VCE PHYSICS 2018

YEAR 12 TRIAL EXAM

Units 3/4
Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A. Multiple Choice Questions	20	20	20
B. Short Answer Questions	22	22	110
		Total	**130**

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Data Sheet VCE Physics 2018 Year 12 Trial Exam Units 3/4

Motion and related energy transformations		
1	velocity; acceleration	$v = \frac{\Delta x}{\Delta t}; \quad a = \frac{\Delta v}{\Delta t}$
2	equations for constant acceleration	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{1}{2}(v+u)t$
3	Newton's second law	$\Sigma F = ma$
4	circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
5	Hooke's law	$F = -kx$
6	elastic potential energy	$\frac{1}{2}k\Delta x^2$
7	gravitational potential energy near the surface of the Earth	$mg\Delta h$
8	kinetic energy	$\frac{1}{2}mv^2$
9	Newton's law of universal gravitation	$F = \frac{GM_1M_2}{r^2}$
10	impulse	$F\Delta t$
11	momentum	mv
12	gravitational field	$g = \frac{GM}{r^2}$
13	Lorentz factor	$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$
14	time dilation	$t = t_O\gamma$

15	length contraction	$L = \frac{L_O}{\gamma}$
16	rest energy	$E_{rest} = mc^2$
17	relativistic total energy	$E_{total} = \gamma mc^2$
18	relativistic kinetic energy	$E_K = (1-\gamma)mc^2$
Generation and transmission of electricity		
19	voltage; power	$V = RI \quad P = VI = I^2R$
20	resistors in series	$R_T = R_1 + R_2$
21	resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
22	transformer action	$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$
23	AC voltage and current	$V_{RMS} = \frac{1}{\sqrt{2}}V_{peak} \quad I_{RMS} = \frac{1}{\sqrt{2}}I_{peak}$
24	electromagnetic induction	emf : $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ flux : $\Phi = BA$
25	transmission losses	$V_{drop} = I_{line}R_{line} \quad P_{loss} = I^2_{line}R_{line}$
Wave concepts		
26	wave equation	$v = f\lambda$
27	constructive interference	path difference = nλ
28	destructive interference	Path difference = $(n-\frac{1}{2})\lambda$
29	fringe spacing	$\Delta x = \frac{\lambda L}{d}$
30	Snell's Law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
31	refractive index and wave speed	$n_1v_1 = n_2v_2$

The nature of light and matter		
32	photoelectric effect	$E_{K\max} = hf - W$
33	photon energy	$E = hf$
34	photon momentum	$p = \frac{h}{\lambda}$
35	de Broglie wavelength	$\lambda = \frac{h}{p}$
36	Heisenberg's uncertainty principle	$\Delta p_x \Delta x \geq \frac{h}{4\pi}$
Data		
37	acceleration due to gravity at Earth's surface	$g = 9.8\ \text{ms}^{-2}$
38	mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
39	charge on the electron	$e = -1.6 \times 10^{-19}$ C
40	Planck's constant	$h = 6.63 \times 10^{-34}$ J s
41	speed of light in a vacuum	$c = 3.0 \times 10^{8}\ \text{m s}^{-1}$
42	universal gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
43	mass of Earth	$M_E = 5.98 \times 10^{24}$ kg
44	radius of Earth	$R_E = 6.37 \times 10^{6}$ m
45	coulomb constant (in air)	$k = 8.99 \times 10^{9}\ \text{Nm}^2\text{c}^{-2}$

Prefixes/Units

p = pico = 10^{-12}

n = nano = 10^{-9}

μ = micro = 10^{-6}

m = milli = 10^{-3}

k = kilo = 10^{3}

M = mega = 10^{6}

G = giga = 10^{9}

STUDENT NUMBER Letter

Figures										
Words										

Student Name....………………………...

VCE Physics 2018 Year 12 Trial Exam Units 3/4

Student Answer Sheet

Instructions for completing exam. Use only a 2B pencil. If you make a mistake, erase it and enter the correct answer. Marks will not be deducted for incorrect answers.

Write your answers to the Short Answer Section in the space provided directly below the question. There are **20 Multiple Choice** questions to be answered by circling the correct letter in the table below.

Question 1	A	B	C	D	*Question 2*	A	B	C	D
Question 3	A	B	C	D	*Question 4*	A	B	C	D
Question 5	A	B	C	D	*Question 6*	A	B	C	D
Question 7	A	B	C	D	*Question 8*	A	B	C	D
Question 9	A	B	C	D	*Question 10*	A	B	C	D
Question 11	A	B	C	D	*Question 12*	A	B	C	D
Question 13	A	B	C	D	*Question 14*	A	B	C	D
Question 15	A	B	C	D	*Question 16*	A	B	C	D
Question 17	A	B	C	D	*Question 18*	A	B	C	D
Question 19	A	B	C	D	*Question 20*	A	B	C	D

VCE Physics 2018 Year 12 Trial Exam Units 3/4

SECTION A – Multiple Choice Questions

(20 marks)

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 questions.
Take the value of g to be 9.8 ms^{-2}.

Question 1
A small particle as shown in **Figure 1** exerts a force all around it. The field is a monopole and it could be

A. electric.
B. magnetic.
C. gravitational or electric.
D. all of the above.

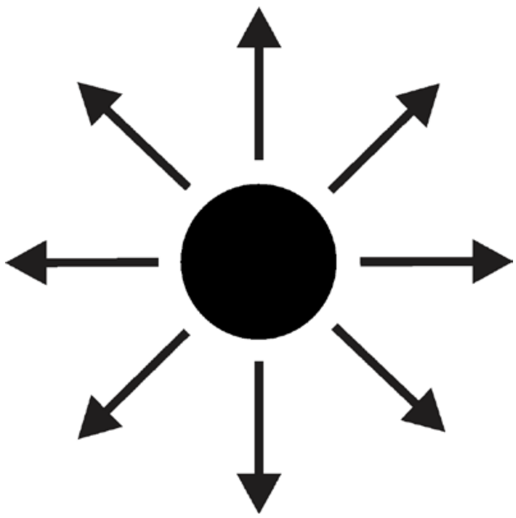


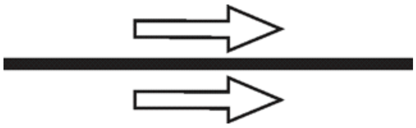
Figure 1

Question 2
Current flows along a length of copper wire in the direction shown in **Figure 2**.

Figure 2

The shape of the magnetic field around the wire in **Figure 2**, is best represented by

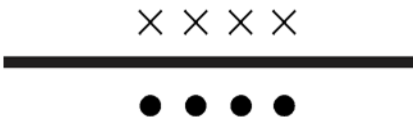
A.



B.

C.

D.



Question 3
A charged particle moving through an electric field of $200\ \text{Vm}^{-1}$ experiences a force of $6.4 \times 10^{-17}\ \text{N}$ .What is the charge on the particle?

A. $1.28 \times 10^{-14}\ \text{C}$

B. $1.28 \times 10^{-16}\ \text{C}$

C. $3.2 \times 10^{-19}\ \text{C}$

D. Cannot be determined.

Question 4
The diagram in **Figure 3** shows induced emf in a coil of wire across a magnetic field as a function of time.

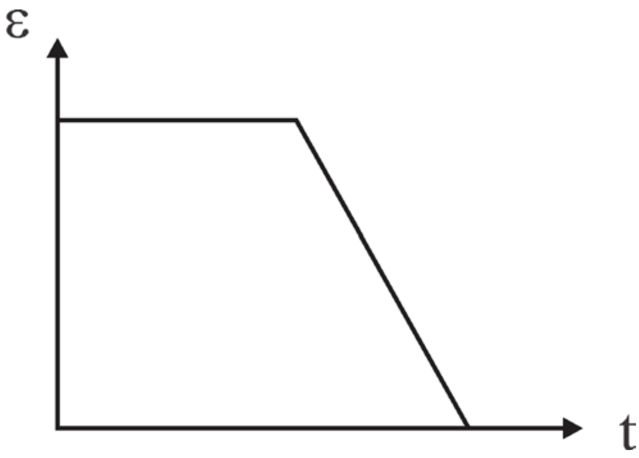
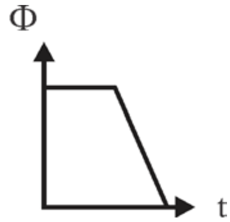


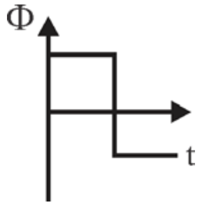
Figure 3

Choose the option which best describes the changes in magnetic flux.

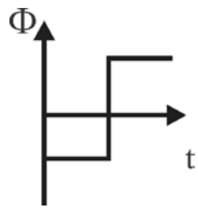
A.



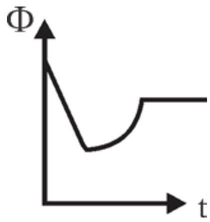
B.



C.



D.



Question 5
An AC voltage pack delivers 18V RMS. The peak-to-peak voltage extends from
A. -9 V to 9 V
B. -18 V to 18 V
C. -25.5 V to 25.5 V
D. 0 to 25.5 V

Questions 6 and 7 relate to the following information.
A step-down AC transformer reduces 240V RMS to 6V RMS. The secondary coil has 120 turns. You may assume that it is an ideal transformer.

Question 6
How many turns does the primary coil have?
A. 3
B. 4800
C. 120
D. 6

Question 7
The peak current in the secondary coil is 0.5 A. What is the best estimate of the power delivery of the secondary coil?
A. 2.1 W_{RMS}
B. 3.0 W_{RMS}
C. 4.2 W_{RMS}
D. 12 W_{RMS}

The following information relates to Questions 8 and 9
The car pictured in **Figure 4** accelerates from 60 kmh^{-1} to 110 kmh^{-1} in that time it travels 120 m (assume the acceleration is uniform).

Figure 4

Question 8
Which of the following best gives the acceleration of the car?
A. 5.46 ms^{-2}
B. 1.37 ms^{-2}
C. 2.73 ms^{-2}
D. 1.00 ms^{-2}

Question 9

Which of the following gives the time over which the car accelerated?

A. 17.3 s
B. 1.7 s
C. 5.1 s
D. 4.5 s

Question 10

Two students, Lenny and Pat, are travelling on a tram to school. The tram is travelling at a speed of 14 ms^{-1} relative to the ground. Lenny walks forward at 3 ms^{-1} relative to the tram to meet his friend Pat. Pat walks back towards Lenny at 2 ms^{-1} relative to the tram.
Which of the following are Lenny and Pat's speed relative to the ground?

A. 17 and 16 ms^{-1}
B. 11 and 16 ms^{-1}
C. 12 and 17 ms^{-1}
D. 17 and 12 ms^{-1}

Question 11

Marcus is returning to Melbourne on the Hume Highway and has stopped in a rest area. He hears the siren of a police car approaching the rest area from the north. The police car is travelling at a constant high speed and heading south. The police car passes by Marcus in his parked car. Which of the following statements is correct about the sound of the siren Marcus hears as the police car approaches the rest area and then passes by the rest area.

A. The siren sound will be continuously higher pitched as the police car approaches and then moves away from Marcus at the rest stop.
B. The siren sound will be continuously lower pitched as it approaches and then moves away from Marcus at the rest stop.
C. The siren sound will appear to change from lower pitch to higher pitch as the police car approaches and then moves away from Marcus at the rest stop.
D. The siren sound will appear to change from higher pitch to lower pitch as the police car approaches and then moves away from Marcus at the rest stop.

Question 12

The popular television show MythBusters recorded rock singer, Jaime Vendera, screaming loudly in front of a wine glass in an attempt to break the glass with his voice. He finally broke the glass with his twelfth scream which measured 105 decibels. Which of the following best explains how this feat was achieved?

A. Jamie's scream generated sound waves with a similar frequency to the natural frequency of the glass, thereby forcing the atoms in the glass to resonate at this frequency. The loudness of the scream had no effect on the amount of resulting vibration.
B. Jamie's scream generated sound waves with a similar frequency to the natural frequency of the glass, thereby forcing the atoms in the glass to resonate at this frequency. The loudness of the scream increased the amount of resulting vibration.
C. Jamie's scream generated sound waves with a very different frequency to the natural frequency of the glass, thereby forcing the atoms in the glass to resonate at this frequency. The loudness of the scream had no effect on the amount of resulting vibration.
D. Jamie's scream generated sound waves with a very different frequency to the natural frequency of the glass, thereby forcing the atoms in the glass to resonate at this frequency. The loudness of the scream increased the amount of resulting vibration.

Question 13
Which of the following statements is **not** correct about the significance of Thomas Young's double slit experiment in our understanding of the properties of light?

A. Young's double slit experiment showed definitively that light behaved as a wave because an interference pattern can only be achieved during wave interactions.

B. Young's double slit experiment showed that light waves emanating in phase from the two slits will create dark spots in the interference pattern due to constructive interference.

C. Young's double slit experiment showed that a red-light source would produce an interference pattern with a wider fringe separation than a blue light source.

D. Young's double slit experiment showed that for a given light source, a wider distance between the slits resulted in the narrow fringe separation, whereas a narrower distance between the slits resulted in a wide fringe separation.

The information below relates to Questions 14, 15 and 16.
An investigation into the photoelectric effect used different frequencies of light, all at the same intensity, shining onto a sodium plate. Stopping voltage data for the photo electrons was collected for each frequency of light used. The maximum kinetic energy and the frequency of light was then plotted to produce the line of best fit as illustrated in **Figure 5**.

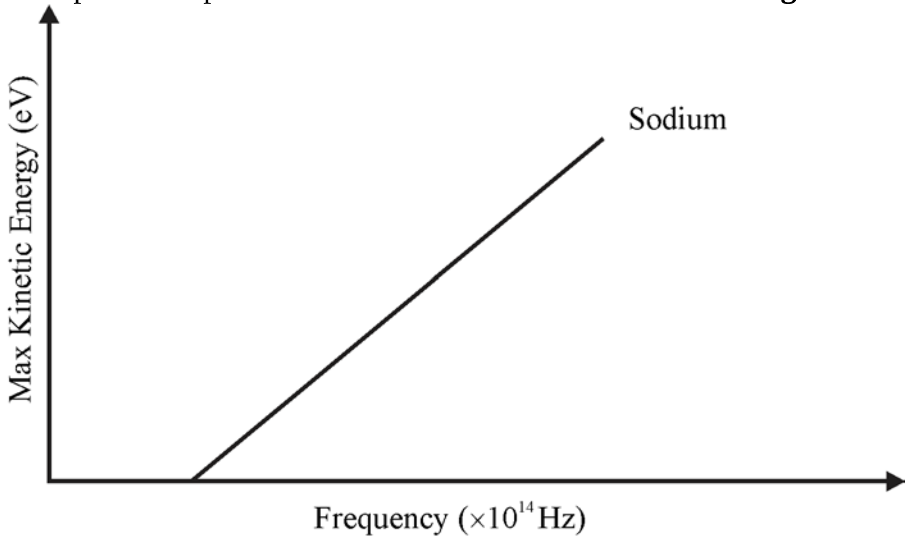


Figure 5

Question 14
Which of the following statements best describes the significance of the x-intercept on the graph illustrated in **Figure 5**?

A. The energy required by an electron to be ejected from the surface of the metal.

B. The frequency at which the photons have an energy equal to the work function of the metal.

C. The frequency at which the photons have an energy greater than the work function of the metal.

D. The maximum energy needed by a photon to eject a metal from the surface of the metal.

Question 15
The intensity of the light used to shine on the sodium metal plate is increased. Which of the lines A, B, C or D in **Figure 6** would be plotted on the graph for the same frequencies of light and using exactly the same scale as in **Figure 5**. Please note that Line C is equivalent to the Sodium line in **Figure 5**.

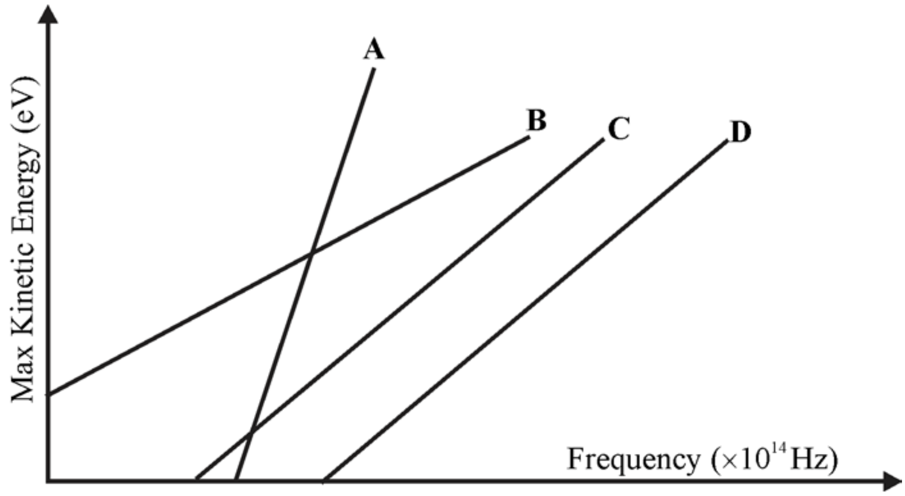


Figure 6

Question 16
The metal plate is replaced with another metal. Which of the lines in **Figure 6,** A, B, C or D could represent the line of best fit for similar data collected using this new metal as the cathode.

Question 17
The following statements concern the properties of light produced by an incandescent light bulb, an LED, a laser and a synchrotron. Which is **incorrect**?

A. An incandescent light bulb produces incoherent light in a broad range of wavelengths including the infra-red and visible light range.

B. An LED light bulb generates coherent light in a narrow range of wavelengths so that lights of a particular colour can be produced.

C. Different lasers may produce monochromatic light of different wavelengths from the infra-red to the ultra violet ranges.

D. A synchrotron produces intense, highly polarised light in a broad range of wavelengths from microwaves to X-Rays.

Question 18

A student investigated Snell's Law using light from a Hodson light box through a semi-circular glass prism as illustrated in **Figure 7**. A protractor was used to measure the angle of the incidence (in glass) and the angle of refraction (in air) as a light ray passed through the prism. The smallest division on the protractor scale was 1 degree.

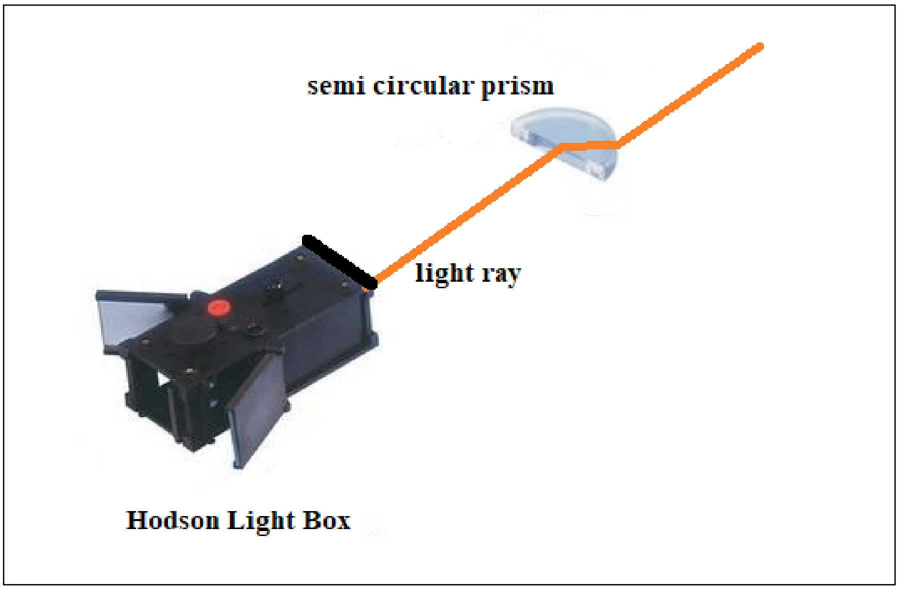


Figure 7

Which of the following measurements of angles of incidence best represents an acceptable measurement using this particular protractor?

A. $23^{o} \pm 1^{o}$

B. $23^{o} \pm 0.5^{o}$

C. $23.0^{o} \pm 0.5^{o}$

D. $23.00^{o} \pm 0.05^{o}$

Question 19
Two resistors are connected in series with a powerpack during an investigation of Ohm's Law. The following measurements including uncertainties were collected using a digital multimeter.

Quantity	Resistor 1	Resistor 2
Circuit current (I)	25.5 ± 0.3 mA	
Potential difference across each component (V)	3.38 ± 0.02 V	0.62 ± 0.02 V

Table 1

The measurements were used to determine the resistance of each resistor using Ohm's Law. Which of the following statements is true regarding the calculation of the uncertainty in the derived value for the resistance of each resistor?

A. The absolute uncertainties in the measurements for the circuit current and potential difference are added together.
B. The absolute uncertainties in the measurements for the circuit current and potential difference are multiplied together.
C. The percentage uncertainties in the in the measurements for the circuit current and potential difference are added together.
D. The percentage uncertainties in the in the measurements for the circuit current and potential difference are multiplied together.

Question 20
The diameter of a plastic tube was measured using a Vernier calliper in three locations marked as A, B and C, along the length of the tube as illustrated in **Figure 8**.

Figure 8: Plastic tube side view

The three measurements obtained were 8.23mm, 8.21 mm and 8.22 mm at location A, B and C, respectively. The percentage uncertainty in the average diameter of the tube is best expressed as:

A. 0.01%
B. 0.1%
C. 1.0%
D. 10.0%

End of Section A

VCE Physics 2018 Year 12 Trial Exam Units 3/4

SECTION B – Short Answer Questions

(110 marks)

Instructions for Section B

Answer **all** questions in the space 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 ms^{-2}.

Question 1 (8 marks)
Deep Space Ten is floating out beyond the solar system looking for comets. It has a mass of 1.00×10^5 t and a radius of 81.7 m.

a. Determine the gravitational field strength at the surface of Deep Space Ten.

Nkg^{-1}

2 marks

b. Commander Quirk pushes off from the surface to admire the space station from afar. Unfortunately, his rope breaks, and he finds himself circling the station at a height of 14 m above the surface. Calculate how long it will take him to complete one orbit.

s

3 marks

c. The view quickly palls on Quirk, and he contacts Captain Vines for help via his helmet radio. Vines says he will make the hull exterior positively charged, and tells Quirk to turn part of his suit into a capacitor. Quirk manages to achieve a net negative charge of 4.0×10^{-4} C by using his radio to charge the outside of his helmet. The electrostatic force between Quirk and Deep Space Ten is 6.0 N at the outset. Calculate the net positive charge over the hull of Deep Space Ten.

C

2 marks

d. Use your answer to **Question 1c** to calculate the electric field acting on Quirk's helmet as soon as it is switched on.

Vm^{-1}

1 mark

Question 2 (6 marks)
A beam of electrons enters a uniform electric field between two charged plates 5 cm apart, and then enters a uniform magnetic field of 0.20 mT as shown in **Figure 1**.

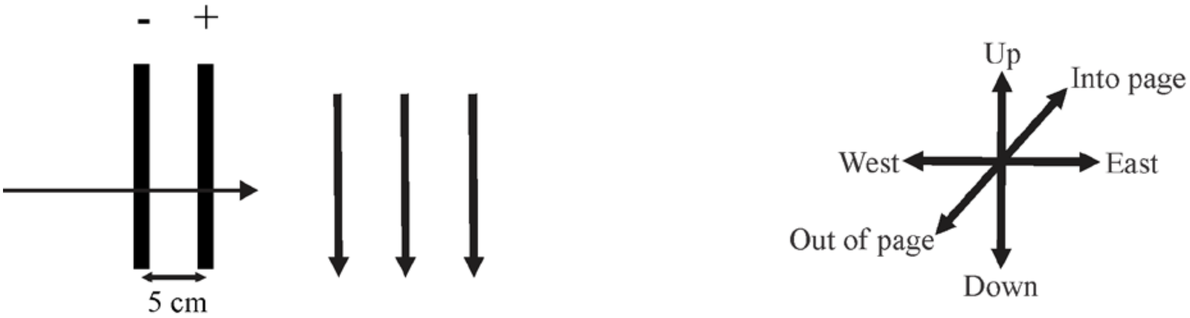


Figure 1

a. The electric field has a strength of $5 \times 10^5\ \text{Vm}^{-1}$. How much additional kinetic energy does each electron acquire through the electric field?

eV

2 marks

b. In which direction do the electrons travel upon entering the magnetic field?

1 mark

c. How much additional kinetic energy does each electron acquire through the magnetic field?

1 mark

d. What is the radius of the path (to the nearest cm) of the electrons in the magnetic field if their velocity is $4.0 \times 10^6\ \text{ms}^{-1}$ after leaving the electric field?

cm

2 marks

Question 3 (3 marks)
Two bar magnets are placed as shown in **Figure 2**, with a conducting wire between them.

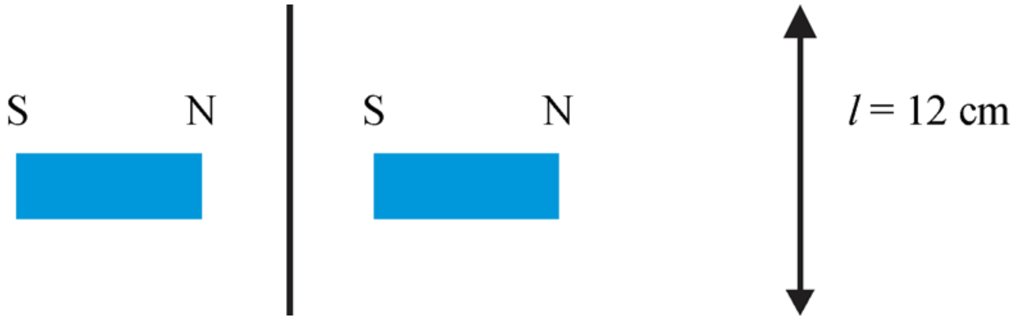


Figure 2

A current of 3.0 mA flows up the page in the wire. The magnetic field is a uniform 15 mT.
Find the magnitude and direction of the force acting on the wire.

Magnitude	Direction

3 marks

Question 4 (7 marks)
A generator has a rectangular coil of 40 turns with dimensions 15 cm × 20 cm between two magnets as shown in **Figure 3**. The coil is connected to terminals via slip rings. With the coil vertical as shown, the flux through the ring is measured to be 0.45 Wb.

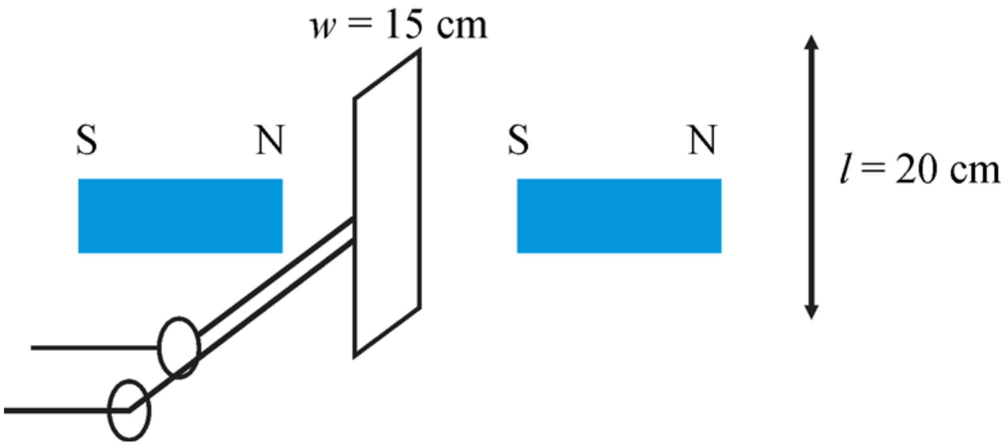


Figure 3

a. Calculate the magnitude of the magnetic field passing through the coil.

T

2 marks

b. The coil is then rotated 10 times per second. Calculate the average emf generated in a quarter turn.

V

3 marks

c. The output from the generator appears on the graph in **Figure 4**. On the same graph, draw the output if the coil's speed of rotation were halved to 5 times per second.

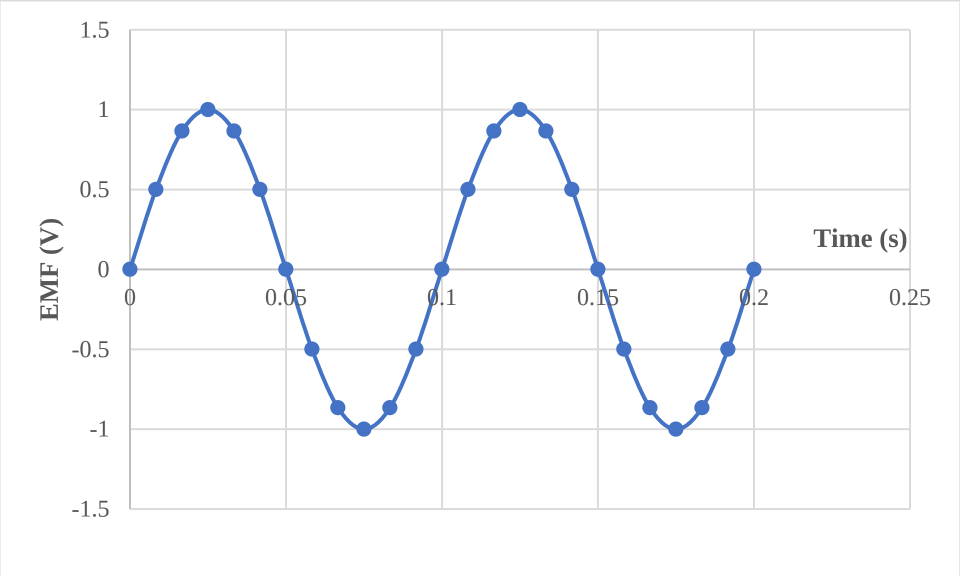


Figure 4

2 marks

Question 5 (11 marks)

The village of Mt Mistake draws its power from a wind farm on the top of the mountain. The wind farm generates 4.0 MW of AC power during average weather conditions. The town substation is 500 m away from the wind farm. When the farm was set up, the voltage from the wind farm was 28.2 kV at peak voltage. The transmission lines have a resistance of 0.06 Ω m^{-1}.

a. Calculate the RMS current flowing through the transmission lines during average weather conditions.

A

2 marks

b. Calculate the available RMS voltage at the village substation, taking into account power losses during transmission.

V

3 marks

c. These power losses were deemed unacceptable, so an additional transformer was added to the substation to bring the RMS voltage up to 80 kV. Calculate the new voltage available to the substation.

V

3 marks

d. Calculate the % efficiency of the new configuration to 1 decimal place.

%

2 marks

e. The village substation uses a step-down transformer to reduce the voltage to 250 V RMS. The secondary coil has 12 turns. How many turns in the primary coil?

1 mark

The following information relates to Question 6.
On a school excursion one of the naughty students drops her banana peel whilst hanging out of the door of the bus, as illustrated in **Figure 5**. The bus is traveling at 72 kmh^{-1} and the height from which the banana peel is dropped is 2.10 m. The student is observed in this wilful act by a stationary pedestrian.

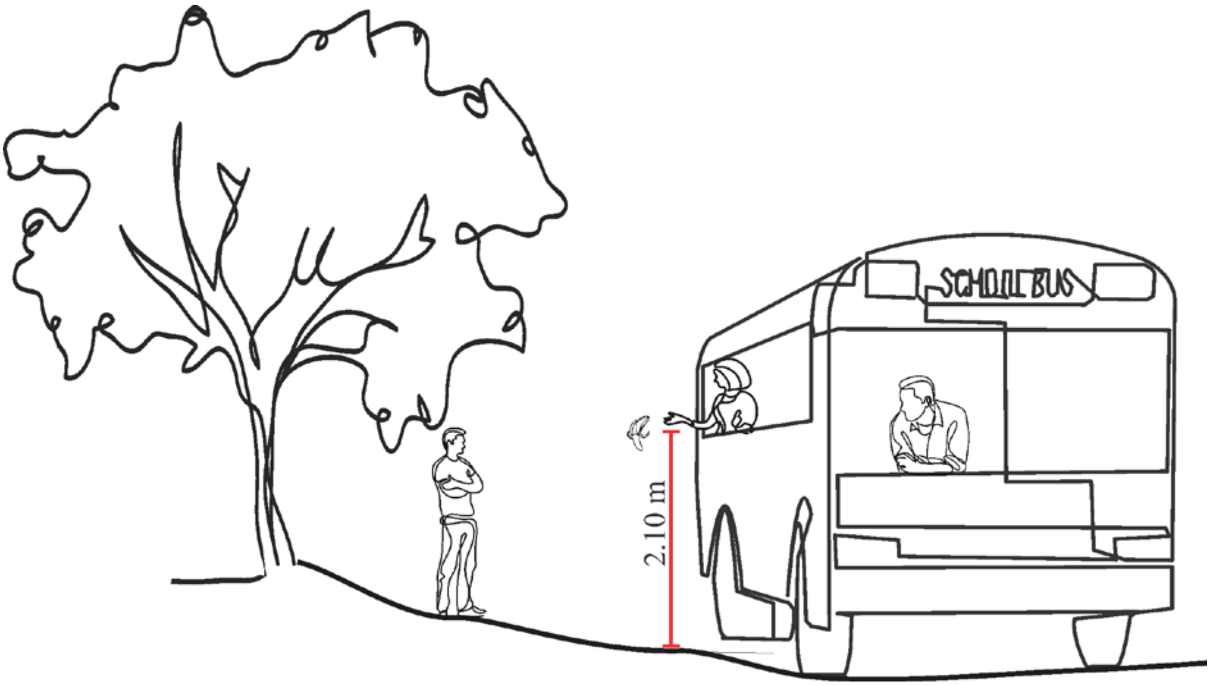


Figure 5

Question 6 (5 marks)

a. Determine the initial vertical and horizontal speeds of the banana peel relative to the ground.

Initial vertical speed	Initial vertical speed
ms^{-1}	ms^{-1}

2 marks

b. Find the time it takes for the banana peel to hit the ground.

s

1 mark

c. Clearly sketch the path of the banana peel as seen by

i. the naughty student.

1 mark

ii. the stationary pedestrian.

1 mark

***Figure 6-7** and the information below relate to Question 7.*

For a long time horses have been used as the power source for mills. The horses have long since been replaced by more modern means. The horse would walk in a circular path at a constant speed to turn a mill wheel. There are several places that still use this source of power.

Figure 6

Question 7 (4 marks)

The horse mill can be modelled as a simple circular motion problem, as shown in the birds-eye view in **Figure 7**. The horse has a mass of 500 kg. The radius of its circular path is 3 m.

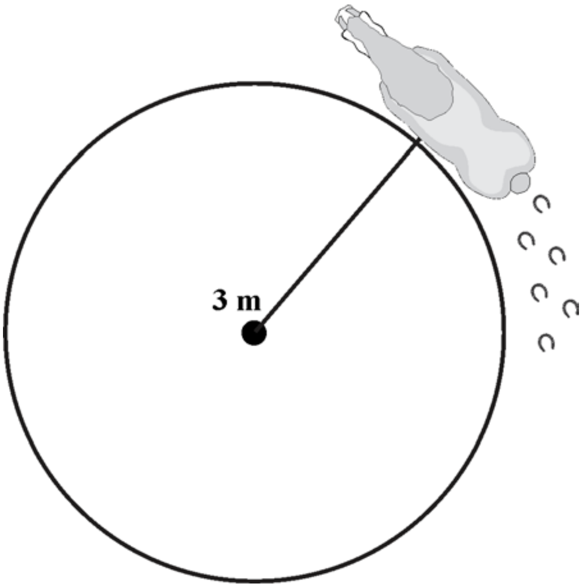


Figure 7

a. If it takes 15 seconds for the horse to complete one revolution calculate the speed of the horse.

ms^{-1}

2 marks

b. Determine the acceleration of the horse towards the centre of the circle.

ms^{-2}

2 marks

This information relates to Question 8.
Many car accidents in Australia occur when a car collides with something on a country road. A BMW X1 (mass 2035 kg) is travelling along a country road at 108 kmh^{-1}. Unfortunately, it hits a van (mass 2045 kg) that has been parked on the road in an obtrusive position. (Before and after the collision, all motion is along the same straight line).

Question 8 (10 marks)

a. After the collision, the BMW continues moving forward at 20.0 ms^{-1}. Determine the speed of the van immediately after the collision.

ms^{-1}

3 marks

b. Calculate the combined total kinetic energy of the BMW and the van just before the collision.

J

2 marks

c. Calculate the combined kinetic energy of the BMW and the van just after the collision.

J

2 marks

d. Comment upon the magnitudes of the total kinetic energies before and after the collision as you have calculated in **Question 8b** and **Question 8c**.

3 marks

Question 9 (3 marks)
Earthquakes are produced by seismic waves that move through the body and the surface of the earth. These waves are generally of two types and can be modelled using a rope and slinky as shown in **Figure 8 i.** and **ii.** respectively.

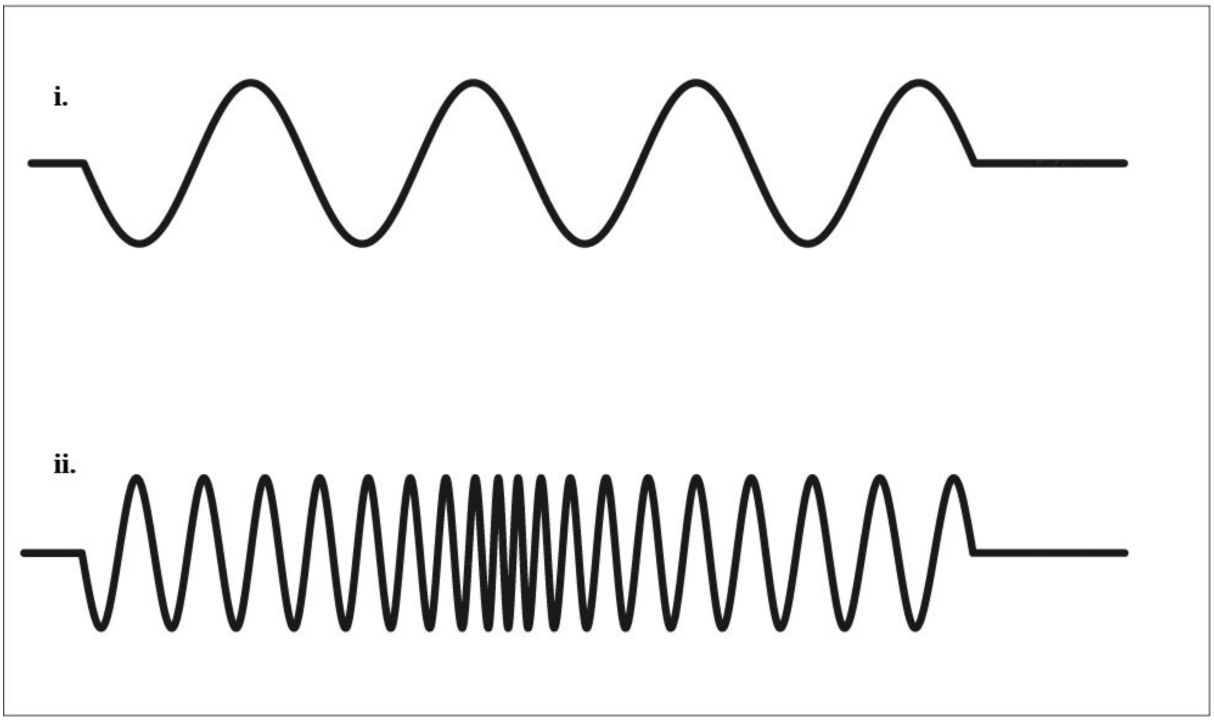


Figure 8

a. Name the types of waves depicted in **Figure 8 i.** and **ii.**

i. ______________________________

ii. ______________________________

1 mark

b. Explain the differences between the waves depicted in **Figure 8 i.** and **ii.** Refer to the movement of particles in the medium through which each wave travels.

____

____

____

1 mark

c. Calculate the wavelength of a seismic body wave travelling through the earth at a speed of 21,600 km/h with a frequency of 10 Hz.

m

1 mark

Question 10 (4 marks)

a. On the crowded tram ride to school, Jonah wants to shut out the surrounding sounds so he switches on his noise cancelling headphones. Use your understanding of wave interactions to explain how his head phones are able to cancel out the surrounding sounds.

____

____

____

2 marks

b. Two waves (Wave 1 and Wave 2) are emitted from adjacent point sources at the same time. The waves are observed at a point some distance away from the source as illustrated in **Figure 9**.
Sketch the resultant wave that will be observed as these two waves interact with each other on **Figure 9**.

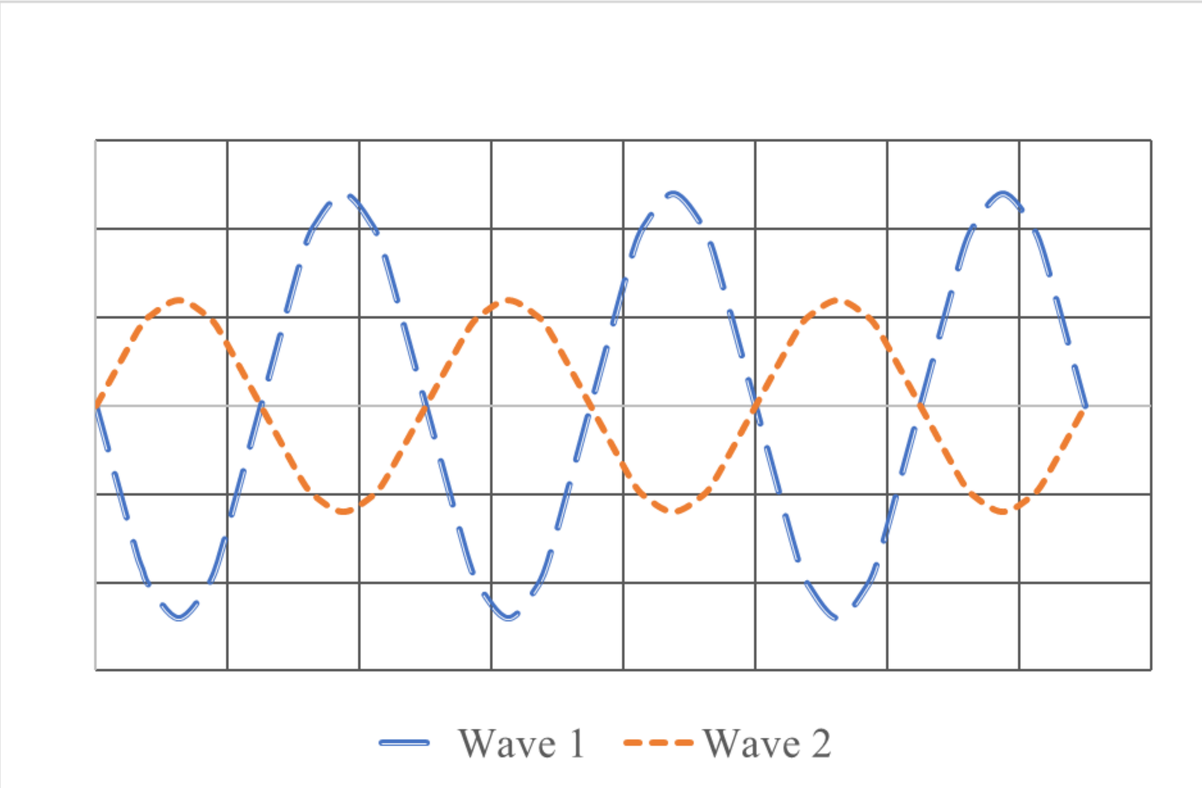


Figure 9

1 mark

c. When a perfectly spherical object is illuminated from behind by a narrow, coherent light source, a circular shadow will be produced on a screen in front of the object as illustrated in **Figure 10**. During the early 1800s French scientist, Siméon-Denis Poisson, argued that if light were a wave then the circular shadow will have a bright spot shining in its centre. Provide an explanation of the wave phenomenon that is able to produce such a bright spot in the centre of the shadow.

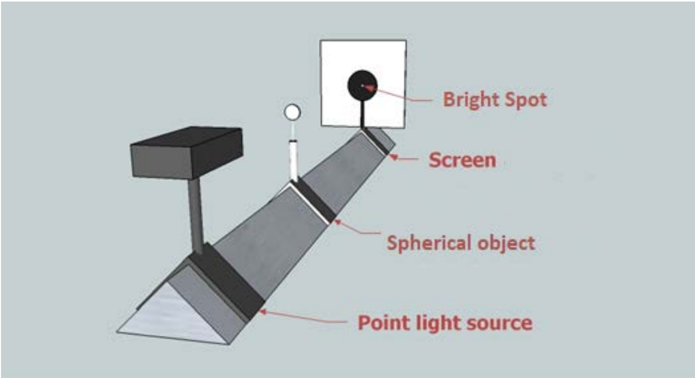


Figure 10: Image sourced from Treisinger at English Wikipedia

____

____

____

1 mark

Question 11 (3 marks)

a. Caitlin wore her brand new polarised sunglasses as she headed out into the bright sunshine. Explain how the polarisers in the sunglasses will affect the light that Caitlin observes.

____

____

____

1 mark

b. Explain how the effect that Caitlin observes supports or refutes the wave nature of light.

____

____

____

1 mark

c. Caitlin then opens up her smart phone while still wearing the sunglasses and notices that the screen on her phone looks black even though it is switched on. Explain why the screen will appear to be black to Caitlin.

____

____

____

1 mark

Question 12 (5 marks)
Archer fish knock down insects with a jet of water fired from their mouths. They are able to accurately locate and target insects while below the surface of the water. **Figure 11** illustrates an archer fish observing an insect on the leaf of a reed through the water. A ray of light originating from the insect that reaches the fish's eye is sketched in **Figure 11** (not to scale). The insect is actually located at an angle of 55^{o} to the water line. The refractive index of air and water is 1.00 and 1.33, respectively.

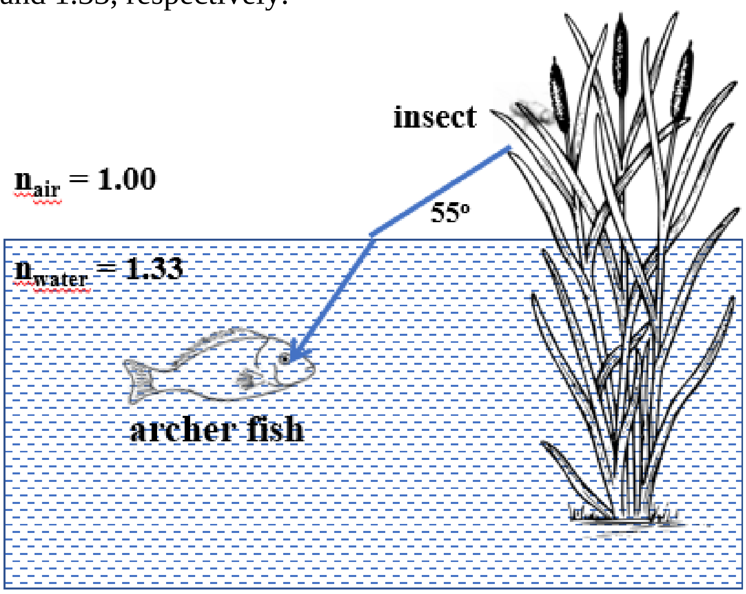


Figure 11

a. The archer fish is able to take into account the effect of refraction when targeting the insect. Where would the insect appear to be located from the fish's perspective? Mark this position on **Figure 11**.

____

____

____

1 mark

b. If a line is drawn from where the insect "appears" to be located and the fish's eye, what is the angle between this line and the horizontal surface of the water?

°

2 marks

c. Meanwhile the insect is keeping an eye out on the water below to check for archer fish. To see the fish, the light originating from the fish must reach the insect's eyes. Calculate the minimum angle of incident light originating from the fish that would cause the fish to not be seen by the insect as shown in **Figure 12**.

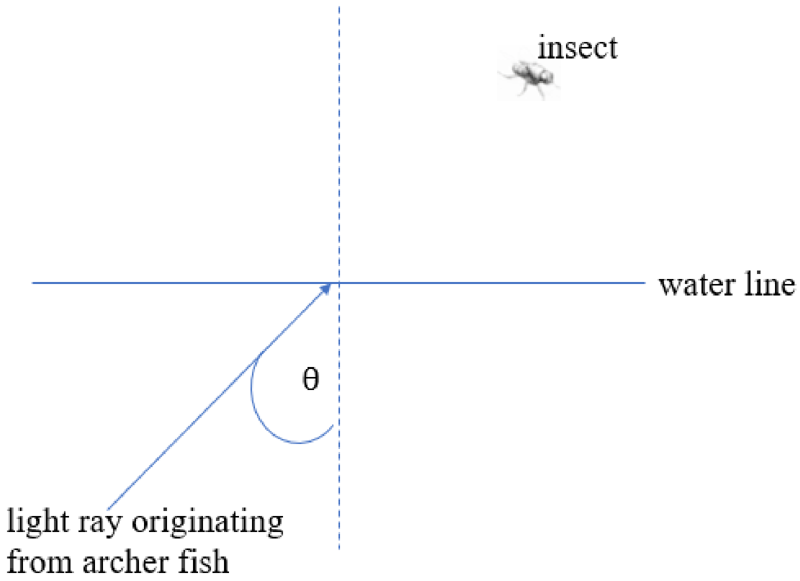


Figure 12

^{o}

1 mark

d. Explain your answer for **Question 12c.**

____

____

____

1 mark

Question 13 (1 mark)
On a sunny winter afternoon, Trinh noticed a small patch of light passing through the glass at the bus stop produced a rectangle containing all the colours of the rainbow on the concrete footpath. Explain what happens to the sunlight as it passes through the glass to produce this phenomenon.

1 mark

Question 14 (3 marks)

a. A double slit experiment has been set up comprising of a red laser light with a wavelength of 632.8 nm directed through a pair of slits that are 175 μm apart. The slits are located 2.5 m from a screen. An interference pattern is produced on the screen as illustrated in **Figure 13** (not to scale). Calculate the distance between the central bright band and the third bright band from the centre.

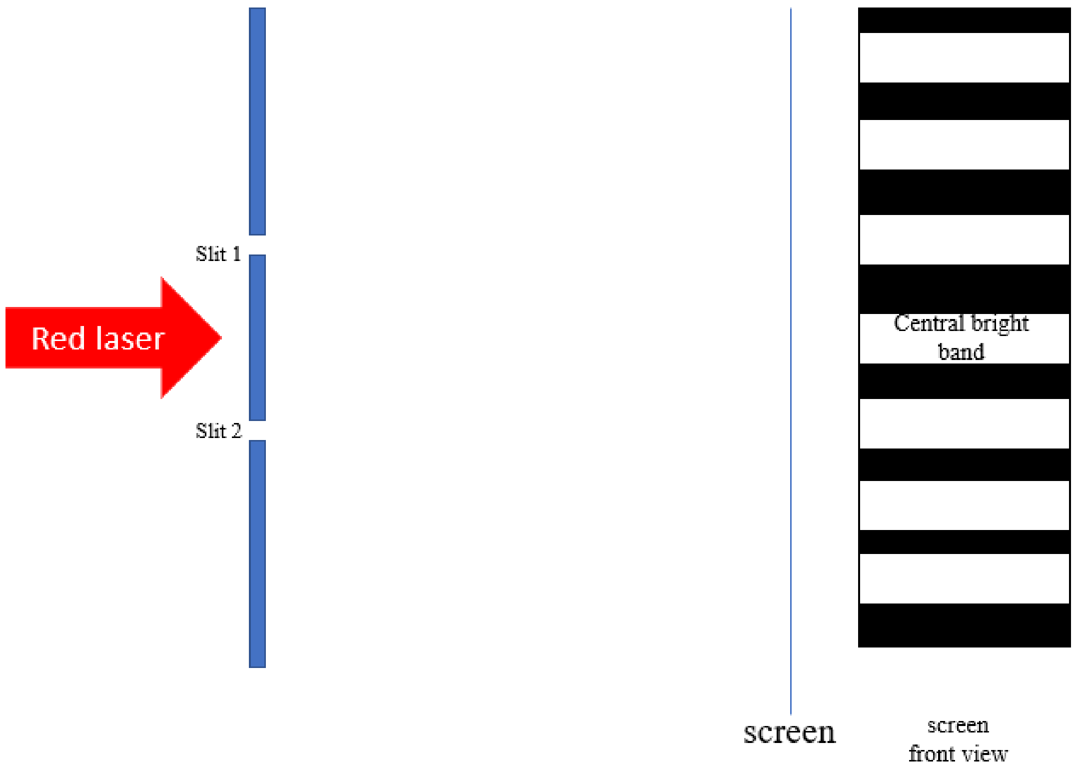


Figure 13

m

2 marks

b. A green laser light replaces the red laser light. Explain the changes you would expect to see in the interference pattern that is produced with the green laser compared with the interference pattern described in **Question 14a** above.

___

___

___

1 mark

Question 15 (4 marks)

a. An investigation of the photoelectric effect determines that the threshold frequency for platinum is 1.50×10^{15} Hz. What frequency of light must be used to produce photoelectrons with a maximum kinetic energy of 2.25 eV when platinum is used as the cathode in this investigation?

Hz

1 mark

b. Visible light is found in the wavelength range between 360 to 700 nm. Can light in the visible range be used to produce photoelectrons with platinum as the cathode in this investigation? Explain your answer.

___

___

___

___

2 marks

c. X-Rays have typical wavelengths between 0.1 and 10 nm. Use calculations to show that photons of X-Rays have more energy than photons of visible light.

___

___

___

1 mark

Question 16 (4 marks)

a. An electron microscope accelerates electrons from rest through a potential difference of 500 kV when in operation. Calculate the de Broglie wavelength of an electron that has reached the maximum velocity in such a microscope, ignoring the effects of relativity.

m

2 marks

b. An electron microscope, operating at the accelerating voltage described in **Question 16a,** obtains a clear image of an influenza virus that is 130 nm in diameter. An optical microscope, however, cannot obtain a clear image of the virus. Explain.

2 marks

Question 17 (3 marks)

a. A sodium vapour lamp is commonly used to light city streets. The lamp produces a yellow light with a wavelength of 589 nm when an electrical current is passed through it. Explain how light can be produced from matter in this way.

2 marks

b. Calculate the energy of a photon of light emitted from the sodium vapour lamp in **Question 17a.**

eV

1 mark

Question 18 (2 marks)

a. Calculate the de Broglie wavelength of a soccer ball with a mass of 430 g that is travelling 6.3 m/s.

m

1 mark

b. Explain why the wavelike nature of the soccer ball wave is not detectable in everyday life.

1 mark

Question 19 (5 marks)

a. When an electron gun, firing a single electron at a time is directed at a metal detector, the electrons are detected at a single point on the detector. However, if the electron beams are passed through a single slit before being detected, a diffraction pattern will be observed on the metal detector. How can the Heisenberg uncertainty principle explain these phenomena?

3 marks

b. The diffraction pattern produced using an electron beam passing through a crystalline structure is similar to the pattern produced using an X-Ray beam passing through the same structure. Explain the significance of this observation in relation to our understanding of light and matter.

1 mark

c. The electrons emitted from the gun in **Question 19a** travel at a speed of $6.5\times10^{6}\ \text{ms}^{-1}$. Calculate the wavelength of the X-Ray beam that produced the diffraction pattern described in **Question 19b**.

m

1 mark

Question 20 (11 marks)

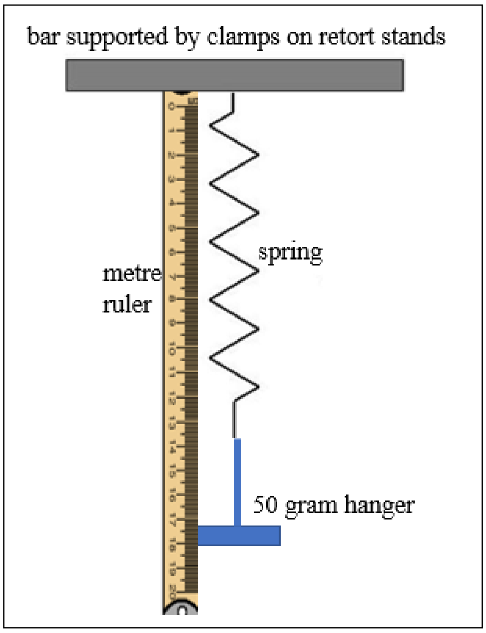


Figure 14: Note illustration is not to scale

Amy was investigating Hooke's law with a spring, a hanger and a set of masses. Each mass weighs 50 g. The hanger also weighs 50 g. The apparatus she used is illustrated in **Figure 14**. She did not have scales available so did not measure the masses used exactly. Amy measured the length of the spring using a one metre ruler and recorded the number of masses added to the hanger for each measurement in her notes. The finest scale division on the metre ruler is 1 mm so Amy noted that the uncertainty in each measurement was ± 0.5 mm. Amy took three readings for each mass. After the first reading she would remove the masses and add them again and wait for the spring to stop oscillating before she took the second reading. Amy repeated this procedure to take the third reading. The data she collected is provided in **Table 2**.

Length (mm)				Mass (g)	Notes
Trial 1	**Trial 2**	**Trial 3**	**Average Length**		
71	72	73		0	No masses
120	121	120		50	Hanger only
169	168	167		100	Hanger + 1 mass
218	219	216		150	Hanger + 2 masses
268	269	271		200	Hanger + 3 masses
316	315	317		250	Hanger + 4 masses

Table 2: Amy's Results

a. **i.** Calculate the average spring length for each trial and complete the data in **Table 2**.

1 mark

ii. Determine the uncertainty in the average length measurement in **mm** when the hanger and 3 masses were added to the spring.

mm

1 mark

b. Identify the controlled, independent and dependent variable(s) in Amy's investigation.

3 marks

c. Are the dependent variable(s) you have identified discrete or continuous variable(s). Explain your answer.

1 mark

Amy uses the data in **Table 2** to calculate the force acting on the spring and the extension on the spring. She plots the calculated values and produces the graph in **Figure 15** to include in her report.

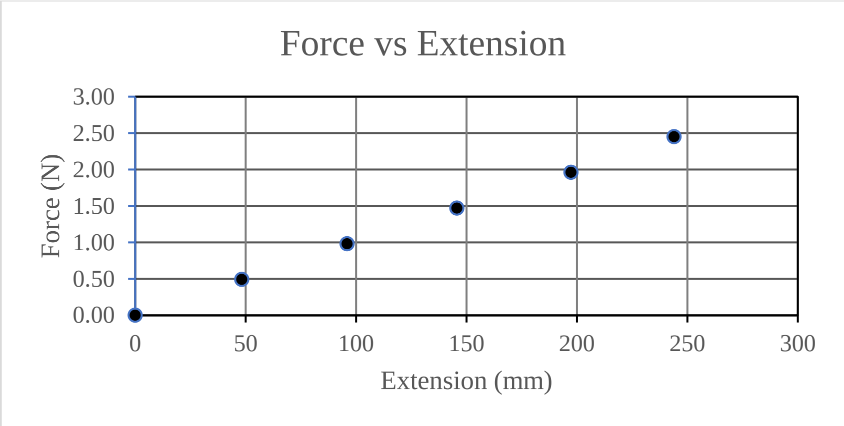


Figure 15

d. Identify the problems with her representation of the data in her graph. Explain your response.

2 marks

e. Discuss the conclusions that Amy will be able to infer from the relationship between force and extension observed in **Figure 15**.

2 marks

f. Explain how Amy could have improved the precision of her measurements in this experiment.

1 mark

Question 21 (5 marks)
A web-based simulation program is used to model the motion of different objects on a fictitious planet, Xactrac. The laws of physics on Xactrac are the same as on Earth. The gravitational field strength on the surface of the planet is not available to the user of the simulation program. As part of the program, a soccer ball is kicked horizontally off a cliff-top and falls to the surface of Xactrac. The data collected from this simulation is shown in **Table 3** and plotted in in the graphs in **Figure 16** and **Figure 17**.

Time (s)	Vertical height above surface (m)	Horizontal distance travelled(m)
0.00	13.00	0.00
0.30	12.65	5.40
0.60	11.79	10.80
0.90	10.42	16.20
1.20	8.55	21.60
1.50	6.16	27.00
1.80	3.27	32.40
2.00	1.05	35.99
2.09	0.00	37.59

Table 3

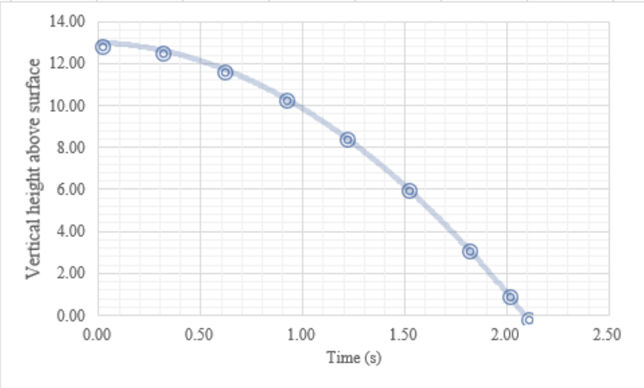


Figure 16

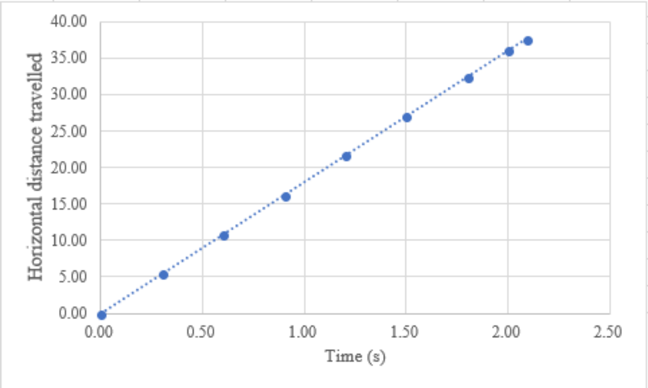


Figure 17

a. The graphs in **Figure 16** and **Figure 17** describe different relationships between the variables represented in each graph. Explain the relationship that is shown in **Figure 16**.

____

____

____

1 mark

b. **i.** The students analysing the data think that **Figure 16** shows that $H \propto t^2$. Use the table and the graph paper below to show how they would then proceed to find the mathematical relationship between the height of the ball and time.

Mathematical relationship is ____

3 marks

ii. Use your results to find the gravitational field strength on Xactrac.

Nkg^{-1}

1 mark

Question 22 (3 marks)

The measurements in **Table 4** were obtained during an investigation of the power losses in particular electrical cables.

Quantity	Reading	% Uncertainty
Current measured through cables	1.35×10^{-3} A	0.5 %
Total Resistance in Cables	3.0 Ω	0.5 %

Table 4

Calculate the range of power loss values that could be observed in the cables under the above stated conditions.

Minimum power loss	Maximum power loss

3 marks

End of Section B

End of Trial Exam

Suggested Answers

VCE Physics 2018 Year 12 Trial Exam Units 3/4

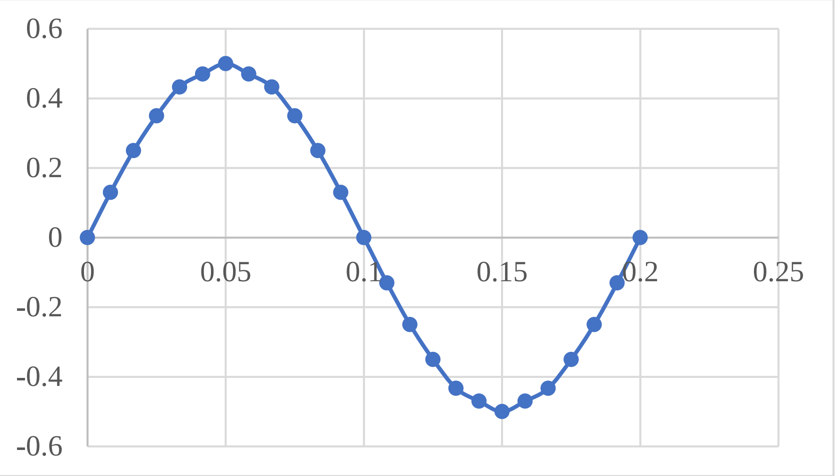
SECTION A – Multiple Choice Answers

Question	Answer	Mark
1.	**A** Magnetic fields cannot be monopoles, and a gravitational field should produce an attractive force. This particle repels, so the field is electric.	**1**
2.	**D** Right-hand grip rule.	**1**
3.	**C** $F = Eq \therefore q = \frac{F}{E} = \frac{6.4 \times 10^{-17}}{200} = 3.2 \times 10^{-19}$ C	**1**
4.	**D** Only **D** can be correct. When the flux decreases there is a positive emf. As the emf declines, the rate of change of flux must increase until emf becomes zero, when the flux must be constant. This tests not only that emf is a rate of change of flux, but also a negative rate of change.	**1**
5.	**C**	**1**
6.	**B**	**1**
7.	**A** If peak current is 0.5A, then $I_{RMS} = \frac{0.5}{\sqrt{2}} = 0.35$ A $P = VI = 6.0 \times 0.35 = 2.1\ W_{RMS}$	**1**
8.	**C** 60 km/h = 16.67 ms^{-1} and 110 km/h = 30.56 ms^{-1} $v^2 = u^2 + 2as$ $30.56^2 = 16.67^2 + 2 \times 120\ a$ $a = 2.73\ ms^{-2}$	**1**
9.	**C** $s = \frac{u+v}{2} \times t$ $120 = \frac{30.56 + 16.67}{2} \times t$ => t = 5.08 s	**1**
10.	**D** Lenny 14 + 3 = 17 ms^{-1}. Pat 14 – 2 = 12 ms^{-1}.	**1**

11.	**D**	The Doppler effect results in the waves sounding higher pitch than they actually are as the police car speeds towards Marcus and then sounding lower pitch as the police car moves away from Marcus.	**1**
12.	**B**	Resonance occurs when the natural frequency of the glass is matched by the frequency of the disturbance (the scream). The loudness of the scream contributes to the amplitude of the resonating waves produced and contribute to shattering the glass.	**1**
13.	**B**	Constructive interference would create a bright spot not a dark spot in the interference pattern.	**1**
14.	**B**	X-intercept represents the threshold frequency which is the frequency at which the photons have an energy equal to the work function of the metal.	**1**
15.	**C**	The change in intensity of incident light does not affect the graph for sodium metal under the same conditions.	**1**
16.	**D**	The line of best fit for the new metal cathode should be parallel to the line for sodium.	**1**
17.	**B**	A LED does not produce coherent light.	**1**
18.	**B**	The smallest division on the protractor is 1mm so the measurements are best quoted to the nearest mm and the uncertainty in the measurement is 0.5 mm.	**1**
19.	**C**	Percentage uncertainties are added when measured quantities are multiplied or divided.	**1**
20.	**B**	When three measurements are averaged, the percentage uncertainty is determined by 1. finding the largest difference between any singular measurement and the average. 2. dividing the largest difference by the average measurement and multiplying the product by 100 to obtain a percentage.	**1**

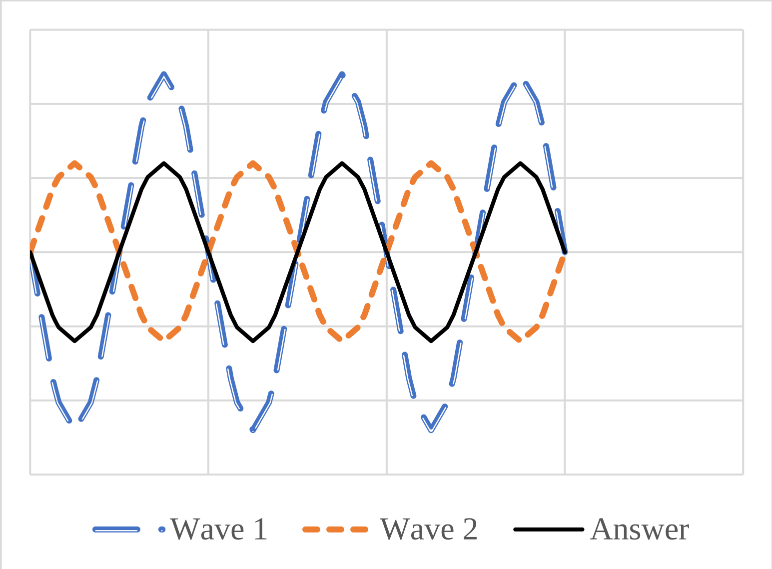
SECTION B – Short Answer (Answers)

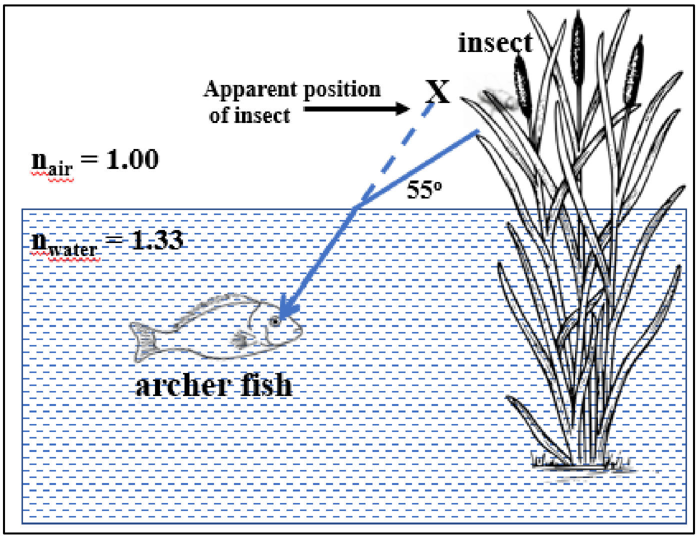
Question	Answer	Mark
1a.	$g = \frac{GM}{r^2} = \frac{6.674 \times 10^{-11} \times 1 \times 10^5}{81.7^2}$ $= 1.00 \times 10^{-6}$ Nkg^{-1}	**1** **1**
1b.	Radius r = 81.7 + 14 = 95.7 m $T^2 = \frac{4\pi^2 r^3}{GM}$ $= \frac{4\pi^2 \times 95.7^3}{6.674 \times 10^{-3}}$ $\therefore T = 7.20 \times 10^4$s	**1** **1** **1**
1c.	Despite the close distance, the charge on DS10's hull still acts as though it were a point at the centre of the station. Hence *r* = still 95.7 m. $F = \frac{kq_1q_2}{r^2} \therefore q_2 = \frac{Fr^2}{kq_1}$ $= \frac{6 \times 95.7^2}{9 \times 10^9 \times 4 \times 10^{-4}}$ $= 0.153$ C	**1** **1**
1d.	$E = \frac{kQ}{r^2} = \frac{9 \times 10^9 \times 0.153}{95.7^2} = 1.50 \times 10^5$Vm^{-1}	**1**
2a.	Electrical energy acquired = Vq. V = Ed, q = 1 if calculations are in eV. $\therefore V = 5 \times 10^5 \times 0.05 = 2.5 \times 10^4$ eV	**1** **1**
2b.	Electrons travel east, so current travels west. Magnetic field points down the page, so by the right-hand slap rule the electrons are impelled directly out of the page.	**1**
2c.	Zero. Magnetic force acts at right angles to direction of travel.	**1**
2d.	$qvB = \frac{mv^2}{r} \therefore r = \frac{mv}{qB}$ $= \frac{9.1 \times 10^{-31} \times 4 \times 10^6}{1.6 \times 10^{-19} \times 2 \times 10^{-4}}$ m = 11cm	**1** **1**

3.	By the right-hand slap rule, the force acts into the page. $F = nIlB$ $= 1 \times 3 \times 10^{-3} \times 0.12 \times 1.5 \times 10^{-2}$ $= 5.4 \times 10^{-6}$ N	**1** **1** **1**
4a.	Area of coil = $0.2 \times 0.15 = 0.030$ m^2 $B = \frac{\Phi}{A} = \frac{0.45}{0.030} = 15$ T	**1** **1**
4b.	$\Delta t = \frac{1}{4} \times \frac{1}{10} = 0.025s$ $n = 40$, $\Delta\Phi = 0 - 0.45 = -0.45$ Wb $\varepsilon = -n \frac{\Delta\Phi}{\Delta t} = \frac{50 \times 0.45}{0.025} = 90$ V	**1** **1** **1**
4c.	 1 mark each for halved amplitude and frequency.	**2**
5a.	28.2 kV peak voltage = 20 kV RMS. $I = \frac{P}{V} = \frac{4.0 \times 10^6}{2.0 \times 10^4} = 200$ A	**1** **1**
5b.	Will require transmission lines to and from the wind farm $\therefore$ 2×500m of transmission lines Line resistance = $500 \times 0.06 \times 2 = 60\Omega$ $V_{loss} = IR = 200 \times 60 = 12000$ V = 12.0 kV Available RMS voltage = 20 – 12 = 8 kV	**1** **1** **1**
5c.	$I = \frac{P}{V} = \frac{4.0 \times 10^6}{8.0 \times 10^4} = 50$ A $V_{loss} = IR = 50 \times 60 = 3000$ V = 3.0 kV Available RMS voltage = 20 – 3.0 = 17 kV	**1** **1** **1**

5d.	Efficiency is measured in transmission line power loss = I^2R $P_{loss} = 50^2 \times 60$ W = 150 kW % efficiency = $100(1-\frac{1.5 \times 10^5}{4.0 \times 10^6}) = 100(1-0.0375) = 96.3\%$	**1** **1**
5e.	Accept either: Before transformer $\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{8.0 \times 10^3}{250} = 32$ $\therefore N_p = 32 \times 12 = 384$ OR After Transformer $\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{1.07 \times 10^4}{250} = 68$ $\therefore N_p = 68 \times 12 = 816$	**1**
6a.	0 ms^{-1} and 20 ms^{-1}	**1** **1**
6b.	$s = ut + ½ at^2$ $2.10 = 0 + ½\ 9.8\ t^2$ t= 0.65 s	**1**
6c.	**i.** Naughty student: Vertical line. **ii.** Stationary pedestrian: Parabolic.	**1** **1**
7a.	s = distance/time $= 2\pi r/T$ $= 2 \times \pi \times 3/15$ $= 1.26\ ms^{-1}$	**1** **1**
7b.	$A = v^2/r$ $= 1.26^2/3$ $= 0.53\ ms^{-2}$	**1** **1**
8a.	Total final momentum. = total initial momentum. Convert 108 km/h to 30 ms^{-1} $m_{cc}v_{cb} + m_{vb}v_{vb} = m_{ca}v_{ca} + m_{va}v_{va}$ $2035 \times 30 + 2045 \times 0 = 235 \times 20 + 2045 \times v_{va}$ $v_{va} = \frac{(2035 \times 30) - 2035 \times 20)}{2045}$ $= 9.95\ ms^{-1}$	**1** **1** **1**

8b.	½ mv^2_{BMW} + ½ mv^2_{van} ½ × 2035 × 30 ^{2} + ½ × 2045 × 0 = 915 750 J	**1** **1**
8c.	9.95 (from **Question 8a**) $\therefore$ ½ × 2035 × 20^2 + ½ × 2045 × 9.95^2 = 508 230 J	 **1** **1**
8d.	The collision is inelastic as kinetic energy has decreased during the collision. The initial kinetic energy was 105 750 J and the final was 508 230 J which represents a loss of 406.5 kJ of kinetic energy. The energy is not lost but kinetic energy has been transformed into heat and sound and crumpled metal.	**1** **1** **1**
9a.	**i.** Transverse wave. **ii.** Longitudinal wave.	**1**
9b.	In transverse mechanical waves, the particles in the medium will move perpendicular to the direction of the motion of the wave. In longitudinal mechanical waves, the particles in the medium will move parallel to the direction of the motion of the wave.	**1**
9c.	Must convert speed to m/s. $v = \lambda f$ $\therefore \ \lambda = \frac{v}{f} = \frac{21600/3.6}{10} = 600 \text{ m}$	**1**
10a.	The sound waves produced by the noise around Jonah can be cancelled if the headphones produce sound waves that have the same frequency and amplitude to the noise. The waves produced by the headphones must be out of phase by half a wavelength or a multiple of half a wavelength. This will mean that the two waves added together will cancel each other out.	**1** **1**

10b.	 Peaks and troughs should be half the amplitude of Wave 1.	**1**
10c.	A bright spot can be produced in the centre of the sphere's shadow because all of the waves of light diffracted around the edge of the sphere will be cohesive and in phase at the centre of the sphere's shadow and produce a bright spot at the centre of the circular shadow through constructive interference.	**1**
11a.	The polarisers in the sunglasses will only allow sunlight that is aligned with the polarisers to reach Caitlin's eyes. Caitlin will therefore be able to see objects around her with less glare as less light will reach her eyes with the glasses than without.	**1**
11b.	This phenomenon provides strong evidence that light behaves like a wave as polarisation only occurs when a transverse wave is only allowed to vibrate in one direction. If light behaved only as a particle, then the phenomenon would not be observed.	**1**
11c.	The fact that the screen appears black to Caitlin suggests that there is a polariser on the screen which is aligned at right angles to the polarisers on the sunglasses. Light from the phone is therefore blocked by the glasses and the phone will appear black.	**1**

12a.		**1**
12b.	incident angle for ray = $(90^o - 55^o) = 45^o$ $n_{air} \sin\theta_{air} = n_{water} \sin\theta_{water}$ $\therefore \theta_{water} = \sin^{-1}(\frac{n_{air} \sin\theta_{air}}{n_{water}})$ $= \sin^{-1}(\frac{1.00 \times \sin 45^o}{1.33})$ $= 32^o$ $\therefore$ angle to waterline = $(90^o - 32^o) = 58^o$	**1** **1**
12c.	$\sin\theta_c = \frac{n_{air}}{n_{water}}$ $\therefore \theta_c = \sin^{-1}(\frac{1.00}{1.33})$ $= 48.8^o$ $\therefore$ minimum incident angle = 48.8^o	**1**
12d.	For the fish to be totally invisible to the insect, all light rays reflecting off the fish must be totally internally reflected within the water.	**1**

13.	The phenomenon observed by Trinh is called dispersion and this occurs when white light (sunlight) is split into its component parts forming the colours of the rainbow, each of which represent different wavelengths of light. The red end of the light spectrum (longer wavelength) will travel faster in the glass than the blue end of the spectrum so they are refracted the least, while the blue end (shorter wavelength) travels slower in the glass and is refracted more. This results in the different colours being separated out as they emerge from the glass.	**1**
14a.	$\Delta x = \dfrac{\lambda L}{d}$ $= \dfrac{632.8\times10^{-9}\times2.5}{175\times10^{-6}}$ $= 9.0\times10^{-3}$m $\therefore$ distance between central and third bright spot is $3\times9.0\times10^{-3} = 2.7\times10^{-2}$m	**1** **1**
14b.	Green light has a shorter wavelength than red light so the interference pattern will show the bright bands closer together than the pattern produced by the red light.	**1**
15a.	$E_{k\,max} = hf - \phi$ $\therefore\ f = \dfrac{E_{k\,max} + \phi}{h}$ $= \dfrac{(2.25 + (4.14\times10^{-15}\times1.50\times10^{15}))}{4.14\times10^{-15}}$ $= 2.04\times10^{15}$ Hz	**1**
15b.	From $c = \lambda f$ 360 nm is equivalent to 8.3×10^{14} Hz 700 nm is equivalent to 4.3×10^{14} Hz Visible light has a lower frequency range than the threshold frequency for platinum and therefore will not be able to produce photoelectrons.	**1** **1**
15c.	From $E = hf$, 360 nm is equivalent to 3.4 eV 700 nm is equivalent to 1.8 eV 0.1 nm is equivalent to 1.2 keV 10 nm is equivalent to 124 eV Therefore, X-Ray photons with wavelengths between 0.1 and 10nm will have much higher energies than those in the visible range.	**1**

16a.	$W = qV$ $= 1.6\times10^{-19}\times\ 5.00\times10^{5}$ $= 8.0\times10^{-14}\text{J} = E_k$ $v_{max} = \sqrt{\frac{2E_k}{m}}$ $=\sqrt{\frac{2\times8.0\times10^{-14}}{9.11\times10^{-31}}}$ $=4.2\times10^{8}\text{ms}^{-1}$ $\therefore \lambda = \frac{h}{mv_{max}}$ $=\frac{6.63\times10^{-34}}{9.11\times10^{-31}\times4.2\times10^{8}}$ $= 1.7\times10^{-12}\text{ m}$	**1** **1**
16b.	The wavelength of the electron is much smaller than the diameter of virus and therefore will not produce noticeable diffraction (i.e. $\lambda << w$). This means that the virus and its features will be easily distinguishable when viewed through the electron microscope. On the other hand, significant diffraction will occur when the virus is viewed using visible light, as the wavelength of light is greater than the width of the object (i.e. $\frac{\lambda}{w}\geq1$). This means that the virus and its features will produce a blurry image when viewed through the optical microscope.	**1** **1**
17a.	The electrical current excites the electrons in the sodium atoms found in the vapour. As they are excited, the electrons move out of their ground state to a higher energy level around the sodium nucleus. After a time, the electrons return to their ground state and a photon of light of light is emitted. The energy of the emitted photon is equivalent to the energy difference between the excited state and the ground state.	**1** **1**
17b.	$E=\frac{hc}{\lambda}=\frac{4.14\times10^{-15}\times3.0\times10^{8}}{5.89\times10^{-7}} = 2.11\text{ eV}$	**1**

18a.	Using De Broglie's equation $\lambda=\dfrac{h}{mv}$ $=\dfrac{6.63\times10^{-34}}{0.430\times6.3}$ $=2.4\times10^{-34}$ m	**1**
18b.	This wavelength is so tiny that it is not detectable with any instruments available at this time or this wavelength is too small to observe any diffraction patterns.	**1**
19a.	Heisenberg's uncertainty principle states that it is not possible to know the position of a sub-atomic particle and its momentum at exactly the same time. In other words, the uncertainty in the position and the uncertainty of the momentum of a sub-atomic particle are inversely proportional to each other. In this example, the electron's momentum is detected by the metal detector – i.e. where it hits the screen and the position is its location within the beam or path taken from the gun to the detector. In the case without the slit, there are no constraints on the path the electron takes from gun to the metal detector, so the uncertainty of the position of each individual electron is large as it travels to the detector. Therefore, Heisenberg's principle tells us that the uncertainty of the momentum of each electron must be small, so the beam is detected at a single point on the detector. In the case with the slit, the size of the beam is narrowed so the uncertainty of the position of the electron is small, therefore by Heisenberg's principle, the uncertainty of the momentum must be large and therefore the fringe of the diffraction pattern is observed to be wide.	**1** **1** **1**
19b.	This observation suggests that the electrons must have the same de Broglie wavelength as the wavelength of the X-Ray beam and this is evidence that the electrons are exhibiting wave-like behaviour as particles cannot produce a diffraction pattern.	**1**
19c.	Using De Broglie's equation for the electrons in the beam. $\lambda=\dfrac{h}{mv}$ $=\dfrac{6.63\times10^{-34}}{9.1\times10^{-31}\times6.5\times10^{6}}$ $=1.0\times10^{-10}$ m $\therefore$ the X-ray wavelength is 1.0×10^{-10} m	**1**

20a. **i.**

Length (mm)				Mass (g)	Notes
Trial 1	Trial 2	Trial 3	Average Length		
71	72	73	**72**	0	No masses
120	121	120	**120**	50	Hanger only
169	168	167	**168**	100	Hanger + 1 mass
218	219	216	**218**	150	Hanger + 2 masses
268	269	271	**269**	200	Hanger + 3 masses
316	315	317	**316**	250	Hanger + 4 masses

1

ii. The biggest difference between average length and individual trial measurement is 2 mm. Therefore, the uncertainty in the average length is $\pm$ 2 mm. **1**

20b. Controlled variables: same ruler is used to take all measurements, only one spring is used during the entire investigation. Done under the same temperature and other conditions. **1**

Independent variable: the number of masses added. **1**

Dependent variable: length of the spring. **1**

20c. The length of the spring is a continuous variable as its value will have an infinite number of possibilities ranging from zero to maximum extension possible, depending on the number and combination of masses added. **1**

20d. **Any two of the following to be included for 2 full marks**:

Problem	Explanation
No line of best fit.	Both the force and extension derived variables are continuous variables and should be represented with a line of best fit.
No error bars on each plot point.	There are uncertainties involved in the measurements of the length and the masses, which should have been identified with horizontal and vertical error bars around each plot point. While Amy has assumed face value measurements for the masses, she should have included horizontal error bars on the length measurements.
SI units not used for all measurements.	Extension lengths should have been represented as metres rather than millimetres as the latter are not SI units.

1

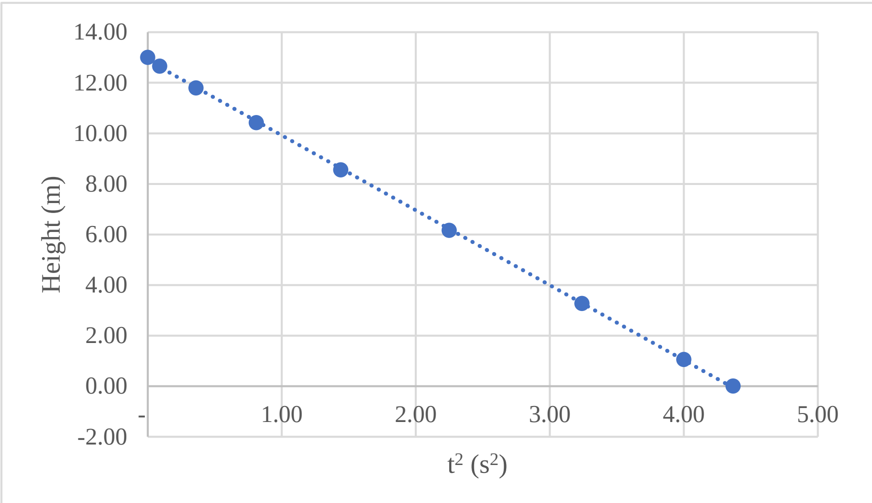
1

20e.	Amy should be able to conclude that as the force vs extension graph is a straight line, then force is directly proportional to extension, i.e. $F \propto x$ where x represents extension $\therefore$ a mathematical relationship would be: F = kx where k represents a constant and is derived from the gradient of the line gra The relationship described by her graph is very similar to Hooke's Law which is given by $F = - k x$. However, Hooke's law relates to the force exerted by the spring which is equal and opposite to the force exerted on the spring by the masses. She could also conclude that the gradient of her graph represents the spring constant for the spring used in her investigation and that her data supports Hooke's Law.	**1** **1**
20f.	The method used by Amy means that she has assumed the face value of the masses and that there is no uncertainty in those values. Amy should have measured the masses she used in her investigation to gain a better understanding of the uncertainty in her results and any derived calculations she could obtain, in particular, the determination of the spring constant.	**1**
21a.	The non-linear graph in **Figure 4** shows that the vertical distance travelled by the ball does not vary proportionately with time. This suggests that the ball is subject to a vertical acceleration as the vertical velocity of the ball will vary over time.	**1**

21b. **i.**

t^2 (s^2)	Height (m)
-	13.00
0.09	12.65
0.36	11.79
0.81	10.42
1.44	8.55
2.25	6.16
3.24	3.27
4.00	1.05
4.37	0.00

1



1

$H \propto t^2$

$\therefore H = mt^2 + c$, where m is the gradient of line and

c is the y-intercept

$$m = \frac{13.00 - 0}{0 - 4.37} = -2.97, c=13$$

1

$\therefore$ $H = -3.0\,t^2 + 13$

1

ii. Given that the laws of physics on Xactrac are the same as on Earth, the equation $H = -3.0\,t^2 + 13$ must have the same form as $x = ut - \frac{1}{2}at^2$ where $u = 0$ ms^{-1} and initial height is 13 m above surface.
As a = g for Xactrac, the gravitational field strength on Xactrac must be 6.0 Nkg^{-1}, (i.e. 2×3.0).

22.	$P_{loss} = I^2R$ $=(1.35\times10^{-3})^2 \times 3.0 = 5.47\times10^{-6}$ W Total % uncertainty = 0.5+0.5+0.5 = 1.5% $\therefore$ the absolute uncertainty in the loss = $1.5\% \times 5.47\times10^{-6}$ $= \frac{1.5}{100} \times 5.47\times10^{-6}$ $= 8.2\times10^{-8}$ minimum value $=5.5\times10^{-6} - 8.2\times10^{-5} = 5.39\times10^{-6}$ W maximum value = $5.5\times10^{-6} + 8.2\times10^{-5} = 5.55\times10^{-6}$ W Mark given for correct derivation of minimum and maximum value.	**1** **1** **1**

End of Suggested Answers