TSSM
Creating VCE Success

2024 Trial Examination

THIS BOX IS FOR ILLUSTRATIVE PURPOSES ONLY

STUDENT NUMBER									Letter

PHYSICS

Units 3 & 4 – Written examination

Reading time: 15 minutes

Writing time: 2 hours and 30 minutes

QUESTION & ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	17	17	110
		Total	130

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers, one double-sided A4 page of notes, one scientific calculator (not CAS or graphical).
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 37 pages. (Including Data and Formula sheet)

Instructions
- Print your VCAA student number (or name) in the space provided on the top of this page.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic communication devices into the examination room.

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}.

Use the following information to answer questions 1 and 2.

An inflated balloon is released from a height of 15 m above ground level and allowed to fall. Initially, as the balloon falls, the speed of the balloon increases; but after 2 seconds the balloon continues to fall with a constant speed.

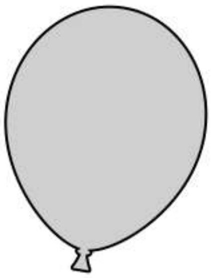


Figure 1

Question 1

One second after its release the acceleration of the balloon is:

A. Less than 9.8 ms^{-2}
B. Equal to 9.8 ms^{-2}
C. Greater than 9.8 ms^{-2}
D. Zero

Question 2

After the balloon has been falling for 2 seconds the acceleration of the balloon is:

A. Less than 9.8 ms^{-2}
B. Equal to 9.8 ms^{-2}
C. Greater than 9.8 ms^{-2}
D. Zero

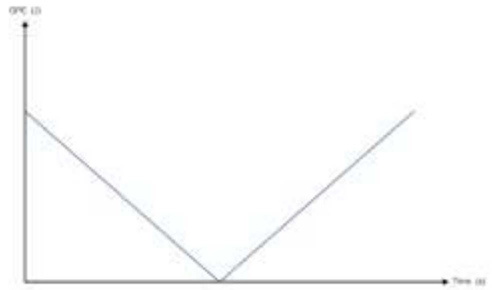
SECTION A- continued

Question 3

A ball was thrown upward at an angle of 45˚. It was caught at the same height as thrown.

Which graph best represents the gravitational potential energy of the ball during the time of flight?

A.



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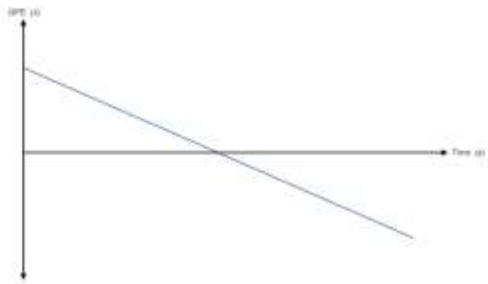

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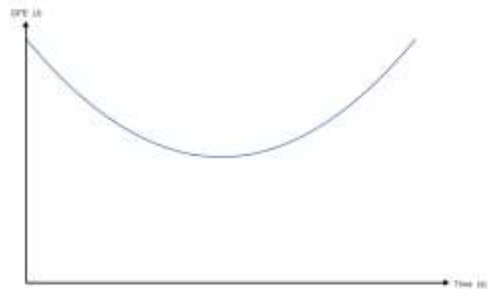

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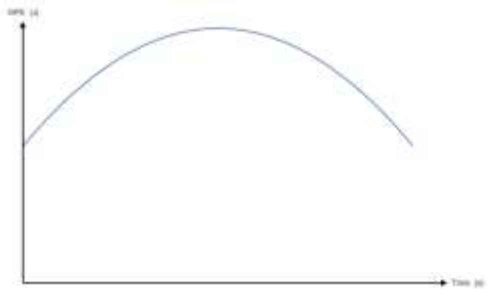


Question 4

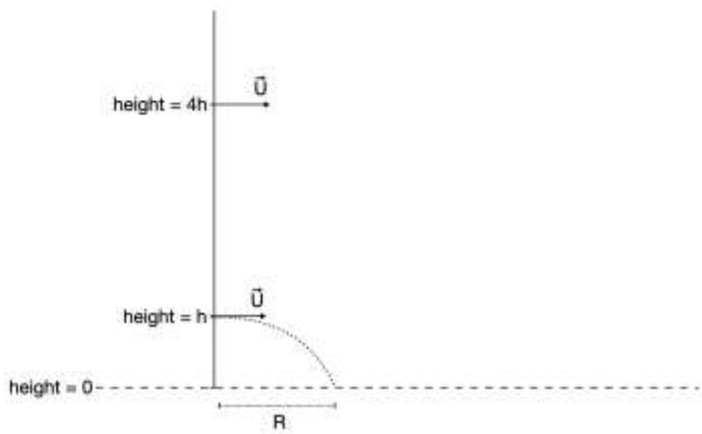


Figure 2

In a student projectile motion experiment, the setup is as shown in Figure 2. For Trial setup 1, an object is launched at height *h* horizontally with speed *U* and achieves a range *R*. In Trial setup 2, the launch height is increased to 4*h*. The expected range, in terms of *R*, will be:

A. 0.5R
B. R
C. 2R
D. 4R

SECTION A- continued

TURN OVER

Use the following information to answer questions 5 and 6.

Two forces are applied to two boxes as shown in Figure 3

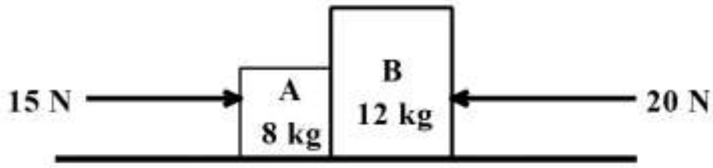


Figure 3

Question 5

The magnitude of the acceleration of the boxes is closest to:

A. 0.25 m s^{-2}
B. 0.57 m s^{-2}
C. 1.0 m s^{-2}
D. 1.75 m s^{-2}

Question 6

What would be the total amount of work done in moving the boxes 3 metres?

A. 1.5 J
B. 15 J
C. 150 J
D. 15 MJ

SECTION A- continued

Use the following information to answer questions 7 and 8.

Two cars enter a turn and take the same time to complete and exit the turn. Radius A (R_A) is 20 metres and Radius B (R_B) is 25 metres.

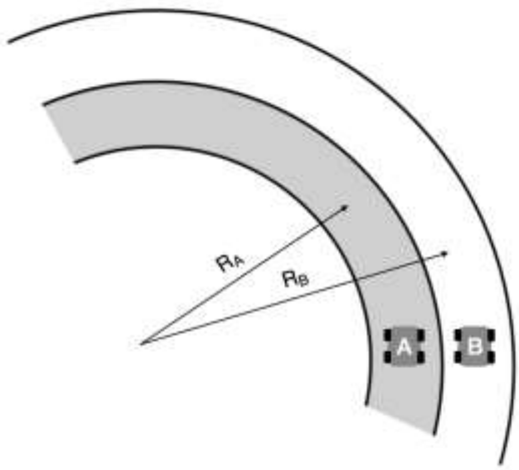


Figure 4

Question 7

The ratio $\frac{Speed\ of\ Car\ A}{Speed\ of\ Car\ B}$ is closest to

A. 0.8
B. 1.0
C. 1.3
D. 1.5

Question 8

The ratio $\frac{acceleration\ for\ Car\ A}{acceleration\ for\ Car\ B}$ is closest to

A. 0.8
B. 1.0
C. 1.3
D. 1.5

SECTION A- continued

TURN OVER

Question 9

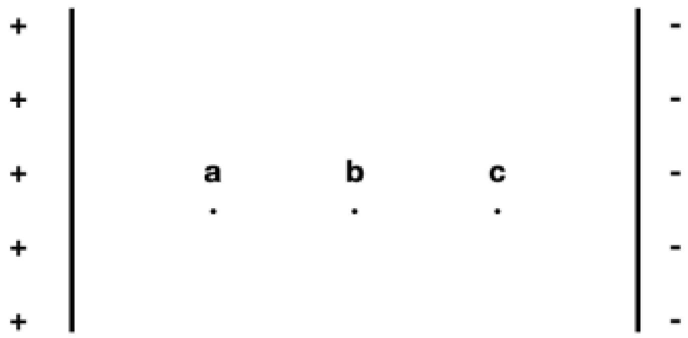
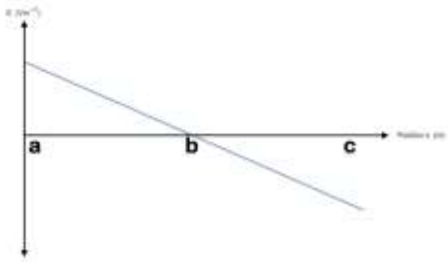


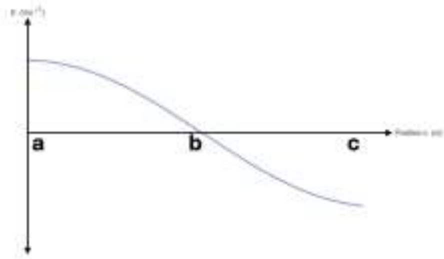
Figure 5

Which of the following graphs best shows the electric field strength, *E*, versus position, *x*, between the two parallel plates.

A.



B.



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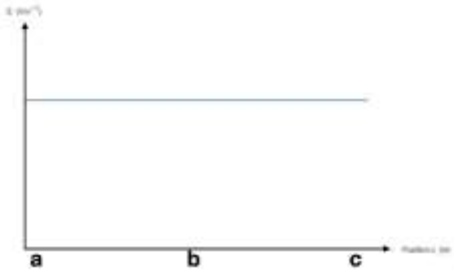
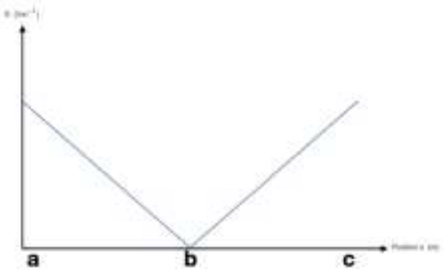


D.



SECTION A- continued

Use the following information to answer questions 10 and 11.

A DC motor is set up as shown in Figure 6. The coil has dimensions 10 cm x 5 cm and a current of 1.5 A runs through the coil. The magnetic field has a strength of 0.4 T.

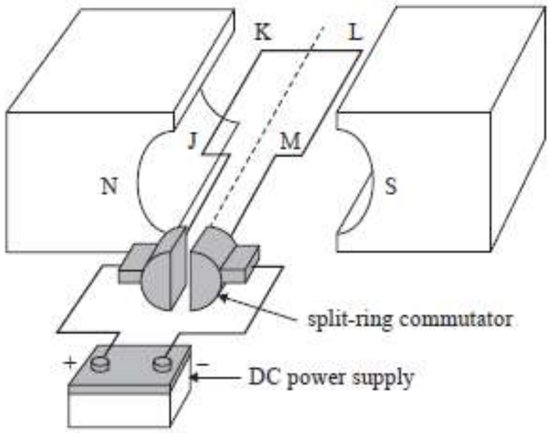


Figure 6

Question 10

What is the force on side LM?

A. 0.06 N up
B. 0.06 N down
C. 0.03 N up
D. 0.03 N down

Question 11

How could the rotation speed of the motor be decreased?

A. Decrease the resistance of the wires
B. Increase the length LM
C. Increase the magnetic field
D. Decrease the number of turns in the coil

Question 12

Electromagnetic radiation:

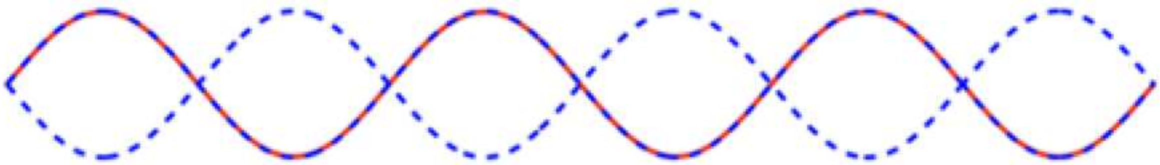
A. Travels at less than the speed of light
B. Travels at speed *c* in a vacuum.
C. Can be described as a longitudinal wave
D. Always travels in straight lines.

SECTION A- continued

TURN OVER

Question 13

A piano string has been struck and the resulting standing waves on the piano string are shown at maximum displacement.



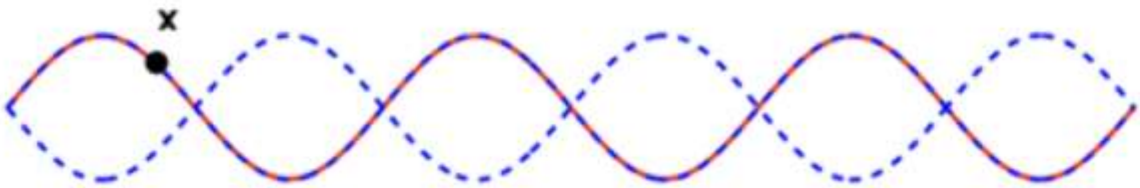
The diagram is not to scale

Which of the following is the best description of the motion of the piano string?

A. The result of two transverse waves travelling in the same direction.
B. The result of two transverse waves travelling in opposite directions.
C. The result of two longitudinal waves travelling in the same direction.
D. The result of two longitudinal waves travelling in opposite directions.

Question 14

The point 'X' is located on the piano string.



Immediately after the instant shown, the point x will move:

A. Downwards
B. To the left
C. To the right
D. Upwards

SECTION A- continued

Question 15

An electron is moving at a speed of 7.6×10^{6} m s^{-1}.

What is the associated de Broglie wavelength of this electron?

A. 5.5×10^{3} m
B. 7.9×10^{-71} m
C. 9.6×10^{-11} m
D. Electrons do not have a wavelength.

Question 16

Green laser light passes through a single narrow slit, forming a diffraction pattern on a nearby screen. The light is then changed to blue and the width of the slit is increased.

Which of the following would be the expected overall effect on the diffraction pattern?

A. Wider
B. Narrower
C. No change
D. Indeterminable given the information provided

Question 17

Which of the following was/were a goal of the Michelson-Morley experiment?

i. find out whether the ether exists
ii. find out whether the Earth moves relative to the ether
iii. measure the speed of light in different reference frames

A. i only
B. iii only
C. i and ii only
D. i, ii and iii.

Question 18

What is a proper time interval?

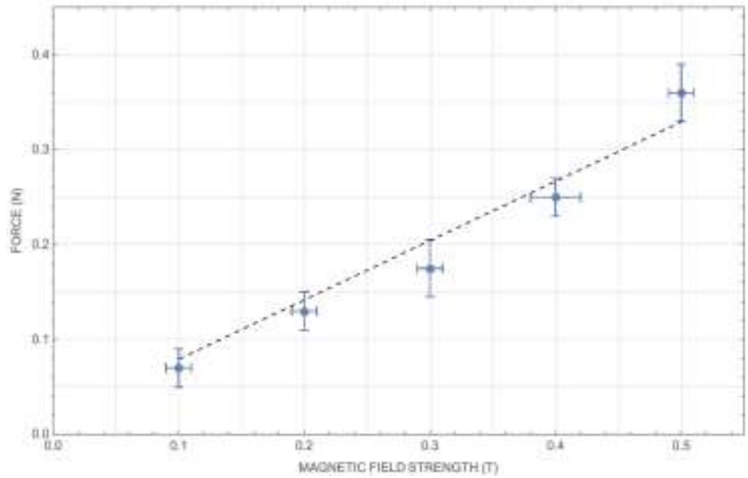
A. A correctly measured time interval.
B. The shorter time interval of the two measured times.
C. The time interval measured by the observers in the moving location
D. The time interval measured by observers at rest relative to an event in the same location.

SECTION A- continued

TURN OVER

Use the following information to answer questions 19-20.

Students conduct an experiment to measure the force applied to a conducting wire in a magnetic field inside a solenoid. They obtain the following graph.



Question 19

Which option correctly identifies the variables?

	Independent variable	Dependent variable	Controlled variable
A.	Magnetic field strength	Length of wire	Current
B.	Force	Magnetic field strength	Area of wire
C.	Force	Magnetic field strength	Length of wire
D.	Magnetic field strength	Force	Current

Question 20

Is their trend line was suitable and why or why not?

- **A.** Yes, it goes through the first and last point.
- **B.** Yes, it goes through all uncertainty bars.
- **C.** No, it doesn't go through all the points.
- **D.** No, it doesn't go through the first and last point.

END OF SECTION A

SECTION B - Short-answer questions

Instructions for Section B
Answer **all** questions in the spaces provided. Write using black or blue pen.
Where an answer box has a unit printed in it, give your answer in that unit.
Where answer boxes are provided, write your final answer in the box.
In questions worth more than 1 mark, appropriate working **must** be shown.
Unless otherwise indicated, diagrams are **not** to scale.
Unless otherwise stated, take the value of **g** to be 9.8 m s^{-2}.

Question 1 (6 marks)

A cyclist is racing around the London Pringle velodrome.

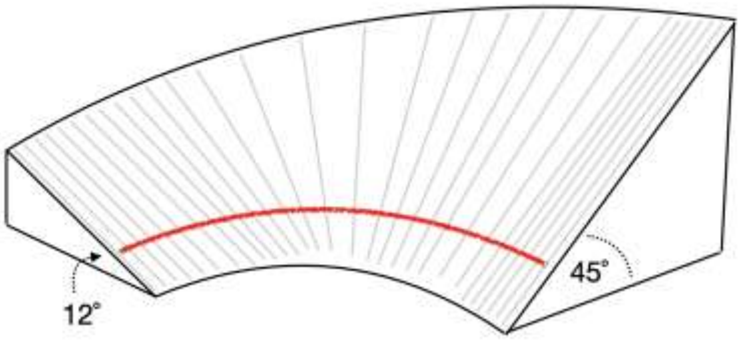
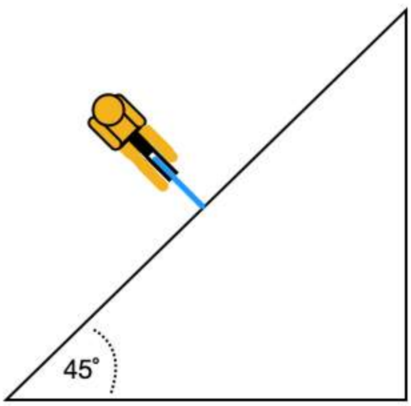


Figure B1: **Cross-section of velodrome track**

a. Indicate on Figure B2 with labelled arrows, the forces on the cyclist as they ride on the steep banked track section with a constant speed.



2 marks

Figure B2: **Cross-section of velodrome track**

SECTION B - Question 1 – continued

TURN OVER

b. The radius of curvature for the high turn is 20 metres and the velodrome track is angled at 45˚. Calculate the speed at which the cyclist can ride around the curve without requiring any friction forces. Show your working.

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m s^{-1}

2 marks

c. Explain how banking the track makes the velodrome track safer for the riders

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2 marks

SECTION B- continued

Question 2 (5 marks)

In an archery competition the target is placed a distance of 70 m with the centre height at 130 cm. The 10-ring target has a diameter of 122 cm. (each point score is 12.2 cm wide.)

An arrow is released with a speed of $v = 100 \text{ m s}^{-1}$

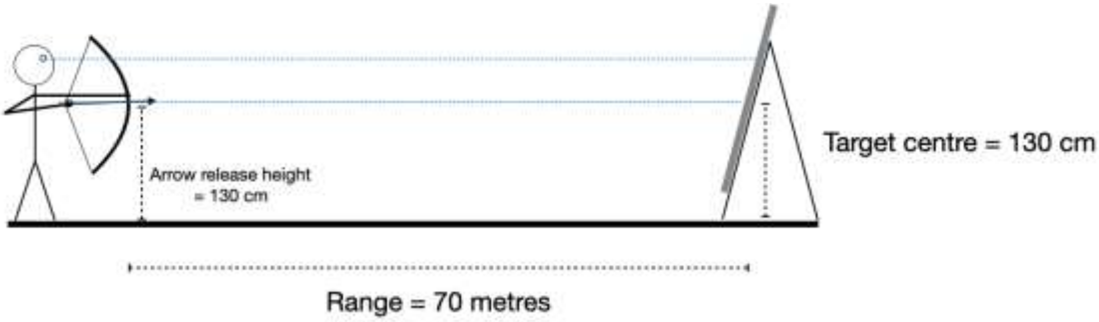

Figure B3

Figure B4

Note1: There is no wind assistance and for these calculations you are to ignore air resistance.

Note2: Diagram is not to scale

a. Draw the path of the arrow on Figure B3 to score a bull's eye (centre of target).

1 mark

b. What is the target scored if a beginner archer aims and releases the arrow horizontally with a speed of 100 m s^{-1}? Show your working.

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2 marks

SECTION B - Question 2 – continued

TURN OVER

c. If the arrow is to be released so that it will score a bull's eye, calculate the angle of release.

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°

2 marks

Question 3 (9 marks)

An Infinity train is to be installed on the train line in the Pilbara region in north western Australia. The train travels from the Cloud Break iron ore mine 280 km to the port city of Port Hedland. It will be a zero emissions train. The train is 3km long, consists of 250 wagons and weighs 5,000 tonnes. When fully loaded with iron ore the entire train weighs an extra 35,000 tonnes. Regenerative braking charges the batteries on the downhill to the port and has sufficient energy to return uphill to the mine. Each of the trains are powered by three battery-electric locomotives and the rail journey typically takes 8 hours. On average there are 15 trains a day, every day.

a. What is the average kinetic energy of each fully loaded wagon?

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J

2 marks

b. What is the maximum elevation for the mine?

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m

2 marks

SECTION B - Question 3 - continued

c. Explain where the energy comes from to power the Infinity train to return uphill to the mine. Describe two assumptions required to achieve a zero emissions train.

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3 marks

d. The regenerative brakes can bring a fully loaded train to a stop in 800 metres.

There are four axles on each ore wagon.

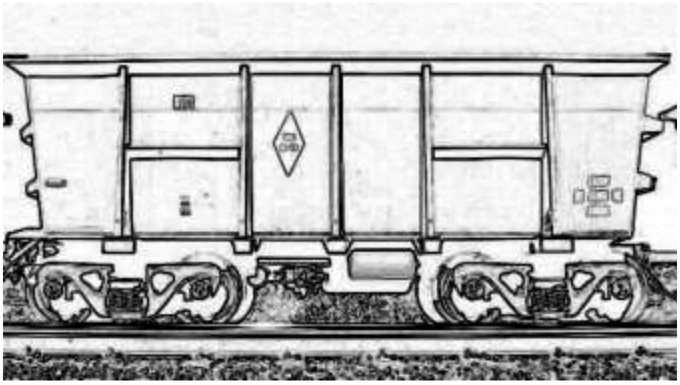

Figure B5: Four axle ore wagon

How much force is applied at each axle to bring the train to a stop?

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kN

2 marks

SECTION B- continued

TURN OVER

Question 4 (3 marks)

If two objects of different mass have the same kinetic energy, which one has the greater momentum? Explain with the use of calculations.

3 marks

Question 5 (9 marks)

Slings are believed to be one of the oldest weapons, with use pre-dating bows and arrows and thrown spears. There are several techniques used to optimise distance and accuracy.
The horizontal sling was used as long ago as 9th century BCE in Mesopotamia. Typical distances thrown are ~70 metres.

a. On Figure B6, draw arrows to indicate any forces on the stone for a horizontal sling.

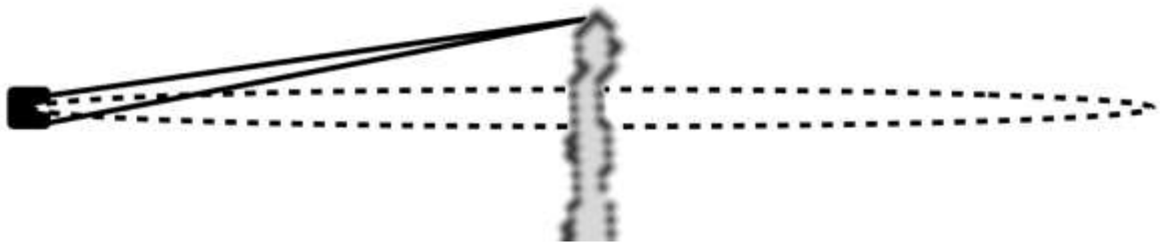

Figure B6

1 mark

Later, around 700 BCE, slingers (people who launch rocks with a sling) were shown using the sling in a vertical circle. Typical measured throws have a range of 250 metres and a release speed of ~35 m s^{-1}.

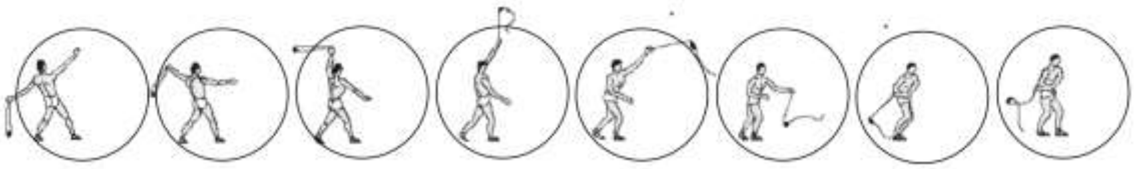

Figure B7: Overhead sling action

SECTION B - Question 5 - continued

b. Calculate the resultant force on a 200 g stone when the stone is released at the top of the action as shown in Figure B7.

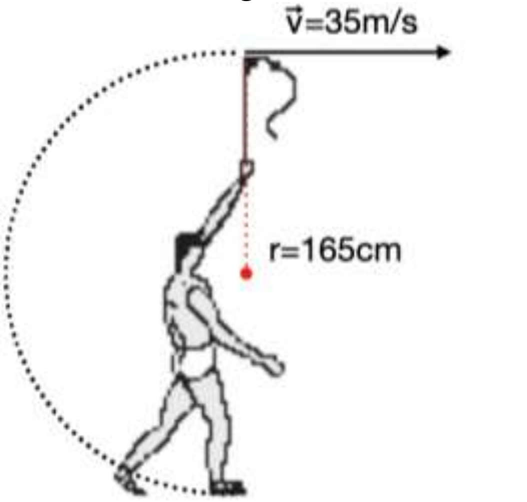

Figure B7: Vertical sling-top point of release

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N

2 marks

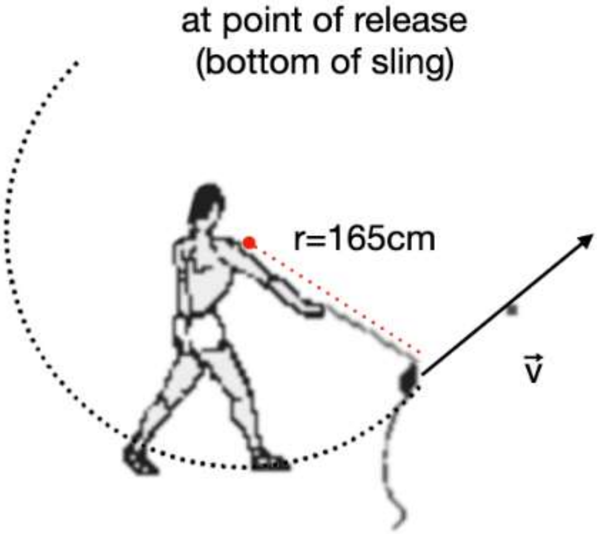

Figure B8: Vertical sling bottom point of release

The rock could also be released at the bottom of the sling as shown on Figure B8

SECTION B - Question 5 – continue**d**
TURN OVER

c. On Figure B9 draw the forces on each type of sling style. Compare the tension at the top and bottom of a vertical sling if the release speed is 35 m s^{-1} and the sling bullet has a mass of 200 g.
Assume the speed and radius of sling is the same for the purposes of comparison.
Also, to simplify comparing the magnitudes and directions of the forces, take the release points as being at the very top and very bottom of the action.

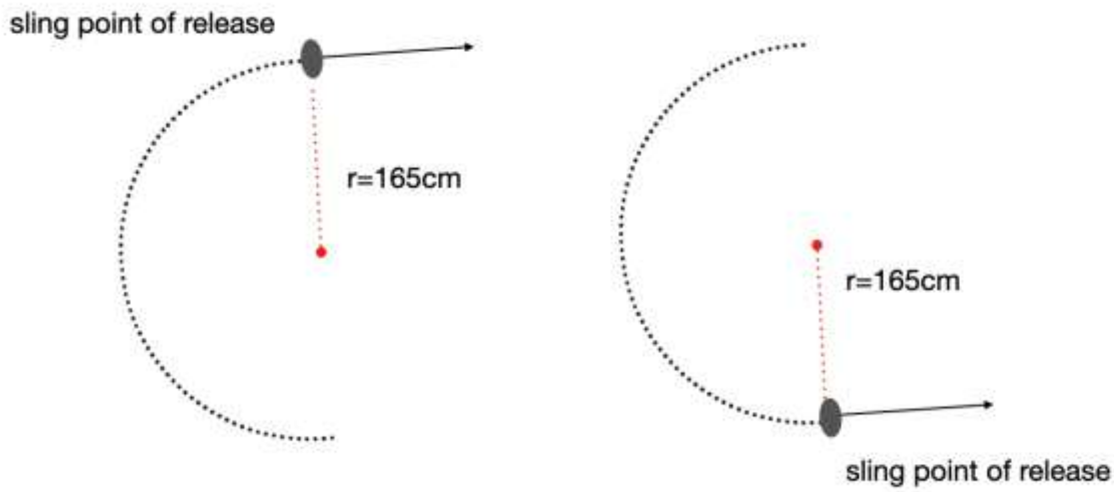

Figure B9: Vertical sling (i) top and (ii) bottom point of release

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3 marks

d. How could the slinger increase the range of the hurled sling bullet? Explain two changes which would increase the range of the projectile.

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3 marks

SECTION B – continued

Question 6 (11 marks)

An object of 920 g is attached to an unstretched spring.

The spring extends vertically to reach equilibrium.

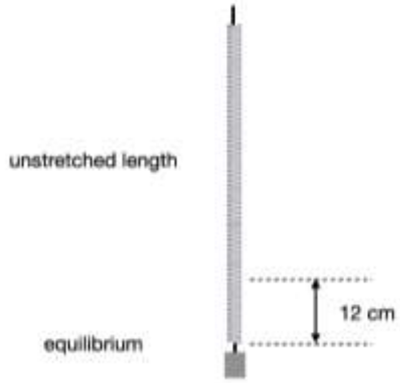

Figure B10: Spring extension

The spring has characteristics as shown on the graph in Figure B11

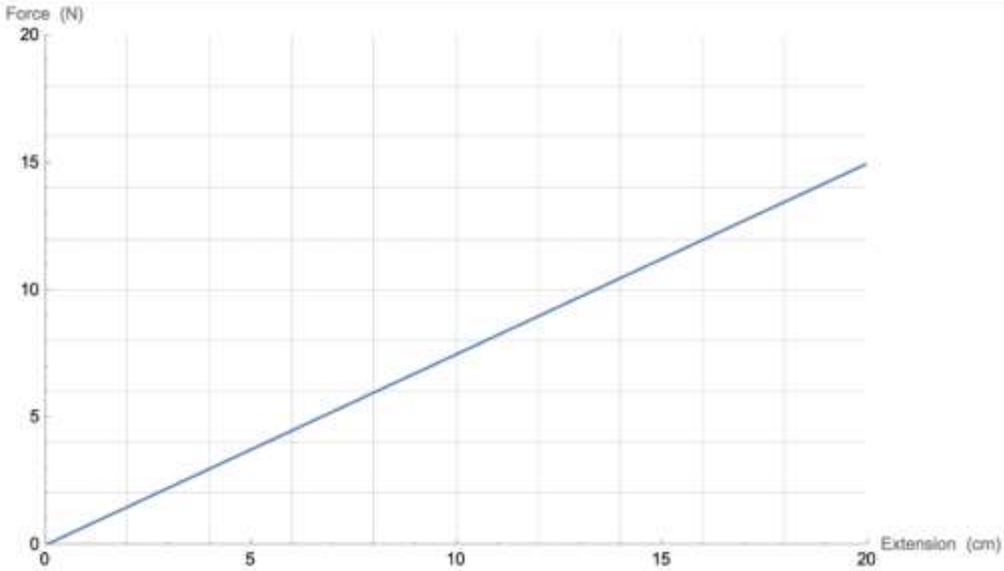

Figure B11: Spring force vs extension graph

a. Calculate the spring constant.

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N m^{-1}

2 marks

SECTION B - Question 6 - continued

TURN OVER

The object is displaced a further 5 cm, and released. The object then oscillates between a maximum and minimum for several minutes.

b. Determine the work done to displace the object a further 5.0 cm

J

2 marks

c. Complete the table with values for the extension of the spring, Δx, in cm.

Energy	Maximum energy	Minimum energy	ZERO energy
E_g			
E_k			
E_s			

4 marks

d. Determine the maximum speed of the object as it passes through the point of equilibrium.

$m\ s^{-1}$

2 marks

e. Explain why the oscillation only lasts 'for several minutes'. Why does the motion come to a stop and the object return to the point of equilibrium?

2 marks

SECTION B – continued

Question 7 (6 marks)

Complete the table by placing a tick in the box when the option applies to each type of field.

		Gravitational field	**Electric field around a point charge**	**Magnetic field around a bar solenoid**
a	Can be attractive			
b	Can be repulsive			
c	Can exist as a dipole			
d	Can exist as a monopole			
e	Is a static field			
f	Has a uniform field			

6 marks

SECTION B- continued

TURN OVER

Question 8 (8 marks)

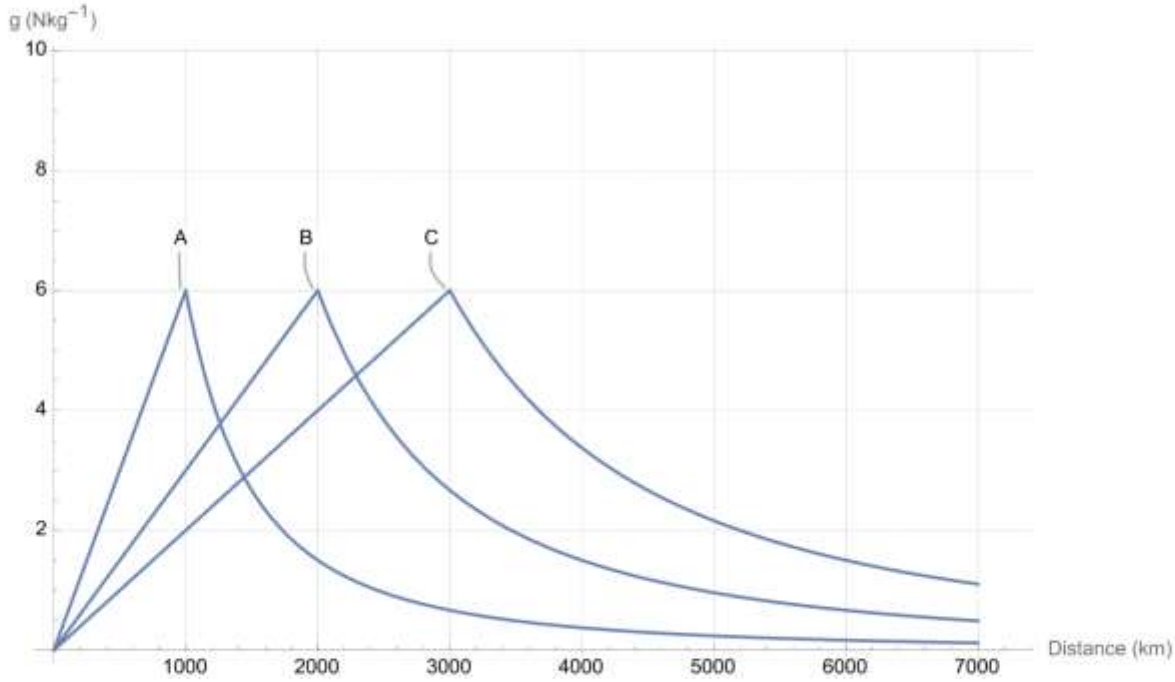

Figure B12

The graph in Figure B12 shows the value for the gravitational field, g, at various distances from the centre of three unknown planets.

a. Which planet has the greatest mass? Justify your response with appropriate calculations.

2 marks

b. Calculate the change in gravitational potential energy for a 400 kg satellite in orbit around planet C moving from a distance of 2000 km to 1000 km ***above*** the surface of the planet.

J

2 marks

SECTION B - Question 8 - continued

c. Calculate the mass of planet A. Give your answer to 3 significant figures

kg

2 marks

d. Calculate the period of orbit for the 400 kg satellite around planet A at a distance of 1000 km above the surface of the planet.

seconds

2 marks

SECTION B- continued

TURN OVER

Question 9 (5 marks)
A uniform magnetic field with strength 0.06 T is shown going into the page.
A proton ($m_P = 1.67 \times 10^{-27}$ kg) is shown about to enter the B-field.
Once in the field, the proton will follow a circular path of radius 50 cm.

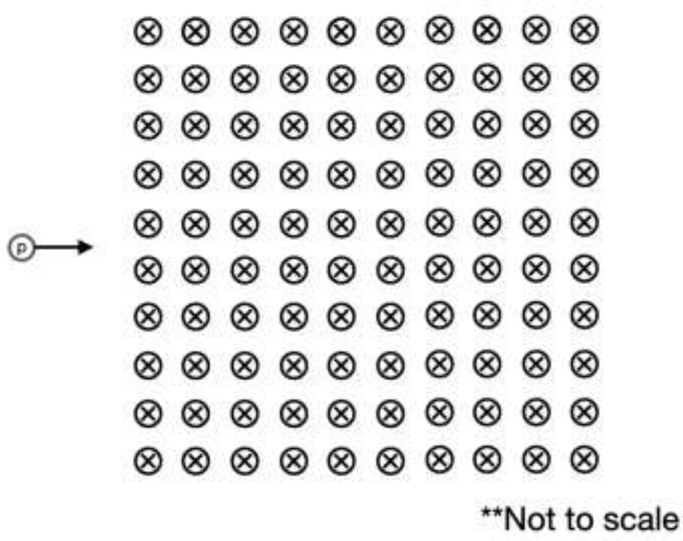

Figure B13

a. Show that the proton entered the B-field with a speed of 2.87×10^{6} m s^{-1}

1 mark

b. On Figure B12, draw the path the proton will follow. Label the direction of the force at several different positions inside the B-field.

2 marks

c. Calculate the magnitude of the force on the proton.

2 marks

N

SECTION B- continued

Question 10 (4 marks)

Two charged particles are placed an equal distance of 15 µm from a distant point, X as shown on Figure B14

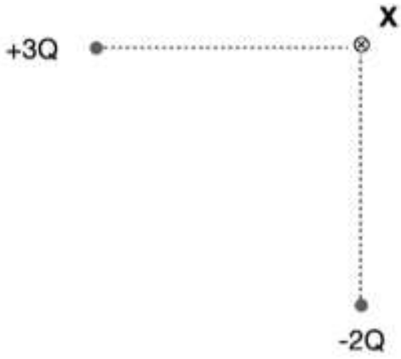

Figure B14

a. Calculate the electric field at location X

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N C^{-1}

2 marks

b. A charge of +2Q is placed at location X. Calculate the magnitude of the force experienced by the new charge.

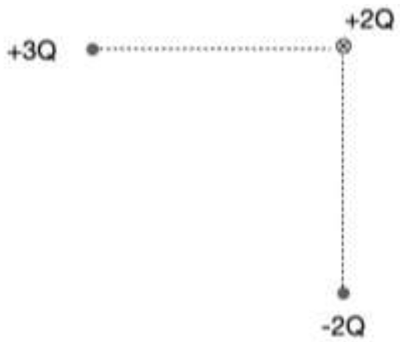

Figure B15

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N

2 marks

SECTION B- continued

TURN OVER

Question 11 (6 marks)

A mass spectrometer can determine the mass of a charged particle. This information can identify particular isotopes.
There are three stages to a gas chromatograph mass spectrometer. (i) ionisation of gas sample (ii) speed selection (iii) mass-charge spectrum
Figure B16 shows the speed selector, charged plates with a uniform electric field of 2300 volts per metre and a magnetic field of 0.045 Tesla in both the speed selector and the deflection chamber.

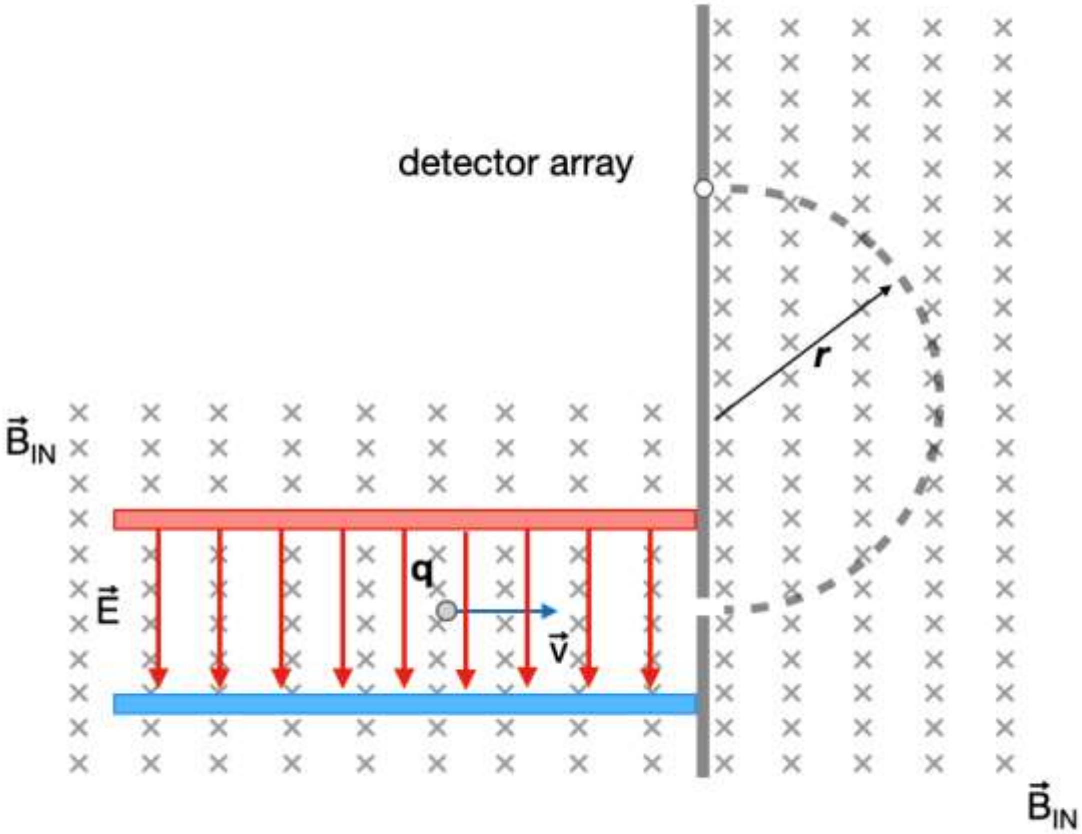

Figure B16: Mass spectrometer

a. Show that the speed selector allows charged particles with a speed of 51.1 km s^{-1} to pass into the deflector chamber.

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2 marks

SECTION B – Question 11 - continued

b. Explain why only certain speeds are permitted to travel straight through the speed selector.

2 marks

c. Calculate the radius of the path for a singly charged ion having a mass $m = 1.82 \times 10^{-26}$ kg and travelling at 51.1 km s^{-1}.

2 marks

m

Question 12 (7 marks)
A student built a simple DC motor, as shown in Figure B17

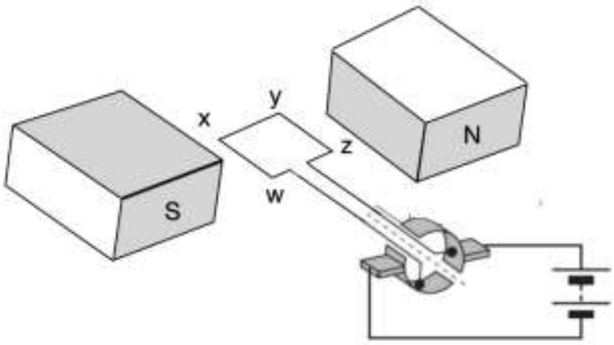

Figure B17: simple DC motor

a. The motor is arranged with the coil horizontal, and an energy source of 6 Volts is applied. Will the motor move? Explain your answer.

3 marks

SECTION B - Question 12 -continued

TURN OVER

b. The student decides the motor is ‘not strong enough’. Describe two options for increasing the torque of the DC motor.

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2 marks

c. Another student suggests that slip rings would be easier to make than a commutator and that slip rings should be used.
Explain the effect that replacing the commutator with slip rings would have, if no other changes were made.

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2 marks

Question 13 (4 marks)

Figure B18 shows a simple DC generator with the output connected to a light globe and an oscilloscope. The oscilloscope has a very large effective resistance. The coil is rotated mechanically.

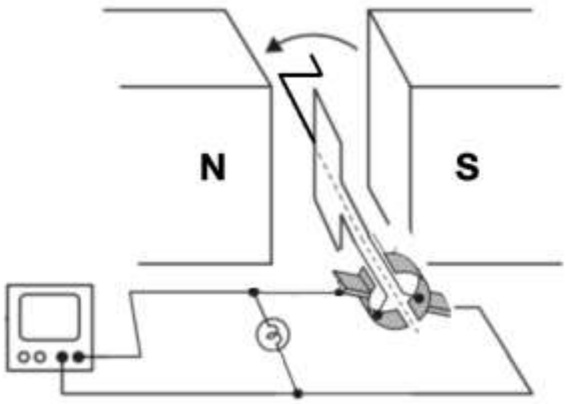

Figure B18

SECTION B - Question 13 - continued

The output on the oscilloscope is shown in Figure B19

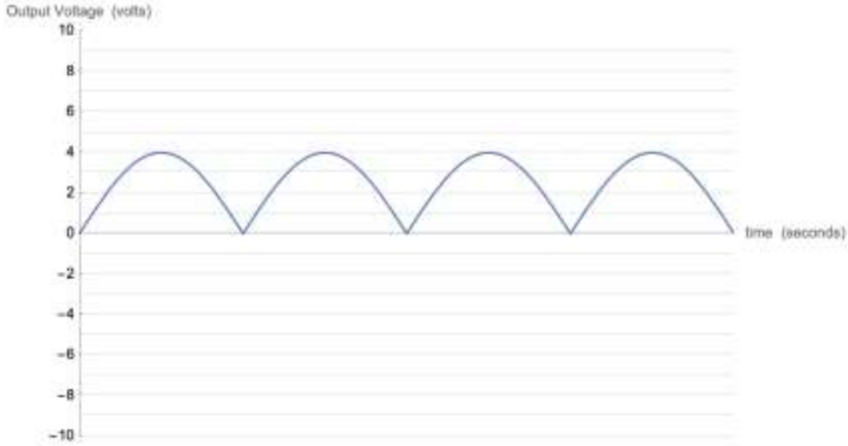

Figure B19

a. The DC generator is to be replaced with a battery.
What voltage should the battery have in order for the light globe to provide the same average brightness as it did with the generator? Show your working.

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2 marks

V

b. The rate of rotation of the loop is doubled.

On Figure B20, sketch the output that will now be seen on the oscilloscope. The original waveform is shown as a dashed line.

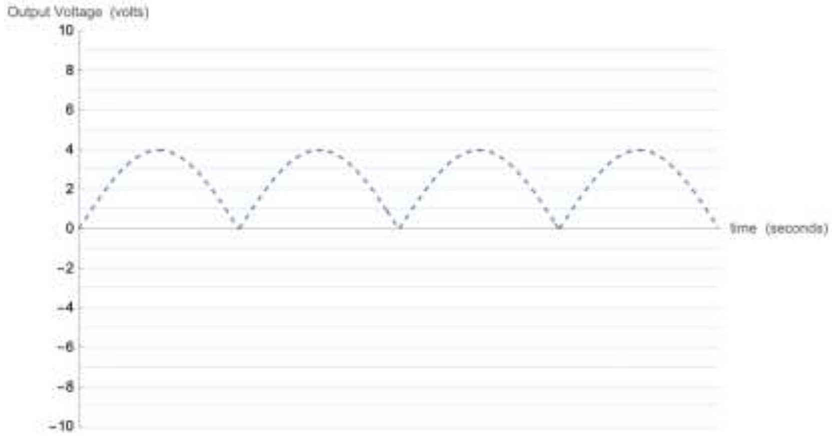


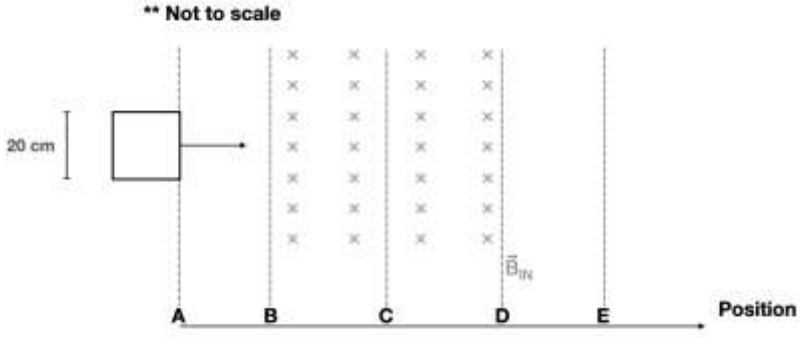
Figure B20

2 marks

SECTION B- continued

TURN OVER

Question 14 (8 marks)
A square coil with a side length of 20 cm moves at a constant speed of 0.40 m s^{-1} through a magnetic field with a strength of 0.0015 T. Figure B21 shows the situation as viewed from above.



Location of leading edge of the coil
Position A outside the B-field
Position B on the edge of the B-field
Position C inside the B-field
Position D on the other edge of the B-field
Position E outside the B-field

Figure B20

a. Draw a magnetic flux vs. position graph for the coil as it moves through the magnetic field. Include a scale of the Y-axis (No scale is required on the X-axis)

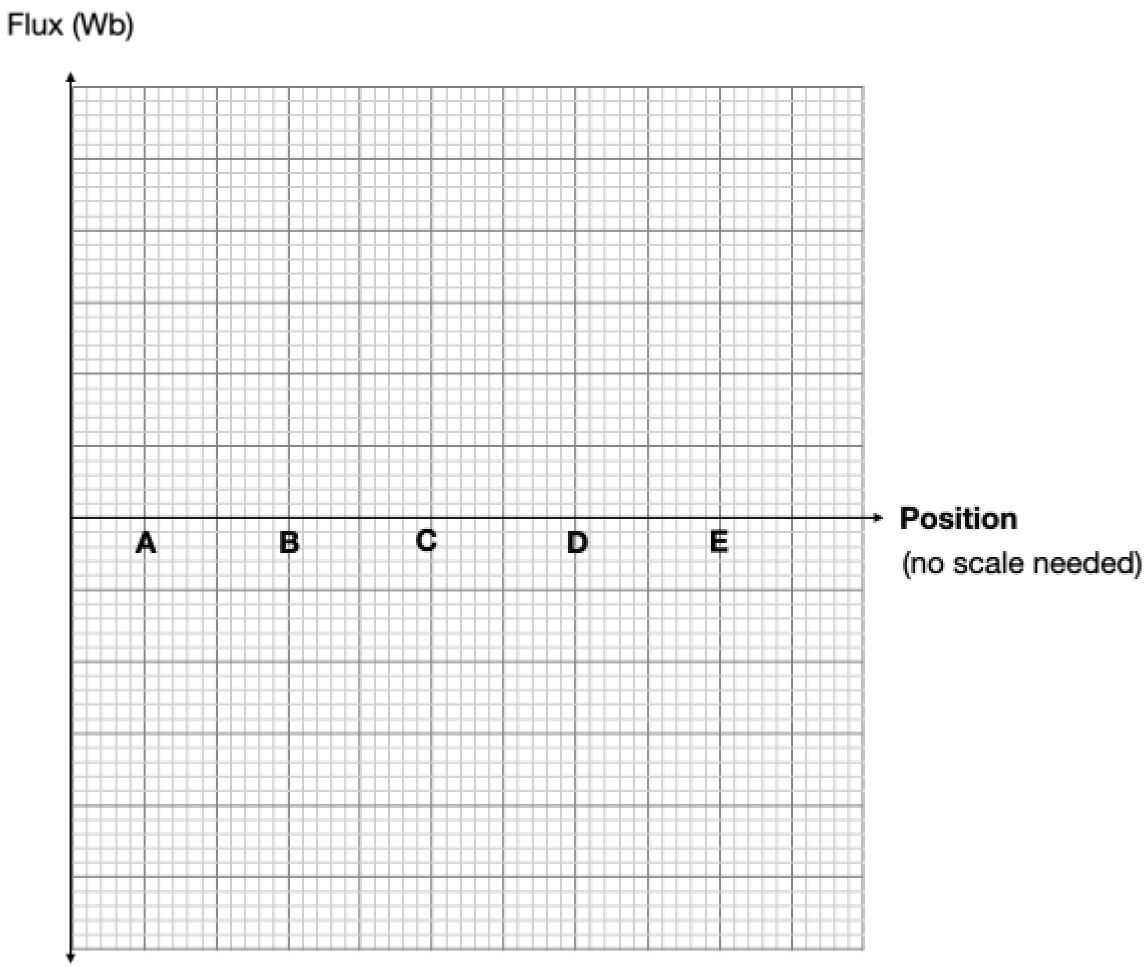


Figure B21

3 marks

SECTION B – **Question 14 -** continued

b. Draw an EMF time graph for the induced EMF in the coil as it moves all the way through the magnetic field. Include a scale on the y axis (no scale is required on the x axis).

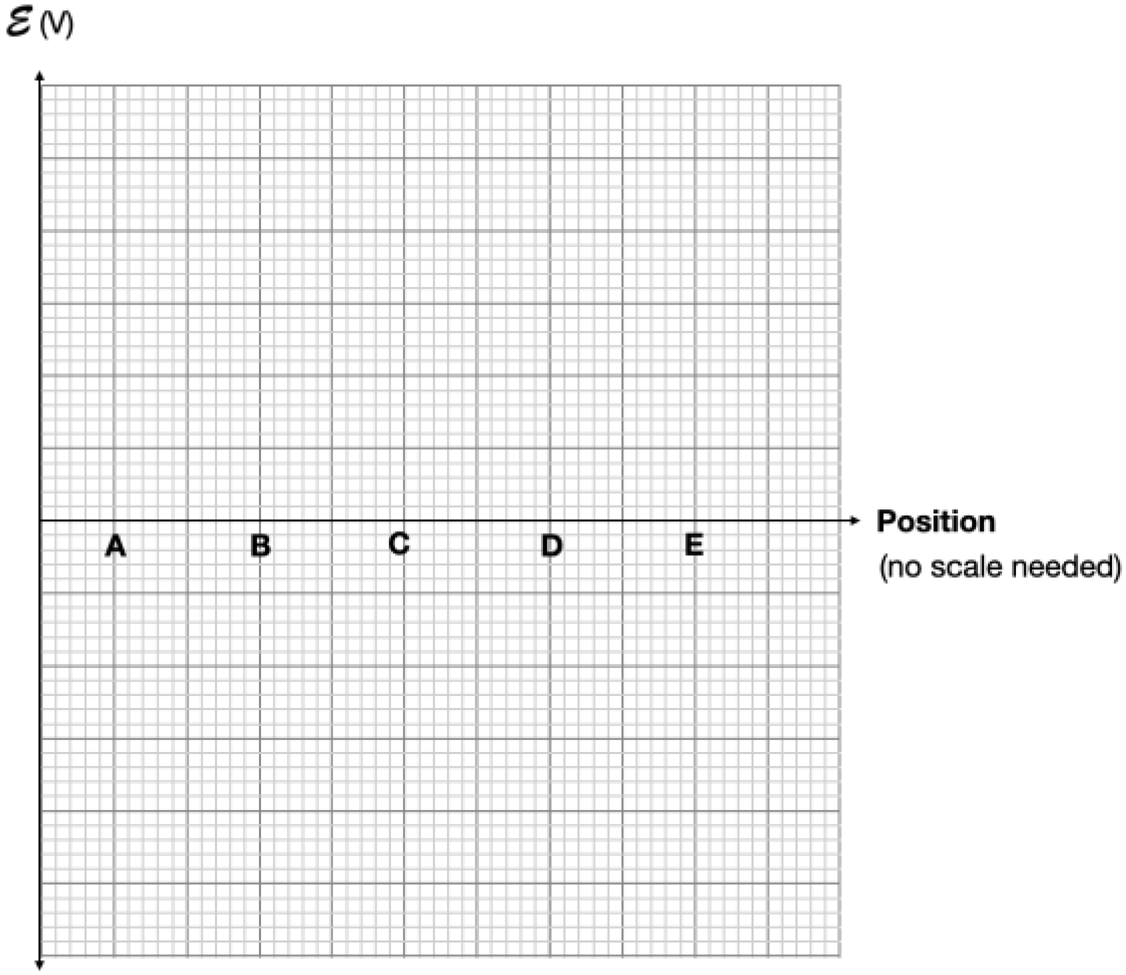


Figure B22

3 marks

c. In which direction will the induced EMF be as the coil enters the field? Justify your response.

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2 marks

Direction:

SECTION B- continued

TURN OVER

Question 15 (5 marks)

A student is conducting the Young double-slit experiment using a green laser ($\lambda = 550$ nm). The two slits are 2.5×10^{-4} m apart. When the laser passes through the slits an interference pattern with adjacent bright bands 5.0 mm apart is produced.

a. Calculate the distance between the double slits and the screen where the interference pattern is observed.

2 marks

m

b. The students find the separation between bright bands hard to measure and wish to make the bright bands further apart. Alice says that they should use a red laser in which the wavelength is longer, while Zehan says they should use a blue laser in which the frequency is higher. Who is correct? Justify your response.

3 marks

SECTION B- continued

Question 16 (7 marks)
An X-ray photon with a wavelength of 5.0 nm, and an electron with a de Broglie wavelength of 5.0 nm, are compared in a diffraction experiment.

a. Calculate and compare the momentum of both the photon and the electron.

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Photon $kg\ m\ s^{-1}$	Electron $kg\ m\ s^{-1}$

2 marks

b. Calculate and compare the energies of the photon and the electron.

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Photon J	Electron J

2 marks

c. Calculate and compare the velocities of the photon and the electron.

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Photon $m\ s^{-1}$	Electron $m\ s^{-1}$

2 marks

d. Compare the diffraction patterns that the photon and the electron would produce from the same targeted substance.

___

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1 mark

SECTION B- continued

TURN OVER

Question 17 (7 marks)

a. The table contains predictions for the behaviour of light incident on a shiny metal sheet. Complete the table by placing a ‘Y’ (Yes) or ‘N’ (No) in the appropriate box if the prediction is supported by the wave **and/or** particle model of light. Some answers have already been provided. It is possible for predictions to be supported by both models.

	Prediction	Particle model	Wave model
I.	The number of photoelectrons produced is proportional to the intensity of the incident beam.		Y
II.	Light of sufficient intensity should produce the photoelectric effect.		Y
III.	Light of high intensity will produce photoelectrons with a greater maximum kinetic energy than light of low intensity.		Y
IV.	Light of low intensity will cause the emission of photoelectrons later than light of high intensity.	N	

One mark each = 4 marks

b. Newton proposed a particle model for light and Huygens proposed a wave model for light. Explain how Einstein's interpretation of the photoelectric effect supported a wave or a particle model.

3 marks

TOTAL SECTION B

110 MARKS

END OF QUESTION AND ANSWER BOOK

Formula and Data Sheet

Motion and related energy transformations

velocity; acceleration	$v = \frac{\Delta s}{\Delta t};\quad a = \frac{\Delta v}{\Delta t}$
equations for constant acceleration	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $s = vt - \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{1}{2}(v+u)t$
Newton's second law	$\Sigma F = ma$
circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
Hooke's law	$F = -k\Delta x$
elastic potential energy	$\frac{1}{2}k(\Delta x)^2$
gravitational potential energy near the surface of Earth	$mg\Delta h$
kinetic energy	$\frac{1}{2}mv^2$
Newton's law of universal gravitation	$F = G\frac{m_1 m_2}{r^2}$
gravitational field	$g = G\frac{M}{r^2}$
impulse	$F\Delta t$
momentum	mv
Lorentz factor	$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$
time dilation	$t = t_o\gamma$
length contraction	$L = \frac{L_o}{\gamma}$
rest energy	$E_{rest} = mc^2$
relativistic total energy	$E_{total} = \gamma mc^2$
relativistic kinetic energy	$E_k = (\gamma - 1)mc^2$

Fields and application of field concepts

electric field between charged plates	$E = \frac{V}{d}$
energy transformations of charges in an electric field	$\frac{1}{2}mv^2 = qV$
field of a point charge	$E = \frac{kq}{r^2}$
force on an electric charge	$F = qE$
Coulomb's law	$F = \frac{kq_1q_2}{r^2}$
magnetic force on a moving charge	$F = qvB$
magnetic force on a current carrying conductor	$F = nIlB$
radius of a charged particle in a magnetic field	$r = \frac{mv}{qB}$

Generation and transmission of electricity

voltage; power	$V = RI$; $P = VI = I^2R$
resistors in series	$R_T = R_1 + R_2$
resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
ideal transformer action	$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$
AC voltage and current	$V_{RMS} = \frac{1}{\sqrt{2}}V_{peak}$ $I_{RMS} = \frac{1}{\sqrt{2}}I_{peak}$
electromagnetic induction	EMF: $\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$ flux: $\Phi_B = B_{\perp}A$
transmission losses	$V_{drop} = I_{line}R_{line}$ $P_{loss} = I^2_{line}R_{line}$

Wave concepts

wave equation	$v = f\lambda$
constructive interference	path difference $= n\lambda$
destructive interference	path difference $= \left(n - \frac{1}{2}\right)\lambda$
fringe spacing	$\Delta x = \frac{\lambda L}{d}$

The nature of light and matter

photoelectric effect	$E_{k\,max} = hf - \phi$
photon energy	$E = hf$
photon momentum	$p = \frac{h}{\lambda}$
de Broglie wavelength	$\lambda = \frac{h}{p}$

Data

acceleration due to gravity at Earth's surface	$g = 9.8$ m s^{-2}
mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
magnitude of the charge of the electron	$e = 1.6 \times 10^{-19}$ C
Planck's constant	$h = 6.63 \times 10^{-34}$ J s $h = 4.14 \times 10^{-15}$ eV s
speed of light in a vacuum	$c = 3.0 \times 10^{8}$ m s^{-1}
universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
mass of Earth	$M_E = 5.98 \times 10^{24}$ kg
radius of Earth	$R_E = 6.37 \times 10^{6}$ m
Coulomb constant	$k = 8.99 \times 10^{9}$ N m^2 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}	t = tonne = 10^{3} kg