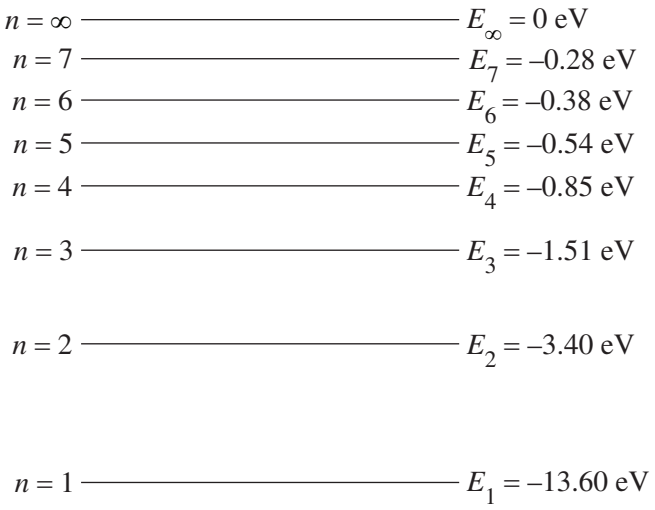


Figure 17

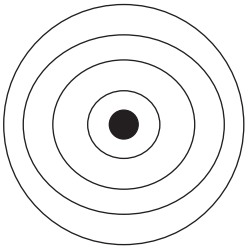
b. Explain why the energy levels represent evidence for the dual nature of matter. 3 marks

c. The band at 486 nm on the absorption spectrum represents an energy of 2.55 eV.

Draw an arrow on Figure 17 to show the initial and final energy levels for a transition of 2.55 eV. Justify your answer. 2 marks

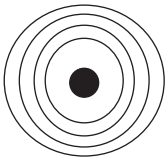
Question 17 (5 marks)

Electrons are accelerated from rest by specific voltages and strike a crystal with a regular atomic structure. The electrons interact with the crystal, which results in a diffraction pattern. Figure 18a shows the diffraction pattern formed by using a low voltage to accelerate the electrons and Figure 18b shows the diffraction pattern formed by using a high voltage to accelerate the electrons. The concentric rings represent positions of constructive interference.



low voltage

Figure 18a



high voltage

Figure 18b

a. Explain how the diffraction patterns occur and state what the patterns suggest about the behaviour of the electrons. 2 marks

b. Explain why the pattern alters when the voltage is changed from low to high. 3 marks

Question 18 (6 marks)
Electrons of energy 30 eV irradiate at a nickel foil with atoms that are 0.215 nm apart.

a. Show that the de Broglie wavelength for the electrons is 2.24×10^{-10} m. 3 marks

b. Determine whether the electrons will diffract as they interact with the nickel foil.
Support your answer with calculations. 3 marks

END OF QUESTION AND ANSWER BOOKLET