Neap:

Trial Examination 2019

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	19	19	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 36 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 2019 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

A battery is rated at 12.0 V RMS.

What are the corresponding peak and peak-to-peak voltages?

	Peak voltage	Peak-to-peak voltage
A.	34.0	17.0
B.	17.0	34.0
C.	17.0	8.5
D.	8.5	17.0

Question 2

Two charges, 10 μC and 100 μC, are 1.0 cm apart.

The force between them is

A. 9.0×10^{-2} N

B. 9.0 N

C. 9.0×10^{2} N

D. 9.0×10^{4} N

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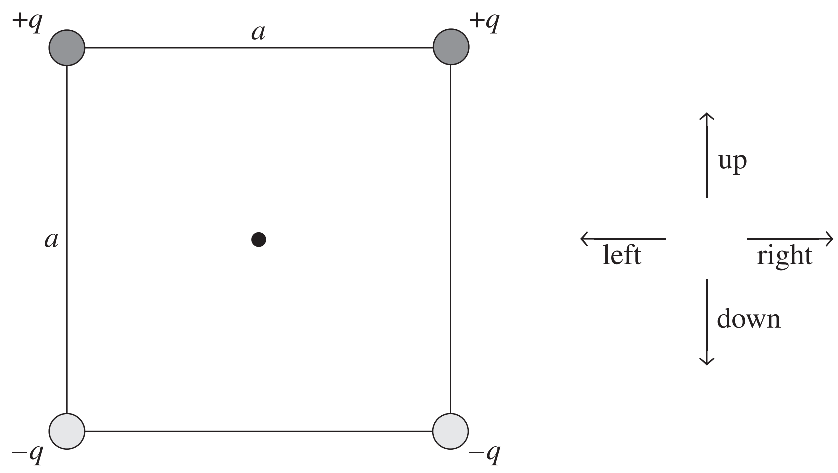
Use the following information to answer Questions 3 and 4.

Two positive charges and two negative charges are arranged in a square pattern as shown below. The charges have the same value. The square has a side length a. The black dot represents the geometric centre of the square.



Question 3

The size of the electric field at the centre of the square due to any one of the charges is represented by

A. $\dfrac{kq}{2a^2}$

B. $\dfrac{2kq}{a^2}$

C. $\dfrac{kq}{a^2}$

D. $\dfrac{\sqrt{2}(kq)}{a^2}$

Question 4

The resultant electric force at the position of the black dot is in which direction?

A. zero (no direction)

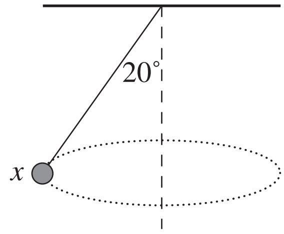
B. up

C. down

D. left

Question 5

The diagram below shows a small ball of mass 50 g on the end of a string. It is set in motion at a constant speed in a horizontal circle, where the string is held at an angle of $\theta = 20°$ to the vertical.



The net acceleration of the ball is

A. 3.4 m s^{-2}

B. 3.6 m s^{-2}

C. 9.2 m s^{-2}

D. 9.8 m s^{-2}

Use the following information to answer Questions 6 and 7.

The diagram below shows a boy of mass 50 kg chasing a runaway shopping trolley of mass 30 kg. The boy runs at 4.0 m s^{-1} and the trolley is rolling in the same direction at 2.0 m s^{-1}.

As the boy catches up to the trolley he jumps on the rear of it, and both the boy and the trolley move forward together.

Question 6

The final speed of the boy and trolley is closest to

A. 2.0 m s^{-1}

B. 2.5 m s^{-1}

C. 3.3 m s^{-1}

D. 4.0 m s^{-1}

Question 7

The collision of the boy and the trolley is described as

A. inelastic, because kinetic energy is not conserved.

B. elastic, because momentum is conserved.

C. inelastic, because momentum is not conserved.

D. elastic, because kinetic energy is conserved.

Question 8

A car of mass 1000 kg travels at 10 m s^{-1} and slows down to rest in 50 s.

The impulse acting on the car over the 50 s is

A. 200 kg m s^{-1}

B. 1000 kg m s^{-1}

C. 10 000 kg m s^{-1}

D. 50 000 kg m s^{-1}

Question 9

An astronaut is floating in the International Space Station, which orbits Earth.

She feels weightless because

A. Earth's gravity is so small.

B. she has no weight inside the space station.

C. she experiences no net force.

D. she is accelerating toward Earth.

Question 10

A string fixed at both ends on a guitar is plucked and one of the frequencies played by it is 300 Hz.

Which one of the following lists the correct range of the smallest possible frequencies played by the same string at the same time?

A. 100 Hz, 200 Hz, 300 Hz

B. 100 Hz, 300 Hz, 400 Hz

C. 100 Hz, 300 Hz, 500 Hz

D. 100 Hz, 300 Hz, 900 Hz

Question 11

Which one of the following best identifies the independent variable, its corresponding dependent variable and a possible control variable in the photoelectric effect experiment?

	Variables in the photoelectric effect experiment		
	Independent variable	**Dependent variable**	**Controlled variable**
A.	photoelectron speed	light intensity	work function
B.	light intensity	light colour	number of photoelectrons
C.	light colour	number of photoelectrons	photoelectron speed
D.	light intensity	number of photoelectrons	stopping potential

Question 12

Recording the length of a string as (12.3 ± 0.1) cm indicates that the

A. error in the measurement is 0.1 cm.

B. difference between the measurement and the correct value is 0.1 cm.

C. experimenter is confident that the true measurement lies somewhere between 12.2 cm and 12.4 cm.

D. experimenter is not confident that the experimental method will acquire the result.

Question 13

A student wishes to conduct an experiment in which the refractive index of vegetable oil is to be determined. The student knows that the vegetable oil floats on water and so is less dense than water. The student also knows that the refractive index of water is 1.33. The student formulates the following hypothesis:

If vegetable oil is less dense than water, then its refractive index should be less than 1.33.

Having undertaken the experiment five times, the following results were obtained for the refractive index of vegetable oil:

$$[1.47 \pm 0.02] \quad [1.45 \pm 0.02] \quad [1.46 \pm 0.02] \quad [1.47 \pm 0.02] \quad [1.47 \pm 0.02]$$

The results best indicate that the hypothesis is

A. inaccurate.

B. refuted.

C. to be rewritten to make it agree with the results.

D. inappropriate.

Question 14

Which one of the following lists the correct order of light categories in increasing diffraction ability through a very small gap?

A. gamma, X-ray, infrared, microwave

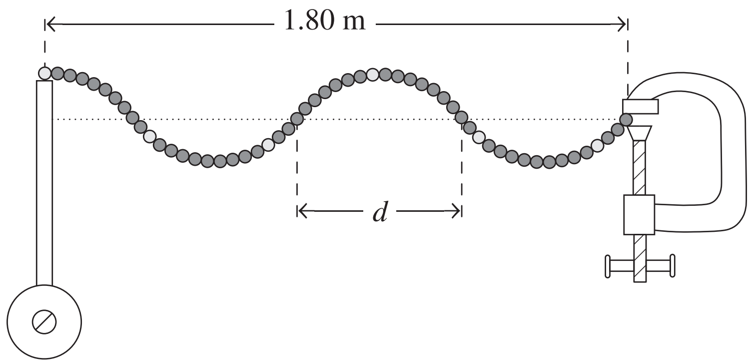
B. X-ray, gamma, microwave, infrared

C. microwave, infrared, X-ray, gamma

D. gamma, infrared, X-ray, microwave

Question 15

A laboratory wave generator consists of a light rope that is fixed at one end by a clamp and is able to be oscillated vertically up and down at the other end using a rod operated by a wheel. The diagram below shows this arrangement with the configuration of the rope at a particular instant. The two ends of the rope are 1.80 m apart.



The value of d is

A. 0.26 m

B. 0.39 m

C. 0.45 m

D. 0.51 m

Question 16

Frida hears a horn from a stationary car. The sound of the horn consists of a single frequency. She hears the horn again as the car is moving away from her.

The sound of the horn from the moving car has a

A. shorter wavelength and lower speed than the horn from the stationary car.

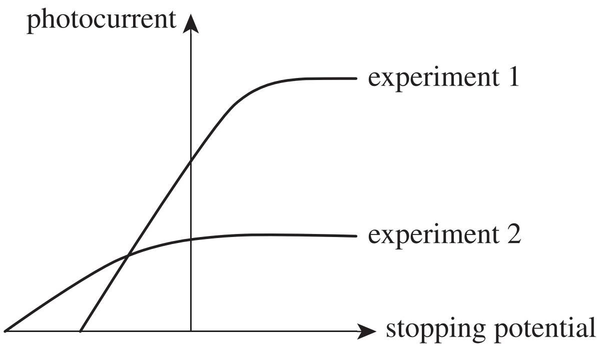
B. shorter wavelength and the same speed as the horn from the stationary car.

C. longer wavelength and higher speed than the horn from the stationary car.

D. longer wavelength and the same speed as the horn from the stationary car.

Question 17

The data from two photoelectric effect experiments is plotted on the graph below. The vertical axis represents the photocurrent and the horizontal axis represents the stopping potential.



How was experiment 2 different from experiment 1?

A. Experiment 2 used more intense light over a range of colours.

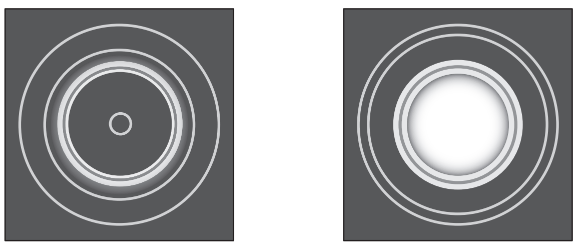
B. Experiment 2 used less intense light over a range of colours.

C. Experiment 2 used light of a lower wavelength and the light was dimmer.

D. Experiment 2 used more intense light and the photocathode was replaced with a different metal.

Question 18

The diagram below shows two diffraction patterns. The pattern on the left is the result of a beam of X-rays passing through a thin sheet of aluminium foil. The pattern on the right is the result of a beam of electrons passing through the same sheet of aluminium foil.



The diffraction patterns indicate that the beams of electrons and the X-rays have the same

A. momentum and energy.

B. momentum and wavelength.

C. energy and wavelength.

D. speed and wavelength.

Question 19

Which one of the following statements best describes the existence of electrons in an atomic energy level?

A. Electrons have a range of random energy values that allows them to exist at an atomic energy level.

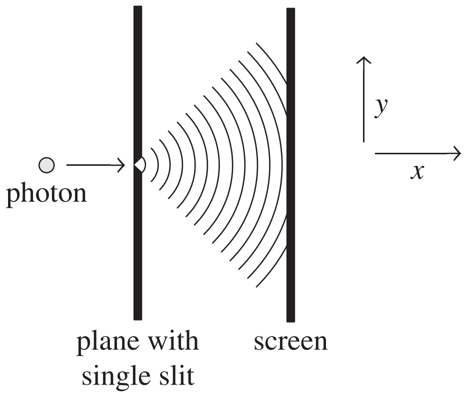
B. Electrons have a de Broglie wavelength that supports a continuous standing wave.

C. The atomic energy level permits electrons to orbit the nucleus without spiralling inwards.

D. The possible atomic energy levels allow electrons to absorb or emit light as they transit between them.

Question 20

The diagram below shows the single-slit diffraction experiment. The experiment illustrates the Heisenberg uncertainty principle. A photon is directed through a single slit of a particular width and the photon passes through the slit and strikes at some position on the screen.



Which one of the following statements correctly describes the position of the photon as the width of the slit is increased?

A. The uncertainty in the *y*-position of the photon is increased and the uncertainty in the photon momentum in the *x*-direction is increased.

B. The uncertainty in the *x*-position of the photon is increased and the uncertainty in the photon momentum in the *x*-direction is decreased.

C. The uncertainty in the *y*-position of the photon is increased and the uncertainty in the photon momentum in the *y*-direction is increased.

D. The uncertainty in the *y*-position of the photon is increased and the uncertainty in the photon momentum in the *y*-direction is decreased.

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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 booklet are **not** drawn to scale.

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

Question 1 (8 marks)

A proton is fired into a region of magnetic field as shown in Figure 1.

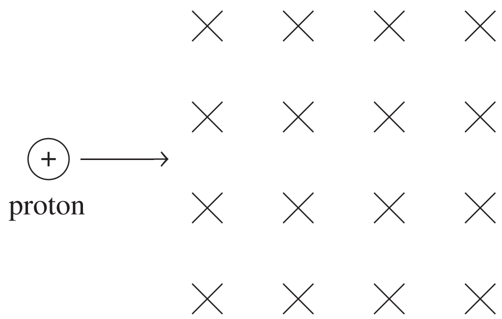

Figure 1

a. Sketch the path of the proton through the region of magnetic field in Figure 1. 1 mark

b. The proton enters the magnetic field with a speed of 1.0×10^6 m s^{-1} and the magnetic field strength is 0.10 T.

Calculate the magnitude of the force acting on the proton due to the magnetic field. Show your working. 2 marks

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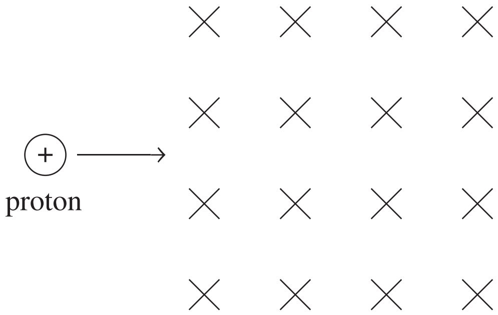
N

c. An electric field is now introduced in the same region as the magnetic field. The proton, travelling at 1.0×10^6 m s^{-1}, now passes straight through the region of electric and magnetic fields at constant velocity.

Draw **five** vectors on the following copy of Figure 1 to show the electric field described above. 1 mark



d. The magnetic field strength remains at 0.10 T and the proton travels at 1.0×10^6 m s^{-1} through the two fields as described in **part c.**

Determine the size of the force acting on the proton due to the electric field as the proton passes through at constant velocity. Show your working. 2 marks

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N

e. Calculate the size of the electric field acting on the proton as it passes through at constant velocity. Show your working. 2 marks

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N C^{-1}

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Question 2 (8 marks)

A group of students assemble a horseshoe magnet, a coil of wire and a split-ring commutator as shown in Figure 2.

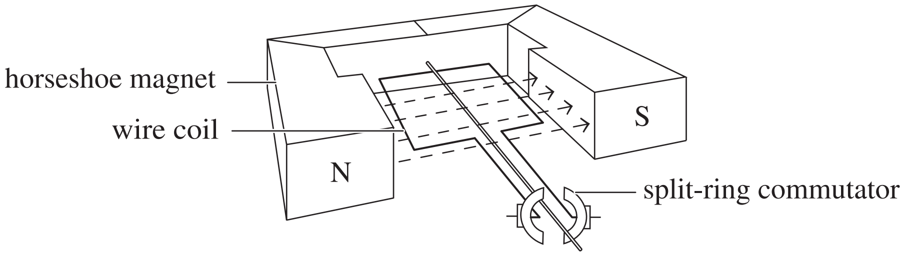

Figure 2

a. The coil is to rotate clockwise from the view shown in Figure 2.

Complete the circuit in Figure 2. Show any missing component(s) and indicate the direction of any current in the circuit. 2 marks

b. At a particular instant, the current in the coil (consisting of 5 turns) is 0.60 A. The magnetic field strength in the vicinity of the coil is 0.20 T.

Determine the maximum force acting on the side of the coil nearest the south pole of the magnet if the side of the coil is 3.0 cm long. Show your working. 2 marks

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N

c. Two of the students are discussing the forces acting on the coil. Minh states that the net force acting on the coil is zero, which does not explain why the coil rotates. Jose replies that since the coil is rotating, the net force acting on it cannot be zero.

Evaluate the opinions of the two students. 4 marks

Question 3 (6 marks)

A rectangular coil of 10 turns and side lengths 5.0 cm and 6.0 cm is shown in Figure 3. The coil moves from region A (inside a magnetic field) to region B (outside the magnetic field). The magnetic field strength is 0.30 T.

Throughout its entire motion, the coil moves at 3.0 cm s^{-1}. The coil begins with its right side at the edge of the magnetic field at time $t = 0$ in region A and travels 6.0 cm in region A. In region B, it travels for 15 cm before coming to rest instantaneously.

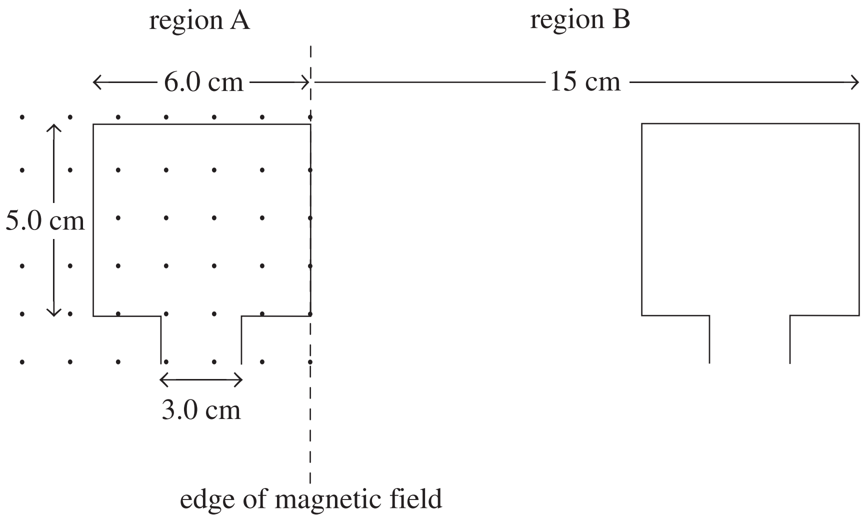
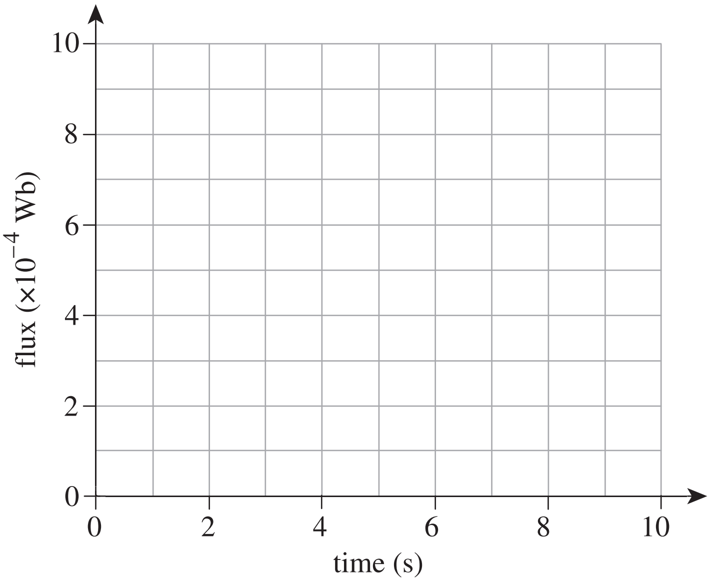


Figure 3

a. Show that the magnetic flux through the coil is 9.0×10^{-4} Wb. 2 marks

b. Sketch the magnetic flux from $t = 0$ s to the time corresponding to the end of region B on the axes provided below. 2 marks



c. Find the magnitude of the induced voltage across the ends of the coil at $t = 1$ s. Show your working. 2 marks

V

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Question 4 (3 marks)

Figure 4 shows a simple AC generator with a square coil that rotates clockwise at 20 Hz in a magnetic field. X and Y are wire positions on either side of an ammeter, A.

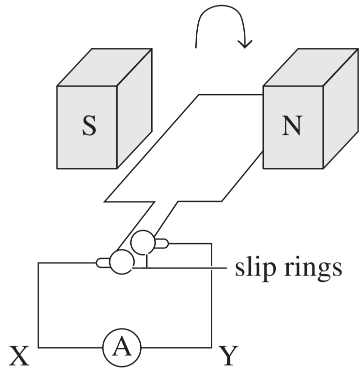


Figure 4

In which direction (X → Y or Y → X) does the induced current flow through the ammeter in the first quarter-turn from the position shown above? Explain your answer.

Question 5 (5 marks)

Figure 5 shows a solenoid consisting of uniformly wound wire with a square coil close to it. The square coil does not move relative to the solenoid. The solenoid is shown with a magnetic field around it for a particular instant.

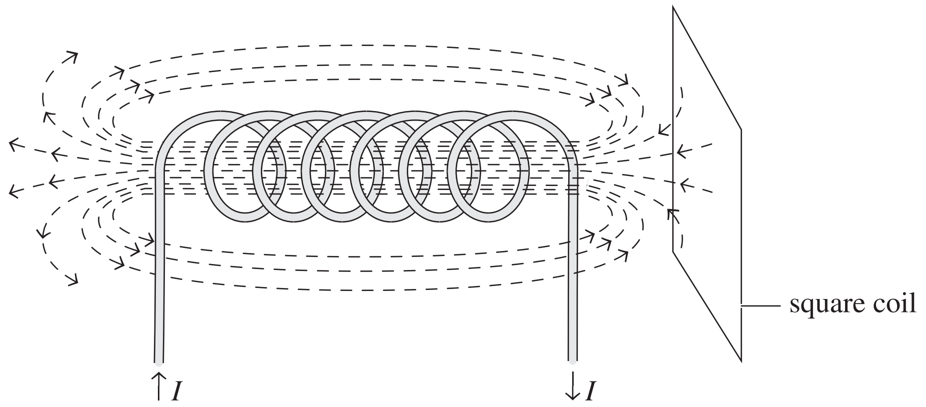
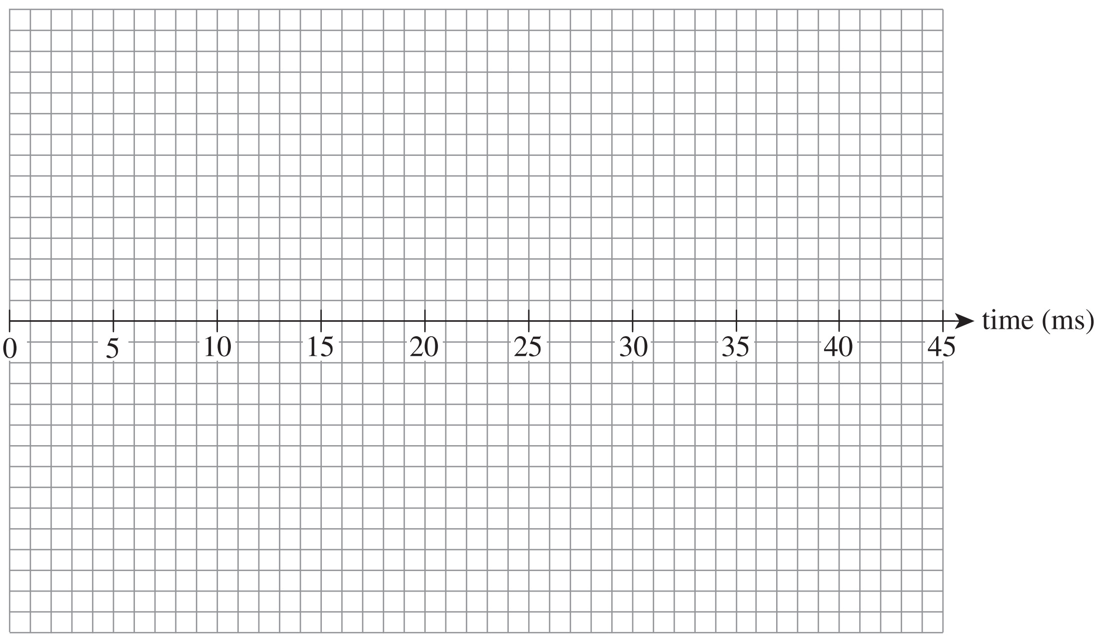


Figure 5

The solenoid is connected to a battery that provides an alternating current, *I,* at 50 Hz.

a. Sketch the magnetic flux through the square coil for 40 ms of time on the grid provided below, assuming that at $t = 0$ the current in the solenoid is 0 A. Do **not** include a vertical scale. 3 marks



b. The voltage output (V) at a particular instant is shown in Figure 6 below.

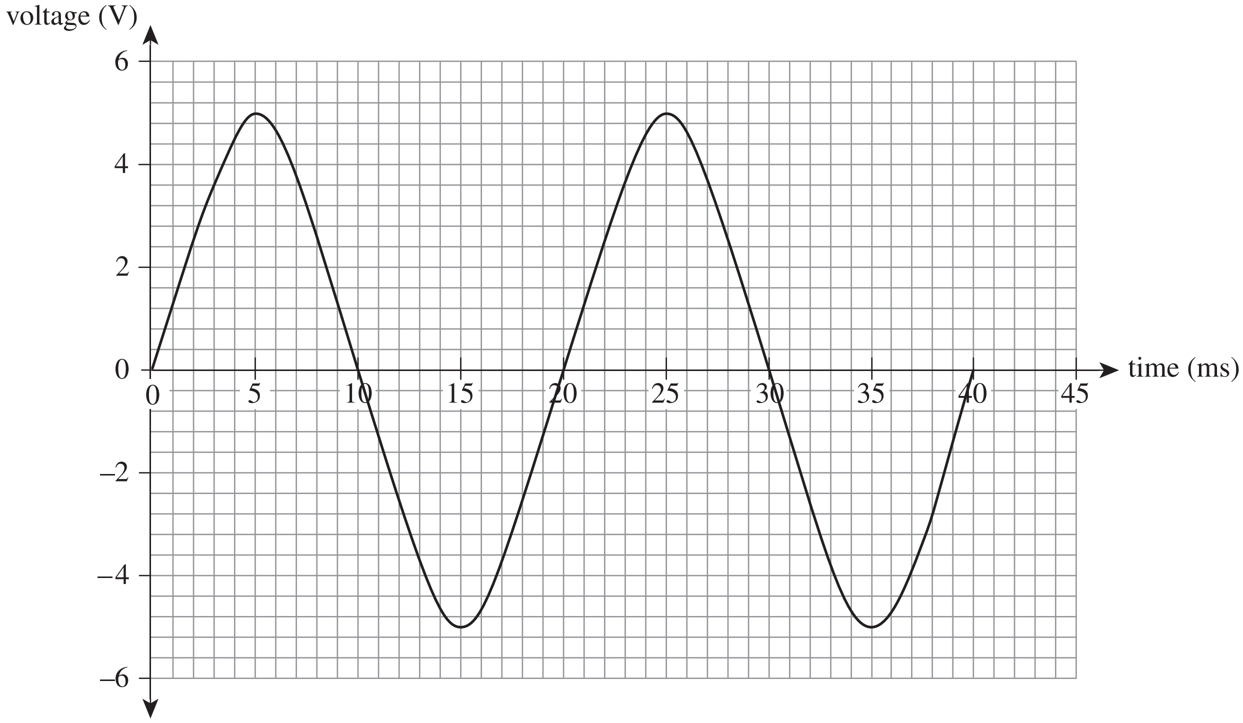


Figure 6

The frequency of the current is altered to 25 Hz.

Sketch the new voltage output for 40 ms of time on Figure 6. 2 marks

Question 6 (11 marks)

A class of students set up a circuit to investigate long-distance electricity transmission. They use a 12 V RMS supply and a resistor. Active and return wires approximately 100 m long connect the ends of the resistor to the power supply. A voltmeter, V, is connected directly across the resistor. This is shown in Figure 7.

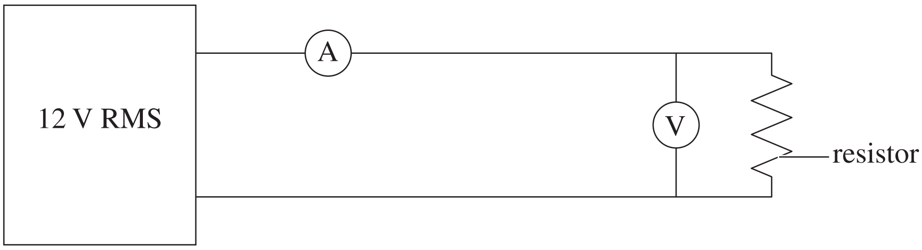


Figure 7

When the battery is switched on, an output of 12 V RMS is assumed and the ammeter, A, reads 1.5 A. The voltmeter reads 7.5 V.

a. Show that the resistance of one of the long-distance wires is 1.5 Ω. 3 marks

The class adds two identical transformers that they pulled out from an old circuit. They are assumed ideal and with no internal resistance. The adapted circuit is shown in Figure 8. The transformer ratios and points X and Y are shown below.

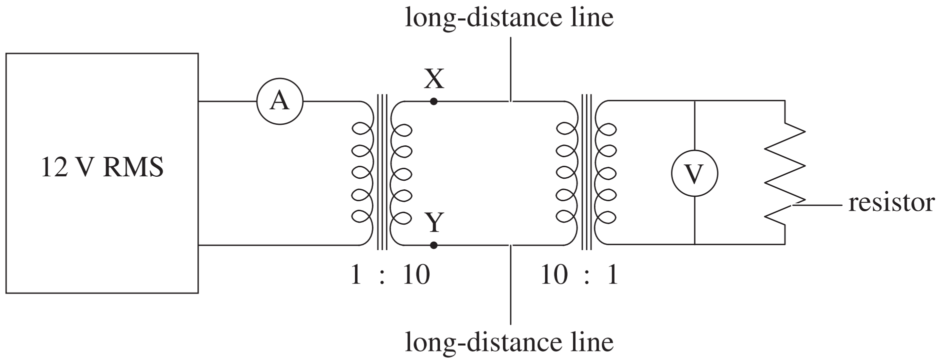


Figure 8

The ammeter still displays 1.5 A.

b. Calculate the potential difference across point X to point Y. Show your working. 2 marks

V

c. Calculate the total power loss in the long-distance lines. Show your working. 3 marks

W

d. Use a calculation to show that the voltmeter reading is greater than 7.5 V. 3 marks

V

Question 7 (5 marks)

Figure 9 shows two carts of 1 kg and 2 kg being pulled along a table by a falling mass of 3 kg via a pulley system.

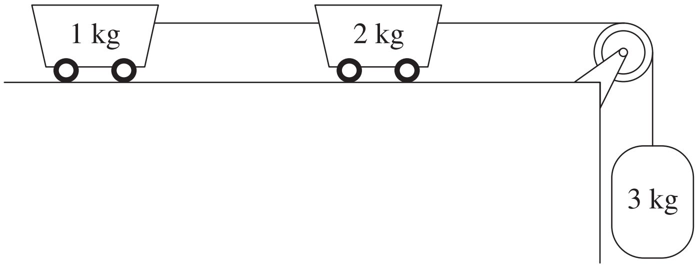


Figure 9

The acceleration of the carts is 4.9 m s^{-2} and friction between the moving parts of the system is negligible.

a. Determine the tension in the string between the two carts as the system moves. Show your working. 2 marks

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N

b. Calculate the tension between the 2 kg cart and the 3 kg falling mass as the system moves. 3 marks

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N

Question 8 (4 marks)

As part of a Physics investigation, a student projects a coin as shown in Figure 10. The coin is projected into a dish that is a height *h* above the plane of its launch. The student knows that the projection speed is 7.0 m s^{-1} at an angle of 60° to the horizontal. The coin travels a horizontal distance of 2.8 m upon landing in the dish. Air resistance acting on the coin can be neglected.

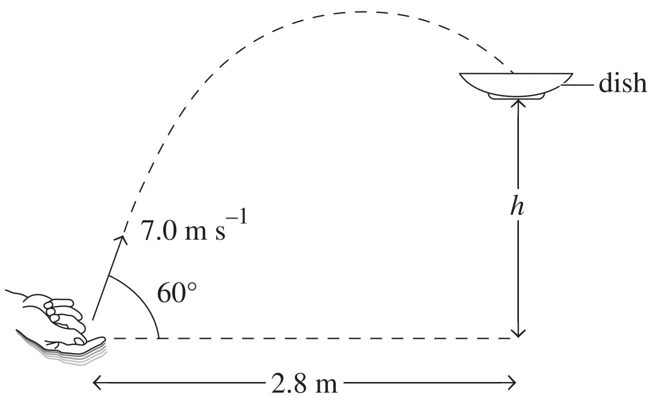

Figure 10

a. Show that the time taken for the coin to land in the dish is 0.80 s. 2 marks

b. Calculate the height of the dish above the launching point of the coin. Show your working. 2 marks

m

Question 9 (5 marks)

A toy car of mass 50 g is being tested as shown in Figure 11. Once it is released from a height above the base of a track, the toy car travels down a ramp and undertakes a vertical loop-the-loop. The diameter of the vertical circular track is 30 cm.

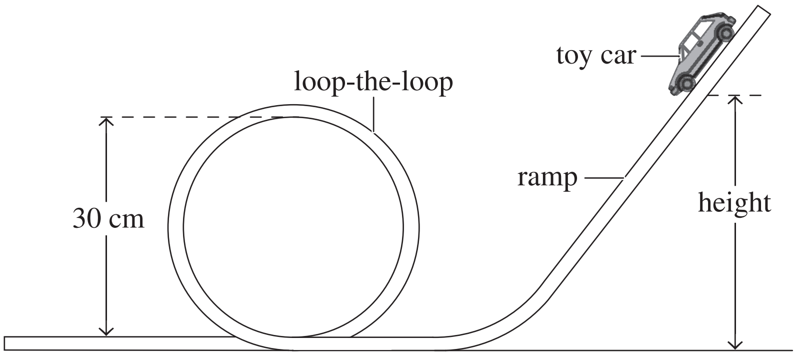

Figure 11

a. Determine the minimum speed of the toy car so that it just remains on the track at the top of the loop-the-loop. Show your working. 2 marks

m s^{-1}

b. What is the minimum release height of the toy car to achieve the minimum speed at the top of the loop? Show your working. 3 marks

m

Question 10 (5 marks)

Figure 12 shows a mass of 1 kg attached to the end of a spring, which is suspended from a beam. A hand holds the mass such that the spring is unextended. A short time later, the mass is released and falls a distance of 49 cm, coming momentarily to rest.

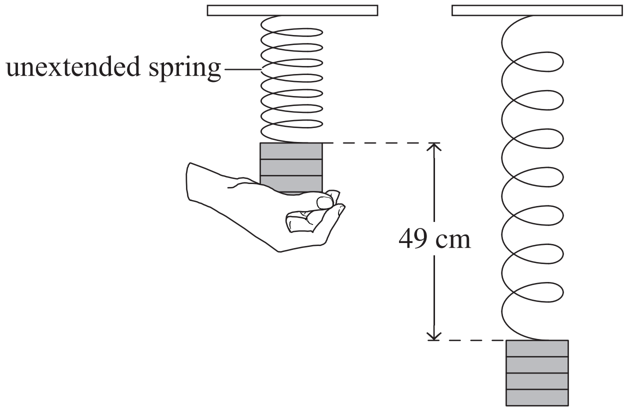

Figure 12

a. Show that the spring constant is 40 N m^{-1}. 2 marks

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b. Determine the value of the greatest acceleration of the mass. Explain how you arrived at your result and show your working. 3 marks

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m s^{-2}

Question 11 (5 marks)

Satellites used in the Global Positioning System (GPS) orbit Earth with an orbital radius of approximately 2.66×10^4 km.

a. Determine the gravitational field strength of Earth at the position of one of these GPS satellites. Show your working. 2 marks

$N\ kg^{-1}$

b. What is the period of a GPS satellite? Express your answer to three significant figures and show your working. 3 marks

h

Question 12 (4 marks)

A muon is a short-lived subatomic particle that can travel at 0.99 times the speed of light relative to an observer on Earth. The mass of a muon is 207 times the mass of an electron when both are at rest.

a. Determine how much greater the travelling muon's mass is compared to the mass of a stationary electron relative to an observer on Earth. Show your working. 2 marks

b. Scientists observe muons travelling inside a chamber of length 1000 m. The scientists are at rest relative to the chamber.

How far have the muons travelled in their frame of reference? Show your working. 2 marks

m

Question 13 (6 marks)

Figure 13 shows a coin sitting in the bottom corner of a glass tank of vegetable oil. The tank is filled to the top. The tank is 40 cm long, 20 cm wide and 20 cm high.

A student's eye is able to see the coin when their eye is over the top of the tank. This is shown in Figure 13. The refractive index of the vegetable oil is 1.47.

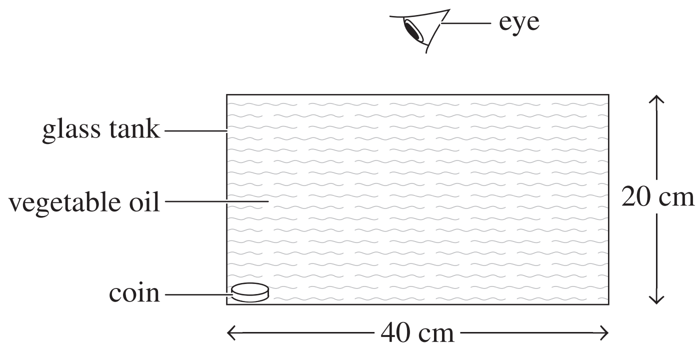

Figure 13

a. What is the speed of light in the vegetable oil? Show your working. 2 marks

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$m\ s^{-1}$

b. The student now places a cover of length 20 cm over the top half of the tank nearest the coin, as shown in Figure 14. The student does not see the coin when their eye is above the cover.

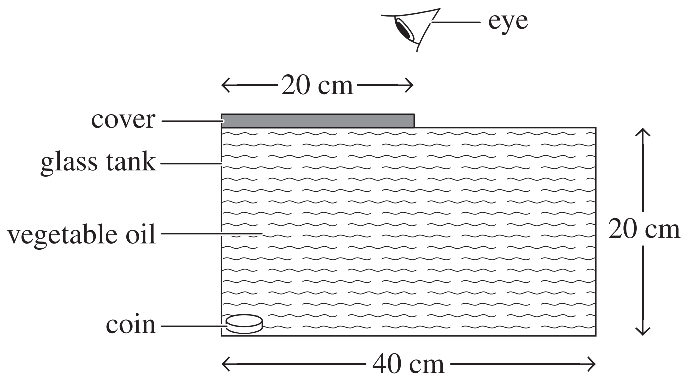

Figure 14

Is it possible for the student to see the coin from above the tank simply by moving backwards to the right in relation to Figure 14? Justify your answer by use of any calculations and explain any relevant physics for this situation. 4 marks

Question 14 (7 marks)

As part of a practical investigation, Marie decides to investigate the speed of a wave in a guitar string when plucked. She plays a single note into a sensor. The sensor plugs into a data logger, which displays the data on a computer screen. The experimental set-up is shown in Figure 15.

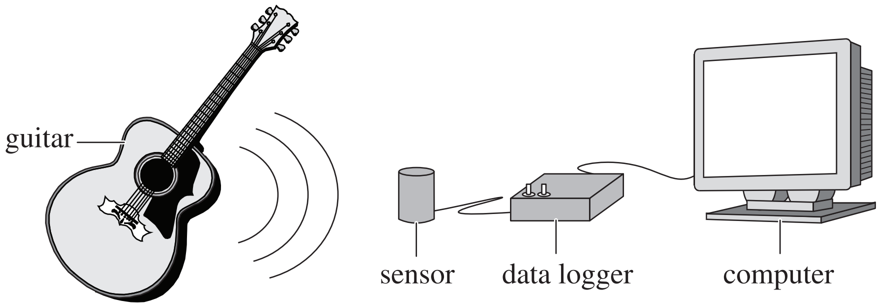

Figure 15

Marie measures and records the first harmonic played when she plucks a particular string. She altered the length of the string using a finger to keep constant the tension in the string. Her results are shown in the table below.

Marie sees a particular pattern in the numerical data and calculates the inverse value of the length, length^{-1}. These values are also recorded in the table below.

Length (m)	**Measured frequency (Hz)**	**Length^{-1} (m^{-1})**
0.57	370	1.75
0.52	400	1.92
0.47	450	2.13
0.42	500	2.38
0.37	570	2.70
0.32	655	3.13

a. Plot a graph of frequency-versus-length^{-1} on the grid provided below. Include a scale on each axis and draw a line of best fit. 4 marks

b. Determine the speed of the wave in the guitar string using the graph from **part a.** Show your working. 3 marks

m s^{-1}

Question 15 (10 marks)

Jenna and Sal conduct an experiment where they shine monochromatic light onto the cathode of a vacuum tube made of a particular metal. This is shown in Figure 16. The figure shows electrons being emitted.

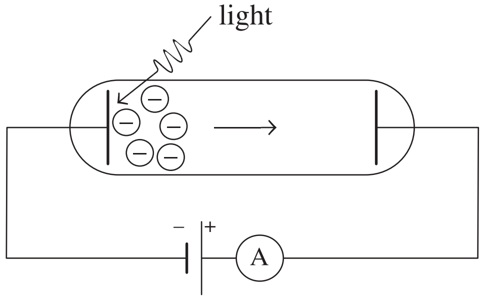

Figure 16

They obtain a graph of the stopping voltage (V) versus light frequency (× 10^{14} Hz), as shown in Figure 17.

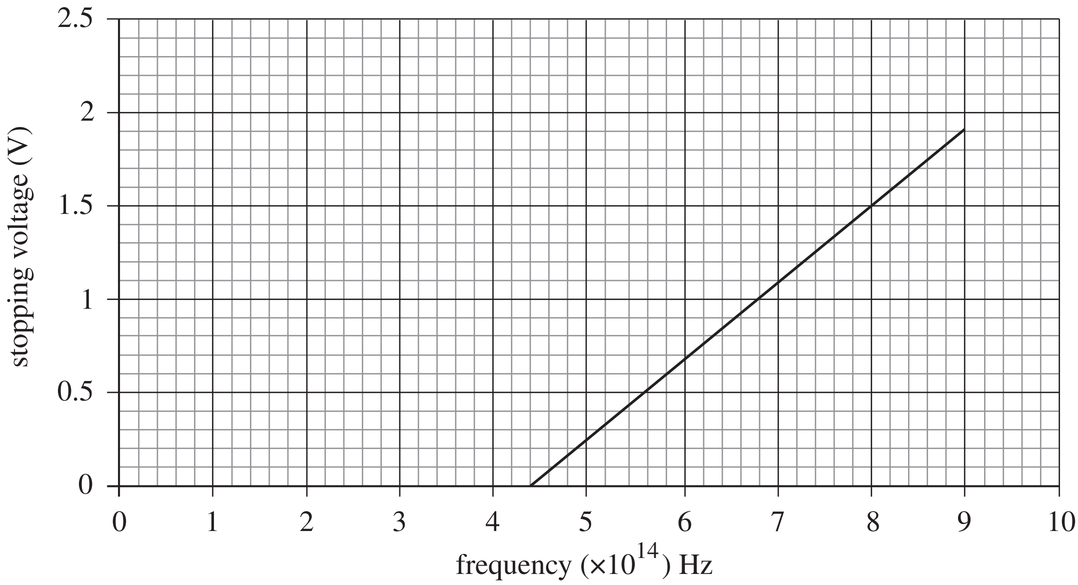

Figure 17

a. Determine the work function of the metal. Show your working. 2 marks

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eV

b. Explain whether or not light of frequency 3.0×10^{14} Hz can cause electrons to be emitted from the metal surface. 2 marks

c. Determine the largest wavelength of light that will cause electrons to be emitted by the metal surface. Show your working. 2 marks

nm

d. Jenna and Sal are discussing the effect on the data shown in the graph by changing some of the aspects of the investigation.

Sal believes that an increase in the intensity of the light will cause the electrons to be emitted with more energy and that more electrons will also be emitted.

Jenna believes that changing the metal of the cathode so that it has a higher work function will allow the frequencies from 1×10^{14} to 4×10^{14} Hz to eject electrons.

Evaluate the opinions of the two students. 4 marks

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Question 16 (7 marks)

Gold atoms in metal are evenly spaced at 0.295 nm. A beam of electrons, accelerated by a potential difference of 10 000 V, is directed at a thin leaf of gold metal.

a. Calculate the wavelength of the electrons. Show your working. 2 marks

nm

b. Calculate the momentum of the electrons. Show your working. 2 marks

kg m s^{-1}

c. Use calculations to support whether the passage of electrons through the thin leaf of gold metal displays wave behaviour. 3 marks

Question 17 (4 marks)

Figure 18 shows the absorption line spectrum for hydrogen.

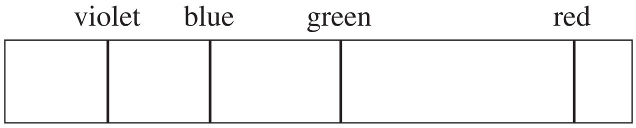

Figure 18

Explain why all other colours are **not** absorbed by hydrogen atoms. As part of your answer, explain the nature of the electron orbits that contribute to this process.

Question 18 (4 marks)

An experiment conducted by a Physics class is shown in Figure 19. The experiment involves passing two identical (coherent and monochromatic) parallel rays of light through a double slit to produce a pattern on the screen.

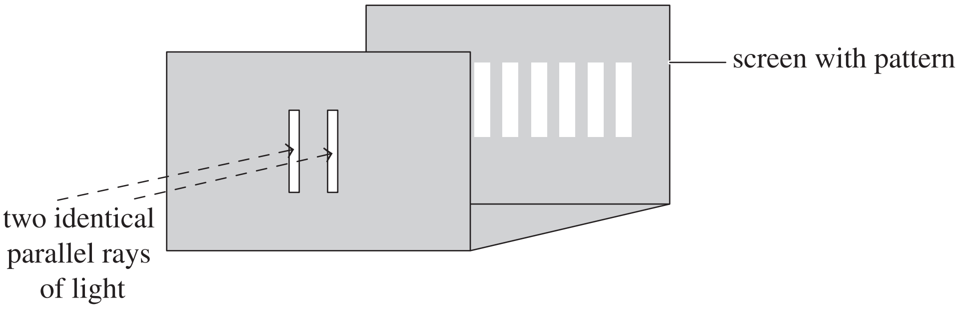

Figure 19

The black dot on Figure 20 indicates the point on the screen that is an equal distance from the two slits.

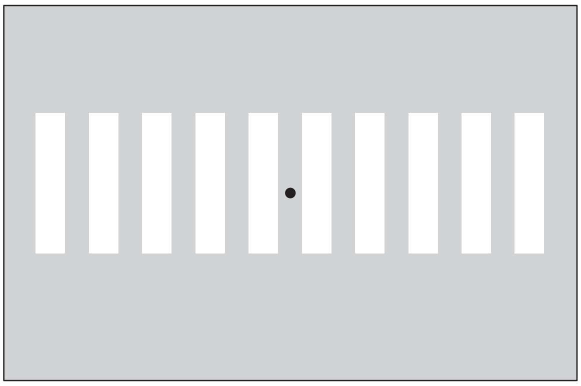

Figure 20

Light of wavelength 635 nm is used in the experiment.

a. Draw the letter X on the screen in Figure 20 to indicate the position where one ray has travelled further than the other ray by 1905 nm. 1 mark

b. Draw the letter Y on the screen in Figure 20 to indicate the position where one ray has travelled further than the other ray by 952.5 nm. 1 mark

c. Light of wavelength 460 nm and of greater intensity than the original is now used.

Explain the effect on the original pattern as a result of using the new light source. 2 marks

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Question 19 (3 marks)

Figure 21 shows the pattern of electrons as they are fired, one at a time, through a double-slit wall.

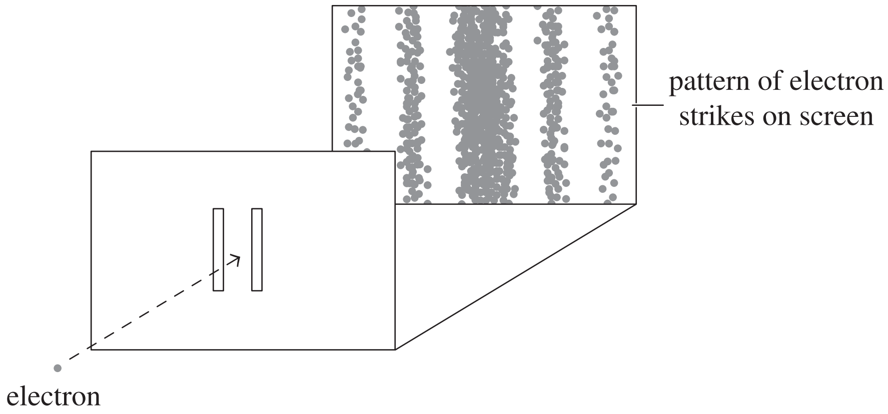

Figure 21

Explain the behaviour of the electrons as they strike the screen over time.

END OF QUESTION AND ANSWER BOOKLET