Neap

Trial Examination 2020

# 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 34 pages

Formula sheet

Answer sheet for multiple-choice questions

**Instructions**

Please ensure that you write your **name** and your **teacher's name** in the space provided on this booklet 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 2020 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

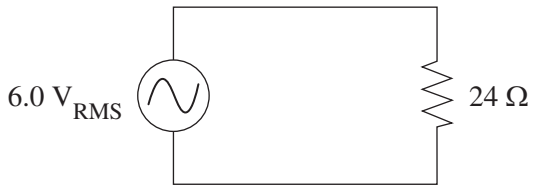
Electric point charge fields and gravitational fields have some common properties.

Which one of the following provides two correct statements about the properties of these field types?

| | Statement 1 | Statement 2 |
|---|---|---|
| **A.** | The inverse square law applies to the magnitude of both field types. | Both field types can create repulsive or attractive forces. |
| **B.** | The inverse square law applies to the magnitude of only one field type. | Both field types can create repulsive or attractive forces. |
| **C.** | The inverse square law applies to the magnitude of both field types. | Only one field type can create repulsive or attractive forces whereas the other can only create attractive forces. |
| **D.** | The inverse square law applies to the magnitude of only one field type. | Only one field type can create repulsive or attractive forces whereas the other can only create attractive forces. |

### Question 2

A 6.0 $V_{RMS}$ power supply is connected across a 24 Ω resistor, as shown in the diagram below.



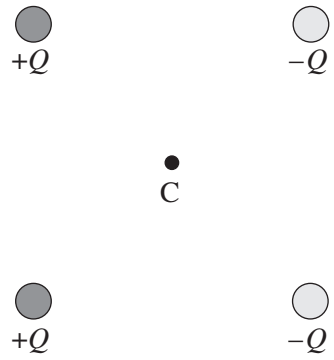

Which one of the following shows the correct peak-to-peak voltage and peak current for the resistor?

| | Peak-to-peak voltage | Peak current |
|---|---|---|
| **A.** | 4.2 V | 0.25 A |
| **B.** | 6.0 V | 0.71 A |
| **C.** | 8.5 V | 0.25 A |
| **D.** | 17 V | 0.35 A |

*Use the following information to answer Questions 3 and 4.*

Four charges of equal magnitude, but different signs, form the vertices of a square, as shown below. The centre of the square is labelled C.




**Question 3**

Which one of the following vector arrows represents the direction of the net electric field at point C?

**A.**

**B.**



**C.**



**D.**

**Question 4**

The square has a side length of 1.0 cm. The value of each charge is 1.0 $\mu$C.

Which one of the following represents the magnitude of the force of one charge of $+Q$ on the other charge of $+Q$?

**A.** $9.0 \times 10^{1}$ N

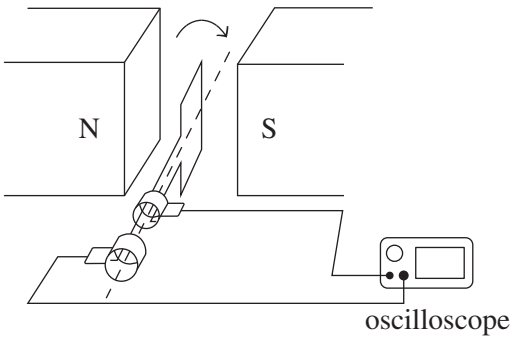
**B.** $9.0 \times 10^{7}$ N

**C.** $9.0 \times 10^{9}$ N

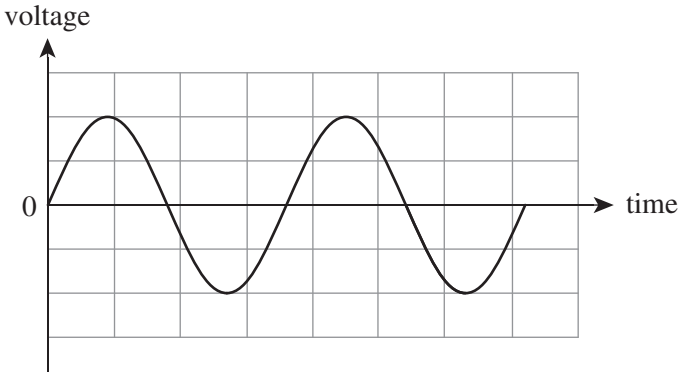
**D.** $9.0 \times 10^{11}$ N

*Use the following information to answer Questions 5 and 6.*

An AC alternator connected to an oscilloscope is shown in the diagram below.



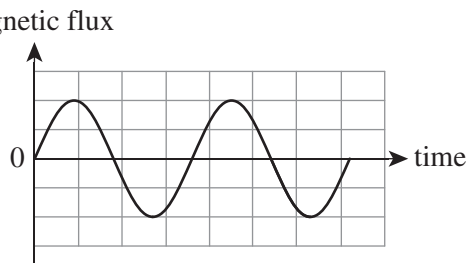

The oscilloscope shows the following output voltage for the alternator from the starting position shown in the diagram above.



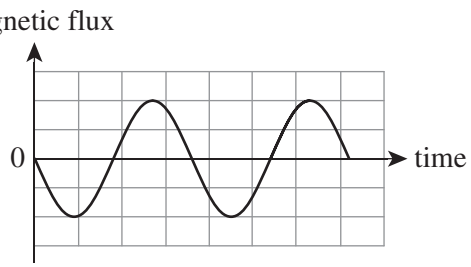

**Question 5**

Which one of the following graphs best represents the variation in magnetic flux versus time?

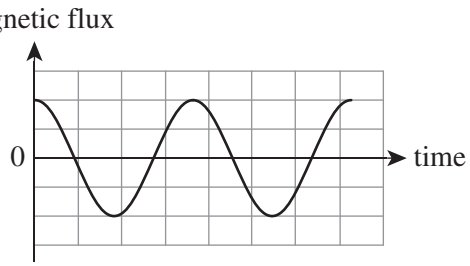
**A.**



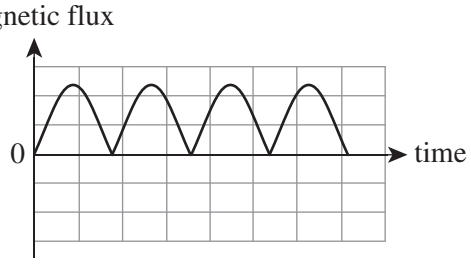

**B.**




**C.**




**D.**

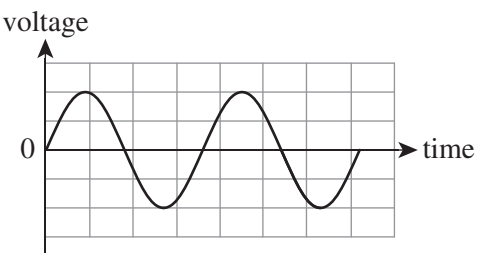


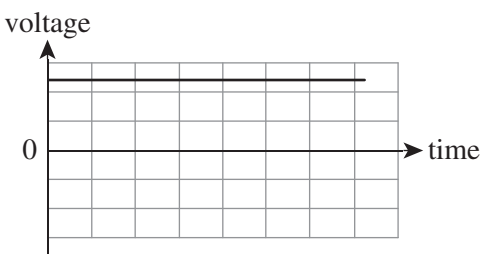
**Question 6**

Which one of the following graphs best represents the voltage output measured by the oscilloscope if the connections between the coil and the oscilloscope were replaced with a split-ring commutator?

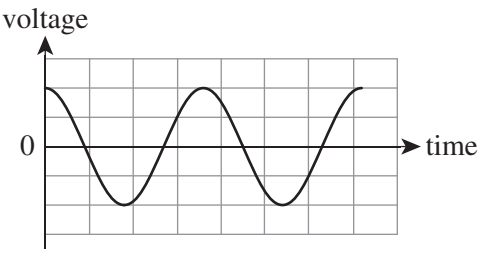
**A.**



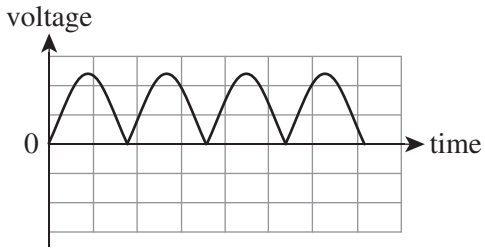

**B.**




**C.**

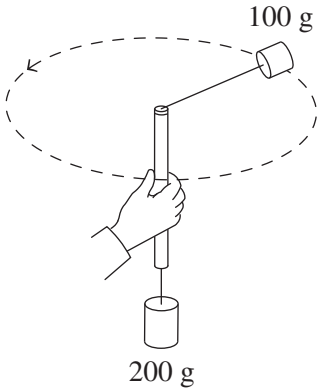



**D.**




**Question 7**

A student holds a rod that has a mass of 100 g attached by a string to one end and a mass of 200 g attached by a string to the other end. They whirl the 100 g mass in a horizontal circle while the 200 g mass remains stationary, as shown in the diagram below. The radius of the circle is 0.30 m




What is the magnitude of the acceleration of the 100 g mass?

**A.** 0.00 m $s^{-2}$

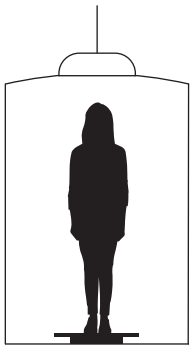
**B.** 4.90 m $s^{-2}$

**C.** 9.80 m $s^{-2}$

**D.** 19.6 m $s^{-2}$

**Question 8**

Jane stands on a weighing scale inside an elevator, as shown below. When the elevator is stationary, the scale reads 55 kg.



At a different time, when the elevator is increasing its speed, the scale reads 53 kg.

At this time, the force of Jane on the scale and the direction of the elevator's motion is

**A.** 19.6 N down.

**B.** 19.6 N up.

**C.** 519.4 N down.

**D.** 519.4 N up.

**Question 9**

Two identical rockets of length $L$ are travelling past each other at a speed of $0.8c$. Robin is in one rocket and Maurice is in the other rocket. They are able to measure the lengths of each other's rocket as they travel past each other.

Which one of the following statements about Maurice and Robin's measurements of each other's rocket is correct?

**A.** Maurice measures Robin's rocket to be longer than $L$ and Robin measures Maurice's rocket to be longer than $L$.

**B.** Maurice measures Robin's rocket to be shorter than $L$ and Robin measures that Maurice's rocket to be shorter than $L$.

**C.** Maurice measures Robin's rocket to be longer than $L$ and Robin measures that Maurice's rocket to be shorter than $L$.

**D.** Maurice measures Robin's rocket to be shorter than $L$ and Robin measures that Maurice's rocket to be longer than $L$.

**Question 10**

A 1 kg ball is released from rest from a height of 10 m above the ground. The ball strikes the ground at a speed of 13 m $s^{-1}$.

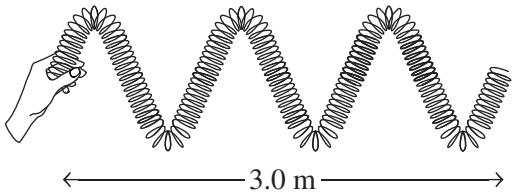
Which one of the following correctly identifies the energies as the ball falls from rest to the ground?

| | Work done by gravity (J) | Energy converted to heat and sound (J) | Energy of the ball at ground level (J) |
|---|---|---|---|
| **A.** | 98 | 0 | 84.5 |
| **B.** | 98 | 13.5 | 84.5 |
| **C.** | 84.5 | 0 | 0 |
| **D.** | 84.5 | 13.5 | 84.5 |

**Question 11**

A transverse wave is generated on a slinky spring such that the energy travels 3.0 m in 1.5 seconds, as shown in the diagram below.

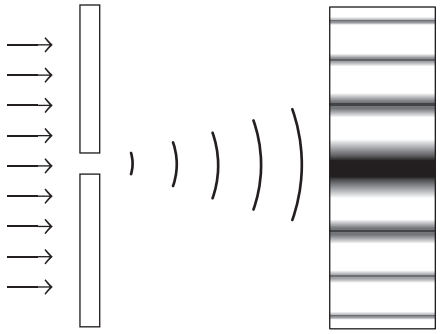



The frequency of the wave is

**A.** 1.0 Hz
**B.** 1.5 Hz
**C.** 2.0 Hz
**D.** 3.0 Hz

**Question 12**

Students in a physics laboratory shine a beam of light of a single colour through a single slit and obtain the pattern of bright and dark bands shown below.




If the width of the slit is increased, what would be the effect on the pattern of bright and dark bands?

**A.** There would be no change to the pattern.
**B.** The positions of the bright and dark bands would remain the same but the bands would become brighter.
**C.** The bright and dark bands would alter their positions and would become closer to each other.
**D.** The bright and dark bands would alter their positions and would become further apart.

**Question 13**

The de Broglie wavelength of an electron is the same as the 500 nm wavelength of a photon.

Which one of the following statements about the electron and photon is correct?

**A.** The electron and photon have the same momentum and total energies.
**B.** The electron and photon have the same momentum but different total energies.
**C.** The electron and photon have the same total energies but different momenta.
**D.** The electron and photon have different total energies and different momenta.

**Question 14**

A photon of blue light has a frequency of $6.00 \times 10^{14}$ Hz.

The best estimate of the photon's momentum is

**A.** $8.28 \times 10^{-9}$ kg m s$^{-1}$

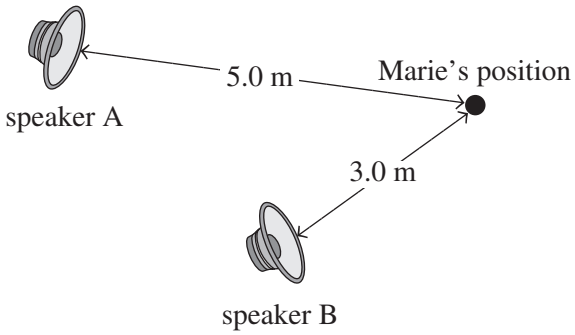
**B.** $3.98 \times 10^{-19}$ kg m s$^{-1}$

**C.** $1.33 \times 10^{-27}$ kg m s$^{-1}$

**D.** $1.11 \times 10^{-48}$ kg m s$^{-1}$

**Question 15**

Marie is standing in a large hall and is positioned 5.0 m from speaker A and 3.0 m from speaker B, as shown below. Both speakers are identical.




When speaker A is switched on, Marie hears a single note (frequency) played at constant volume. While the note from speaker A is still playing, speaker B is switched on and plays the same note with the same volume output. The volume of the note now seems lower to Marie compared to when only speaker A played the note.

The possible wavelengths of sound played by the speakers are

**A.** 1.0 m, 3.0 m, 5.0 m

**B.** 1.3 m, 2.0 m, 4.0 m

**C.** 0.5 m, 1.5 m, 2.5 m

**D.** 0.8 m, 1.3 m, 4.0 m

**Question 16**

Which one of the following best describes the condition that results in resonance?

**A.** interference of two travelling waves that produces a resulting wave

**B.** interference of two waves at a point, resulting in the production of a different wave

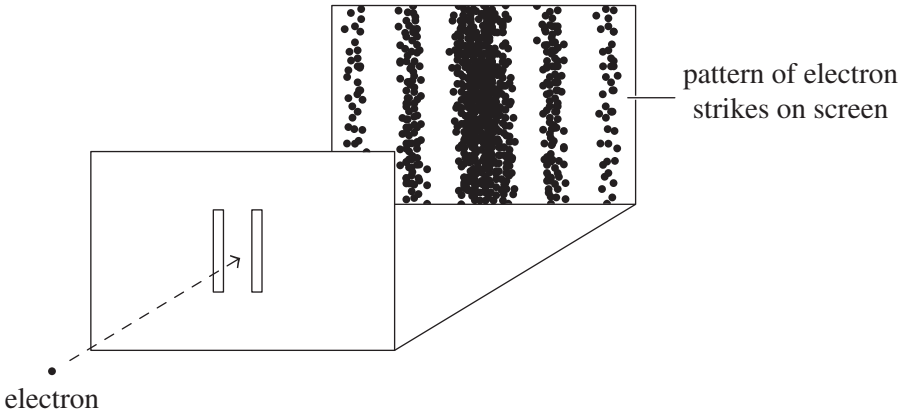
**C.** interference of a wave and its reflection created with a frequency that is natural to the medium

**D.** interference of many waves, resulting in high amplitudes of energy

**Question 17**

An electron beam gun projects electrons, one at a time, toward a double-slit arrangement. The electrons are projected at the same speed. After some time, an interference pattern is observed on the screen placed on the other side of the double-slit, as shown in the diagram below. The electrons are observed to strike the screen one at a time.




The pattern of electron strikes on the screen indicates that the

**A.** electrons display wave behaviour.

**B.** electrons display particle behaviour.

**C.** behaviour of the electrons depends on the size and separation of the slits.

**D.** electrons display both wave and particle behaviour.

*Use the following information to answer Questions 18–20.*

A group of Physics students are interested in determining the fall time of a tennis ball from a height of 5.0 m. The students release the ball from rest and measure the time it takes for the ball to strike the ground. They undertake five trials, all conducted in the same way.

The students record the following results:

1.0 s  1.5 s  0.9 s  1.1 s  1.1 s

The students decide that the uncertainty in their measurements is ±0.1 s. They also perform a calculation and believe the true result to be 1.0 s.

The students choose to discard the 1.5 s measurement.

**Question 18**

Which one of the following represents the error in the 1.5 s measurement?

**A.** 0.1 s
**B.** 0.5 s
**C.** the difference between the average of all the results and the 1.5 s measurement
**D.** the difference between the average of all the results not including the 1.5 s measurement and the 1.5 s measurement

**Question 19**

Once the 1.5 s measurement has been discarded, the set of four remaining measurements is best described as

**A.** precise and accurate.
**B.** accurate and certain.
**C.** precise and true.
**D.** accurate and true.

**Question 20**

If the students had used different balls in each trial (for example: a marble, golf ball, tennis ball, squash ball, and ball bearing) then the data set obtained would

**A.** have had a different measurement of uncertainty for each trial.
**B.** have rendered the experimental method unreliable.
**C.** have had more than one independent variable and so be non-comparable.
**D.** still have been reliable to achieve the aim of the experiment.

## SECTION B

**Instructions for Section B**

Answer **all** questions in the spaces provided. Write using blue or black pen.

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** (4 marks)

The centres of a positively charged plate of value $1.0 \times 10^{-6}$ C and a negative point charge of value $-1.0 \times 10^{-6}$ C are 1.0 cm apart, as shown in Figure 1. The plate is fixed and the point charge is able to move.

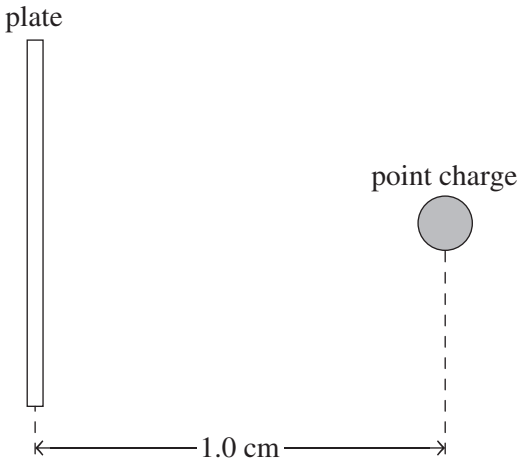



**Figure 1**

**a.** Sketch on Figure 1 the electric field lines between the plate and the point charge.
Use at least **five** field lines. 2 marks

**b.** Explain what happens to the magnitude of the acceleration of the point charge as it moves as a result of the interaction with the plate. 2 marks

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**Question 2** (6 marks)

Figure 2 shows the path of a charged particle accelerated into a region of magnetic field that is directed into the page.

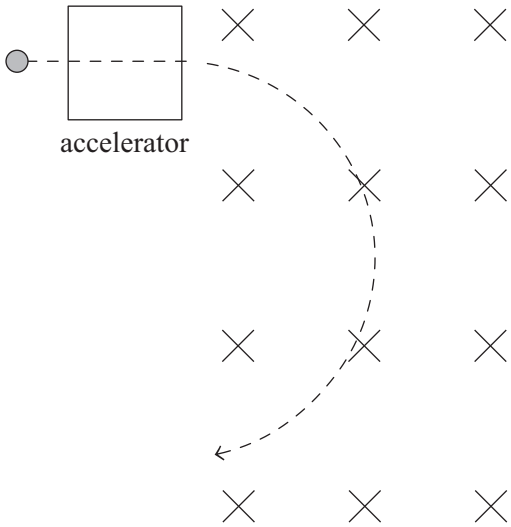


**Figure 2**

**a.** Is the charge of the particle in Figure 2 positive or negative.? 1 mark

_____

**b.** Sketch on Figure 2 vectors that represent the magnetic force acting on the charged particle at **three** different points on particle's curved path. 2 marks

**c.** Determine the size of the force acting on the particle if it has a charge of $1.6 \times 10^{-19}$ C and enters the region of magnetic field of value 7.00 T at a speed of $8.00 \times 10^{6}$ m $s^{-1}$.
Give your answer to two significant figures. Show your working. 3 marks

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N

 

**Question 3** (5 marks)

A rectangular coil EFGH is connected to a DC battery to produce a motor arrangement as shown in Figure 3.

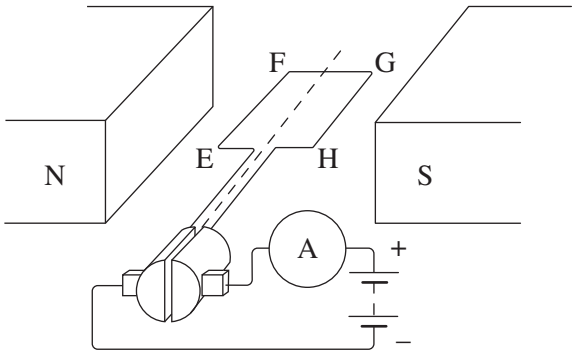


**Figure 3**

**a.** For the instance shown above, the coil rotates but the net force acting on the coil is zero.

Explain how this occurs for the coil **and** state the direction of rotation. 3 marks

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**b.** The coil consists of 50 turns. The resistance of the coil is 24 Ω. The battery voltage is 6.0 V. The sides EF and GH are 5.0 cm in length.

Determine the size of the force acting on side EF if the size of the magnetic field is 0.020 T. Show your working. 2 marks

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N

**Question 4** (4 marks)

A graph of gravitational field strength versus distance from Earth's centre is shown in Figure 4.

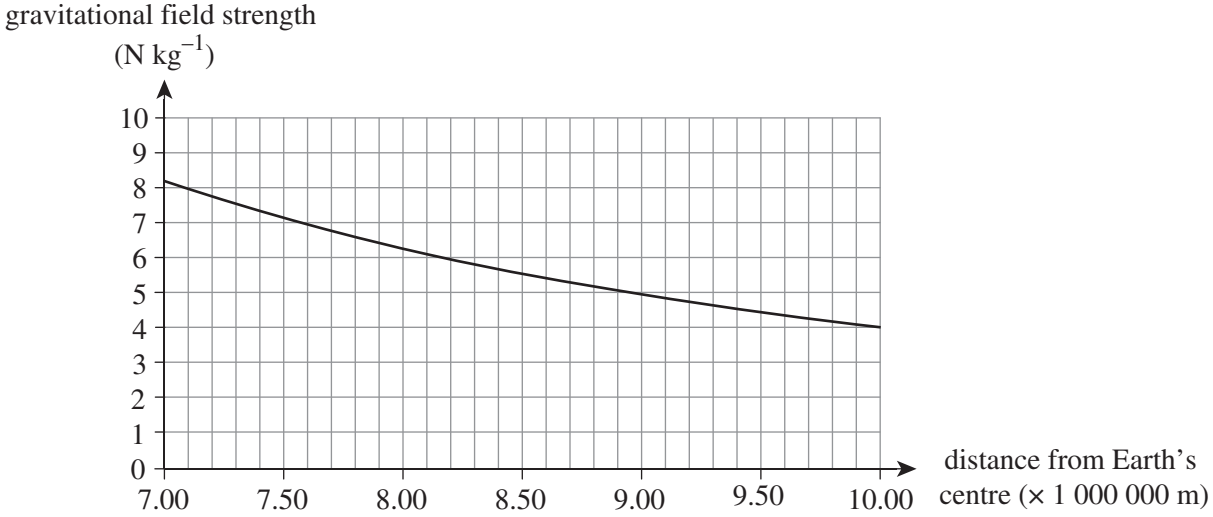


**Figure 4**

A rocket of mass 10 000 kg is positioned at $7.30 \times 10^6$ m from the centre of the Earth. The crew estimates that it has enough fuel to provide it with $1.0 \times 10^{10}$ J of energy.

Is the amount of energy available enough to allow the rocket to move in a straight line to a distance of $1.00 \times 10^7$ m from Earth's centre? Support your answer with a calculation.

 

**Question 5** (3 marks)

The Chandrayaan-2, an Indian spacecraft on a scientific expedition to the Moon, was in orbit around the Moon as part of its preparation for landing. It maintained an altitude of 123 km above the surface of the Moon for a while. Some relevant data is shown below.

**Data**

| | |
|---|---|
| mass of Chandrayaan-2 | 682 kg |
| mass of the Moon | $7.35 \times 10^{22}$ kg |
| radius of the Moon | $1.74 \times 10^{6}$ m |
| altitude of Chandrayaan-2 above Moon's surface | $1.23 \times 10^{5}$ m |
| gravitational constant | $6.67 \times 10^{-11}$ N m$^2$ kg$^{-2}$ |

Calculate the period of the Chandrayaan-2 in orbit around the Moon. Show your working.

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|---|---|
| | s |

**Question 6** (8 marks)

In a class experiment, a group of students set up a circuit using a fixed 12 $V_{RMS}$ voltage supply and a 10 Ω resistor. A voltmeter is inserted in the circuit and all of the wiring used is very short. This is shown in Figure 5.

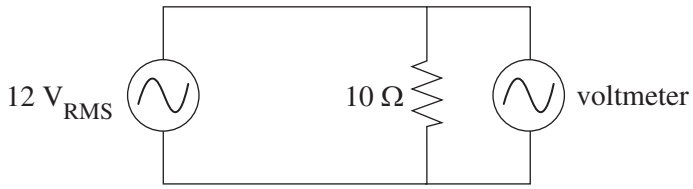


**Figure 5**

The students record the reading of the voltmeter as 12 V.

They now alter the circuit to include 200 m rolls of wire on either side of the power supply, connecting it to the 10 Ω resistor. The voltmeter is positioned in the same way. This is shown in Figure 6.

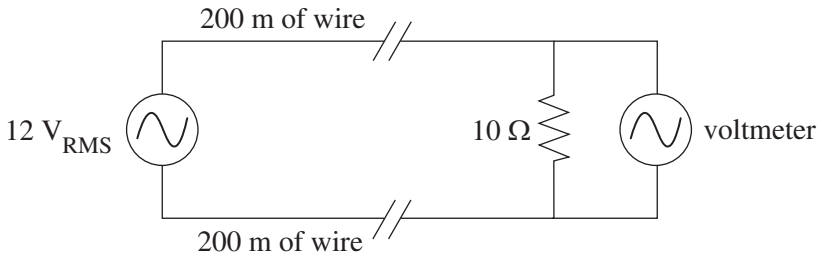


**Figure 6**

A 200 m roll of wire has a resistance of 1.6 Ω. The voltmeter now reads 9.1 V.

**a.** Provide calculations to show that the voltmeter reads 9.1 V. Show your working. 3 marks

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**b.** Determine the power loss as a result of the two 200 m rolls of wire. Show your working. 2 marks

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W

 

**c.** Describe how the students could use the same circuit shown in Figure 6 and any other equipment to achieve a reading close to 12 $V_{RMS}$ on the voltmeter. 3 marks

**Question 7** (12 marks)

Two students, Shane and Aisha, construct a coil of 25 rectangular loops of side dimensions 10.0 cm by 4.0 cm. The coil sits in a magnetic field of size 0.20 T, and the field lines are horizontal. This is shown in Figure 7.

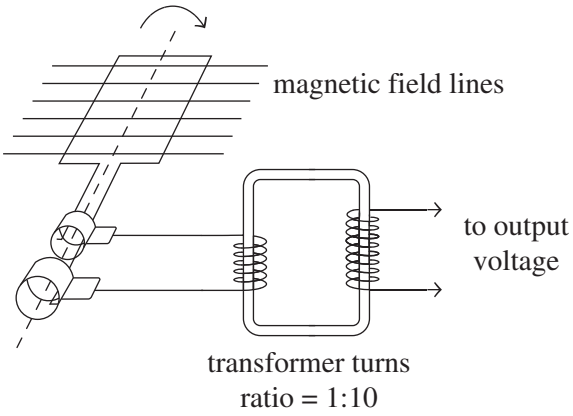


**Figure 7**

The loop system connects to a transformer of ratio 1:10. The output voltage from the transformer is recorded over time. The coil's starting position is as shown in Figure 7. It is turned at 2.5 rotations per second in the direction shown in Figure 7.

**a.** What is the maximum flux that the coil experiences in its rotation? Show your working. 2 marks

_____

_____

_____

_____

Wb

**b.** How long does the coil take to achieve its maximum flux from the starting position shown in Figure 7? 1 mark

_____

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s

**c.** What is the average voltage across the output terminals of the transformer in the time that the coil moves from the starting position shown in Figure 7 to the time of its maximum flux? Show your working. 2 marks

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V

 

Figure 8 shows the original output that results from the operation of the circuit shown in Figure 7.

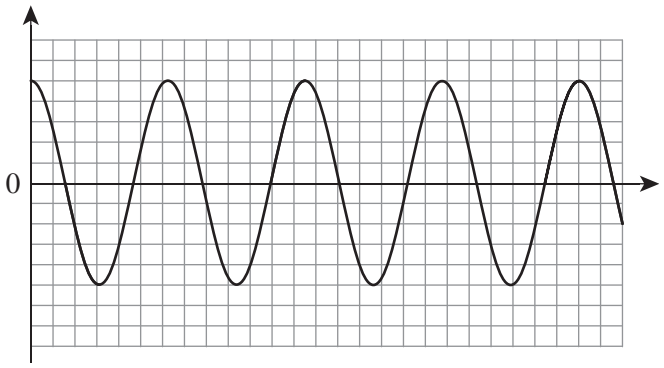


**Figure 8**

Figure 9 compares the original output shown in Figure 8 and a new output.

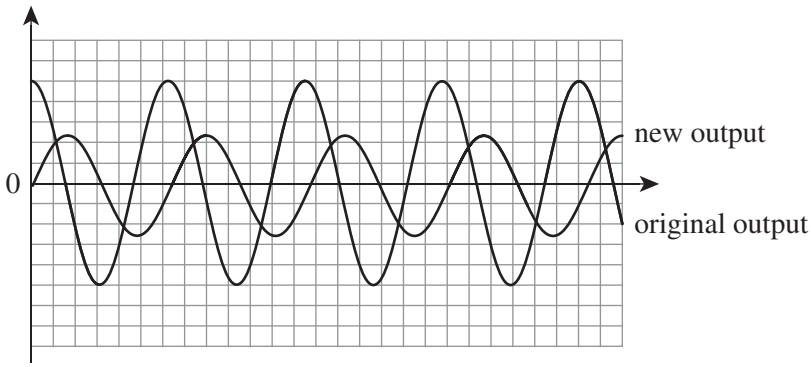


**Figure 9**

Aisha and Shane are discussing how they would alter the configuration shown in Figure 7 so that the original output shown in Figure 8 appears as the new output shown in Figure 9.

**d.** Explain what alterations Aisha and Shane should make to the hardware and/or the operation shown in Figure 7 so that the new output is achieved. Support your answer with an explanation of any relevant principles of physics. 4 marks

**e.** Aisha and Shane are now discussing how to convert the assembly shown in Figure 7 so that it would operate as a motor. They both agree that a DC battery should connect to the output terminals and a split-ring commutator should replace the rings that connect to the coil. They choose to keep the transformer between the DC battery and the split-ring commutator.

Explain whether the new assembly will or will not operate as a motor. Support your answer with an explanation of any relevant principles of physics. 3 marks

 

**Question 8** (5 marks)

A golf ball is projected from the top of a platform at a speed of 30 m $s^{-1}$ at an angle of 25° to the horizontal, as shown in Figure 10. The ball position is initially *h* m above ground level.

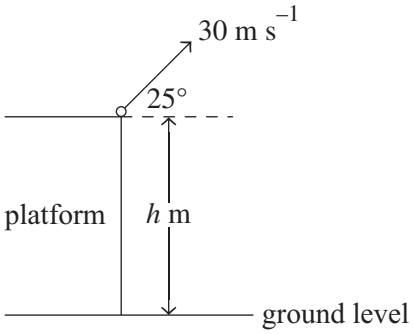


**Figure 10**

The golf ball travels a horizontal distance of 87.0 m as it first strikes the ground.

**a.** Show that the flight time of the golf ball from its initial starting point to when it first strikes the ground is 3.2 seconds. Ignore air resistance. Show your working. 2 marks

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**b.** Determine the height, *h*, of the golf ball at its initial position. Show your working. 3 marks

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m

**Question 9** (5 marks)

A car of mass 1000 kg travels to the right at 20 m $s^{-1}$ and has a head-on collision with a truck of mass 3000 kg travelling to the left at 5.0 m $s^{-1}$. After the collision, the car rebounds to the left at 10 m $s^{-1}$, as shown in Figure 11.

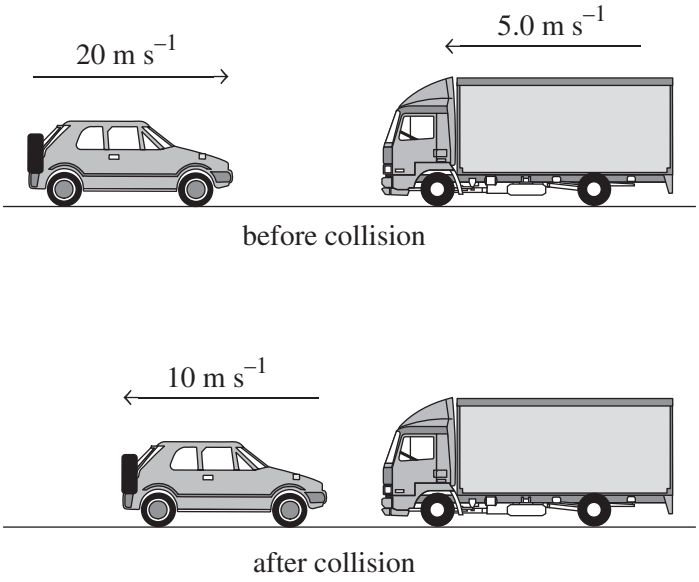


**Figure 11**

**a.** Determine the magnitude of the velocity of the truck immediately after the collision. Show your working. 2 marks

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m $s^{-1}$

**b.** Determine, using calculations, whether the collision is elastic or inelastic. Show your working and indicate your reasoning. 3 marks

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**Question 10** (5 marks)

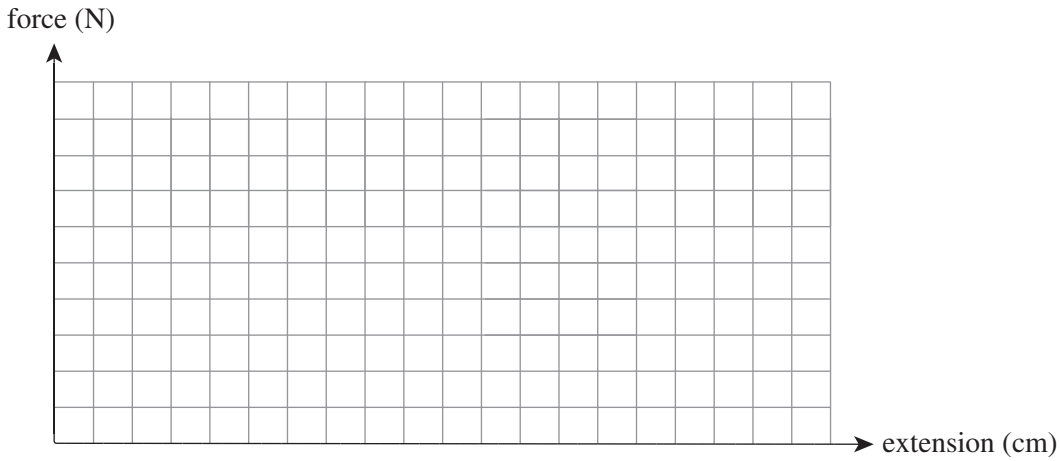
A slingshot uses a rubber band and fires a pellet of mass 25.5 g to a vertical height of 18 m. The rubber band was stretched by 10 cm prior to the vertical release of the pellet.

The release of the pellet and its rise through the air is assumed to be a totally efficient event. The extension of the rubber band does not disrupt any of the material bonds in the rubber.

On the axes provided below:

- sketch the force (N) versus extension (cm) graph for the rubber band
- label the horizontal and vertical axes with numerical scales.

Show the workings used to determine the numerical scales on the lines below.



**Question 11** (5 marks)

A car of mass 800 kg is undergoing a loop-the-loop stunt at a carnival, as shown in Figure 12.

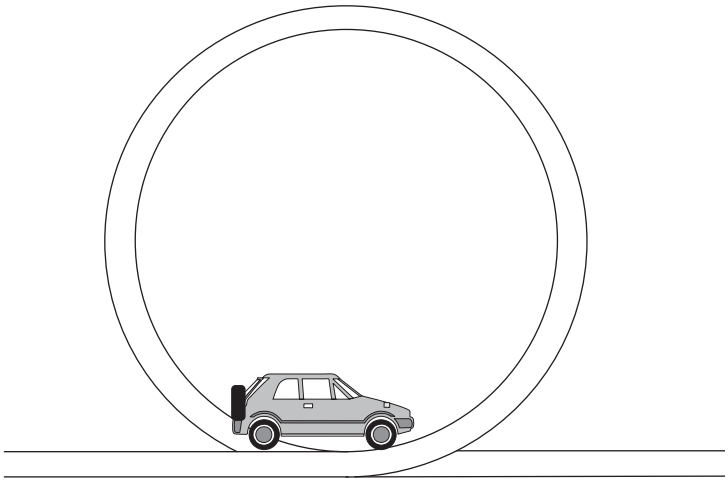


**Figure 12**

**a.** On Figure 12, draw and label the forces acting on the car. The size of the force vectors must indicate if they are of equal or different size. 2 marks

**b.** At the bottom of the loop, the car travels at 12 m $s^{-1}$. The diameter of the loop is 10.0 m. The track of the loop is assumed frictionless.

Determine the size of the normal reaction on the car when it is at the bottom of the loop. Show your working. 3 marks

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N

 

**Question 12** (6 marks)

Gianna is an observer in spacecraft A, watching spacecraft B fly past at a relative speed of 0.51$c$. She measures the length of spacecraft B from her frame of reference to be 103.22 m.

**a.** Calculate the Lorentz factor. Show your working. 2 marks

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**b.** What is the length of spacecraft B according to Gianna if she were standing in it? 2 marks

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m

**c.** Gianna's flight instruments record the spacecraft B to take 674.6 ns to travel past her spacecraft.

State whether a scientist in spacecraft B records a lesser, equal or greater time for spacecraft A to travel past it. Calculations are **not** required. Justify your answer. 2 marks

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**Question 13** (4 marks)

In a class experiment, a group of students investigated the speed of a wave in a rope. One of the students oscillated one end of the rope at right angles to the length of the rope. The other end of the rope was fixed to the wall. The resulting pattern is shown in Figure 13.

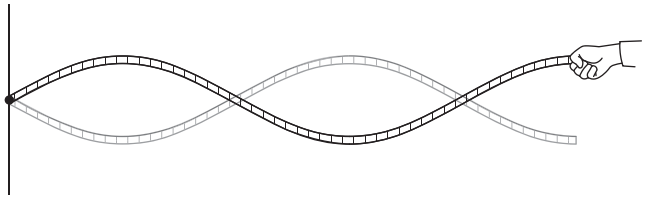

**Figure 13**

The student's hand is oscillating at 1.5 Hz, and the length of the rope used is 1.20 m.

**a.** Determine the speed of the wave in the rope. Show your working. 2 marks

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| | |
|---|---|
| | m $s^{-1}$ |

**b.** Using the same piece of rope, the students now want to create the resulting pattern shown in Figure 14.

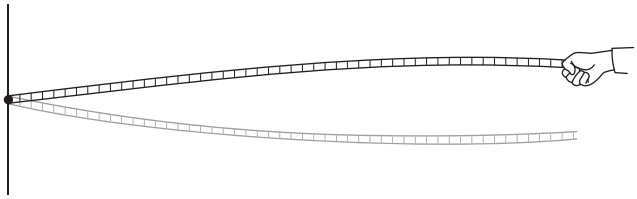

**Figure 14**

Explain how the pattern in Figure 14 is related to the pattern in Figure 13. 2 marks

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**Question 14** (6 marks)

A group of students set up a sound generator and program it to produce a sound of constant intensity and a single frequency. The sound is directed towards a double-slit arrangement where it passes through slits $S_1$ and $S_2$. The students record positions $M_A$, $M_B$ and $M_C$, where successive minima in intensity occur along a screen to the right of the double-slit arrangement. Point P is directly across from the centre of the two slits. This is shown in Figure 15.

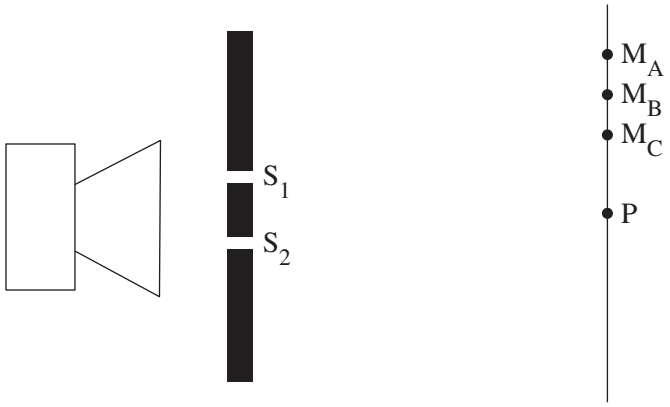


**Figure 15**

The students record the following distances:

| | |
|---|---|
| distance from $S_1$ to $M_A$ | 3.62 m |
| distance from $S_1$ to $M_B$ | 3.43 m |
| distance from $S_1$ to $M_C$ | 3.35 m |
| distance from $S_2$ to $M_A$ | 5.02 m |
| distance from $S_2$ to $M_B$ | 4.43 m |
| distance from $S_2$ to $M_C$ | 3.95 m |

**a.** Determine the wavelength of the sound generated. Show your working. 3 marks

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m

**b.** Two of the students, Melinda and Chen, are discussing how changes to the sound may affect the positions and qualities of the points $M_A$, $M_B$ and $M_C$. Melinda suggests that a higher frequency will cause the positions of the minima to shift further away from point P. Chen suggests that a higher frequency will cause the distances between the minima to decrease.

State whether each student is correct or incorrect. Justify your answers. 3 marks

 

**Question 15** (13 marks)

In stage 1 of an experiment, green light of frequency $5.5 \times 10^{14}$ Hz is shone onto the metal cathode of a photocell as shown in Figure 16.

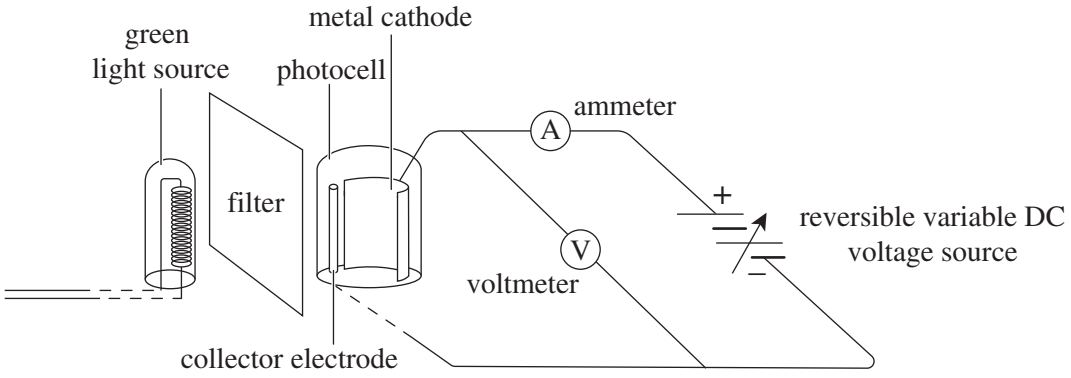


**Figure 16**

The ammeter displays a reading when the DC voltage source is 0 V. The ammeter reading drops to zero when the DC voltage is increased to 2.03 V.

**a.** Explain why the ammeter registers a reading when the green light is shone onto the metal cathode and why the reading drops to zero when the DC voltage is increased to 2.03 V. 3 marks

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**b.** Determine the work function of the metal in the metal cathode. Show your working. 2 marks

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eV

In stage 2, the experiment is repeated using violet light of twice the intensity.

**c.** Compare and contrast the two stages of the experiment in terms of

**i.** any reading observed on the ammeter display when the DC voltage source is 0 V. 2 marks

**ii.** any reading observed on the ammeter display when the DC voltage source is increased to 2.03 V. 3 marks

**d.** Explain the effect that doubling the intensity of light would have on the experimental results according to the wave model. Indicate whether the model's prediction agrees or disagrees with the observations. 3 marks

 

**Question 16** (5 marks)

An experiment is conducted in a vacuum tube whereby a stream of electrons is fired at a sample of powdered graphite. Some atoms in the graphite are $2.46 \times 10^{-10}$ m apart and some are $6.71 \times 10^{-10}$ m apart. The electrons are accelerated from rest by a voltage of 2.0 V before being directed through the powdered graphite.

**a.** Show that the de Broglie wavelength of the electrons under these conditions is $8.68 \times 10^{-10}$ m. Show your working. 2 marks

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**b.** Explain whether the electrons exhibit particle or wave behaviour under the conditions described above. 3 marks

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**Question 17** (6 marks)

The energy level diagram for a hydrogen atom is shown in Figure 17.

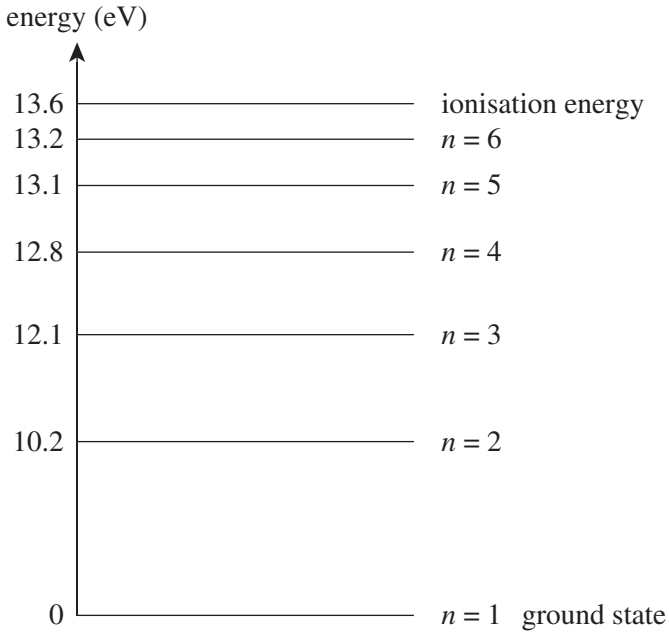



**Figure 17**

**a.** Explain whether it is possible for photons of 2.0 eV to be emitted by a hydrogen atom in the $n = 3$ state. 2 marks

**b.** Explain whether it is possible for a hydrogen atom in the $n = 3$ state to absorb a photon of 2.0 eV. 2 marks

**c.** Explain how the energy levels of a hydrogen atom represent evidence of the dual nature of matter. 2 marks

**Question 18** (8 marks)

Two Physics students undertake a practical investigation to determine the wave speed in a slinky spring and the wave speed's dependence on the length of the slinky spring. The students record the following hypothesis:

*The wave speed will remain constant for all trials.*

One end of the slinky spring is connected to a fixed block, and one of the students holds the other end, as shown in Figure 18.

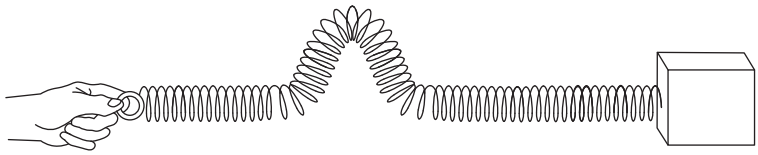


**Figure 18**

The other student records the length of the slinky spring and the time it takes a wave to travel to the block and back to the hand. After each trial, the slinky spring is stretched so that it has a new length for the next trial. Their results are shown in the table below.

| Length (m) | Time (s) |
|---|---|
| 1.6 | 1.4 |
| 2.0 | 1.6 |
| 2.4 | 1.8 |
| 2.8 | 1.9 |
| 3.2 | 2.0 |
| 3.6 | 2.2 |

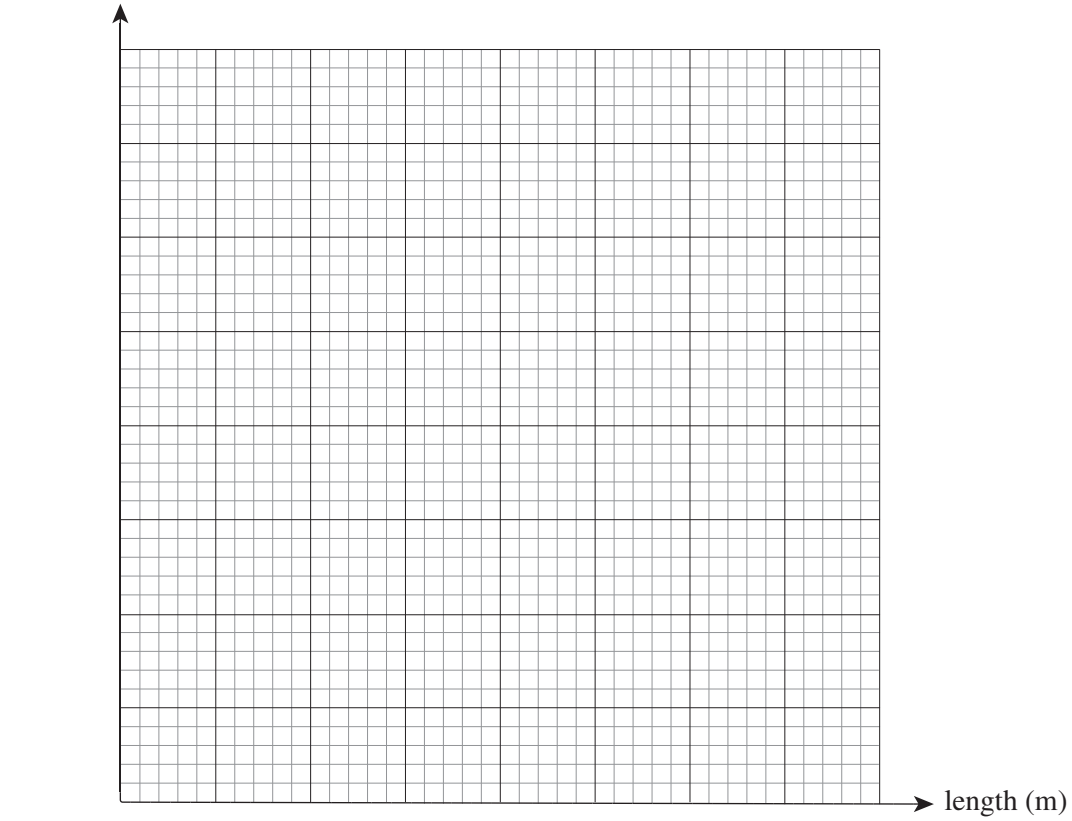
The students produce the table below, showing the calculated wave speeds and the length of the slinky spring.

| Length (m) | Wave speed (m $s^{-1}$) |
|---|---|
| 1.6 | 2.2 |
| 2.0 | 2.5 |
| 2.4 | 2.7 |
| 2.8 | 2.9 |
| 3.2 | 3.1 |
| 3.6 | 3.3 |

The uncertainty in the wave speed is calculated to be $\pm 0.2$ m $s^{-1}$ for all speeds.

**a.** On the axes provided below:

- plot a graph of wave speed (m $s^{-1}$) versus spring length (m) for the spring
- include a scale for each axis
- insert uncertainty bars for the speed values on the graph
- draw a line that best fits the data. 5 marks




**b.** State whether the students' hypothesis is supported or rejected. Support your answer with an explanation of the relationship between the wave speed and the length of the slinky spring. Calculations are **not** required. 3 marks

**END OF QUESTION AND ANSWER BOOKLET**