Neap

VCE Physics Units 3&4

Question and Answer Booklet

2024 Trial Examination

Reading time: 15 minutes

Writing time: 2 hours 30 minutes

Student's Name: _____

Teacher's Name: _____

Approved materials

- One scientific calculator
- Pre-written notes (one folded A3 sheet or two A4 sheets bound together by tape)

Materials supplied

- Question and Answer Booklet of 38 pages
- Formula Sheet
- Multiple-Choice Answer Sheet

Instructions

- Write **your name** and your **teacher's name** in the spaces above on this page.
- Follow the instructions on your Multiple-Choice Answer Sheet.
- At the end of the examination, place your Multiple-Choice Answer Sheet inside the front cover of this booklet.

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

Contents pages

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2024 VCE Physics Units 3&4 Examination.

Section A – Multiple-choice questions

Instructions

- Answer **all** questions in pencil on the Multiple-Choice Answer Sheet.
- 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.

Question 1

Consider the following relationships for a collision of two vehicles.

$$\text{total momentum before a collision} = \text{total momentum after the collision} + p$$
$$\text{total kinetic energy before a collision} = \text{total kinetic energy after the collision} + E$$

Which one of the following best describes the values of p and E for an inelastic collision?

	p	***E***
A.	zero	zero
B.	zero	greater than zero
C.	greater than zero	zero
D.	greater than zero	greater than zero

Question 2

A spring sits horizontally and is fully compressed by 10 cm with a 10 g ball against one end. When the spring is released and fully extends, the ball moves away at a speed of 10 m s^{-1}.

What is the spring constant?

A. 0.10 N m^{-1}

B. 1.0 N m^{-1}

C. 10 N m^{-1}

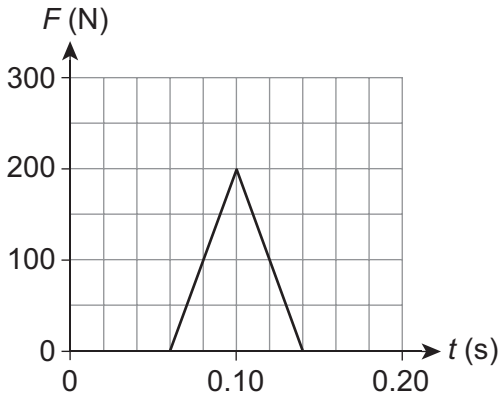
D. 100 N m^{-1}

Question 3

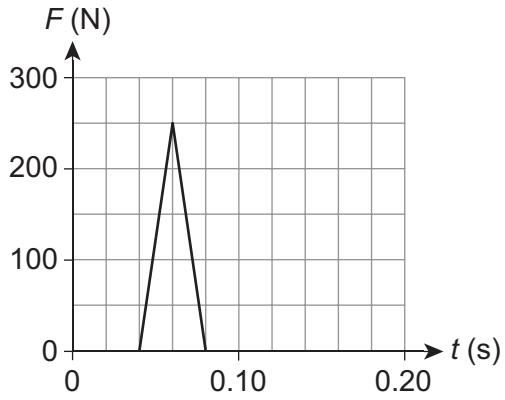
A tennis ball experiences an impulse of 5.0 N s after being hit by a racquet.

Which one of the following force, *F*, versus time, *t*, graphs best represents the impulse?

A.



B.



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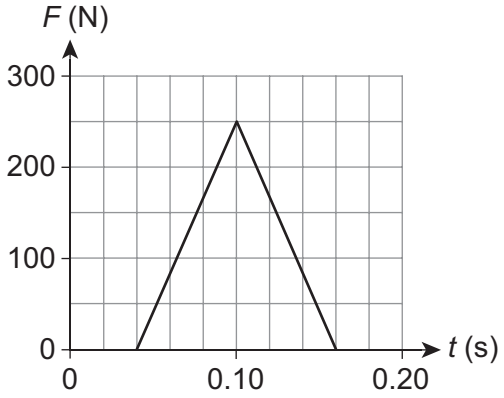
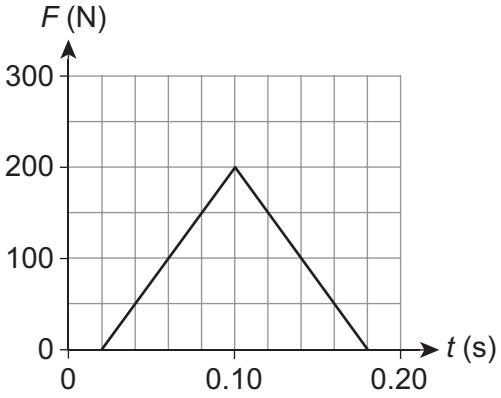
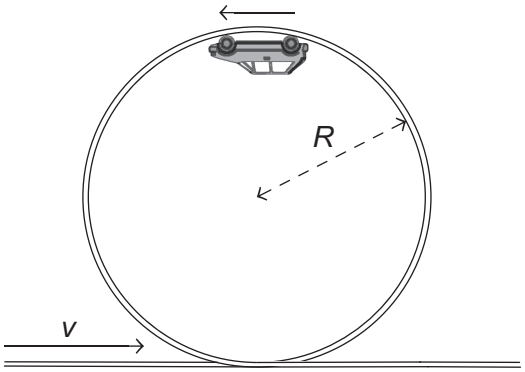


D.



Question 4

A toy car of mass m is travelling horizontally at speed v as it approaches a vertical circular loop of radius R. The toy car travels through the loop, as shown in the diagram below. It loses contact with the track at the top of the loop.



What is the correct expression for the car's kinetic energy at the top of the loop? Ignore friction.

A. $\frac{1}{2}mgR$

B. mgR

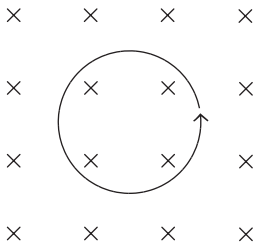
C. $2mgR$

D. $4mgR$

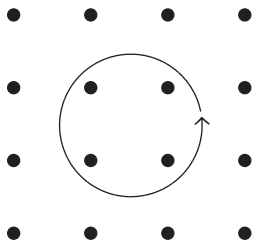
Question 5

Which one of the following diagrams best represents a magnetic field around a current-carrying circular loop?

A.



B.



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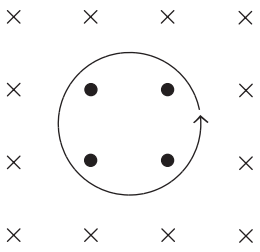
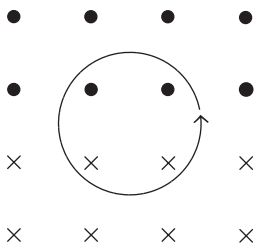
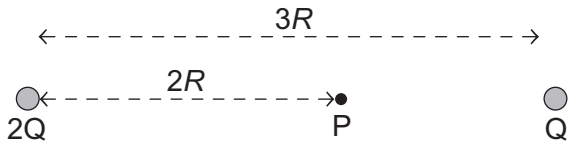


D.



Question 6

Two positive charges, 2Q and Q, are in fixed positions and separated by a distance of 3*R*, as shown in the diagram below. Position P is at a distance of 2*R* from 2Q.

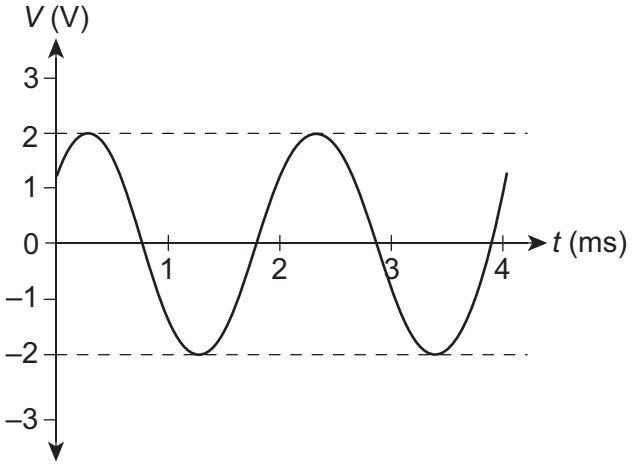


Which one of the following best represents the magnitudes and directions of the electric fields due to charges 2Q and Q at position P?

	Electric field due to charge 2Q at position P	Electric field due to charge Q at position P
A.	→	←
B.	←	→
C.	→	←
D.	←	→

Question 7

A voltage output, *V*, versus time, *t*, graph is shown below.

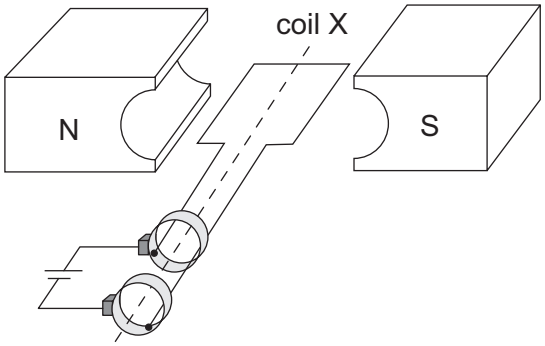


Which one of the following identifies the period, peak voltage and frequency of the voltage output?

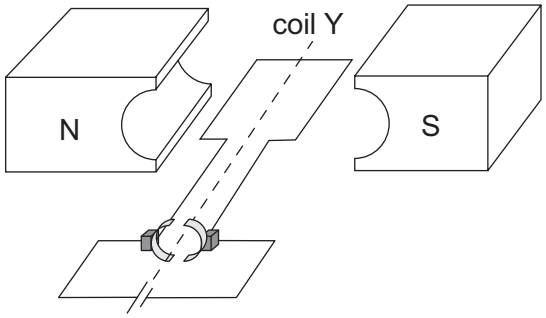
	Period (ms)	Peak voltage (V)	Frequency (Hz)
A.	2	1.41	50
B.	500	2	500
C.	2	2	500
D.	500	1.41	50

Question 8

Two identical coils of wire, X and Y, are each positioned between the poles of two magnets and experience identical magnetic fields, as shown below. Both coils are connected to a battery, but the coils are connected in a different arrangement.



Generator 1



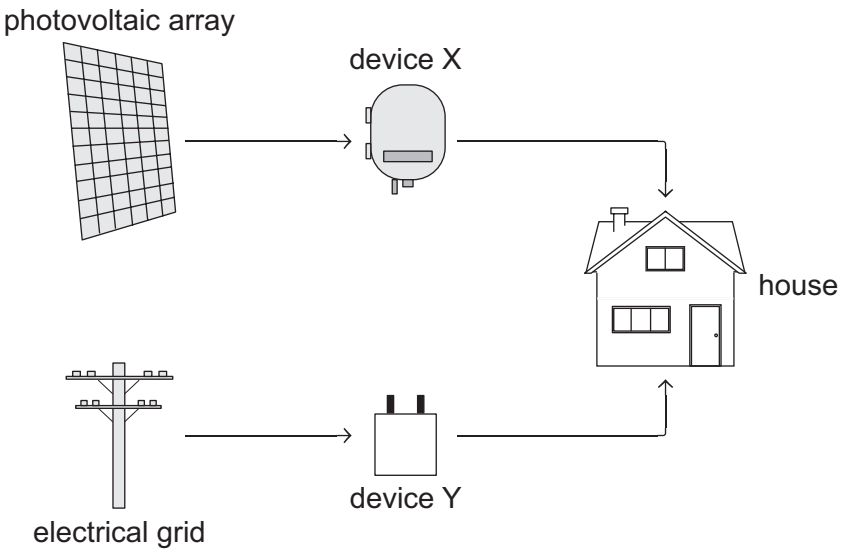
Generator 2

Which one of the following describes the movement of the coils?

	Coil X	Coil Y
A.	turns anticlockwise continuously	makes a quarter-turn anticlockwise from the position shown and then oscillates to rest vertically
B.	makes a quarter-turn anticlockwise from the position shown and then oscillates to rest vertically	turns anticlockwise continuously
C.	turns clockwise continuously	makes a quarter-turn clockwise from the position shown and then oscillates to rest vertically
D.	makes a quarter-turn clockwise from the position shown and then oscillates to rest vertically	turns clockwise continuously

Question 9

The diagram below illustrates a house's electrical power system. The system uses electricity from a photovoltaic array and the electrical grid. Device X is required between the photovoltaic array and the house, and device Y is required between the electrical grid and the house.



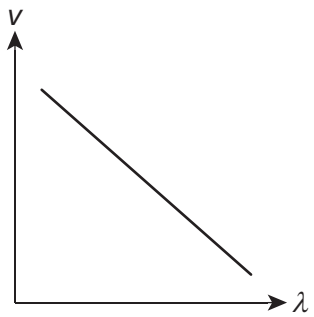
Which one of the following identifies the functions of device X and device Y?

	Device X	Device Y
A.	alters the DC output from the photovoltaic array to AC	steps down the electrical grid voltage to 240 V RMS
B.	alters the DC output from the photovoltaic array to 240 V DC	steps up the electrical grid voltage to 240 V RMS
C.	steps down the DC output from the photovoltaic array to 240 V RMS	inverts the electrical grid voltage to 240 V RMS
D.	steps up the DC output from the photovoltaic array to 240 V RMS	inverts the electrical grid voltage to AC

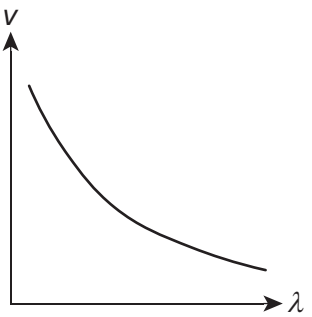
Question 10

Which one of the following graphs best represents the relationship between the speed, v, and wavelength, λ, of colours of light?

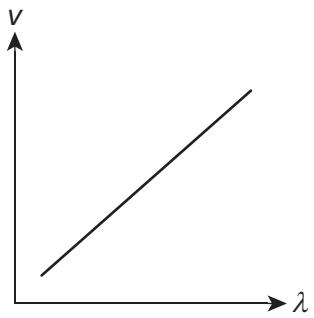
A.



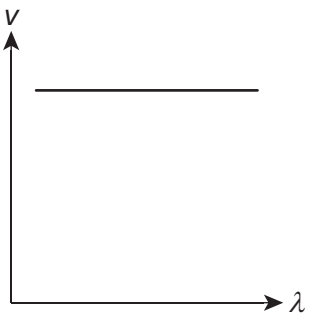
B.



C.

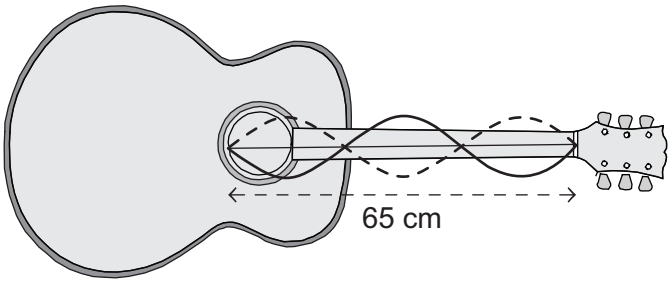


D.



Question 11

A standing wave in a guitar string is illustrated below. The frequency of the wave is 935 Hz.



The speed of the wave is

A. 135 m s^{-1}

B. 270 m s^{-1}

C. 405 m s^{-1}

D. 540 m s^{-1}

Question 12

Sam is viewing two small, identical objects of diameter *w* through a microscope. They expect the objects to appear as shown in diagram 1. However, the two objects appear as shown in diagram 2.

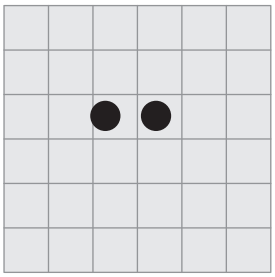


Diagram 1

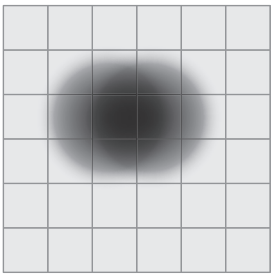


Diagram 2

Which one of the following best explains why Sam sees the objects as shown in diagram 2?

A. The separation of the two objects is large enough so that the interference of light from their vicinity causes the two images to overlap, making them appear as one image.

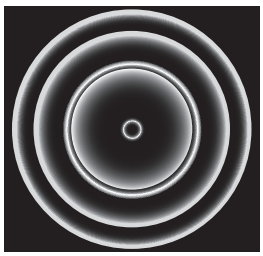
B. The separation of the two objects is large enough so that different beams of light from the edges of the objects cause the two images to overlap, making them appear as one image.

C. The $\frac{\lambda}{w}$ ratio for the range of wavelengths of light is large enough that diffraction is significant, which causes the two images to overlap, making them appear as one image.

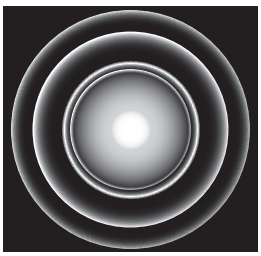
D. The $\frac{\lambda}{w}$ ratio for the range of wavelengths of light is small enough that diffraction is significant, which causes the two images to overlap, making them appear as one image.

Question 13

In an experiment, a beam of X-rays of wavelength 0.154 nm is directed towards the surface of nickel foil at various angles. The experiment is repeated using a beam of electrons instead of X-rays; all the electrons travel at the same speed. The resulting diffraction patterns are shown below.



X-rays



electrons

What is the speed of the electrons?

A. 2.17×10^{3} m s^{-1}

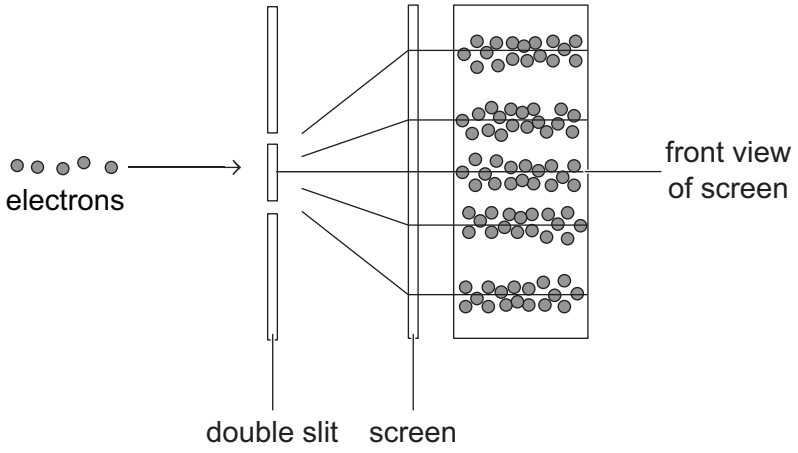
B. 4.73×10^{6} m s^{-1}

C. 5.32×10^{7} m s^{-1}

D. 8.92×10^{7} m s^{-1}

Question 14

The diagram below shows electrons being fired one at a time towards a double-slit arrangement. The electrons travel at the same speed and strike particular points on a screen that is positioned on the other side of the double-slit arrangement.



The behaviour of the electrons is best described as

A. particle-like only.

B. particle-like and wave-like.

C. wave-like only.

D. neither particle-like nor wave-like.

Question 15

Which one of the following was the null result of the Michelson–Morley experiment?

A. The aether did not exist.

B. There was no significant difference between the speed of light values when Earth travelled parallel to and at right angles to an assumed aether.

C. The speed of light values varied between right-angled directions of motion when Earth was in orbit.

D. The speed of light was constant in all directions on Earth.

Question 16

A spacecraft passes an observer at a speed of 0.80*c*. The proper length of the spacecraft is 120 m.

The measured length of the spacecraft as it passes the observer is

A. 43 m

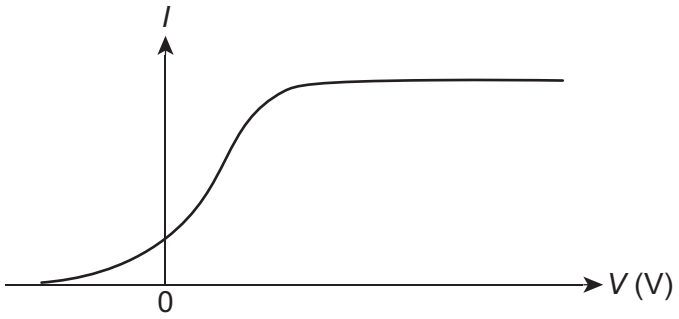
B. 54 m

C. 72 m

D. 200 m

Question 17

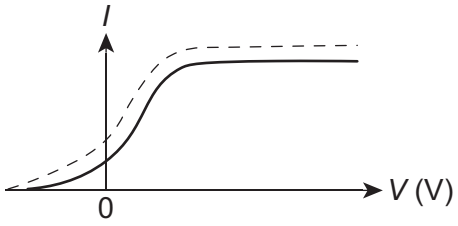
A Physics student is investigating the photoelectric effect. The student shines red light on a metal surface and records their data in the photocurrent, *I*, versus voltage, *V*, graph shown below.



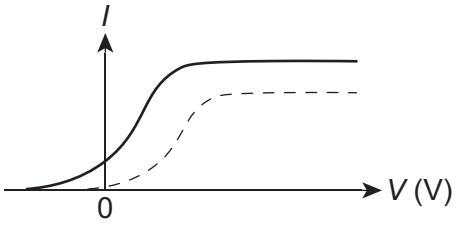
The student repeats the experiment with blue light that has greater intensity than the red light.

Which one of the following could be the photocurrent versus voltage graph for the red light (solid line) and blue light (dashed line) experiments?

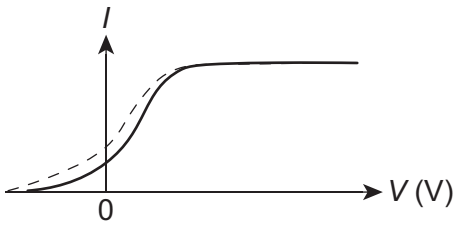
A.



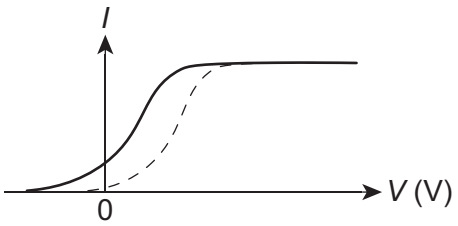
B.



C.

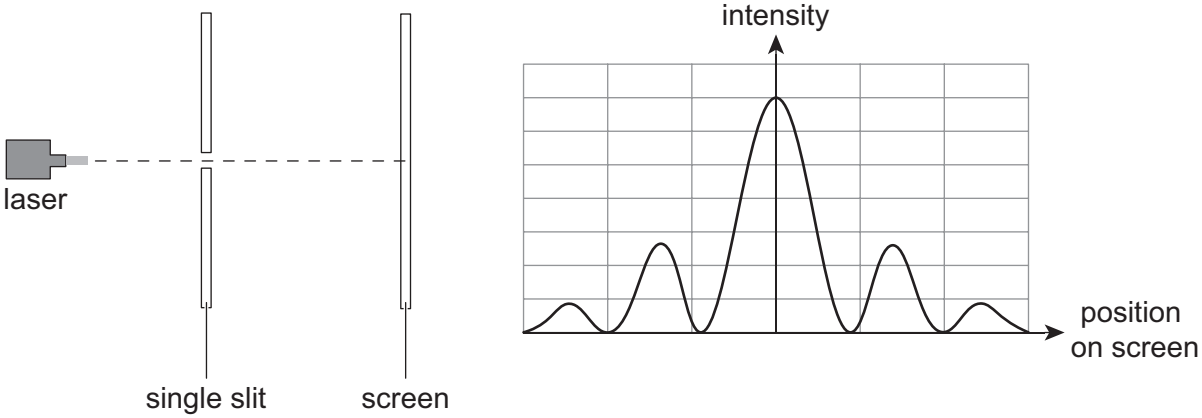


D.



Question 18

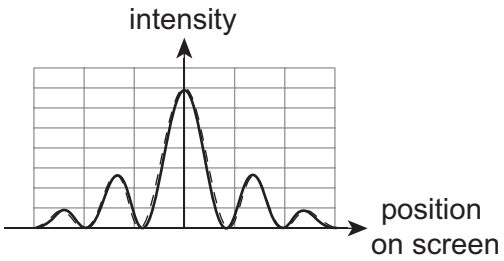
In an experiment, an orange laser is shone through a single slit and onto a screen, creating a diffraction pattern. The experimental set-up and diffraction pattern are shown below.



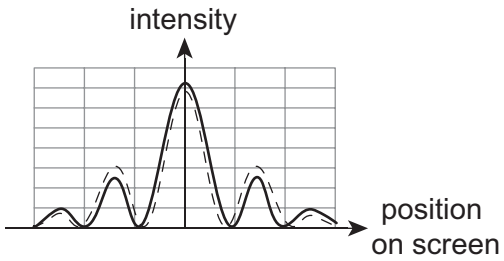
The orange laser is then replaced with a green laser of the same power. The green laser is shone through the same slit and onto the same screen.

Which one of the following could be the diffraction patterns of the orange laser (solid line) and green laser (dashed line)?

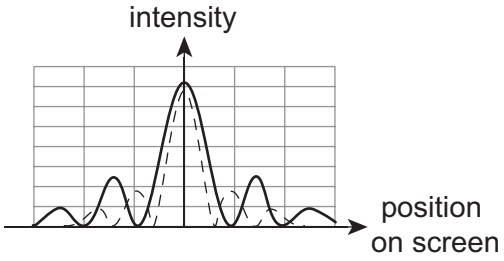
A.



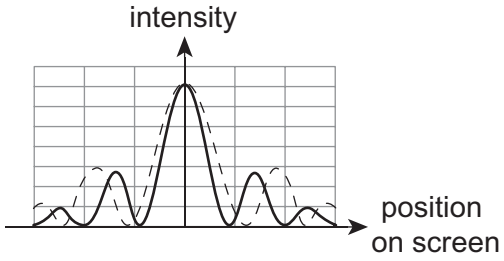
B.



C.



D.



Question 19

One of the fusion reactions that occurs in the Sun involves the combining of two identical helium-3 particles to produce a helium-4 particle and two protons. The reaction occurs according to the following equation.

$$\text{helium-3 particle} + \text{helium-3 particle} \rightarrow \text{helium-4 particle} + \text{proton} + \text{proton}$$

The mass of each particle type can be represented as follows.

Particle	Mass
helium-3	$m_{\text{He-3}}$
helium-4	$m_{\text{He-4}}$
proton	m_{p}

Which one of the following expressions best represents the energy produced by the fusion reaction?

A. $\left(m_{\text{He-4}} + 2m_{\text{p}} - 2m_{\text{He-3}}\right)c^2$

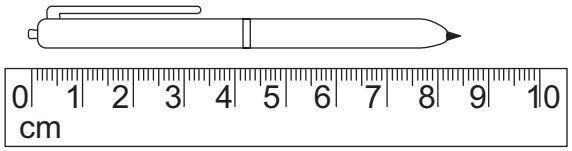
B. $\left(2m_{\text{He-3}} - m_{\text{He-4}} - 2m_{p}\right)$

C. $\left(2m_{\text{He-3}} + m_{\text{He-4}} + 2m_{p}\right)c^2$

D. $\left(2m_{\text{He-3}} - m_{\text{He-4}} - 2m_{p}\right)c^2$

Question 20

The following diagram shows a student's method of measuring the length of a pen.



The student measures the length of the pen to be 9.50 cm instead of 8.50 cm.

Which one of the following identifies the measurement error and uncertainty?

	Measurement error	Uncertainty
A.	1.00 cm	±0.05 cm
B.	0.05 cm	±1.00 cm
C.	9.50 cm	±0.05 cm
D.	9.5 cm	±1.0 cm

End of Section A

Section B

Instructions

- Answer **all** questions in the spaces provided.
- Write your responses in English.
- Where an answer box is provided, write your final answer in the box.
- 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.

Question 1 (4 marks)

A 2.0 kg block is positioned on a table and connected to a hanging 0.50 kg block via a string and pulley, as shown in Figure 1. The system of blocks is released and moves. Ignore friction between the table surface and the 2.0 kg block.

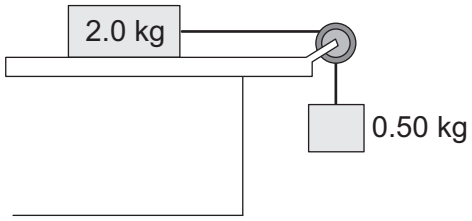


Figure 1

a. Show that the magnitude of the acceleration of the 2.0 kg block is 1.96 m s^{-2}. 2 marks

b. Determine the tension in the string. Show your working. 2 marks

N

Question 2 (7 marks)
A rocket of mass 5.00×10^5 kg is to launch from the surface of Earth into an orbit of altitude 7.50×10^5 m above the surface of Earth. Figure 2 shows the graph of the gravitational field strength of Earth versus the altitude of the rocket.

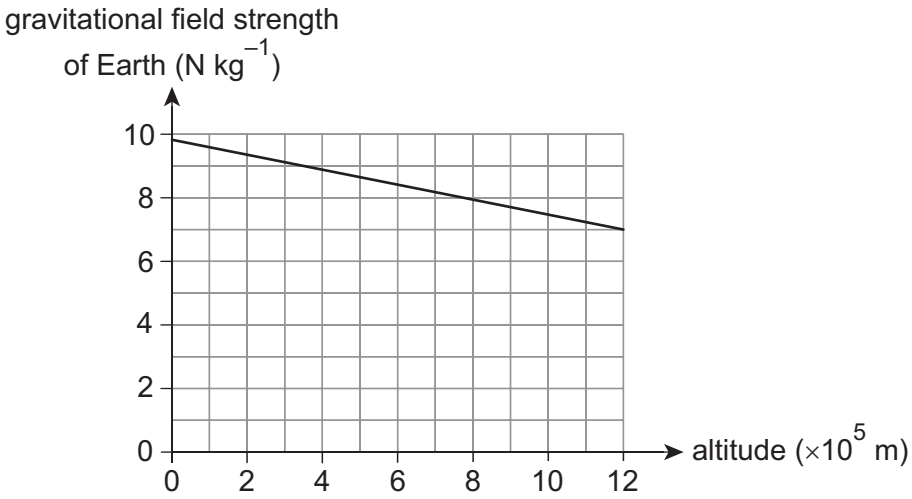


Figure 2

a. Determine the minimum energy required for the rocket to reach an altitude of 7.50×10^5 m above the surface of Earth. Show your working. 3 marks

J

b. Once the rocket has established a stable, circular orbit at an altitude of 7.50×10^5 m above the surface of Earth, what would be the period of the orbit? Show your working. 4 marks

s

Question 3 (5 marks)

Phobos is one of the moons of Mars. It orbits at an approximate distance of 5.99×10^6 m from the centre of Mars. The mass of Mars is 6.42×10^{23} kg, and the mass of Phobos is 1.07×10^{16} kg.

a. Determine the magnitude of the force of attraction between Mars and Phobos. Show your working. 2 marks

N

b. What is the orbital speed of Phobos? Show your working. 3 marks

$m\ s^{-1}$

Question 4 (3 marks)

A 200 g ball is attached to the end of a string and swung in a horizontal circle, as shown in Figure 3.

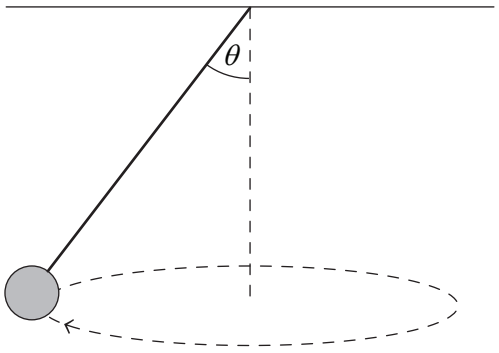


Figure 3

The string forms a constant angle, θ, with the vertical. The ball's constant horizontal speed is 1.96 m s^{-1} and its radius of motion is 0.500 m.

Calculate the tension in the string. Show your working.

N

Question 5 (3 marks)

Figure 4 shows a 1 kg ball attached to the end of a string in two positions. Position X shows the ball suspended vertically. Position Y shows the ball at the lowest point of its swing.

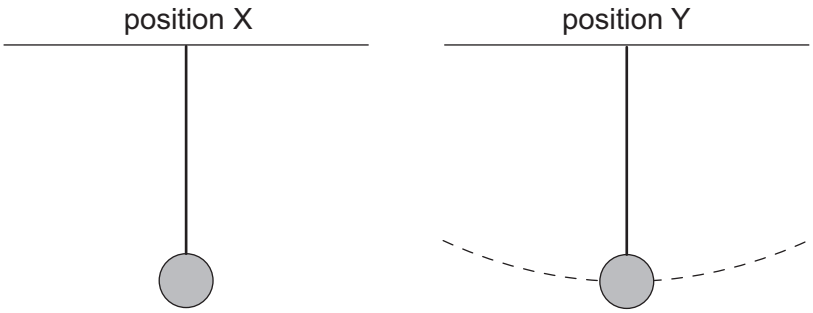


Figure 4

Using physics principles, compare the tensions in the string when the ball is in position X and position Y.

Question 6 (5 marks)

A corked champagne bottle sits in a bucket on a table. The cork has a mass of 10 g and is positioned 1.2 m above the floor. The cork pops out of the bottle and reaches its highest point 0.80 s later. The cork continues to move through the air and strikes the floor at a position that is a horizontal distance from its initial position, as shown in Figure 5. Ignore air resistance.

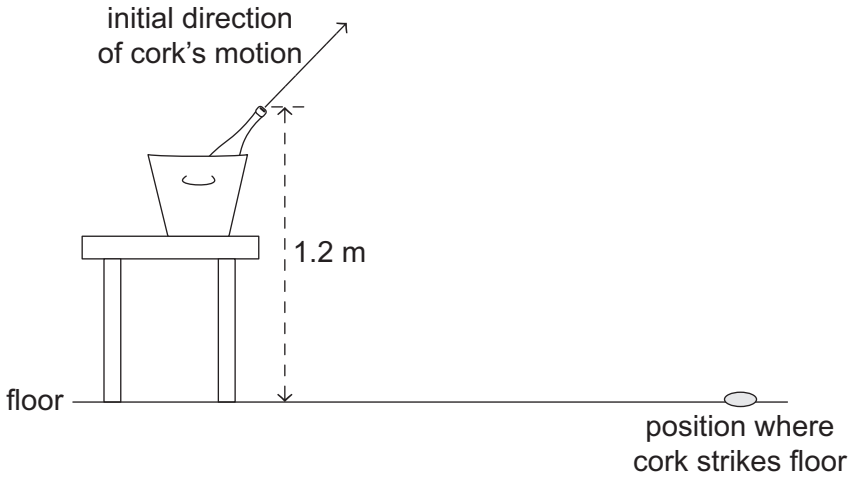


Figure 5

a. What is the maximum height above the floor that the cork reaches?
Show your working. 3 marks

m

b. Determine the gain in kinetic energy of the cork from its initial position in the bottle to when it strikes the floor. Show your working. 2 marks

J

Question 7 (5 marks)

A group of Physics students wish to determine the mass of a negatively charged sphere. They set up two electrically charged plates, positioning them 10 cm apart vertically with a potential difference of 2.0 kV between them. They place the sphere with a charge of -5.00×10^{-6} C between the plates, as shown in Figure 6. The sphere remains stationary upon being placed in the position shown.

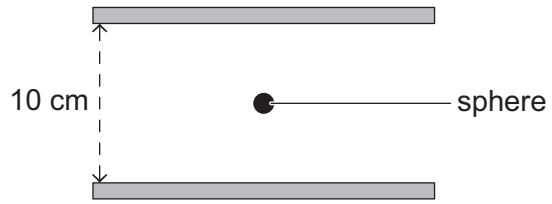


Figure 6

a. Calculate the magnitude of the electric field at the sphere's position. Show your working. 2 marks

N C^{-1}

b. On Figure 6, label the positive plate. 1 mark

c. Calculate the mass of the sphere. Show your working. 2 marks

kg

Question 8 (3 marks)

As part of a project, a pair of Physics students build the DC motor illustrated in Figure 7.

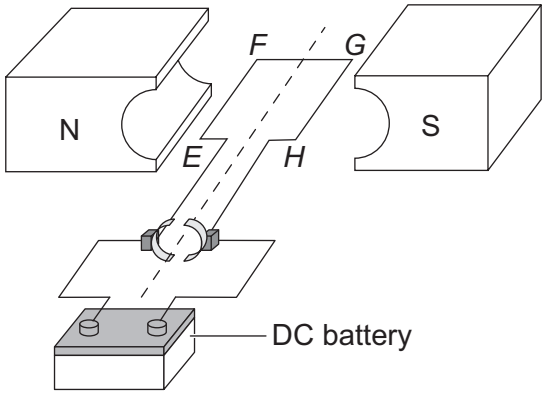


Figure 7

The students switch the battery on, and the coil rotates freely. One of the students states that the sum of the forces acting on the coil is zero.

Explain why the coil rotates if there is a net force of zero acting on it.

Question 9 (3 marks)

A single beam of positive charges travels into a region of vacuum consisting of an external magnetic field. The charges enter the magnetic field with the same speed. The beam separates into two paths, A and B, as it travels through the magnetic field, as shown in Figure 8. Paths A and B strike a detector.

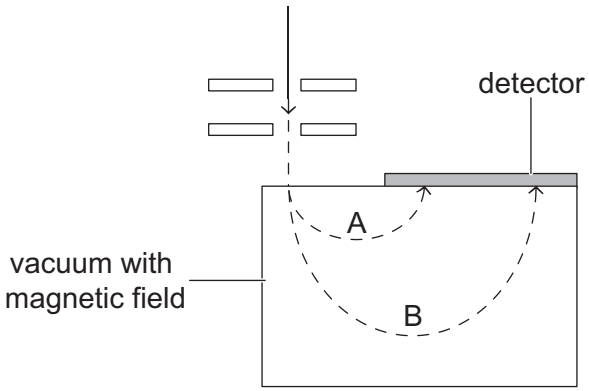


Figure 8

a. State **two** factors that could have resulted in path B having a greater radius than path A. 2 marks

b. State the direction of the external magnetic field. 1 mark

Question 10 (10 marks)

A square coil has a side length of 10 cm and consists of 10 turns. The coil rotates at a rate of 1.0 Hz in the presence of an external magnetic field of strength 0.10 T, as shown in Figure 9.

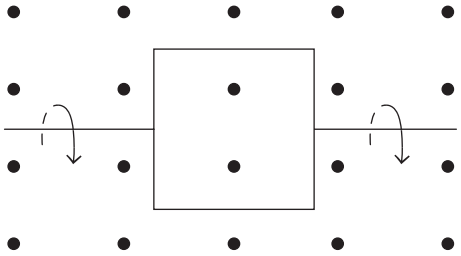


Figure 9

a. Calculate the magnitude of the flux through the coil when it is in the position shown in Figure 9. Show your working. 2 marks

Wb

b. Calculate the average EMF developed in the coil during one quarter of a full rotation if the rotation commences from the position shown in Figure 9. Show your working. 3 marks

V

c. Explain how your answer to **part b.** would change if the coil rotated at 4.0 Hz. No calculations are required. 2 marks

d. Draw an arrow on Figure 9 to show the direction of the induced current in the coil as the coil begins to rotate from the position shown. Justify your answer using physics principles. 3 marks

Question 11 (5 marks)

A food centre at a market operates using an AC generator. Figure 10 illustrates the circuit diagram. The generator is a few hundred meters away from the food centre and connects to two transformers, T_1 and T_2, via long transmission lines. The transformers are ideal and the wiring between them has a total resistance of 8.0 Ω. The transformer ratios are shown below each transformer.

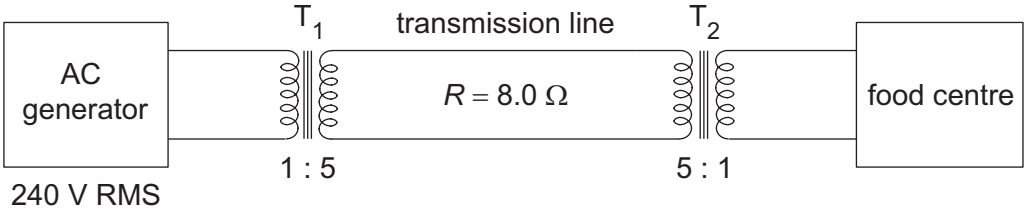


Figure 10

The generator's output voltage is 240 V RMS. The appliances in the food centre will not operate if the voltage supplied is less than 220 V.

During the food centre's busiest period, the current into the primary coil of T_1 is 40 A.

Determine whether the appliances will be operational during the busiest period. Show your working.

Question 12 (9 marks)

In an experiment, beams of white light are directed through a double-slit arrangement, producing a spectrum of dark and coloured bands on a screen. The screen is located 3.00 m from the plane of the double slits. The experimental set-up is shown in Figure 11, where P represents the position on the screen that is equidistant from both slits.

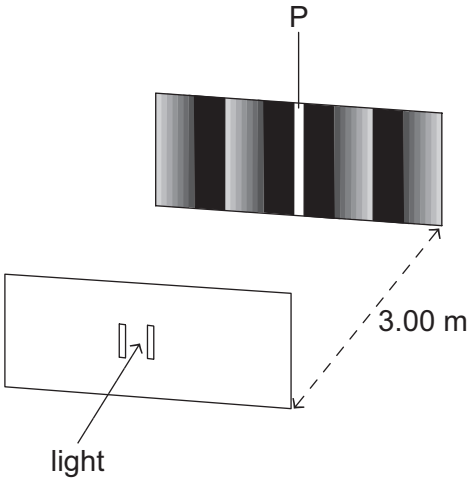


Figure 11

Figure 12 shows a section of the screen. There are coloured bands between the dark bands, and each coloured band consists of thin bands of the seven colours of white light. The positions of the violet and red bands that are closest to the centre are shown.

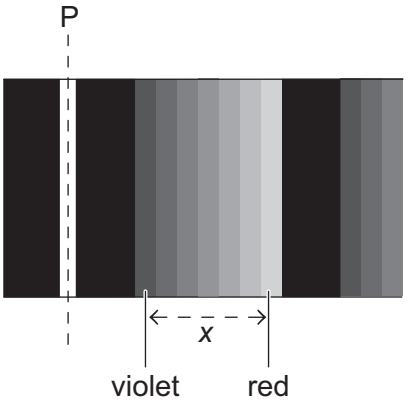


Figure 12

a. What is the colour of the band at position P? Justify your answer using physics principles. 3 marks

b. Explain what the spectrum of bands on the screen indicates about the nature of light. 3 marks

c. The table below shows some data from the experiment.

wavelength of red light	663 nm
wavelength of violet light	405 nm
distance between slits	200 μm

Calculate the distance between the violet and red bands, *x*, shown in Figure 12.
Show your working. 3 marks

m

Question 13 (10 marks)

Leila is a physicist who is investigating the photoelectric effect. In her experimental set-up, she uses a voltmeter to measure stopping voltage and a microammeter to measure current. Her set-up is shown in Figure 13.

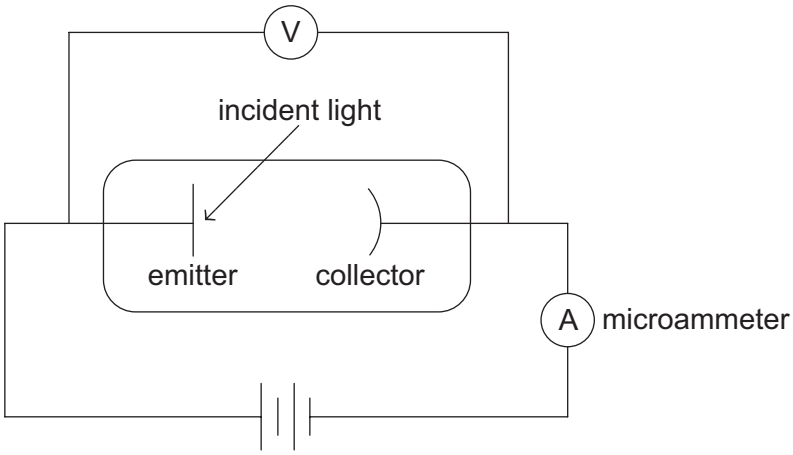


Figure 13

Leila conducts two experiments, A and B, and obtains the following data.

Experiment A

Trial	Colour	Light intensity ($W\ m^{-2}$)	Frequency (Hz)	Stopping voltage (V)	Current (μA)
1	violet	100	7.41×10^{14}	1.48	0.36
2	violet	200	7.41×10^{14}	1.48	0.73
3	violet	300	7.41×10^{14}	1.48	1.08
4	violet	400	7.41×10^{14}	1.48	1.43
5	violet	500	7.41×10^{14}	1.48	1.79

Experiment B

Trial	Colour	Light intensity ($W\ m^{-2}$)	Frequency (Hz)	Stopping voltage (V)	Current (μA)
1	ultraviolet	400	8.21×10^{14}	1.84	1.43
2	violet	400	7.41×10^{14}	1.48	1.43
3	blue	400	6.88×10^{14}	1.25	1.43
4	green	400	5.49×10^{14}	0.67	1.43
5	yellow	400	5.20×10^{14}	0.54	1.43

a. Using the experimental data, explain why the wave model does not account for the photoelectric effect. 3 marks

b. Leila's colleague, Colin, wishes to repeat experiment B, using the same five colours at an intensity of 800 W m^{-2}.

Explain which results would be expected to be different in Colin's experiment. 3 marks

Leila plots a graph of stopping voltage, $V_{stopping}$, versus light frequency, f, for experiment B. The graph includes a line of best fit, as shown in Figure 14.

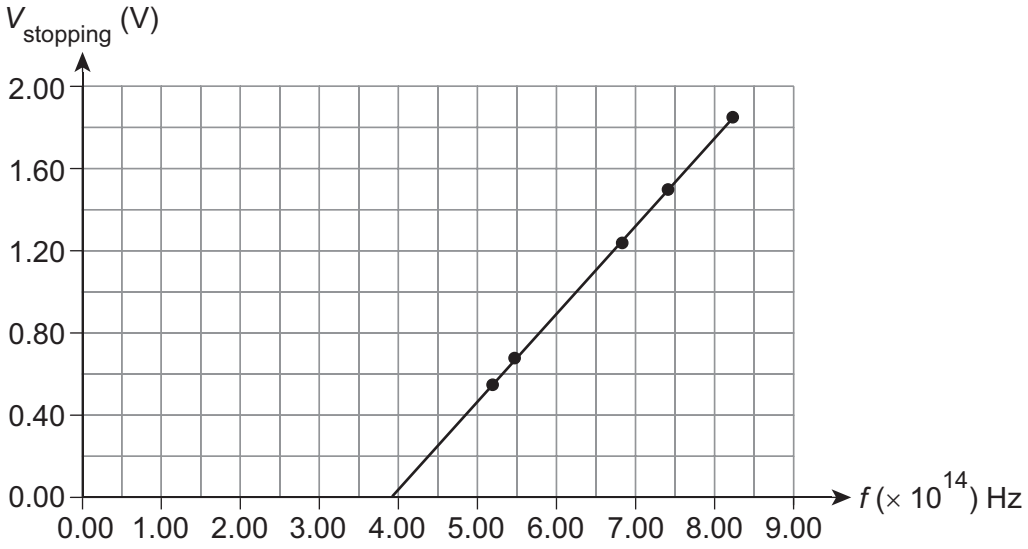


Figure 14

c. Calculate the work function of the metal. Show your working. 2 marks

eV

d. Leila performs another similar experiment, experiment C. She uses a different metal that requires a voltage of 0.40 V when it is irradiated by light of frequency 6.00×10^{14} Hz.

On Figure 14, plot the graph for this data. 2 marks

Question 14 (5 marks)

Beams of electrons irradiate the upper layers of a crystal such that two of the beams reflect from two atoms, 1 and 2. The reflected beams then travel different distances to arrive at the same position, A, on a screen, as shown in Figure 15.

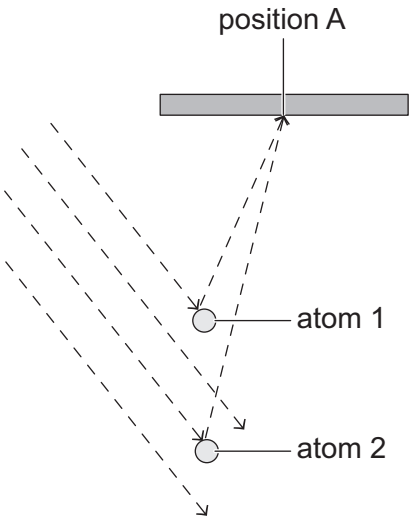


Figure 15

The reflected electrons of both beams travel at a speed of 4.36×10^{6} m s^{-1}. Atom 2 is 3.34×10^{-10} m further away from position A than atom 1.

a. Show that the de Broglie wavelength of the electrons is 1.67×10^{-10} m. 2 marks

b. Describe the behaviour of the reflected electrons of both beams when they reach position A. Justify your answer. 3 marks

Question 15 (4 marks)

The energy level diagram of a sodium atom is shown in Figure 16.

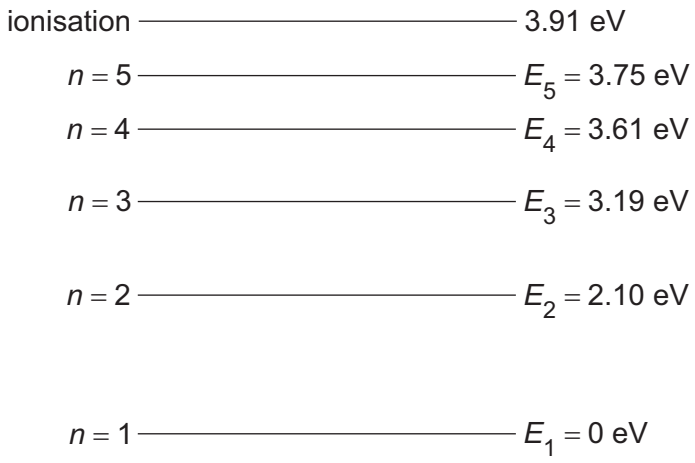


Figure 16

a. Calculate the longest wavelength that can be emitted by an electron in a transition. Show your working. 2 marks

m

b. Explain why the energy levels of a sodium atom are described as being quantised. 2 marks

Question 16 (7 marks)

A muon is a particle that is created in Earth's upper atmosphere. Muons travel at a speed of $0.99c$ ($\gamma = 7.09$) and exist for 2.2×10^{-6} s relative to their frame of reference before decaying into a different particle. They have a rest mass–energy of 106 MeV.

a. According to a stationary observer on Earth, how far do muons travel before decaying? Show your working. 3 marks

m

b. Muons travel approximately 650 m before decaying as measured in their frame of reference.

Explain whether your answer to **part a.** is consistent with the shorter distance measured in the muon's frame of reference. No calculations are required. 2 marks

c. Calculate the total energy of a muon as measured by a stationary observer on Earth. Show your working. 2 marks

MeV

Question 17 (12 marks)

In an experiment, a technique for determining the charge on a small test sphere is being investigated. A vacuum chamber houses a fixed sphere of known charge, and the test sphere can be placed at any position that is 10–60 cm from the fixed sphere. The distance between the centres of the spheres is represented by *d*. The test sphere connects to a sensor, which registers the force, *F*, acting on the test sphere. A computer program records the data. The set-up is shown in Figure 17.

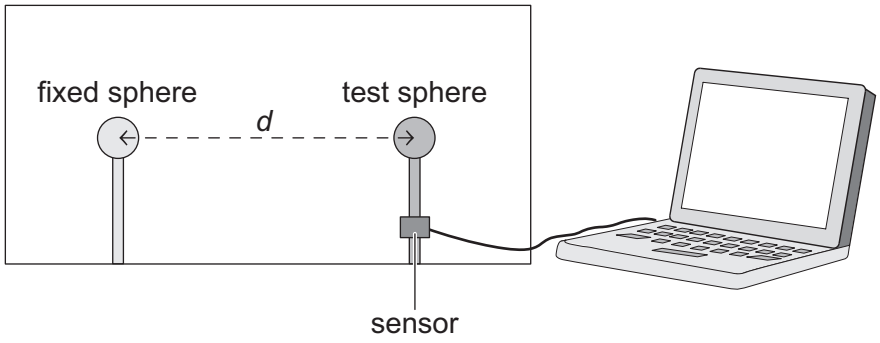


Figure 17

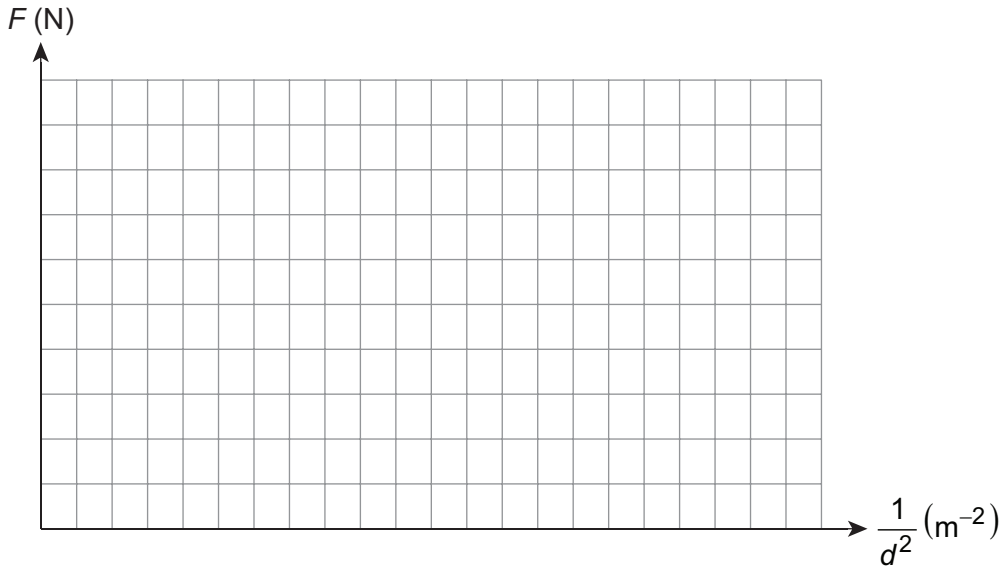
a. The table below shows the values of *d* used in the experiment and the resulting force acting on the test sphere, *F*.

Complete the table by calculating the values of $\frac{1}{d^2}$. 1 mark

d **(m)**	***F*** **(N)**	$\frac{\mathbf{1}}{\boldsymbol{d^2}}\left(\mathbf{m^{-2}}\right)$
0.100	2.2	100
0.150	0.96	
0.200	0.55	
0.250	0.40	
0.300	0.25	

b. On the axes below:

- plot a graph of F versus $\frac{1}{d^2}$
- include a point for $F = 0$
- include uncertainty bars of $\pm$ 0.10 N for the F values
- draw a straight line of best fit. 6 marks



c. Using the graph plotted in **part b.**, calculate the gradient of the line of best fit.
Show your working and give your answer correct to three significant figures. 2 marks

N m^{-2}

d. The charge of the fixed sphere is 1.0 μC.

Using the gradient calculated in **part c.**, calculate the charge of the test sphere.
Show your working. 3 marks

C

End of examination questions