Neap:

Trial Examination 2017

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	13	13	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 38 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 2017 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.

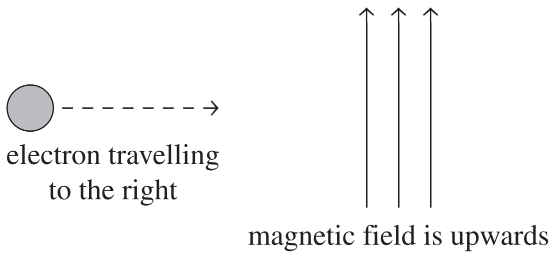
No marks will be given if more than one answer is completed for any question.

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

Take the value of g to be 10 m s^{-2}.

Question 1

The diagram below shows an electron fired into a region of magnetic field.



As the electron initially enters the magnetic field, the direction of motion of is

A. upwards.

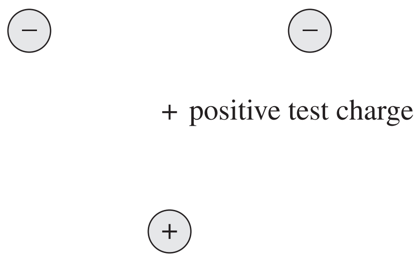
B. downwards.

C. out of the page.

D. into the page.

Question 2

Two negative charges and a positive charge are placed such that they are equidistant from each other.
A positive test charge is placed at a position that is equidistant from each of the charges mentioned. This is shown in the diagram below.



Which of the vector arrows, **A.–D.**, shows the direction of the initial motion of the positive test charge?

A. $\longrightarrow$

B. $\longleftarrow$

C. $\downarrow$

D. $\uparrow$

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Question 3

A charge Q has an electric field strength of value E at a distance d from it.

Which one of the following is the correct value of the electric field strength if the charge is now replaced by $8Q$ and the distance in question is now $2d$?

A. E

B. $2E$

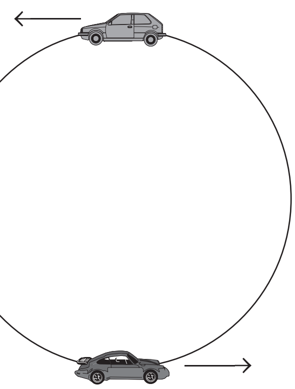
C. $4E$

D. $8E$

Question 4

A car travels in a circle and slows down as it does so. The view from the top of the circle is shown in the diagram below. The positions A and B are shown on the circular path and the momentum vectors of the car are shown at these positions.

car at position B travelling left



car at position A travelling right

Which one of the following shows the change in momentum of the car as it travels from position A to position B?

A. $\longleftarrow$

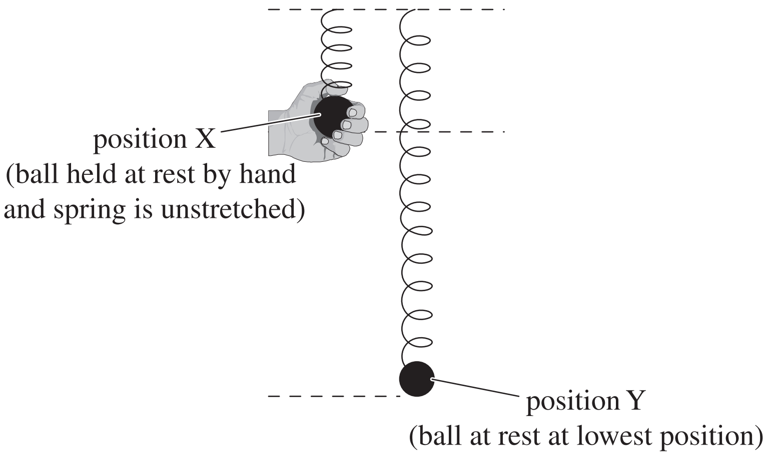
B. $\longrightarrow$

C. $\xrightarrow{\hspace{3em}}$

D. $\xleftarrow{\hspace{3em}}$

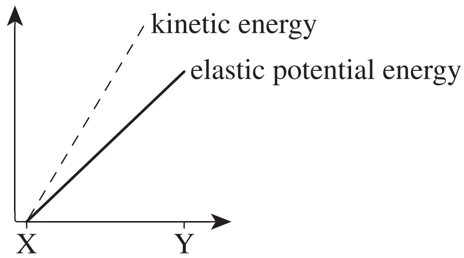
Question 5

A ball is held stationary at the end of an unstretched vertical spring as shown in the diagram below. The ball is then released and stretches the spring as it falls. The ball reaches its lowest point at which it then returns upwards.

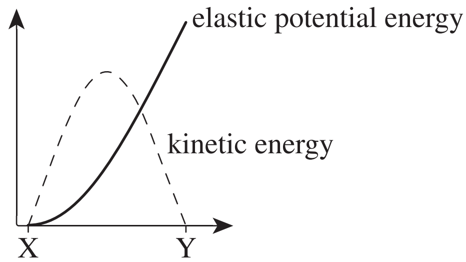


Which one of the following correctly shows the variation of the ball's kinetic energy and the elastic potential energy stored in the spring as the ball moves from position A to position B?

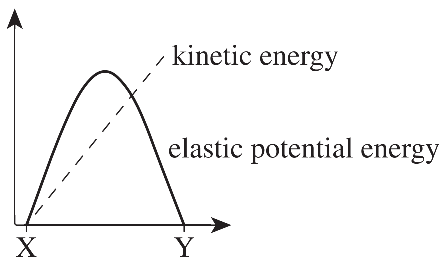
A.



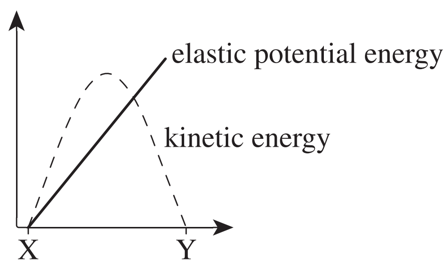
B.



C.

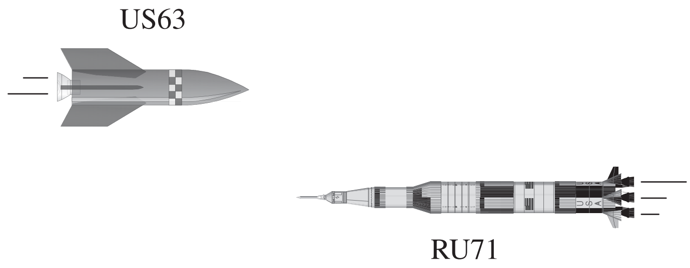


D.



Question 6

Two rockets, US63 and RU71, are travelling past each other at a speed of $0.6c$, where c is the speed of light. Both rockets are inertial frames of reference. This is shown in the diagram below.



An astronaut in RU71 measures the time taken for a pencil travelling at constant speed from one end of their rocket to the other to be 20.00 seconds.

An astronaut in US63 also measures the time taken by the pencil travelling from end to end of the rocket in RU71.

Which one of the following represents the time of the event measured by the astronaut in US63?

A. 31.63 seconds
B. 31.25 seconds
C. 25.00 seconds
D. 16.00 seconds

Question 7

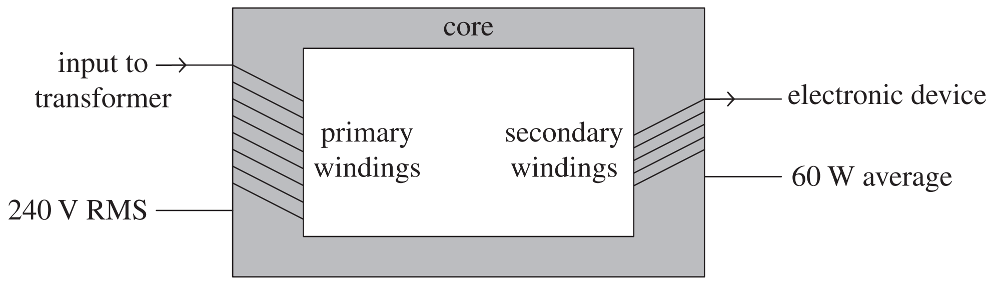
An electron of mass 9.11×10^{-31} kg is accelerated from rest to a speed of $0.99c$.

Which one of the following represents the kinetic energy of the electron at this speed?

A. 5.12 MeV
B. 4.61 MeV
C. 3.63 MeV
D. 3.12 MeV

Question 8

A transformer is used to provide power of 60 W (average) to an electronic device from a 240 V RMS power supply. The transformer is assumed to be ideal. This is shown in the diagram below.

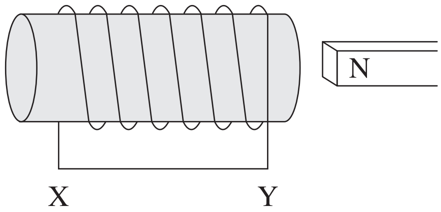


Which one of the following represents the **peak** current input to the transformer?

A. 4.2 A
B. 3.0 A
C. 0.35 A
D. 0.25 A

Question 9

A magnet is placed with its north end near a coil as shown in the diagram below. Two points, X and Y, are on either end of the straight section of the coiled wire.



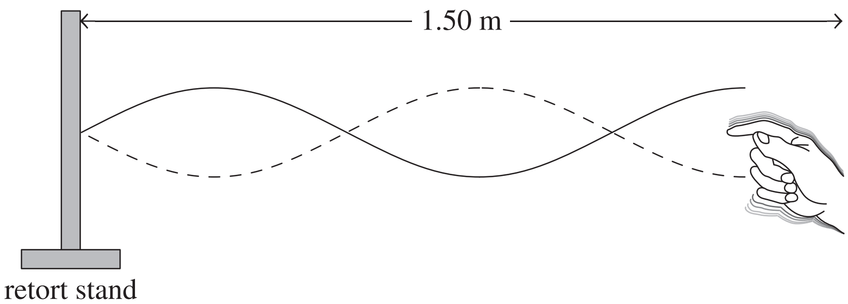
The magnet is suddenly pulled to the right and away from the vicinity of the coil.

Which of the following best describes the change in external magnetic flux experienced by the coil and the direction of the current induced in the coil when the magnet is suddenly pulled away to the right?

	Change in external magnetic flux experienced by the coil	Direction of induced current in the coil
A.	to the left	from Y to X on the straight section of the wire
B.	to the right	from Y to X on the straight section of the wire
C.	to the left	from X to Y on the straight section of the wire
D.	to the right	from X to Y on the straight section of the wire

Question 10

A student experiments with a string that is tied to a retort stand at one end. The student vigorously shakes the other end of the string as shown in the diagram below.



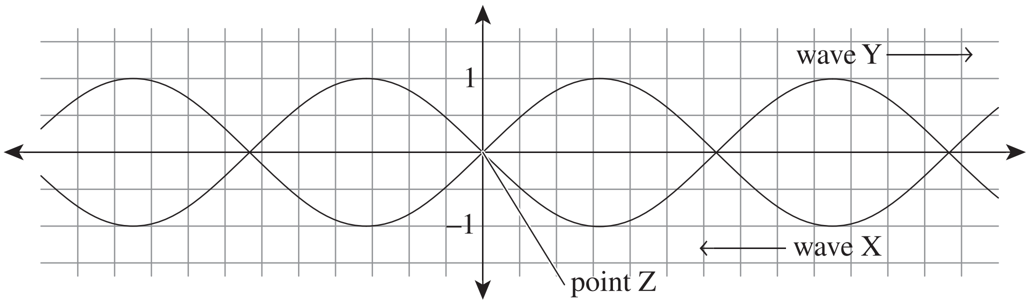
The length of the string is 1.50 m.

Which of the following represents the **longest wavelength** that the student is able to create by vigorously shaking the end of the string?

A. 6.00 m
B. 2.00 m
C. 1.50 m
D. 1.20 m

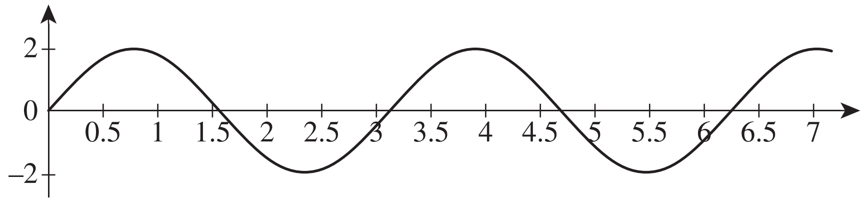
Question 11

Two identical transverse waves, X and Y, are moving through each other as shown below. Wave X moves to the left and wave Y moves to the right. The two waves move at a constant speed relative to each other. Point Z is also shown.

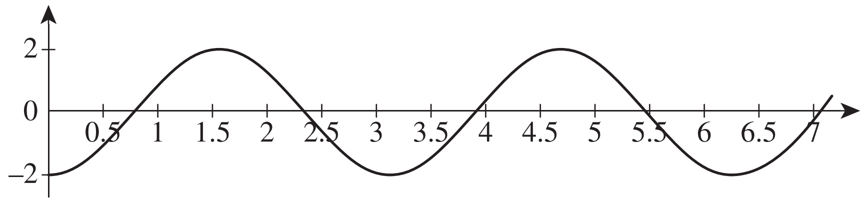


Which of the following graphs shows the amplitude of the resultant wave with time at point Z from the instant shown in the diagram above?

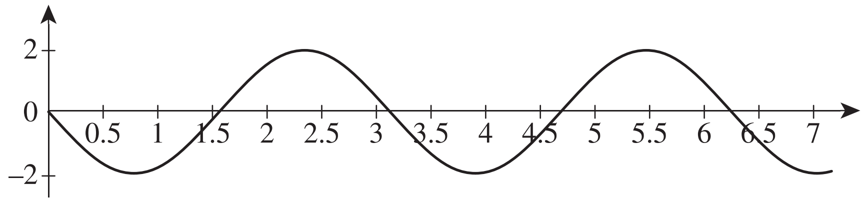
A.



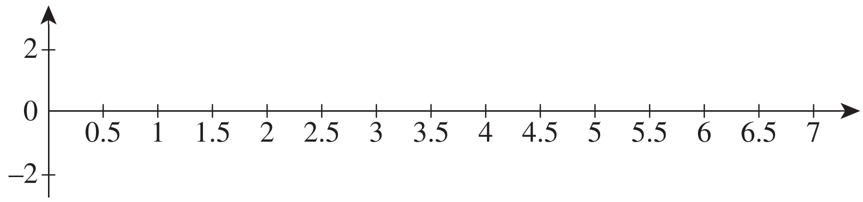
B.



C.

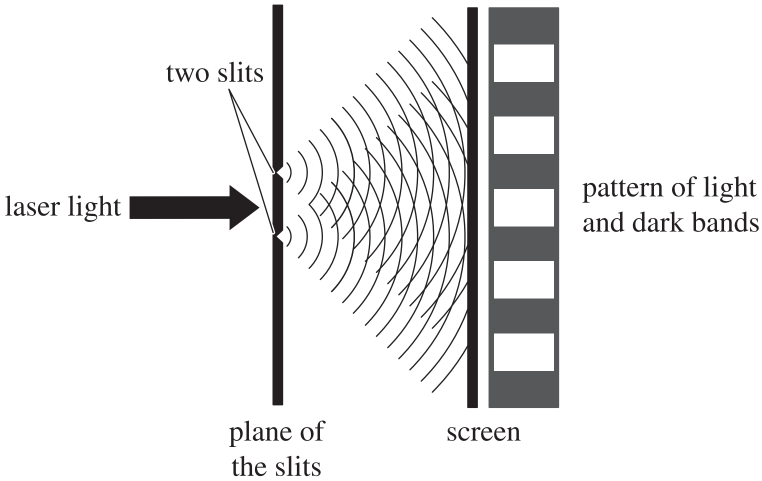


D.



Question 12

Young's double slit experiment is performed using blue laser light as shown below.



The experiment is repeated whereby the pattern of light and dark bands are now closer than shown.

Which of the following represents the possible changes to the experimental setup so that the pattern of bright and dark bands are closer together?

A. The blue laser light was replaced with a red laser light.

B. The blue laser light was replaced with a red laser light and the screen was brought further away from to the plane of the slits.

C. The blue laser light was replaced with a red laser light and the two slits were brought closer together.

D. The blue laser light was replaced with a violet laser light and the two slits were placed further apart.

Question 13

A particular lamp emits light when a series of p–n junctions are electrically activated.

Which of the following represents the source of the light from this lamp?

A. LED

B. synchrotron

C. incandescent

D. laser

Question 14

Blue light of frequency 6.50×10^{14} Hz is directed toward a hair of thickness 1.5×10^{-5} m.

Which of the following explains whether or not the light will diffract around the hair?

A. The light will not significantly diffract around the hair since the wavelength : diameter ratio is 1.5×10^{-5}.

B. The light will not significantly diffract around the hair since the wavelength : diameter ratio is 0.031.

C. The light will significantly diffract around the hair since the wavelength : diameter ratio is 0.031.

D. The light will significantly diffract around the hair since the wavelength : diameter ratio is 31.

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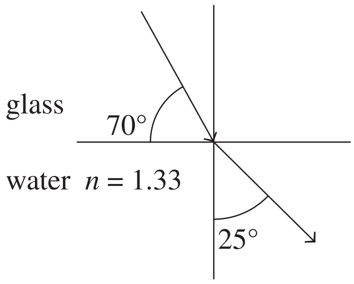
Question 15

A student performs an experiment where she passes light from glass into water as shown below.



Which of the following is the refractive index of the glass?

A. 1.75

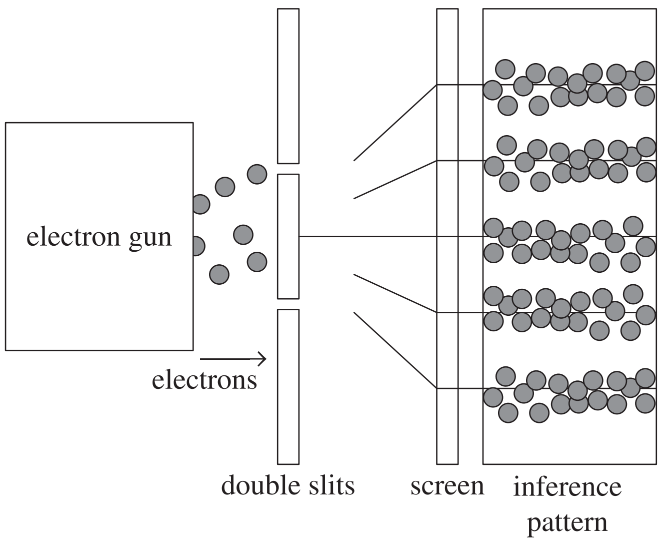
B. 1.64

C. 1.57

D. 1.49

Question 16

The diagram belwo shows the firing of electrons one at a time toward a pair of slits that are very close together.



Which of the following is the best interpretation of the results of the experiment?

A. The results represent evidence that the electrons are behaving as particles.

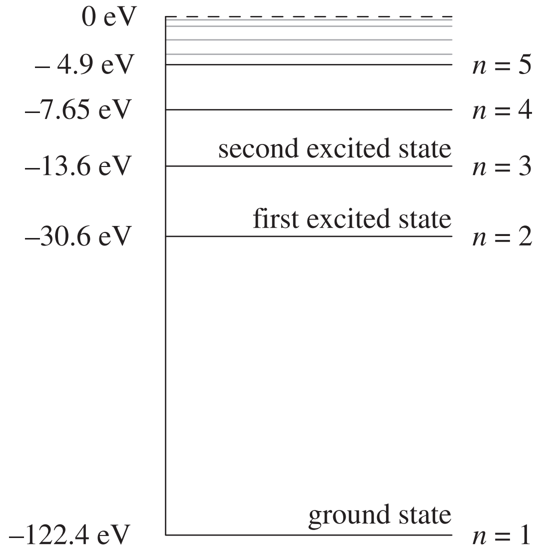
B. The results represent evidence that the electrons are behaving as waves.

C. The results represent evidence that the electrons behave as waves during their passage through the double slit, but behave as particles when they strike the screen.

D. The results represent evidence that the electrons behave simultaneously as particles and waves throughout their motion.

Question 17

The energy level diagram for a particular element is shown below.



Which of the following does **not** represent the energy of a photon emitted from an atom of the element?

A. 25.7 eV

B. 17.0 eV

C. 8.70 eV

D. 7.35 eV

Question 18

In the photoelectric effect, electrons are observed to be emitted from a material when said material is irradiated with light of a single frequency. The wave model of light could only partially account for the results of the experiment of the photoelectric effect.

Which of the following is **correct** about the prediction of the results based on the wave model for light?

A. The maximum kinetic energy of the emitted electrons was dependent on the frequency of the light used.

B. The number of emitted electrons was directly proportional to the intensity of the light.

C. Light of all colours caused the emission of electrons from the material irradiated by light.

D. The time delay for the emission of electrons from the time the light first irradiates the material to the time the electron emission occurs, depends on the intensity of the light.

Question 19

A proton is accelerated by a potential of 100 V. The mass of the proton is 1.66×10^{-27} kg and its charge is 1.6×10^{-19} C.

Which of the following represents the proton's de Broglie wavelength?

A. 1.74×10^{-10} m

B. 1.23×10^{-10} m

C. 4.07×10^{-12} m

D. 2.88×10^{-12} m

Question 20

The wavelength of a wave in a string is measured to be 0.3521 m and its frequency is measured to be 49.3 Hz.

Which of the following represents the calculated speed of the wave based on its measured frequency and wavelength?

A. 17.4 m s^{-1}

B. 17.36 m s^{-1}

C. 140 m s^{-1}

D. 140.0 m s^{-1}

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 10 m s^{-2}.

Question 1 (11 marks)

A particular Crookes tube is constructed such that the anode is shaped as a Maltese cross as shown in Figure 1.

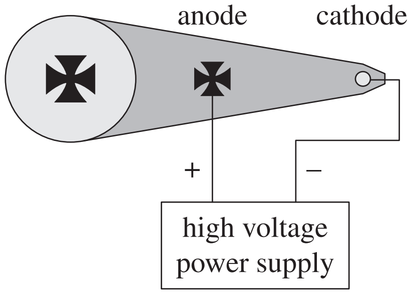


Figure 1

The distance between the anode and cathode is 10.0 cm and the applied voltage is 2000 V.

a. Determine the size of the electric field strength between the anode and the cathode. 2 marks

V m^{-1}

b. An electron is emitted from the cathode toward the anode inside the tube.

What is the energy supplied to the electron that is emitted into the tube? 2 marks

J

c. Determine the electrical force acting on an electron that is emitted into the tube. 2 marks

N

d. How long does the electron take to reach the anode from the cathode in a direct line once it has been emitted? Assume the electron is initially at rest. 3 marks

s

e. A magnet of field strength 0.10 T is placed in the vicinity of the glass casing of the tube while it is in operation releasing electrons.

At a particular instant when the electrons reach a speed of 1.90×10^7 m s^{-1}, the high voltage supply is turned off.

Determine the radius of curvature of the path of the electrons in the presence of the magnetic field. 2 marks

m

Question 2 (13 marks)

The Tiangong-2 is a Chinese space station that supports a crew of two astronauts. It orbits between a height of 370 km (6.740×10^6 m from Earth's centre) and 378 km (6.748×10^6 m from Earth's centre).

a. Determine the magnitude of the gravitational field strength of the Earth when the space station is at 370 km above its surface. 3 marks

N kg^{-1}

b. Determine the speed of the satellite when it is at 370 km above the surface of the Earth. 3 marks

m s^{-1}

c. An astronaut stationed inside the orbiting space station floats without touching any of the insides or components of the Tiangong-2. The astronaut believes there is no force acting on her.

Explain whether or not there are any forces acting on the astronaut and how this relates to her state of motion of floating in the space station. 3 marks

The graph in Figure 2 shows the size of the gravitational force acting on the space station ($\times 10^4$ N) versus the position of the space station from the centre of the Earth ($\times 10^6$ m).

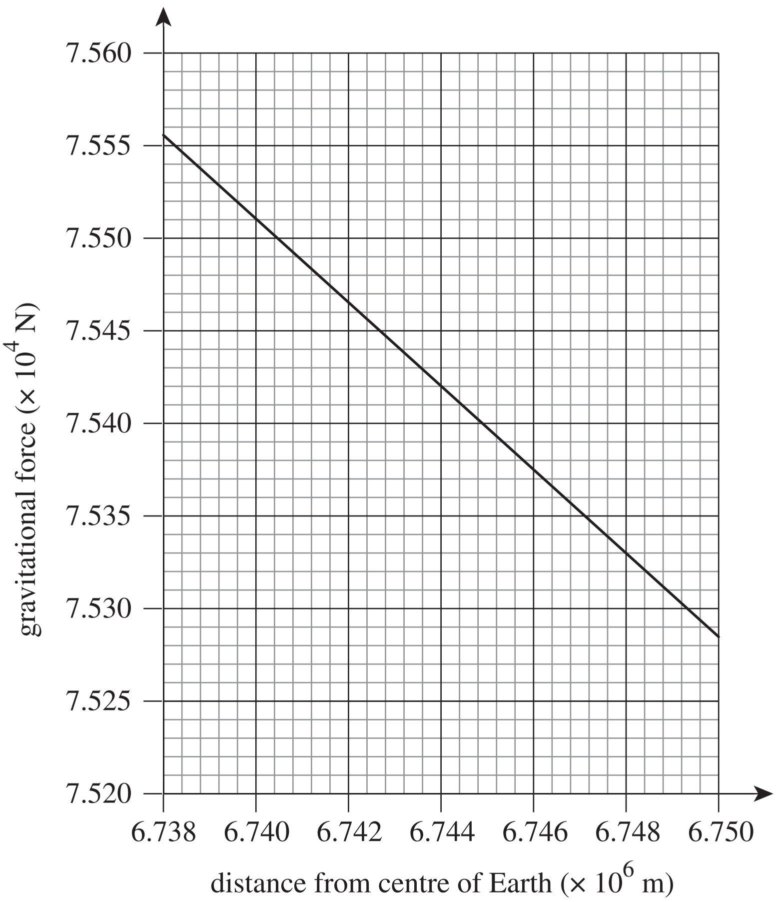


Figure 2

d. Determine the change in gravitational potential energy as the space station moves from 370 km to 378 km above the Earth's surface. Express your answer to four significant figures. 4 marks

J

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Question 3 (8 marks)

A student builds a simple DC motor as shown in Figure 3. The plane of the coil is horizontal.

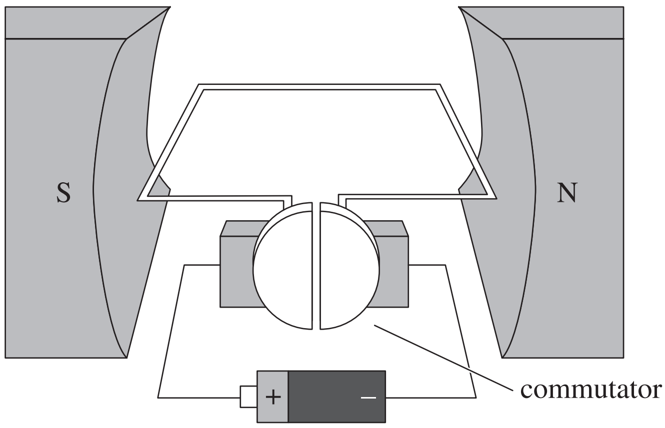


Figure 3

a. Draw arrows on Figure 3 to show the direction of the forces on the side of the coil nearest the north pole and on the side nearest the south pole. If the force on a side is zero, then label that side 'zero force'. 1 mark

b. The coil is a single loop square with side length 8.0 cm and the magnetic field strength between the magnetic poles is 0.20 T. Some friction exists between the coil and its connection to the commutator such that a minimum of 0.050 N of force is required on each side of the coil nearest the magnetic poles.

What is the minimum current required from the battery in order to cause the coil to start to rotate? 2 marks

A

The student reorients the coil so that its plane is now vertical as its starting position. This is shown in Figure 4.

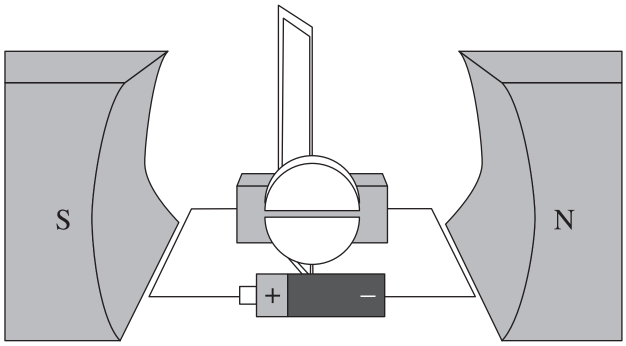


Figure 4

The coil does not rotate. The student replaces the battery with one of a greater voltage in order to provide a greater current, but the coil still does not rotate.

c. Explain why the coil does not rotate from its starting position shown in Figure 4. 2 marks

d. The split ring commutator is removed and the coil is connected directly to the DC battery with the coil beginning in the orientation shown in Figure 3.

Explain how this change affects the rotation of the coil. 3 marks

Question 4 (12 marks)

A student sets up a simple generator as shown in Figure 5.

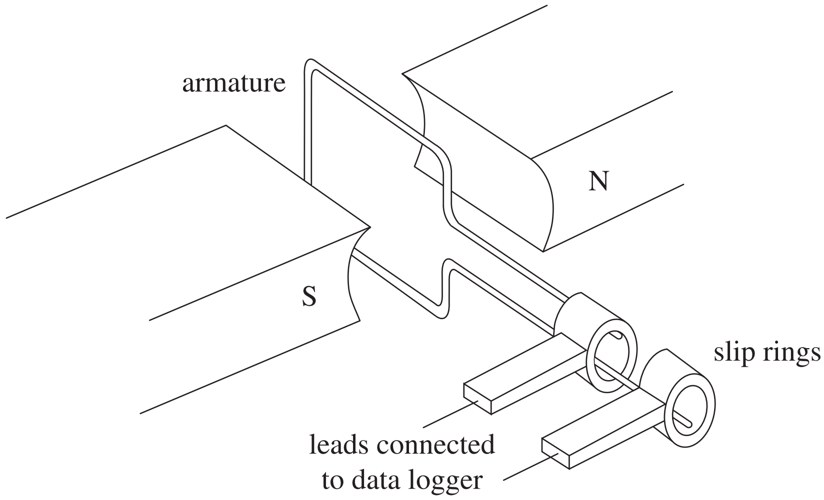


Figure 5

The coil is turned at a rate of 4.0 Hz and the coil side length dimensions are 5.0 cm and 6.0 cm. The coil consists of 10 turns.

The magnetic field strength in the region of the coil is 0.25 T.

a. Determine the change in magnetic flux in the coil over a half revolution in its rotation from the position shown in Figure 5. 2 marks

Wb

b. Determine the average voltage induced in the coil over a half of a revolution in its rotation from the starting position shown in Figure 5. 3 marks

V

The output from the leads is recorded by a data logger and the resulting voltage output, (in volts) and time, (in seconds) is shown in Figure 6.

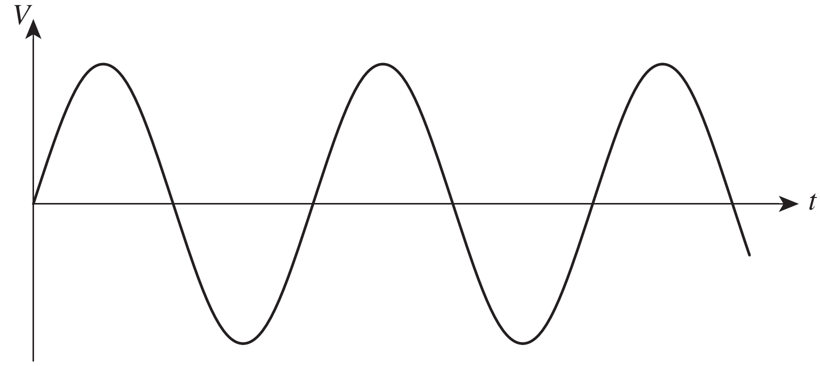


Figure 6

The student uses a voltmeter to determine the average voltage across the ends of the leads to be 0.10 V RMS while turning the coil at a rate of 4.0 Hz.

c. On Figure 6, label the vertical and horizontal scales according to the information provided. Provide calculations to show how particular values are obtained. 4 marks

The student now alters the equipment so that the slip rings are replaced by a split ring commutator as shown in Figure 7.

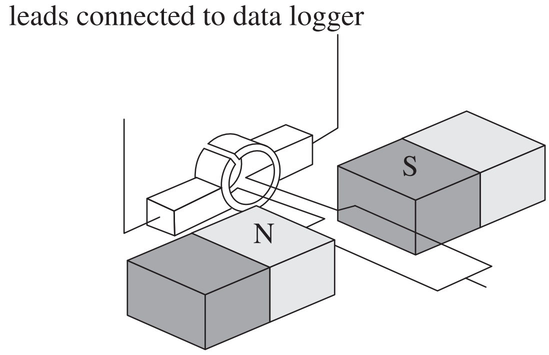
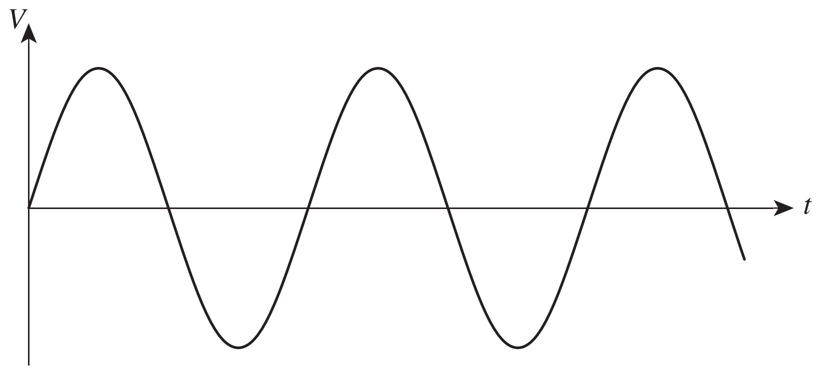


Figure 7

The student now turns the coil at 2.0 Hz from the starting position shown in Figure 7.

d. On the copy of Figure 6 below, show the recording of one complete cycle recorded by the data logger for the operation of the generator of Figure 7. 3 marks



Question 5 (12 marks)

As part of a class investigation, Robert and Malala conduct an experiment to determine the power of gravity. Their experiment involves the timing of the fall of a golf ball, from rest, over a range of fall heights and establishing a pattern from which to draw conclusions. They know that the work done on the golf ball will equal its change in gravitational potential energy over the fall height. They hypothesise that since the acceleration due to gravity is constant, the power supplied by gravity is also constant.

They use a data logging device to determine the time of the fall. The set up is shown in Figure 8.

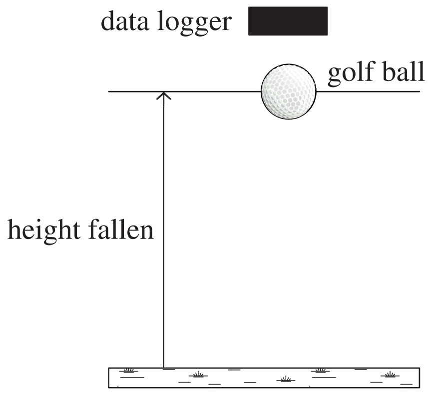


Figure 8

The recordings of the students from their logbooks are shown in Figure 9.

mass of golf ball = (0.046 ±0.001) kg

	fall height (m)	fall time (sec)
	0	0
	0.50	0.32
	1.00	0.45
	1.50	0.55
	2.00	0.64
	2.50	0.58
	3.00	0.78
	3.50	0.85
	4.00	0.90
	4.50	0.96
	5.00	1.01
uncertainty	±0.02	±0.10

Although the ball could not be dropped from zero height, it is included as part of the data since it would require zero time to fall.

Figure 9

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Robert and Malala are discussing which of the variables are dependent and independent.

a. Explain how Robert and Malala should decide which is the independent variable and which is the dependent variable stating each as part of your answer. 3 marks

b. Plot the data from the logbook recordings on the axes provided below and show the vertical uncertainty bars (or error bars) for the **data point** that occurs for fall height = 4.00 m. 3 marks

fall time (sec)

fall height (m)

c. From the graph plotted in **part b.**, determine the conclusion that would be drawn regarding the validity of all of the data. 2 marks

d. Robert and Malala are expecting to draw a straight line of best fit through their data.
Explain whether or not this is a correct procedure in their analysis. 2 marks

e. Does Robert and Malala's hypothesis agree with the relationship displayed by the results? 2 marks

Question 6 (8 marks)

Harry and Kate are interested in the factors that affect the bounce height of a basketball. They perform an experiment whereby they release a basketball from rest from a particular height (the drop height) and measure the bounce height. They perform the experiment for 16 different drop heights and record the data as shown in Figure 10.

	drop height (m)	**bounce height (m)**
	2.00	0.95
	1.90	0.81
	1.80	0.73
	1.70	0.65
	1.60	0.57
	1.50	0.43
	1.40	0.33
	1.30	0.20
	1.20	0.18
	1.10	0.16
	1.00	0.14
	0.90	0.12
	0.80	0.11
	0.70	0.10
	0.60	0.09
	0.50	0.08
uncertainty	±0.01	±0.02

Figure 10

They plot the bounce height (m) versus the rebound height (drop height, m) on axes as shown in Figure 11.

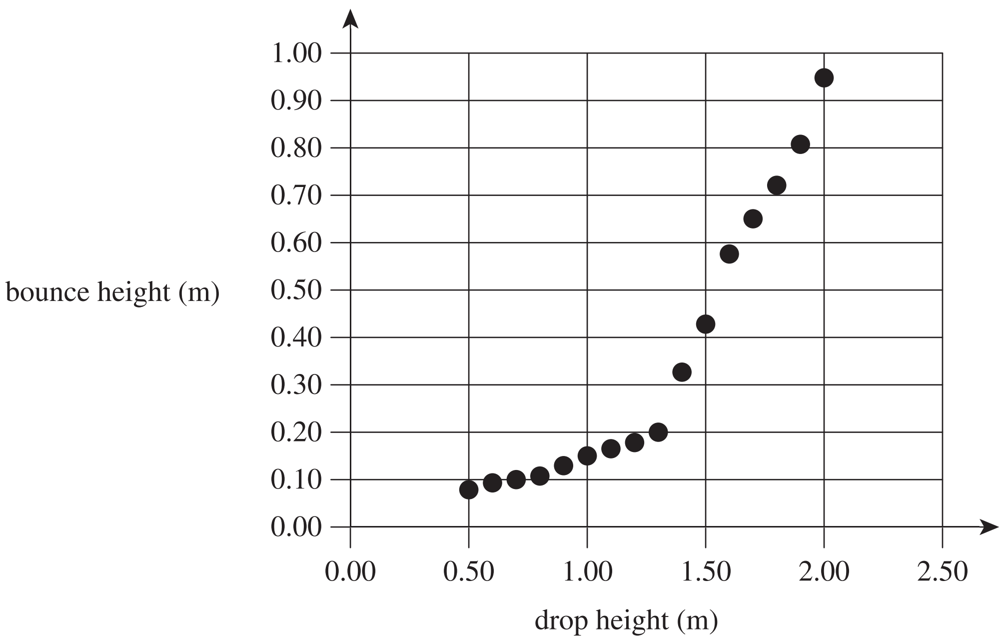

Figure 11

Harry and Kate noticed that the ball had deflated excessively over the course of the experiment.

a. Explain how the problem caused by the deflation is related to one of the variables, commenting on the type of variable involved. 2 marks

b. Explain whether the data gained from the experiment is valid or not. 2 marks

c. Explain what Harry and Kate need to change in order to perform the experiment in a way that obtains meaningful data. 1 mark

d. Harry and Kate are interested in the ratio of bounce height to drop height.

Calculate the ratio $\frac{\text{bounce height}}{\text{drop height}}$ and its uncertainty for the drop height of 0.70 m.
Significant figures and decimal consistency must be regarded. 3 marks

Question 7 (13 marks)

A stone of mass 0.500 kg and string of length 1.50 m is whirled in a horizontal circle where the string forms an angle of 30° with the vertical as shown in Figure 12.

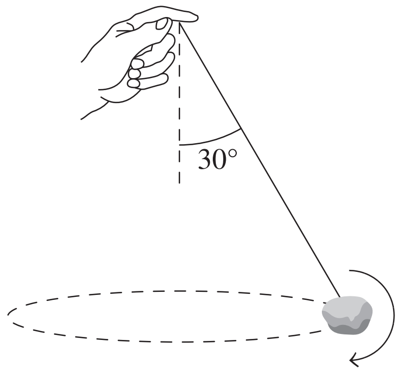

Figure 12

The stone completes 15 revolutions in 34 seconds.

a. Determine the net force acting on the stone. 3 marks

N

b. Determine the tension in the string as the stone whirls in a horizontal circle. 2 marks

N

The stone is now whirled in a vertical circle. Figure 13 shows the stone at the top and bottom of its path. The string length remains 1.50 m and the mass of the stone is unchanged.

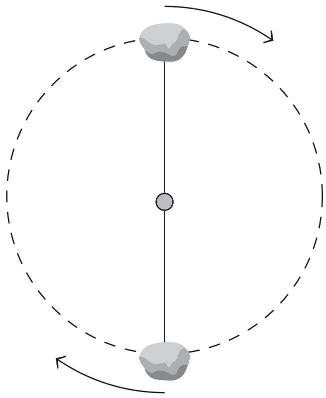

Figure 13

c. How fast must the stone be travelling at the bottom of its path such that the tension in the string is three times the weight of the stone? 3 marks

m s^{-1}

d. How fast must the stone be travelling at the top of its path such that the tension in the string is reduced to zero? 2 marks

m s^{-1}

As the stone is whirled in a vertical circle, the tension in the string is increased such that the stone is then released at an angle of 45° to the horizontal when it is at a position of 2.60 m above ground. This is shown in Figure 14.

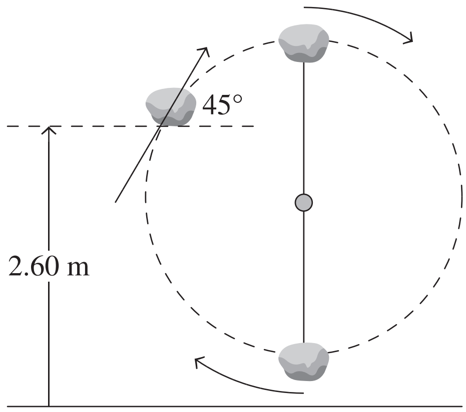

Figure 14

The stone is released at a speed of 10.0 m s^{-1}.

e. Determine the maximum height that the stone reaches above the ground in its path.
Ignore air resistance. 3 marks

m

Question 8 (4 marks)

A jolly jumper consists of a harness connected to a spring which can be clasped to the arches of a doorway. A toddler is sat in the harness and is able to jump up and down, enjoying the springing effect of the motion of the harness.

A toddler of mass 19 kg is placed in the jolly jumper of mass 1 kg and then held by the parent such that the spring is unextended. When released from rest, the toddler and the harness descend at distance, *d*, below the zero extension position, where they are momentarily at rest before being flung up. The toddler in the jolly jumper is shown in Figure 15.

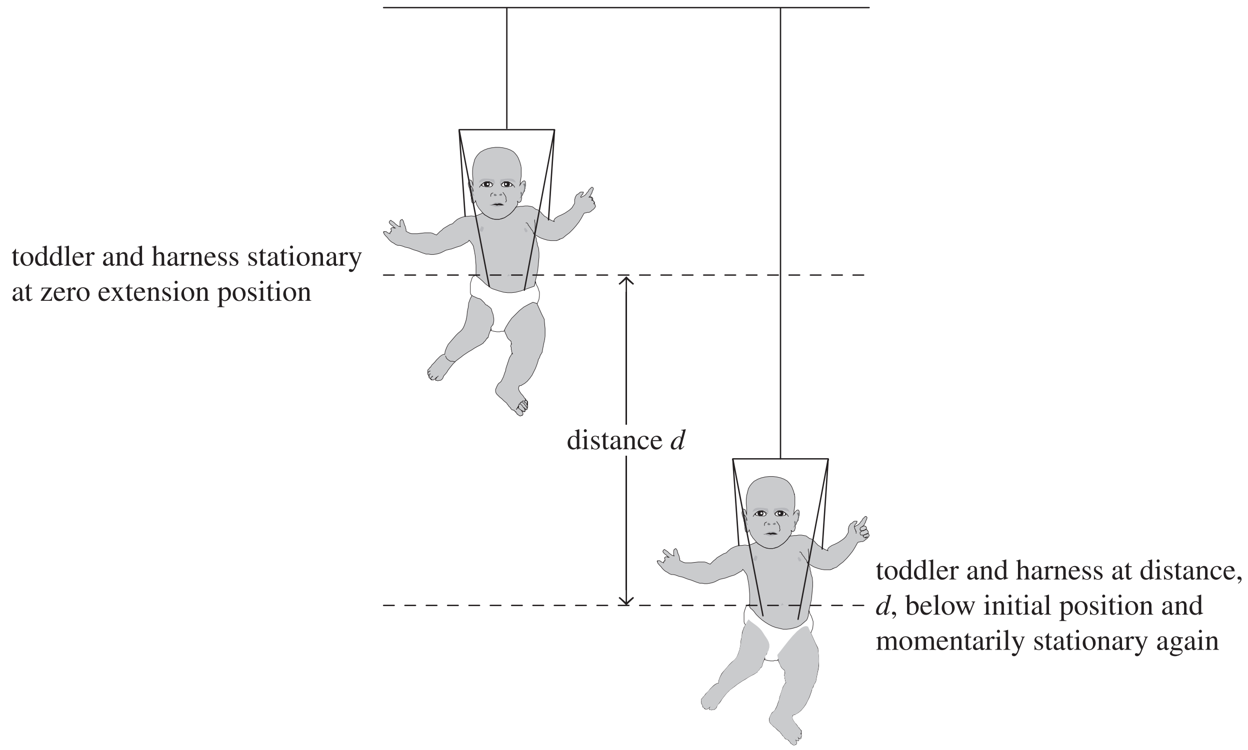

Figure 15

The stiffness constant of the spring is 250 N m^{-1}.

a. Determine the distance, *d*, that the toddler has descended. 2 marks

m

The parent now extends the jolly jumper and toddler occupying it to 1.0 m below the zero extension position as shown in Figure 16.

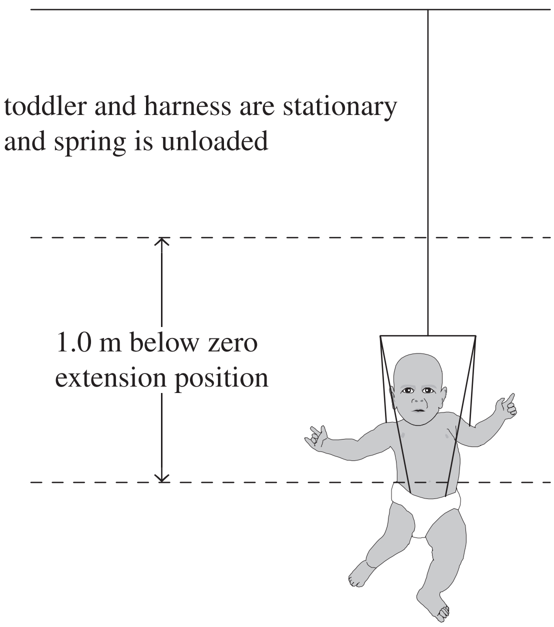

Figure 16

The parent releases the toddler and it moves upwards.

b. Calculate the speed of the toddler when its centre of mass has moved 0.5 m upwards from the position shown in Figure 16. 2 marks

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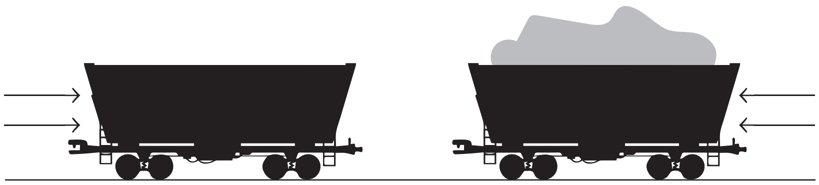
	m s^{-1}

Question 9 (6 marks)

Two railway coal carriages are on the same frictionless railway line. Carriage X of mass 4000 kg and moving to the right at 1.0 m s^{-1} approaches carriage Y of mass 6000 kg that is moving to the left at 0.5 m s^{-1}. This is shown in Figure 17.



carriage X (moving at 1.0 m s^{-1} to the right)

carriage Y (moving at 0.5 m s^{-1} to the left)

Figure 17

They collide gently and carriage Y now moves to the right at 0.2 m s^{-1}.

a. Determine the velocity (magnitude and direction) of carriage X after the collision, and circle the correct option in the box below. 3 marks

m s^{-1}	left right

b. Explain the nature of the collision as to whether it is elastic or inelastic. Provide a calculation to justify your explanation. 3 marks

Question 10 (8 marks)

A class of physics students create water waves in a ripple tank by using a wave generator as a single point source to create waves where small sections of the waves then pass through two small slits, S_1 and S_2.The crests of the water waves are represented by the black spherical lines, and points V and W are referred to in Figure 18 as shown.

The water waves are measured to travel 0.40 m s^{-1} and the frequency generator that created the waves was operating at 20 Hz.

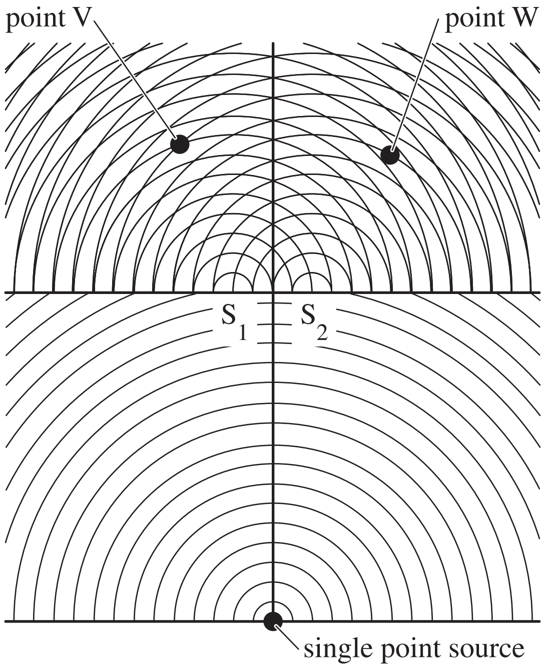


Figure 18

a. Calculate the wavelength of the water waves in the ripple tank. 1 mark

m

b. Explain how the waves that have passed through both slits are interacting at point V. 2 marks

c. Point W is 13.0 cm from S_1.

Determine how far it is from S_2. 2 marks

cm

d. Explain the effect on the interference pattern if the students change the wave generator frequency from 20 Hz to 30 Hz. 3 marks

Question 11 (8 marks)

In an experiment involving the photoelectric effect, the results for the stopping voltage, *V*, versus the light frequency ($\times 10^{14}$ Hz) for a particular metal is shown in Figure 19.

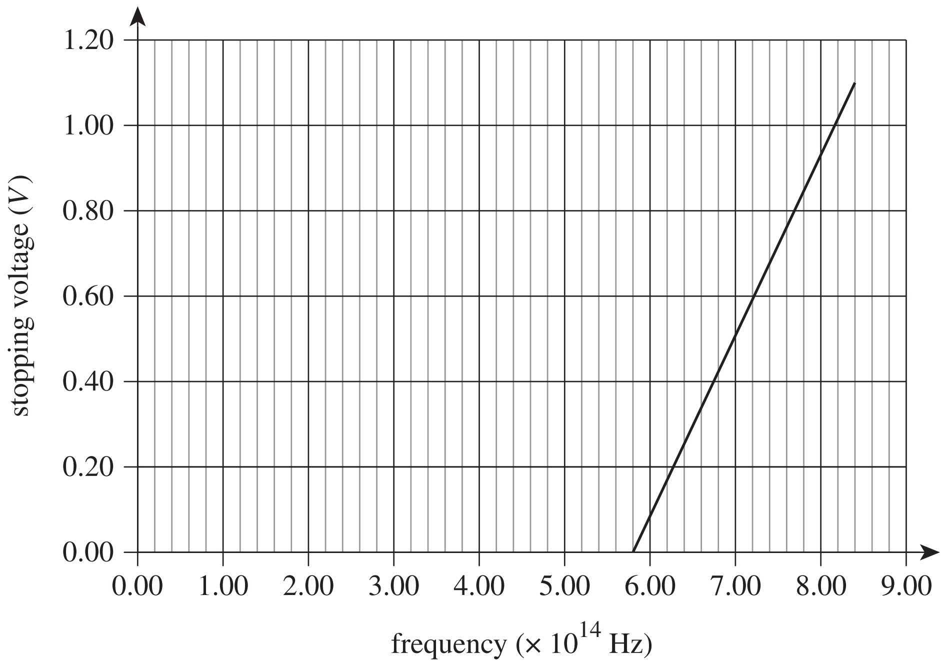


Figure 19

The critical frequency is 5.80×10^{14} Hz.

a. Determine the stopping voltage needed if light of frequency 1.20×10^{15} Hz is used. 2 marks

V

b. On the axes provided above, sketch the graph of the results if a metal whose work function of 1.95 eV is used instead. Any relevant calculations used to assist in sketching should be shown below. 3 marks

The relationship between the photoelectron current (y-axis) and the cathode potential (x-axis) applied to the vacuum tube in the photoelectric effect is shown in Figure 20.

The metal used in the cathode is the same as that for the data of Figure 19.

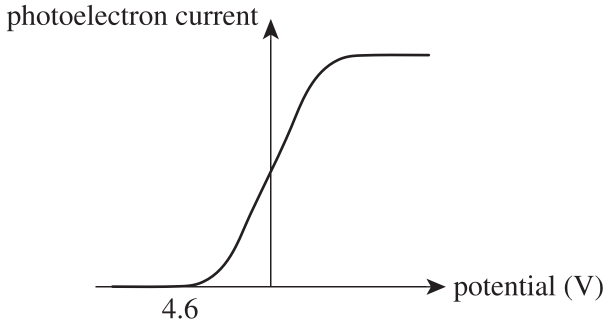


Figure 20

The stopping voltage in Figure 20 is 4.6V.

c. Explain how the graph in Figure 20 would alter, if at all, if light of wavelength 650 nm is used. Any calculations used to assist your answer must be shown. 3 marks

Question 12 (4 marks)

X-rays of frequency 4.12×10^{18} Hz are shone onto a crystal, pass through it, and project onto a screen to produce the diffraction pattern shown in Figure 21.

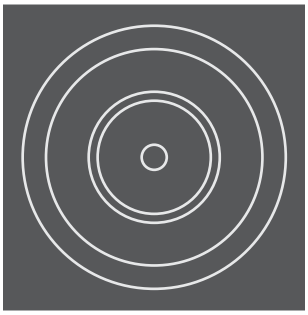


Figure 21

Electrons of momentum 1.82×10^{-23} kg ms^{-1} are then shone onto the same crystal and pass through it. The electrons then project onto the same screen as did the X-rays.

Explain the type of pattern that is produced and compare its features to that of Figure 21. Show any calculations to support your explanation.

Question 13 (4 marks)

An electron is passed through a single slit as shown in Figure 22. The *x* and *y* directions are shown.

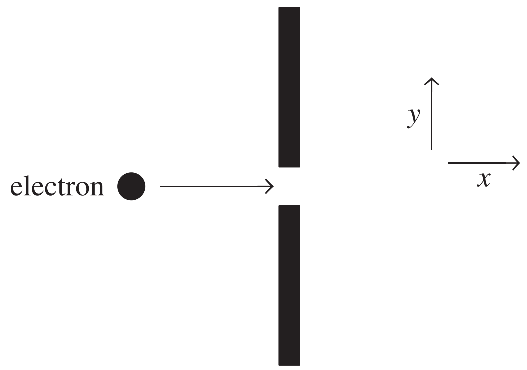


Figure 22

The electron's characteristics are such that Heisenberg's uncertainty principle applies to it once it has passed through the slit.

Explain how the position and momentum of the electron are subject to Heisenberg's uncertainty principle. Make reference to either of the directions *x* or *y* as shown.

END OF QUESTION AND ANSWER BOOKLET