YEAR 12 *Trial Exam Paper*

2019

PHYSICS

Written examination

STUDENT NAME:

QUESTION AND ANSWER BOOK

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

Structure of book

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

- Students are permitted to bring the following items into the examination: 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 sheets of blank paper or correction fluid/tape into the examination.

Materials provided

- Question and answer book of 47 pages
- Formula sheet
- Answer sheet for multiple-choice questions

Instructions

- Write your **name** in the box provided above, and on the answer sheet for multiple-choice questions.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- You must answer all questions in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.
- You may keep the formula sheet.

Students are NOT permitted to bring mobile phones and/or any unauthorised electronic device into the 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.

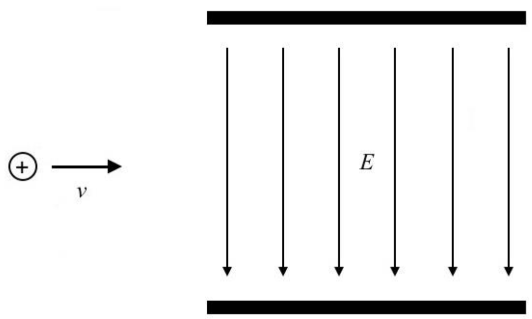
No marks will be given if more than one answer is completed for any question.

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

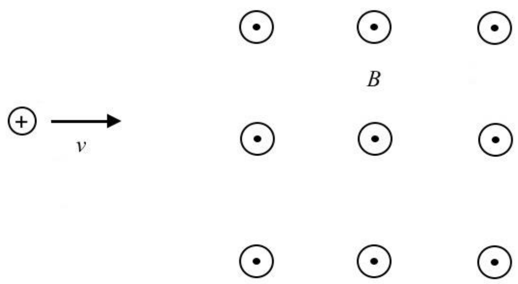
Take the value of g to be 9.8 m s^{-2}.

Question 1

Consider two positively charged particles travelling at a constant speed, v. One particle enters a uniform electric field, with field strength E, between two parallel plates, as shown below (left). The other particle enters a uniform magnetic field, with field strength B, directed out of the page, as shown below (right).



Electric field



Magnetic field

What is the shape of the path of each particle in each of the force fields?

	Electric field	Magnetic field
A.	parabolic	parabolic
B.	parabolic	circular
C.	circular	circular
D.	circular	parabolic

Use the following information to answer Questions 2 and 3.

An alpha particle, which has a +2 charge, is stationary in deep space.

Question 2

Determine the magnitude of the force that the alpha particle exerts on an electron that is brought to a position 5 μm from it.

A. 115 N

B. 1.84×10^{-17} N

C. 1.84×10^{-23} N

D. 9.21×10^{-23} N

Question 3

The electron is now removed, leaving the alpha particle on its own.

Which one of the following describes the electric field around the alpha particle?

A. changes with time

B. uniform

C. non-uniform

D. moving

Question 4

A bundle of 10 wires, each carrying 0.70 A current, is placed in a uniform magnetic field. A straight section of the bundle with a length of 0.45 m is entirely within the magnetic field. The bundle of wire experiences a force of 3.7 mN.

Calculate the strength of the magnetic field.

A. 1.17×10^{-1} T

B. 1.17×10^{-2} T

C. 1.17×10^{-3} T

D. 1.17×10^{-4} T

Question 5

The strength of the gravitational field reduces with distance from Earth's centre of mass.

What is the gravitational potential, to 3 significant figures, at the peak of Mount Kosciuszko, which is 6.38×10^6 m from Earth's centre of mass?

A. 9.79 N kg^{-1}

B. 9.80 N kg^{-1}

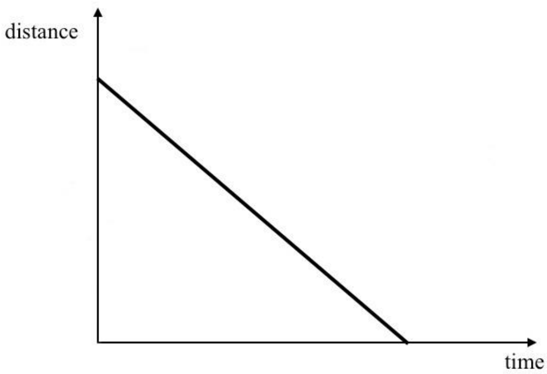
C. 9.81 N kg^{-1}

D. 9.82 N kg^{-1}

Question 6

Which one of the following distance–time graphs represents a moving object that is slowing down to a stop?

A.



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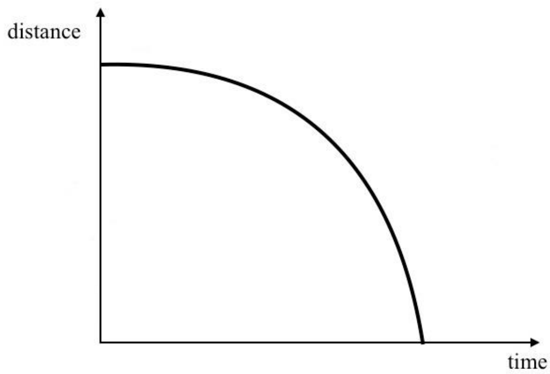
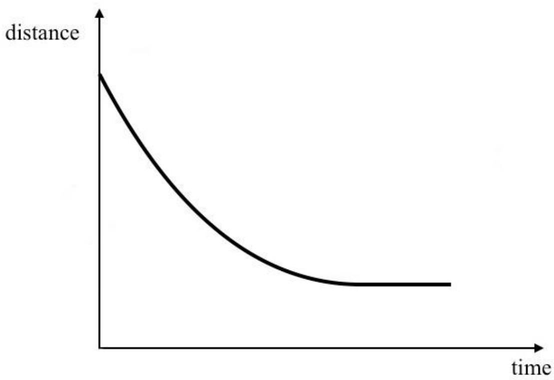
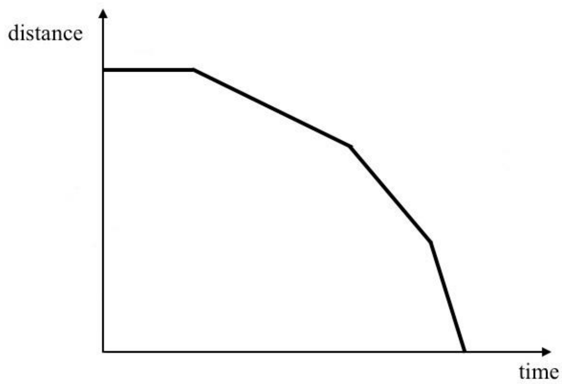


C.

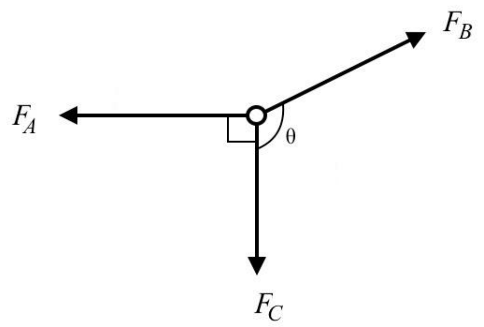


D.



Question 7

A circular ring is pulled by three forces, $F_A = 12$ N, $F_B = 13$ N, $F_C = 5$ N, as shown below. The net force on the ring is 0 N. The effects of the size of the ring and friction may be considered negligible.



Determine the size of θ, the angle between F_B and F_C.

A. 113°

B. 115°

C. 155°

D. 157°

Question 8

Both the Kosmos-2251 satellite and the Iridium 33 satellite orbit Earth at the same altitude.

Which one of the following statements must be correct regarding the motion of both satellites?

A. The mass of Kosmos-2251 is the same as the mass of Iridium 33.

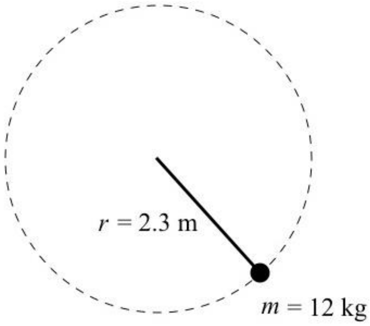
B. The speed of Kosmos-2251 is the same as the speed of Iridium 33.

C. Both Kosmos-2251 and Iridium 33 orbit Earth along the same orbital path.

D. The relative speeds of the satellites are directly proportional to their relative masses.

Use the following information to answer Questions 9 and 10.

A 12 kg ball is attached to a length of rope with a breaking strength of 750 N. The ball executes uniform horizontal circular motion with a radius of 2.3 m, as shown below.



Question 9

The maximum speed of the ball that will not break the rope is closest to

A. 1.2 m s^{-1}

B. 6.3 m s^{-1}

C. 12 m s^{-1}

D. 63 m s^{-1}

Question 10

The ball is already travelling at the maximum speed allowed by the breaking strength of the rope.

If the speed of rotation is maintained at this value, which one of the following changes will cause the rope to break?

A. increase the radius of the uniform circular motion

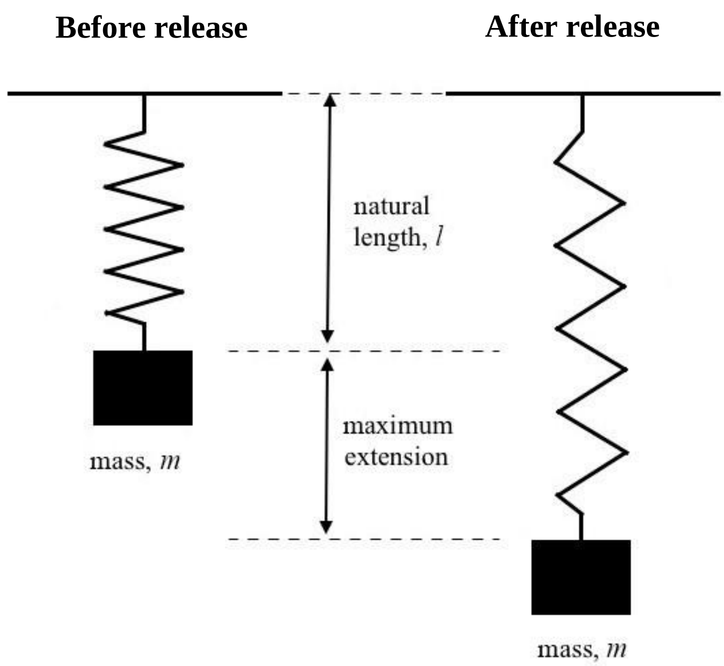
B. decrease the radius of the uniform circular motion

C. increase the breaking strength of the rope

D. decrease the mass of the ball

Question 11

A mass, *m*, is attached to a spring of natural length, *l*. The mass is allowed to fall under gravity and the spring reaches maximum extension, as shown below. Air resistance may be ignored.



Which one of the following statements is correct?

A. At maximum extension, the total energy of the mass is the same as that at zero extension.

B. At maximum extension, the kinetic energy of the system is maximum.

C. At zero extension, the total energy of the mass is maximum.

D. At zero extension, the kinetic energy of the system is maximum.

Question 12

A laser with a wavelength of 630 nm is operated in air. The orange laser beam enters a rectangular glass block at an angle and is refracted.

Comparing between the laser beam in air and the laser beam in the rectangular block, which one of the following physical properties remains the same?

A. frequency

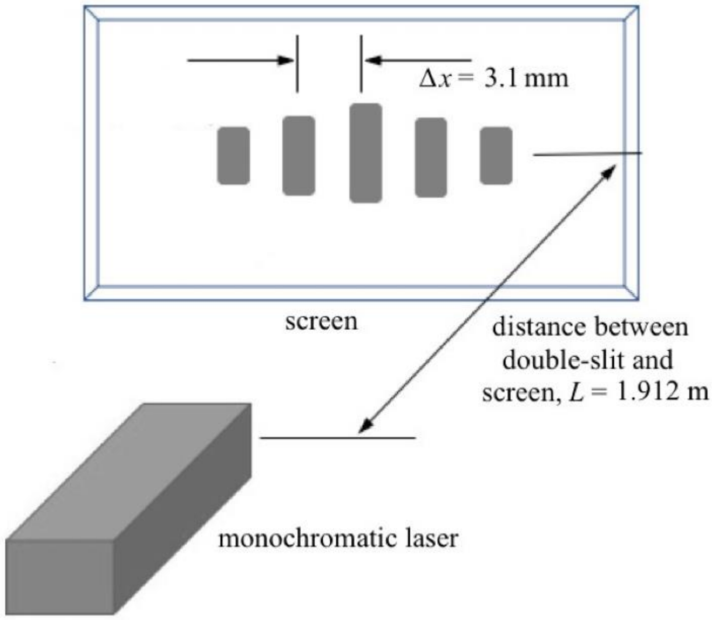
B. intensity

C. speed

D. wavelength

Use the following information to answer Questions 13 and 14.

Chester is given a monochromatic laser of an unknown wavelength. He carries out a double-slit interference experiment using the laser. Having determined that the distance between the two slits is $d = 250\ \mu$m, he then projects the interference pattern onto a screen. The distance from the double-slit to the screen is 1.912 m, and the distance between the central maximum and the first maxima is $\Delta x = 3.1$ mm, as shown below.



Question 13

Determine the wavelength of the laser.

A. 154 nm

B. 237 nm

C. 247 nm

D. 405 nm

Question 14

Using the levels of precision implied in the data provided above, the percentage uncertainty in the wavelength of the laser is closest to

A. 1.38%

B. 1.41%

C. 1.61%

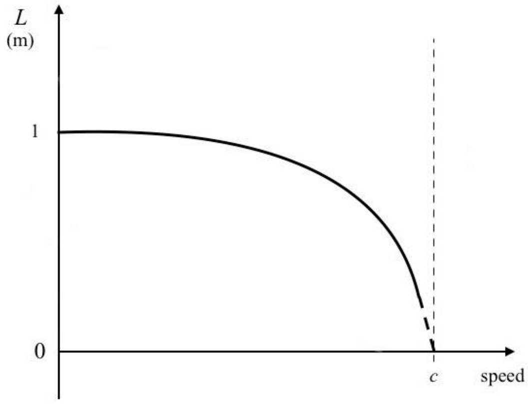
D. 1.84%

Question 15

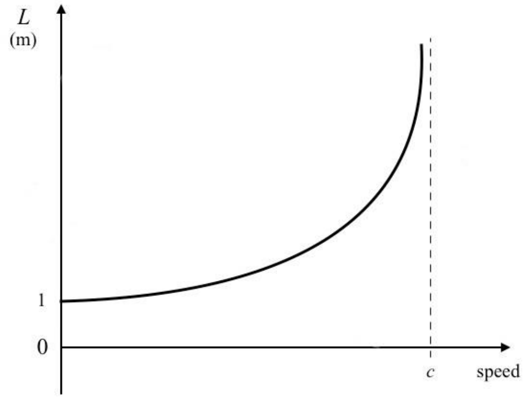
The Australian Synchrotron produces high-intensity light using a beam of electrons travelling in circular motion. The synchrotron accelerates the beam of electrons from rest to nearly the speed of light, in a circular ring. In one particular run, the electrons pass a 1 m ruler placed lengthwise in the direction that the electrons are moving, outside the beamline, as it completes a circuit of the ring.

From an electron's frame of reference, which of the following diagrams represents the graph of *L*, the length of the ruler, versus the speed of the electron?

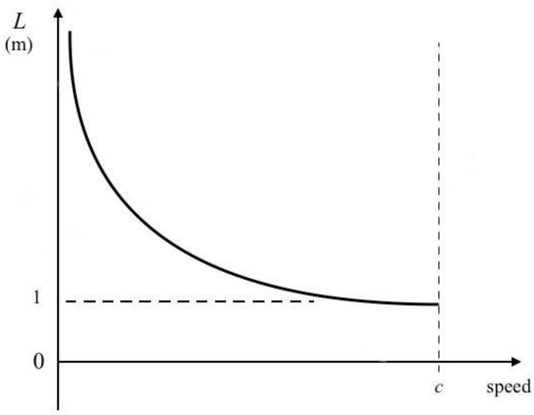
A.



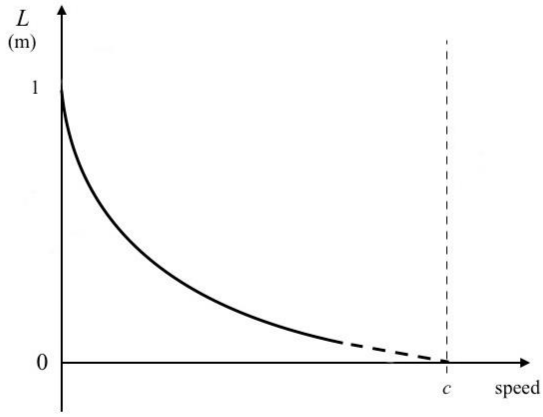
B.



C.

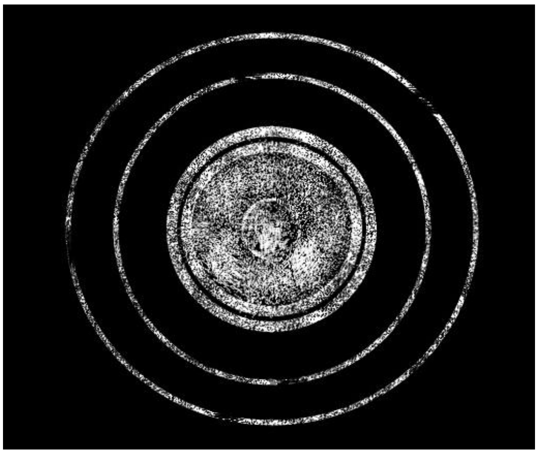


D.



Question 16

A beam of electrons passing through a thin layer of crystal produces a diffraction pattern, shown below.



The voltage used to accelerate the electrons is 36 V. Calculate the de Broglie wavelength of the pattern.

A. 8.19×10^{-10} m

B. 5.76×10^{-10} m

C. 2.05×10^{-10} m

D. 1.28×10^{-10} m

Question 17

In 1902, Philipp Lenard's experiments with photoelectrons, in which he shone light onto a metal target, provided the key evidence for the particle-like nature of light. Which of the following observations in the experiment supports the particle model of light?

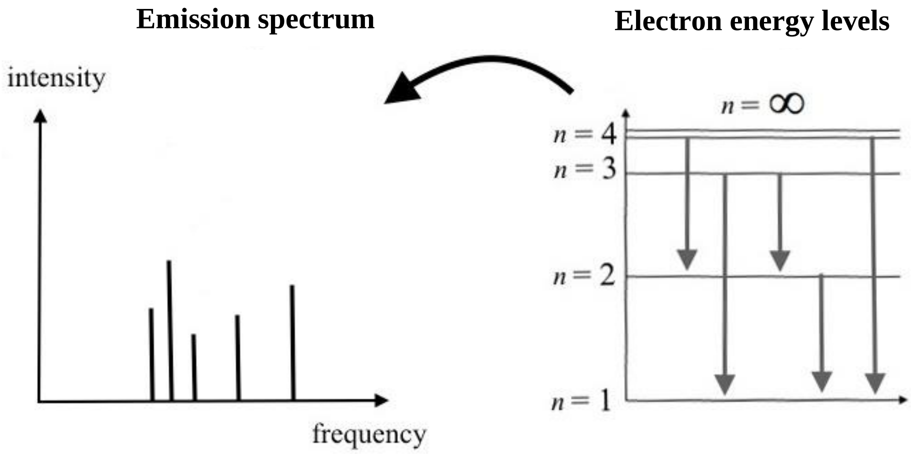
A. A higher intensity light source would result in photoelectrons with higher kinetic energy, and thus a higher stopping voltage.

B. A light source at any frequency would still produce photoelectrons, but lower frequencies may experience a time delay.

C. A higher frequency light source would result in photoelectrons with higher kinetic energy, and thus a higher stopping voltage.

D. A lower intensity light source would result in photoelectrons with lower kinetic energy, and thus a lower stopping voltage.

Question 18



The emission spectrum of elements (above left) shows discrete lines corresponding to the different light frequencies emitted by electrons as they transition between energy levels (above right). They support the idea of the wave-like behaviour of the electrons as they orbit around the nucleus of the atom.

Which one of the following statements explains this behaviour?

A. Electrons orbit as matter waves, with energy levels corresponding to the intensity of the light emitted.

B. Electrons orbit in wave-like orbital paths around the nucleus of the atom.

C. Electrons orbit in wave-like orbital paths that increases in frequency at higher energy levels.

D. Electrons orbit as matter waves, with energy levels corresponding to harmonics (integer multiples) of standing waves.

Question 19

Which one of the following errors cannot be reduced by having an experiment repeated by different experimenters using the same set of apparatus and equipment, and taking the average value of all measurements?

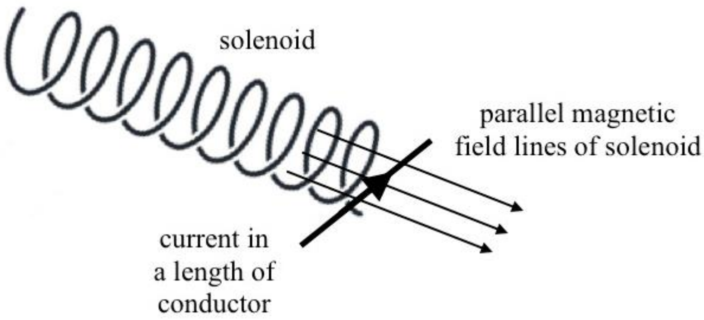
A. random errors

B. systematic errors

C. outliers

D. personal errors

Question 20



Angela is carrying out an experiment to determine the magnetic field strength of a solenoid, using $F = BIl$, by measuring the force on a length of conductor that is perpendicular to the magnetic field at one end of the solenoid, as shown above. The current in the conductor is modified using a variable resistor.

Which one of the following options correctly describes the variables in the experiment?

A. The current is the independent variable, the length of the conductor is the controlled variable, the force on the conductor is the dependent variable.

B. The magnetic field strength is the dependent variable, the current is the independent variable, the force on the conductor is the derived quantity.

C. The magnetic field strength is the independent variable, the force on the conductor is the dependent variable, and the current is the controlled variable.

D. The current is the independent variable, the force on the conductor is the controlled variable, and the length of the conductor is the dependent variable.

 END OF SECTION A

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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 book are **not** drawn to scale.

Take the value of g to be 9.8 m s^{-2}.

Question 1 (5 marks)

A metal sphere, labelled S1, carries 8.0 μC of positive charge. The radius of the sphere is not significant so S1 may be considered as a point charge. A second similar sphere, labelled S2, without any charge, is placed at a distance d = 5.8 cm from S1, as shown in Figure 1.

Both spheres are held in place with perfectly insulating rods.

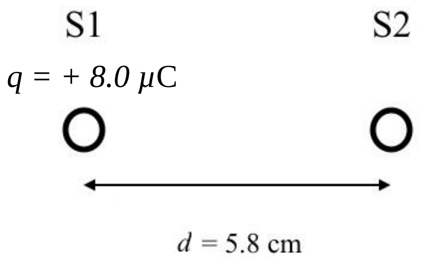


Figure 1

a. State the magnitude of the electrical force exerted by S1 on S2.

1 mark

N

b. Sphere S2 is then brought into contact with sphere S1. After a few seconds, it is returned to its original position.

What is the magnitude of the charge on S2 now? Give your answer correct to two significant figures.

2 marks

mC

c. On Figure 1 on the opposite page, draw an arrow from the centre of S1 to indicate the direction of the force that S2 will exert on it. Explain your answer.

2 marks

Question 2 (6 marks)

A stationary loop of metal wire with a cross-sectional area of 13.7 cm^2 is placed completely inside the magnetic field of an electromagnet, as shown in Figure 2. The loop is connected to a voltmeter, which measures any EMF generated between the two terminals of the loop.

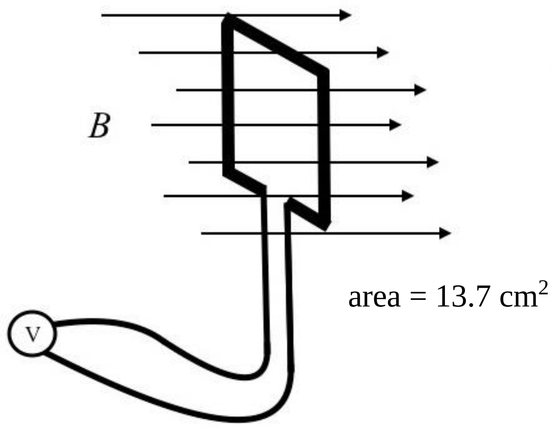


Figure 2

The electromagnet is initially switched off. The current that is used to generate the electromagnet is then varied such that the magnetic field strength changes according to the graph, as shown in Figure 3.

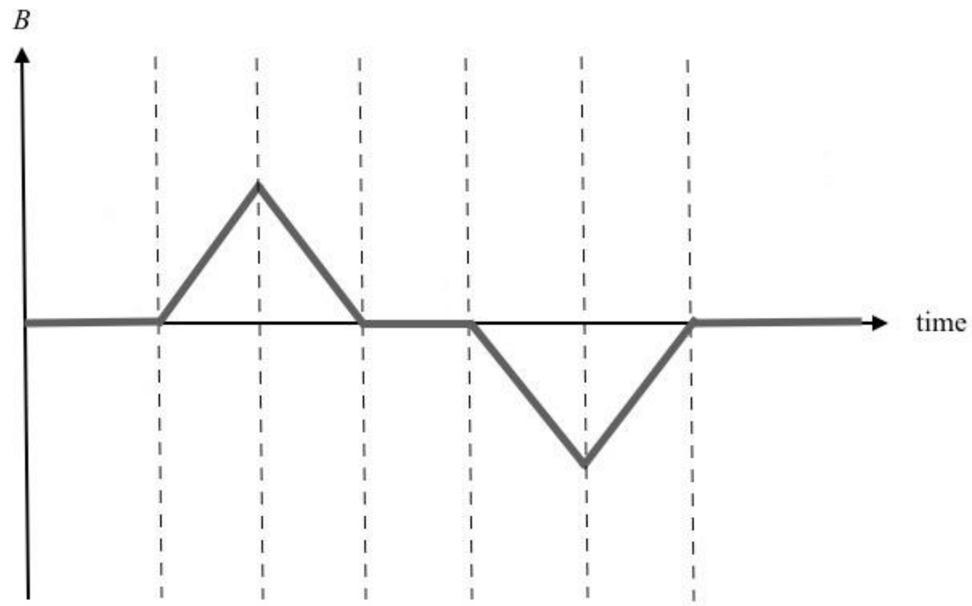
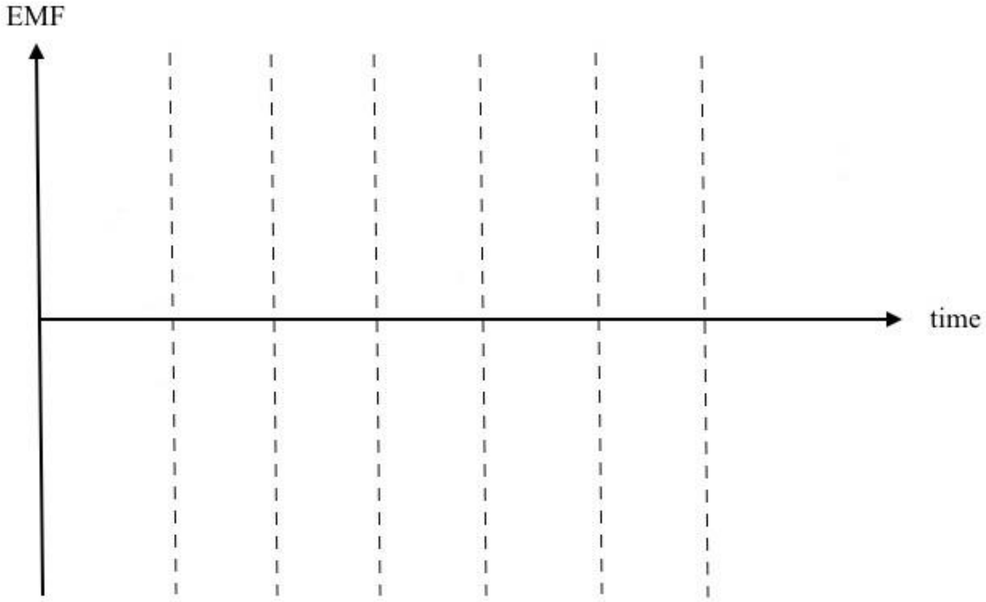


Figure 3

a. Sketch the EMF induced in the loop as the magnetic field strength of the electromagnet varies. You do not need to include any values on the axes.

3 marks



The electromagnet is switched off. It is then switched on and the magnetic field strength increases linearly to a value of $B = 0.06$ T in a time of 0.09 s.

b. What is the maximum magnetic flux through the loop?

1 mark

____

____

Wb

c. Calculate the magnitude of the EMF generated in the loop in this time period. Show your working.

2 marks

____

____

____

____

V

Question 3 (4 marks)

A U-shaped magnet is used to study the effect of a magnetic field on a conductor carrying a current, as shown in Figure 4. The conductor receives current from a pair of wires that are wholly outside the magnetic field of the magnet.

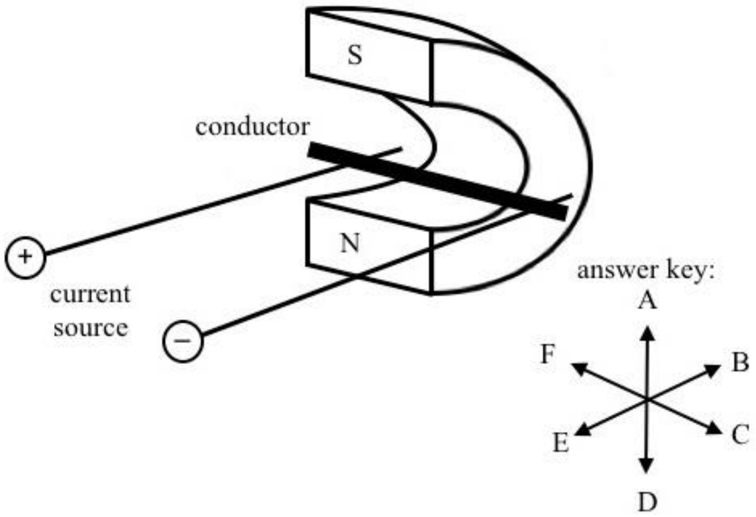


Figure 4

a. The current source is switched on and the conductor experiences a force due to the magnetic field of the magnet. Use the answer key to state the direction of the force on the conductor. Explain your answer.

2 marks

b. The length of the conductor that is within the magnetic field is 6.5 cm. The current through the conductor is 0.39 A. A force-meter measures the magnetic force on the conductor as 7.3×10^{-6} N.

Determine the strength of the magnetic field of the U-shaped magnet. Show your working.

2 marks

T

Question 4 (14 marks)

Lord Armstrong, a 19th-century British engineer, is believed to have been the first to use hydropower to light his home. He installed water turbines that drove electric generators to produce 4.5 kW of DC electric power at an output voltage of 55 V. This was the same voltage required for the electric arc lamps, located in the home about 120 m away, to operate normally. Copper cables were used to transmit the electric power directly, with a total transmission cable resistance of 0.3 Ω.

The power supply and transmission system may be modelled as a simple DC circuit, with a single electric arc lamp for analysis, as shown in Figure 5.

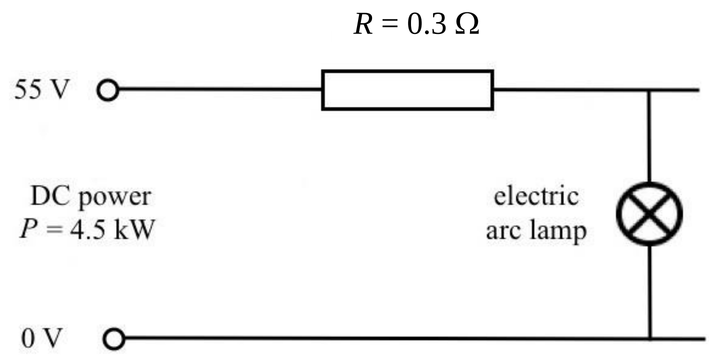


Figure 5

a. What is the size of the current in the transmission line?

2 marks

A

b. Calculate the total voltage drop across the transmission line.

2 marks

V

c. Determine the voltage available to the electric arc lamp.

2 marks

V

d. If the DC generator is replaced with an AC generator, and a suitable pair of step-up and step-down transformers are used, as shown in Figure 6, the voltage drop across the transmission lines could be reduced, thus providing more voltage to the electric arc lamp. For simplicity, the turns ratio of the step-up transformer is the same as the turns ratio of the step-down transformer.

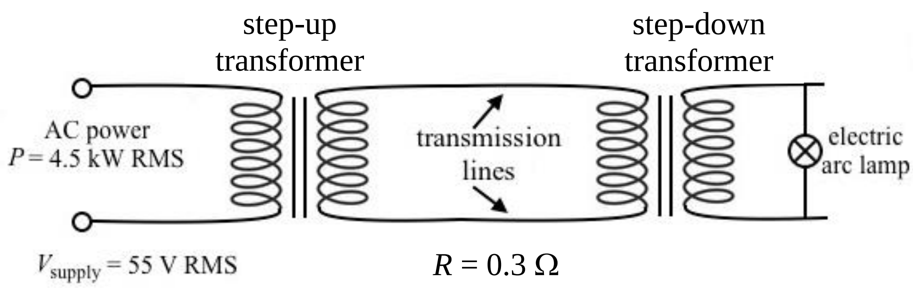


Figure 6

i. Using a modest turns ratio of 1:3 step-up, what are the expected values of the transmission line current?

1 mark

A

ii. Using a modest turns ratio of 1:3 step-up, what are the expected values of the voltage on the transmission line side of the transformer?

1 mark

V

e. Determine the new voltage drop across the transmission line in this new set-up.

2 marks

	V

f. At the step-down transformer, what is the expected voltage across the primary side?

2 marks

	V

g. Using the same turns ratio, determine the expected voltage available to the electric arc lamp after the step-down transformer.

2 marks

	V

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Question 5 (8 marks)

Major highways often incorporate ramps to the side of the road in hilly areas so that runaway trucks and vehicles with faulty brakes can be brought safely to a stop. One such design is a smooth ramp that gradually rises to a horizontal gravel track that is 40 m above the road level, as shown in Figure 7. Friction on the sloped ramp is negligible.

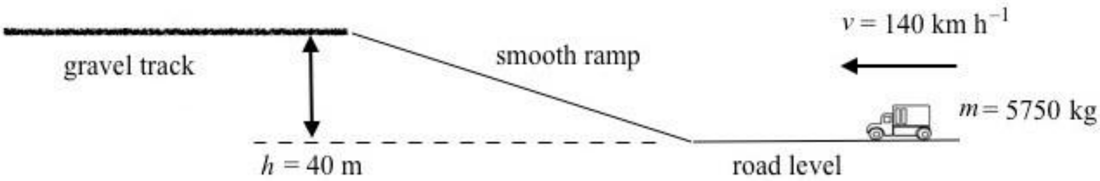


Figure 7

A truck with mass 5750 kg approaches the ramp at a speed of $v = 140$ km h^{-1}.

a. Convert the speed of the truck from kilometres per hour to metres per second.

1 mark

m s^{-1}

b. Determine the kinetic energy of the truck at the road level as it approaches the ramp. Show your working.

2 marks

J

c. What is the kinetic energy of the truck at the top of the 40 m height ramp, just prior to entering the gravel track? Show your working.

3 marks

J

d. The gravel track then exerts an average friction force of 25 kN on the still-moving truck.

Determine the distance that the truck continues to travel until it fully stops.

2 marks

m

Question 6 (7 marks)

A 7.1 kg bowling ball is placed on a compressed spring that is held rigidly inside a tube, as shown in Figure 8. The spring has a stiffness, k, of 261 N m^{-1}. The spring is released and returns to its natural length, while the ball rises to a maximum height of 0.89 m above its initial position.

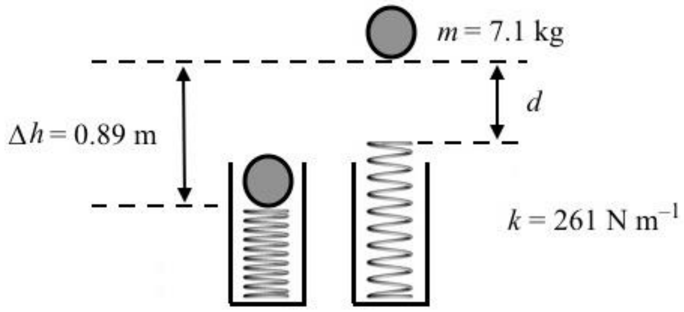


Figure 8

a. Determine the distance, d, that is the distance between the top of the uncompressed spring and the bottom of the bowling ball at its maximum height. Show your full working.

4 marks

m

b. When the spring was first released, the ball was accelerated upwards by the compressed spring that was returning to its natural length. The ball stopped accelerating upwards at some point in its upward journey.

What is the compression of the spring when the ball stopped accelerating upwards? Show your working.

3 marks

m

Question 7 (7 marks)

Jackie is a stunt coordinator in a movie that is being filmed in the Docklands. She is planning to run along the flat roof of a building and leap horizontally off the edge onto the flat roof of an adjacent building located 4.9 m away. The roof of the adjacent building is 6.3 m lower than the roof of the building she is leaping from, as shown in Figure 9.

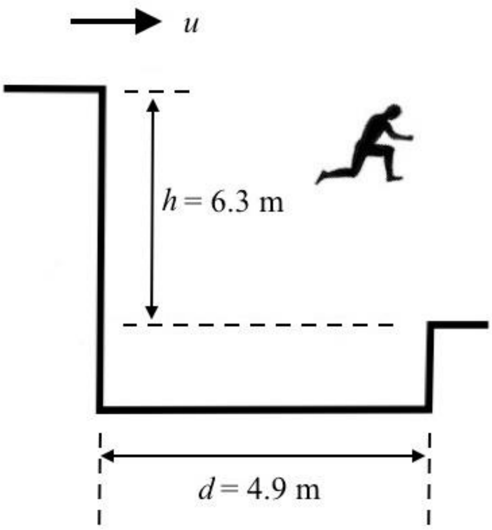


Figure 9

a. Ignoring the effects of air resistance, what is the minimum horizontal speed at which Jackie must run in order to land safely on the roof of the adjacent building?

3 marks

$\mathrm{m\ s^{-1}}$

b. Ignoring the effects of air resistance, calculate Jackie's expected vertical speed just prior to landing on the roof of the adjacent building.

2 marks

$\mathrm{m\ s^{-1}}$

c. Jackie's mass is 72 kg. Upon landing on the adjacent building, she plans to bend her knees and roll over such that her **vertical** speed will drop to zero over a period of 1.3 s.

Calculate the average **vertical** component of the force on Jackie over this period.

2 marks

N

Question 8 (8 marks)

Two rigid boxes, A and B, are placed next to each other on a flat, rough floor. The masses of the boxes are $m_A = 20$ kg and $m_B = 12$ kg. A force of 248 N is applied to the boxes from the left, as shown in Figure 10.

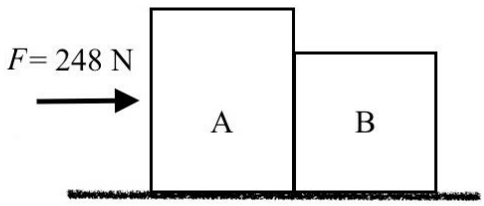


Figure 10

a. The size of the friction force of the floor on each box increases with the mass of the box at the rate of 4.51 N kg^{-1}.

Show that the size of the friction force of the floor on box B is 54.1 N.

2 marks

b. The friction force of the floor on box A is 90.2 N.

Determine the acceleration of box A.

3 marks

m s^{-2}

c. Calculate the magnitude of the force on box B by box A.

3 marks

N

Question 9 (7 marks)

The OSIRIS-REx is a space probe sent to the asteroid 101955 Bennu to collect a sample and return it to Earth. The probe reached the region of the asteroid in December 2018. For the next 2 years it will orbit the asteroid in order to study it from afar and to calculate its mass accurately in preparation for a safe landing.

After making several hundred orbits around the asteroid in a month, the orbital data of the probe will be:

- orbital diameter: 3480 ± 80 m
- orbital period: $209\ 000 \pm 900$ s

a. Using the orbital data of OSIRIS-REx provided above, calculate the mass of asteroid 101955 Bennu.

3 marks

kg

b. Show that the percentage uncertainty of the orbital period is 0.43%. You must show your working clearly.

2 marks

c. 101955 Bennu may be considered as a sphere with a radius of 300 m. When OSIRIS-REx lands on its surface, what would be the expected gravitational field strength on its surface?

2 marks

N kg^{-1}

Question 10 (6 marks)

Andrew is sitting on the edge of a merry-go-round at a park near his home. His mass is 47 kg, and his centre of mass is located at a distance of 1.9 m from the centre of the merry-go-round, as shown in Figure 11. The merry-go-round is travelling at a constant rate of rotation, completing one full revolution every 4.9 s.

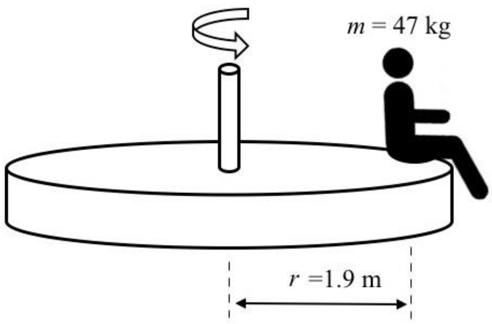


Figure 11

a. What is the tangential speed at which Andrew is going around the merry-go-round?

1 mark

$\square$ m s^{-1}

b. What is the magnitude of the net force acting on Andrew while he is travelling on the merry-go-round?

2 marks

$\square$ N

c. Andrew decides to move towards the centre of the merry-go-round such that his centre of mass is now 1.5 m from the centre. The merry-go-round is still travelling at the same constant rate of rotation, completing one full revolution every 4.9 s.

i. Circle the correct response.

The net force acting on Andrew will

remain the same increase decrease

1 mark

ii. Provide an explanation for your choice.

2 marks

Question 11 (10 marks)

The Kundt's tube is an apparatus that uses the standing wave phenomenon to determine the speed of sound in a gas, as shown in Figure 12. It comprises a clear plastic tube with a loudspeaker at one end and a sliding wall at the other end that can vary the length, *L*, of the section in between. Talcum powder is scattered along the length of the tube.

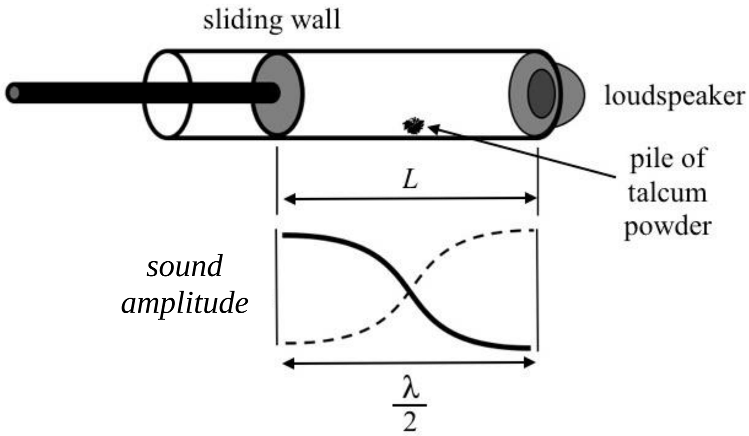


Figure 12

When the loudspeaker plays a pure tone sound, the sliding wall is moved until the sound volume reaches maximum loudness, indicating that *L* matches a resonant frequency. The talcum powder provides visual confirmation that the resonant frequency is fundamental because it forms a pile in the middle of the enclosed section, indicating that there is a node in the middle. *L* corresponds to half the wavelength of the fundamental frequency, $\frac{\lambda}{2}$.

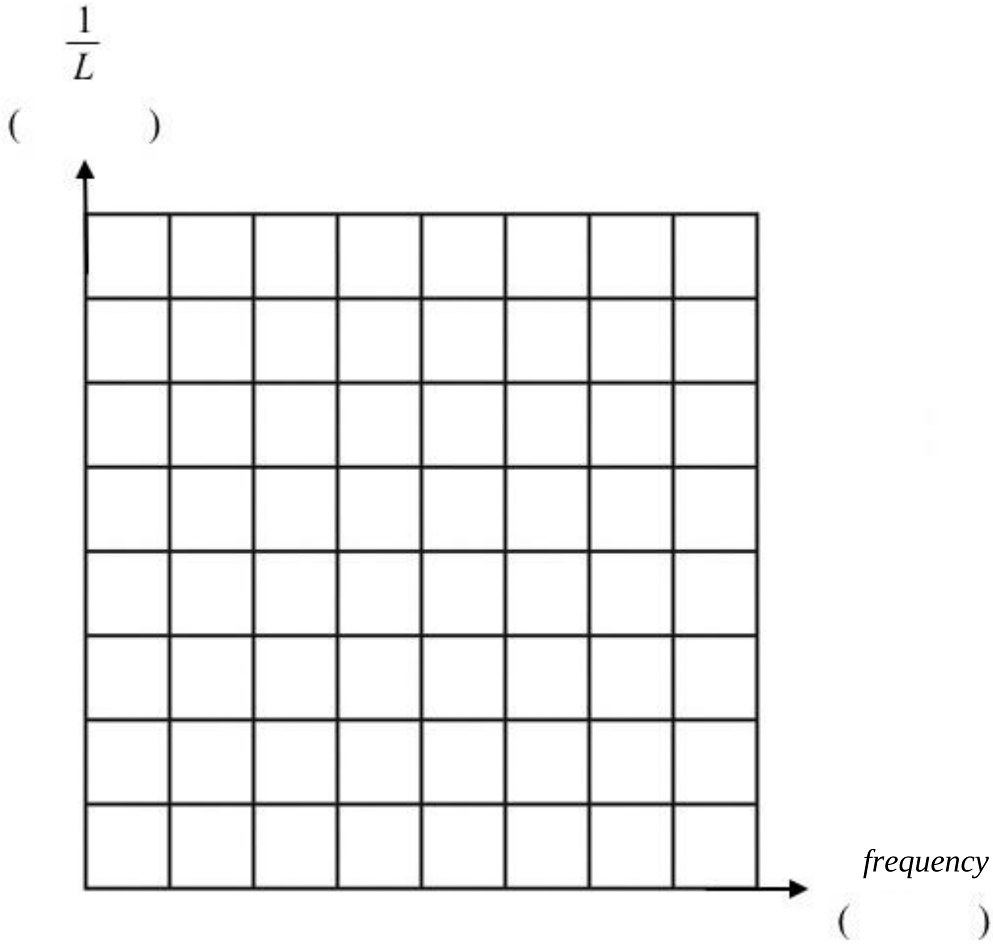
A class of students collect the following data for a few pure tone frequencies, *f*, and the length, *L*.

Frequency, *f* (Hz)	**Length, *L* (cm)**	$\frac{1}{L}$
165	109.1	0.92
330	52.9	1.89
587	29.2	3.42
880	19.3	5.18
1175	14.4	6.95

a. On the grid provided below:

- plot the data from the table
- include scales and units on each axis
- draw a line of best fit.

5 marks



b. Determine the gradient of the line of best fit drawn in **part a.** Show the working to obtain the gradient.

2 marks

s m^{-1}

c. Use the value of the gradient calculated in **part b.** to calculate the speed of sound in air. Show your full working.

3 marks

m s^{-1}

Question 12 (4 marks)

Kristen is experimenting with a semicircular block of Perspex and several lasers of different colours to investigate the phenomenon of refraction. Apart from the frequency of the laser light, every other feature, such as the beam power and dimension of the laser beams, are the same.

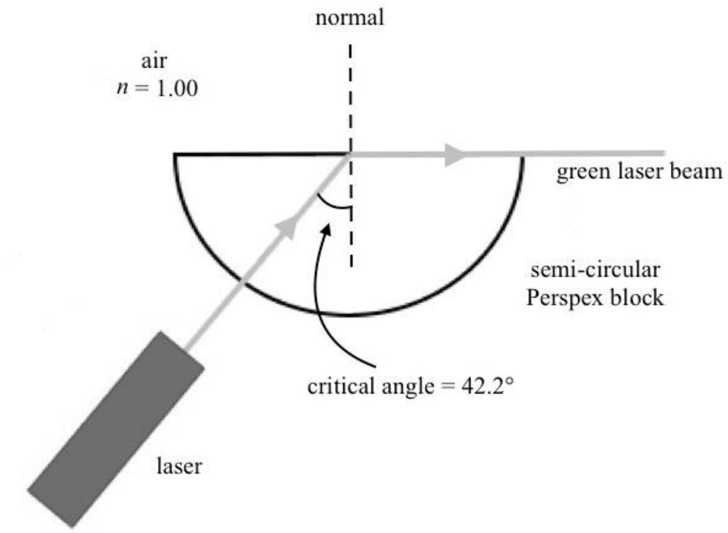


Figure 13

Kristen directs a green laser beam into the Perspex block radially and it is incident on the Perspex–air boundary, as shown in Figure 13. The angle of incidence is at the critical angle $i_{\text{crit}} = 42.2°$ and the beam exits the block at the refracted angle of 90°.

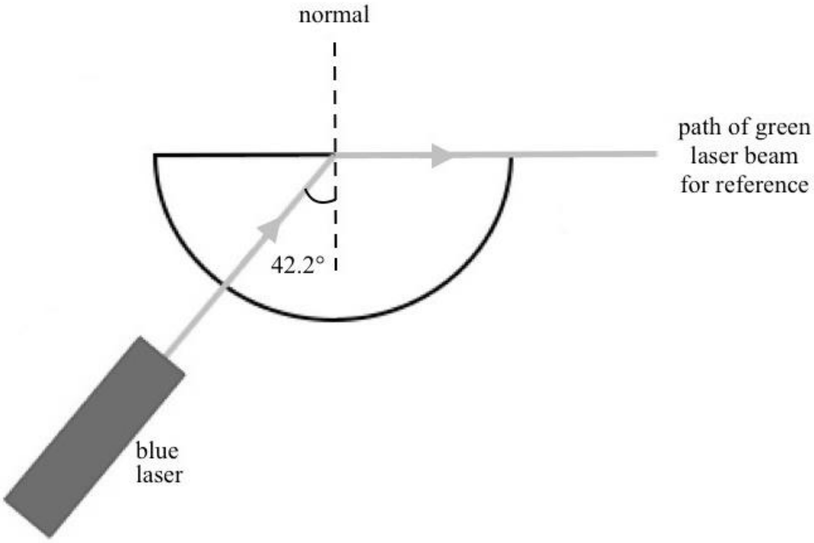
a. Given that the index of refraction of air, n_{air}, is 1.00, find the index of refraction for Perspex.

2 marks

b. The green laser is replaced with a blue laser at the same location, and the blue laser beam is directed into the Perspex block and follows the **same** radial path as the green laser. It is also incident on the Perspex–air boundary at the angle of incidence $i = 42.2°$.

On the diagram below, sketch the path of the blue laser beam that could be observed. The path of the green laser beam is included for reference.

2 marks



Question 13 (3 marks)

Asha, Bharat and Chantel are discussing GP Thomson's experiment with directing single electrons through a double-slit filter to produce interference patterns on a fluorescence screen.

Asha says that GP Thomson's results are similar to those of Young's double-slit experiment; thus, electrons can be modelled as waves and their interference patterns will be the same when the photon energy is equal to the electron's kinetic energy.

Bharat replies that the similarity of the interference patterns obtained by Thomson with electrons and by Young with light demonstrates that both matter and light can be modelled as waves.

Chantel suggests that Young's double-slit experiment results could be used to interpret Thomson's results because interference is a wave phenomenon; thus, electrons are not particles but waves.

Which student is correct? Describe what is wrong in the explanation given by the other two students.

Question 14 (4 marks)

A 9 V DC supply is used to heat up a tungsten filament to generate free electrons in a vacuum chamber. The electrons may be considered to be stationary at this point. As shown in Figure 14, they are then accelerated between two charged plates, which are at a potential difference of 2.4 MV DC.

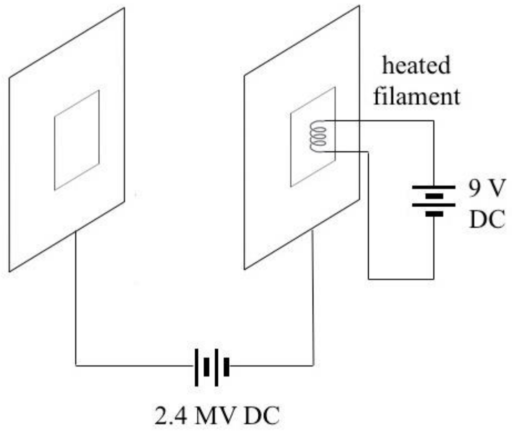


Figure 14

a. Using the classical physics equations for electrical potential energy and kinetic energy, show that the expected velocity of the electrons when they arrive at the positively charged plate is equal to 9.19×10^{8} m s^{-1}.

2 marks

b. Explain why the expected velocity of the electrons cannot be attained when calculated using classical physics.

2 marks

Question 15 (2 marks)

A stream of electrons that has just been accelerated in a linear accelerator is known to be under relativistic effects. The most energetic electrons have a kinetic energy of 3.84×10^{-13} J.

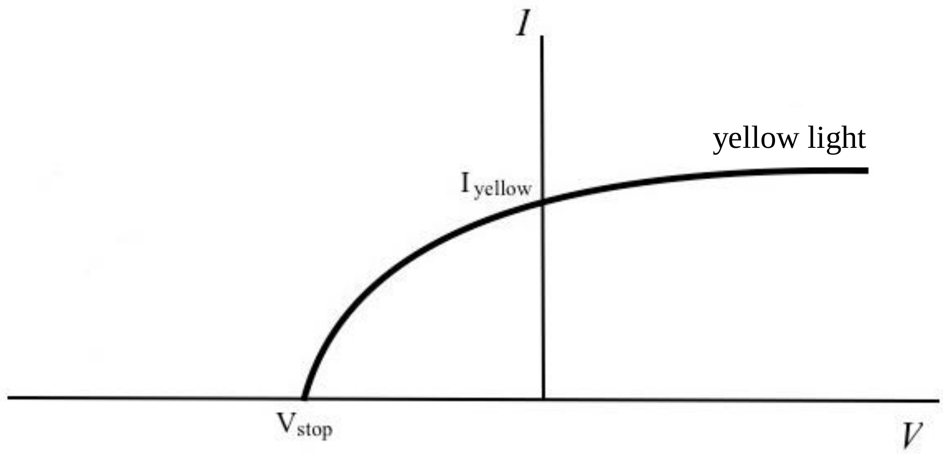
Calculate the gamma (γ) value for the most energetic electrons. You do not need to calculate the velocity.

γ =

Question 16 (3 marks)

Jon and Muriel are investigating the photoelectric effect.

With a yellow filter in place, a certain light power output is incident on a metal plate. By adjusting a variable DC voltage, the following graph of the photocurrent is plotted on the *I*–*V* axes. The voltage at which the photocurrent goes to zero is $V = \mathrm{V_{stop}}$ and the photocurrent when the variable voltage is zero is $I = \mathrm{I_{yellow}}$.



The intensity of the light source is increased so that the light power output of the yellow light incident on the metal plate increases.

a. On the same axes above, sketch the graph of the photocurrent expected, using a solid line.

1 mark

b. The filter is changed to a green filter. The intensity of the light source is adjusted so that the light power output of the green light incident on the metal plate is the same as that of the yellow light at the beginning, which produced the graph on the axes.

On the same axes above, sketch the graph of the photocurrent expected, using a dashed line.

2 marks

Question 17 (3 marks)

Diffraction patterns may be obtained from X-rays and electrons passing through thin metal crystals. The pattern from an electron experiment is combined, to the same scale, with one from an X-ray experiment, as shown in Figure 15.

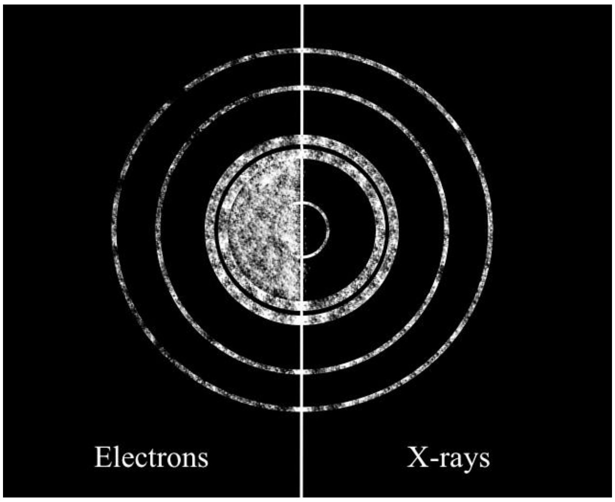


Figure 15

The X-ray energy that produced the pattern is 1.75×10^4 eV.

Find the voltage required to accelerate the electrons to generate the pattern.

V

Question 18 (3 marks)

The electron energy-level diagram for the element lithium is shown in Figure 16. As the electrons transition from a higher energy level to a lower one, they emit photons of particular wavelengths, which show up as lines on the emission spectrum.

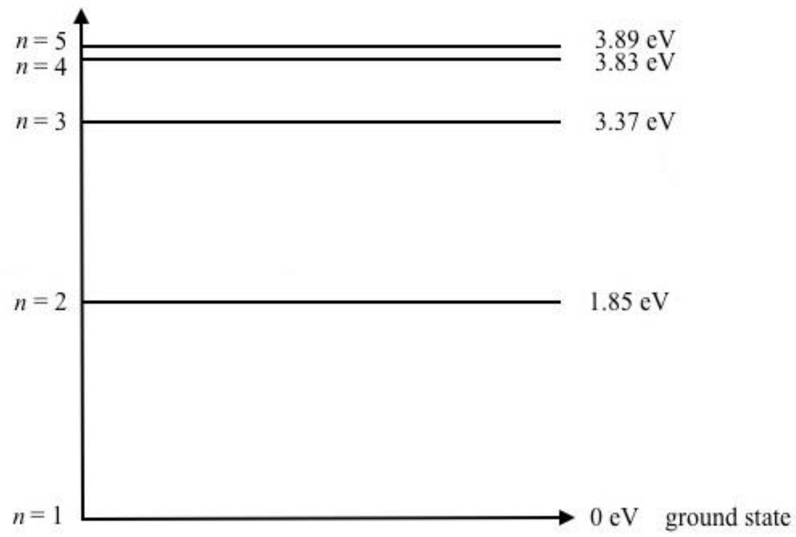


Figure 16

a. One of the emission lines on the spectrum for lithium has a wavelength of 627 nm.

Show that the energy of the photons that produce this emission line is 1.98 eV.

2 marks

____

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____

b. On the diagram above, draw an arrow that represents the transition that will emit the photon with a wavelength of 627 nm. Clearly show where the arrow starts and ends.

1 mark

SECTION B – continued
TURN OVER

Question 19 (3 marks)

The spectra of frequencies for three different light sources are shown in Figures 17, 18 and 19.

a. For each spectrum of frequencies, select from the following list of descriptors **all** that are applicable to the spectrum and write them in the spaces provided:

- continuous
- discrete
- monochromatic
- polychromatic.

b. For each spectrum of frequencies, match **one** light source from the following list to the correct spectrum and write it in the space provided:

- incandescent light
- laser
- mercury vapour lamp.

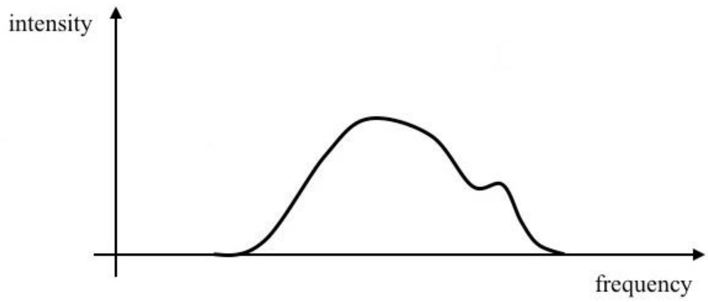

Figure 17

a. ______________________________

____

____

b. ______________________________

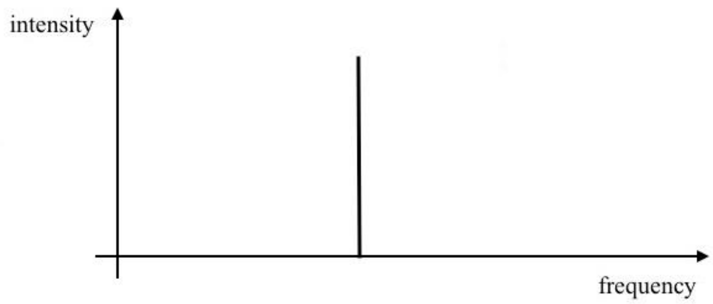

Figure 18

a. ______________________________

____

____

b. ______________________________

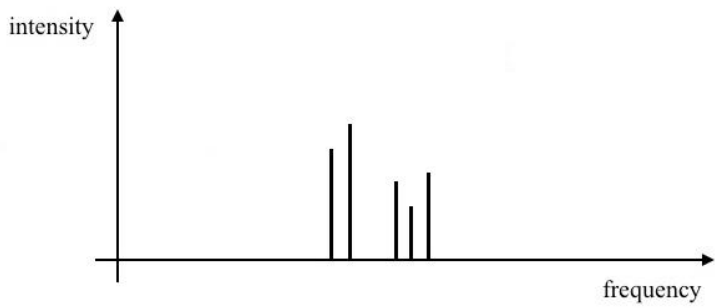

Figure 19

a. ______________________________

____

____

b. ______________________________

Question 20 (3 marks)

Xabi, Yosi and Zin are discussing how Heisenberg's uncertainty principle can be illustrated by the single-slit electron diffraction pattern.

The single-slit set-up is shown below in Figure 20.

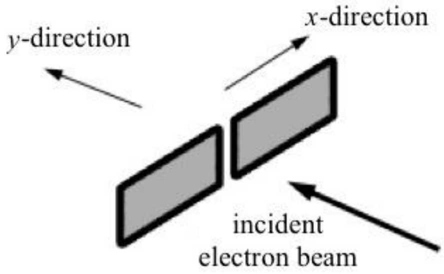

Figure 20

Xabi says that knowing that the uncertainty in the electron's speed being large leads to uncertainty in its kinetic energy being small.

Yosi suggests that knowing that the uncertainty in the electron's position in the *x*-direction is small leads to a large uncertainty in the electron's momentum in the *x*-direction.

Zin replies that knowing that the uncertainty in the electron's momentum in the *x*-direction is small leads to a large uncertainty in the slit's width.

Which student is correct? Describe the error in the explanation provided by the other two students.

END OF QUESTION AND ANSWER BOOK