SCIENCE TEACHERS ASSOCIATION VICTORIA 2023

TRIAL EXAMINATION

QUESTION AND ANSWER BOOK

Total writing time: **2 hours 30 minutes**

PHYSICS

UNITS 3 & 4

Student name

Student ID | | | | | | | | |

Letter | |

Structure of book

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

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners rulers, one folded A3 sheet or two A4 sheets bound together by rape of pre-written notes that may be single or double-sided and an approved scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape, mobile phones and/or any other unauthorised electronic devices.

Materials supplied

- Question and answer book of 37 pages.
- Detachable multiple-choice answer sheet inside the front cover.
- Detachable formula sheet in the centrefold.

Instructions

- Detach the formula sheet from the centre of this book and the answer sheet for multiple-choice questions during reading time.
- Write your name and student ID in the space provided above on this page.
- Unless otherwise indicated, the diagrams in this book are not drawn to scale.
- All written responses should be in English.

At the end of the examination

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

STAV PUBLISHING

Published by STAV
© STAV August 2023

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2023

PHYSICS
Units 3 & 4 Trial Examination
MULTIPLE CHOICE ANSWER SHEET

STUDENT NAME:	

INSTRUCTIONS: **USE PENCIL ONLY**

- Write your name in the space provided above.
- Use a **PENCIL** for **ALL** entries. For each question, **SHADE** the box which indicates your answer.
- Marks will **NOT** be deducted for incorrect answers.
- **NO MARK** will be given if more than **ONE** answer is completed for any question.
- If you make a mistake, **ERASE** the incorrect answer – **DO NOT** cross it out.

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

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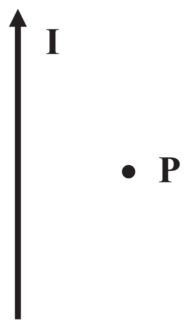
SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1; an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1.

A long wire is carrying a current, I, up the page as shown in the diagram on the right.



The direction of the magnetic field at the point P is best described as:

A. to the right

B. out of the page

C. up the page

D. into the page

Question 2.

An old style 1 metre long wooden blackboard ruler has marked increments of 1 cm.

Which of the following best represents a measurement that could be made using this ruler?

A. 8.1 ± 0.5 cm

B. 8 ± 0.5 cm

C. 8 ± 1.0 cm

D. 7.5 cm to 8.5 cm

Question 3.

Several students are using handheld digital stopwatches to measure event times in an experiment.

The reason for the variations in the students' time measurements is **most likely** to be due to:

A. random error

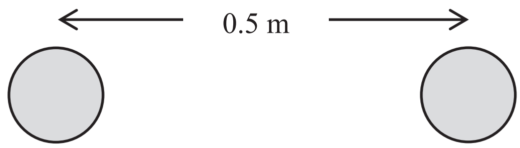
B. relative error

C. systematic error

D. mechanical error

Question 4.

Two particles with an equal positive charge are placed as shown in the diagram on the right.



Which of the following statements about the electric field at the midpoint between the two charges is true?

A. The electric field is never zero.

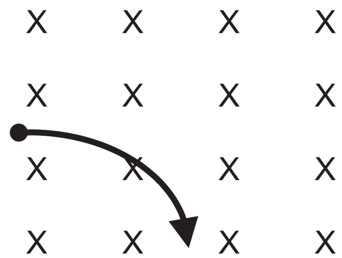
B The electric field is zero at the midpoint between the charges.

C. The electric field at the midpoint between the charges is to the right.

D The electric field at the midpoint between the charges is to the left.

Question 5.

A decaying radioactive source is emitting radiation into a magnetic field. The radiation is tracked and follows the path in the direction of the arrow shown in the diagram on the right. The magnetic field is into the page.



The radiation could be:

A. an alpha particle

B. a neutron

C. an electron

D. a gamma-ray

Question 6.

A siren on an emergency vehicle is emitting sound at a frequency of 684 Hz. A student, who is stationary, listens to the siren and hears it as a sound of frequency 650 Hz. This can **best** be explained by:

A. the emergency vehicle is travelling towards the student

B. the emergency vehicle is travelling away from the student

C. the student's hearing is faulty

D. a strong wind blowing the sound towards the student

Question 7.

The planet Mars has a mass of 6.42×10^{23} kg and the average **diameter** of Mars is 6.78×10^{6} m.

What is the magnitude of the gravitational field on the surface of Mars?

A. 0.93 N kg^{-1}

B. 1.2 N kg^{-1}

C. 6.2 N kg^{-1}

D. 3.7 N kg^{-1}

Question 8.

Which one of the following statements is **incorrect**?

A. Electric fields point towards a negative charge.

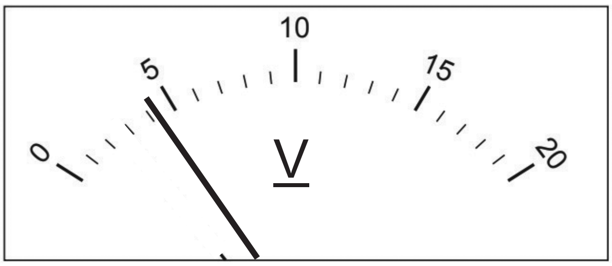
B. Magnetic fields point from a North pole to a South pole.

C. Electric fields are measured by the resulting force on a test charge.

D. Gravitational fields start and finish at the central mass.

Question 9.

The diagram on the right shows a properly calibrated voltmeter with its pointer registering a voltage of close to 4 V. Which one of the following is the most appropriate measure of the uncertainty of this pointer?



A. 0.05 V

B. 0.5 V

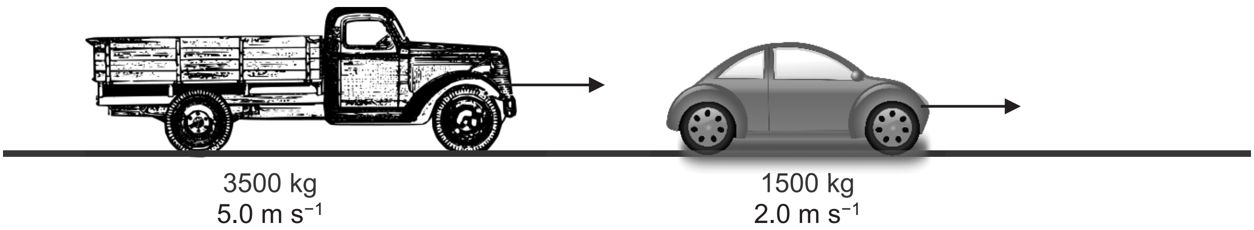
C. 4.2 V

D. 1 V

Questions 10 & 11 refer to the following information

A truck has a mass of 3500 kg and is travelling at 5.0 m s^{-1} to the right when it runs into the back of a car of mass 1500 kg travelling at 2.0 m s^{-1} in the same direction. The two vehicles are joined together during the crash.

Before the collision



After the collision

Question 10.

What is the best estimate of the speed of the two connected vehicles the instant after the crash?

A. 1.4 m s^{-1}

B. 2.0 m s^{-1}

C. 4.1 m s^{-1}

D. 5.9 m s^{-1}

Question 11.

Which one of the following best describes the magnitude of the force exerted by the truck (T) on the car (C) ($F_{T\ on\ C}$) and the magnitude of the force exerted by the car on the truck ($F_{C\ on\ T}$) at the instant of collision?

A. $F_{T\ on\ C} < F_{C\ on\ T}$

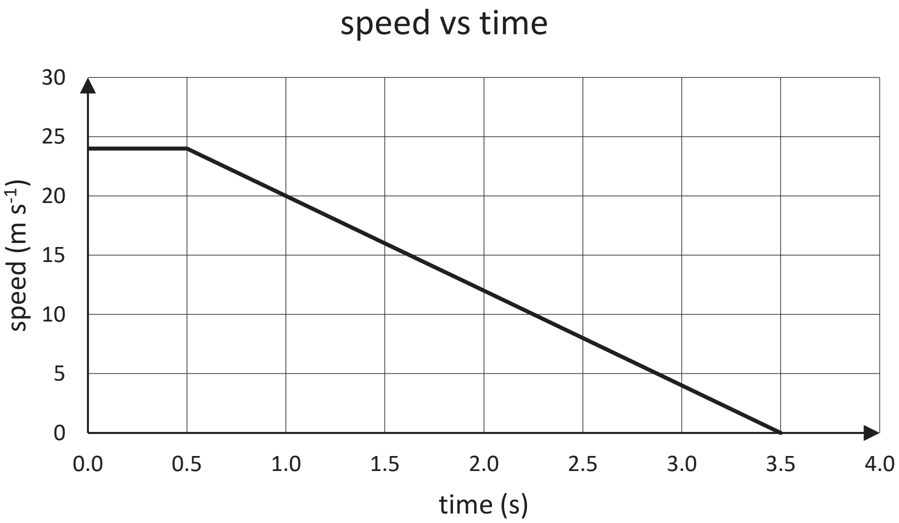
B. $F_{T\ on\ C} > F_{C\ on\ T}$

C. $F_{T\ on\ C} = F_{C\ on\ T}$

D. the magnitude of the two forces cannot be determined

Questions 12 & 13 refer to the following information

Brian is driving a car of mass 1200 kg at 24 m s^{-1} when he sees a child in the middle of the road ahead of him. He takes 0.50 s to react and then brakes to a stop with a constant braking force. This motion is shown in the speed – time graph below. Brian manages to stop before hitting the child.



Question 12.

How far does Brian's car travel from the moment he sees the child (t = 0 s) to coming to a stop?

A. 12 m

B. 36 m

C. 42 m

D. 48 m

Question 13.

Which one of the following is closest to the magnitude of the braking force acting on Brian's car during his braking time?

A. 9.6×10^3 N

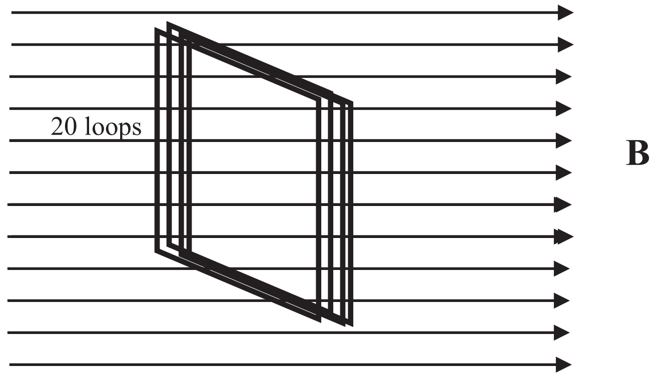
B. 8.6×10^3 N

C. 8.3×10^3 N

D. 7.1×10^3 N

Question 14.

A rectangular coil consisting of 20 loops has a length of 5.0 cm and a width of 4.0 cm. The coil is placed in a uniform magnetic field B of strength 0.06 T so that the plane of the coil is perpendicular to the field direction, as shown in the diagram below.



The magnetic flux through the coil is closest to:

A. 0 Wb

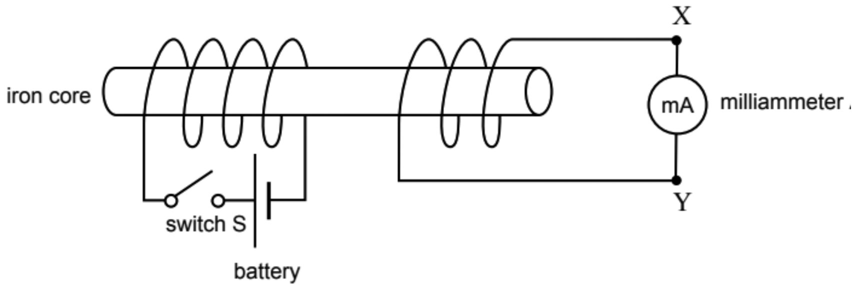
B. 1.2×10^{-4} Wb

C. 2.4×10^{-3} Wb

D. 0.12 Wb

Question 15.

To study Lenz's law, students set up the following experiment using the circuit shown below.



Initially switch S is open. Which one of the following will **best** describe the current through the milliammeter A, when the switch S is closed?

A. Current flows momentarily in the direction X to Y.

B. Current flows momentarily in the direction Y to X.

C. Current flows continuously in the direction X to Y.

D. Current flows continuously in the direction Y to X.

Question 16.

An ideal transformer has 2000 turns in the primary coil and 80 turns in the secondary coil. Which of the following input voltages will give a secondary voltage of 12 V AC?

A. 300 V DC

B. 300 V AC

C. 12 V AC

D. none

Question 17.

A spaceship is travelling away from Earth and towards a space station when the captain of the ship sends a radio signal, as shown in the diagram below. The rocket is travelling at a constant high velocity, V, away from the Earth,

As observed from Earth the speed of the radio signal emitted from the spaceship, where 'c' is the speed of light, is:

A. c + V

B. c − V

C. c ± V

D. c

Question 18.

Which of the following statements is **incorrect**?

A. Polarisation can only be found in transverse waves.

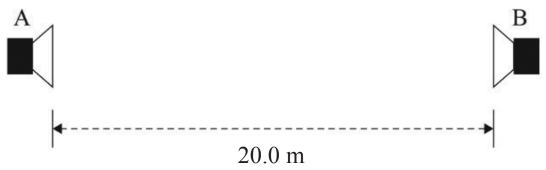
B. Longitudinal sound waves consist of compressions and rarefactions.

C. Light always travels at 3.0×10^8 m s^{-1} in a vacuum.

D. Only sound waves can produce the Doppler Effect.

Question 19.

April sets up the following experiment in a large open area. She connects two speakers that are facing each other, as shown in the diagram below. Both speakers are connected 20.0 m apart to the same signal generator and amplifier, which is producing a sound with a wavelength of 2.0 m.



April then moves from Speaker A towards Speaker B and experiences a sequence of loud and quiet regions. The loud and soft regions are created because of:

A. refraction.

B. diffraction.

C. the Doppler effect.

D. interference.

Question 20.

Quantised energy levels within atoms can best be explained by:

A. electrons transitioning to higher energy levels by emitting fixed energy photons.

B. electrons transitioning to lower energy levels by absorbing specific energy photons.

C. photons behaving as waves, with only standing waves at particular wavelengths allowed.

D. electrons behaving as waves, with only standing waves at particular wavelengths permitted.

END OF SECTION A

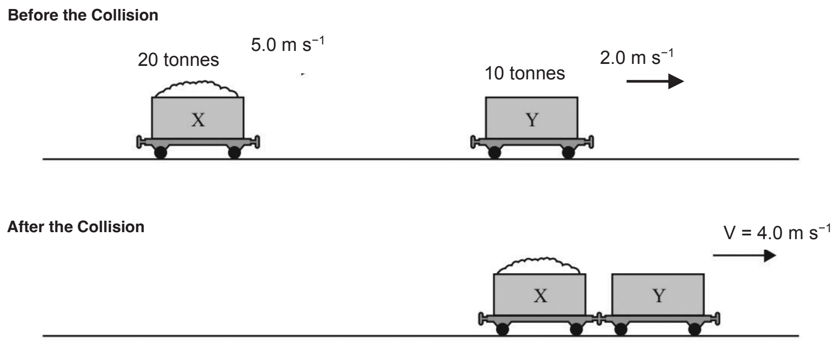
SECTION B (110 marks)

Instructions for Section B

Answer **all** questions in the spaces provided.
Where an answer box is provided, write your final answer in the box.
If the 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 diagrams are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1. (6 marks)

A loaded railway truck X of mass 20 tonnes, moving at 5.0 m s^{-1}, collides with an empty railway truck Y of mass 10 tonnes also moving to the right at 2.0 ms^{-1}. After the collision the trucks are joined together and move off as one at 4.0 m s^{-1}. The situation is shown in the diagram below.



a. Is this collision of the railway trucks elastic or inelastic?

Circle your choice: **elastic** **inelastic**

Support your choice with appropriate calculations.

[3 marks]

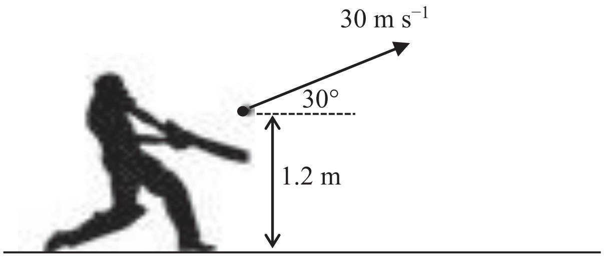
b. The truck X exerts a force on truck Y during the collision, $F_{(X \text{ on } Y)}$ of 12 kN. What is the time taken for this collision to occur?

s

[3 marks]

Question 2. (9 marks)

A batter plays a cracking shot that leaves the bat at a height of 1.2 m above the ground. The ball leaves the bat with a velocity of 30 m s^{-1} at an angle of 30° to the horizontal, heading for the boundary of the ground. Assume that the cricket ground is flat.



a. How far above the ground level was the maximum height reached by the ball?

m

[3 marks]

b. How long was the ball in the air from the moment it left the bat until it returned to the ground? Name one very important assumption you are making in your calculation.

s

Assmption

[4 marks]

c. If the boundary fence of the cricket ground was 72 m away from where the ball left the bat, did the batter's shot go over the boundary before hitting the ground?
You must show appropriate working to support your choice to obtain any marks.

C***ircle your choice***: **YES** **NO**

[2 marks]

Question 3. (7 marks)

SpaceX launches a space communications satellite into orbit at an altitude of 500 km above the Earth's surface. Assume that the satellite's orbit is a circular orbit.

a. What is the orbital radius of the satellite?

m

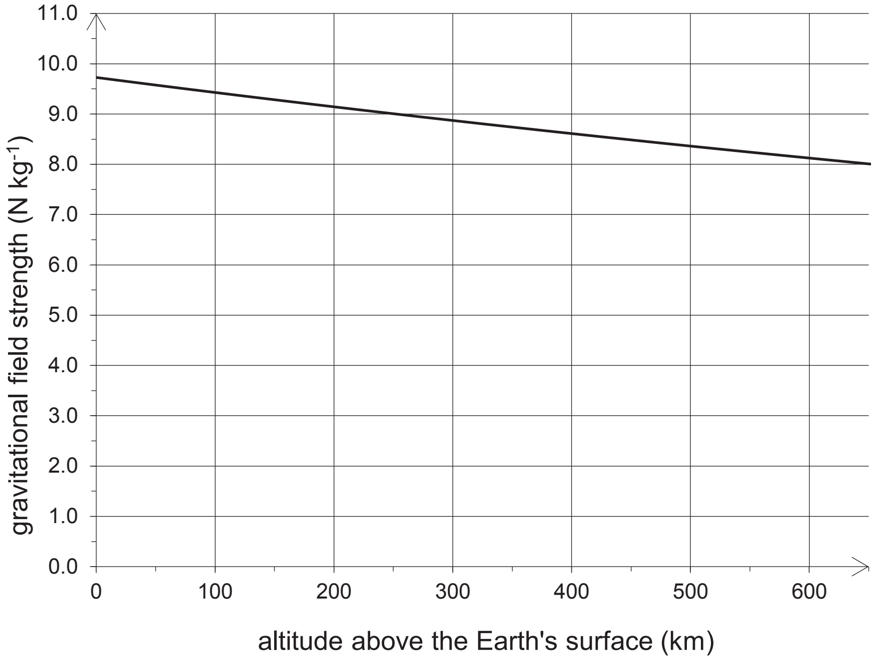
[1 mark]

b. Calculate the orbital period of the satellite correct to three significant figures.
Show your working.

s

[3 marks]

c. The graph below shows the strength of the Earth's gravitational field, g, as a function of orbital altitude, h, above the surface of the Earth.



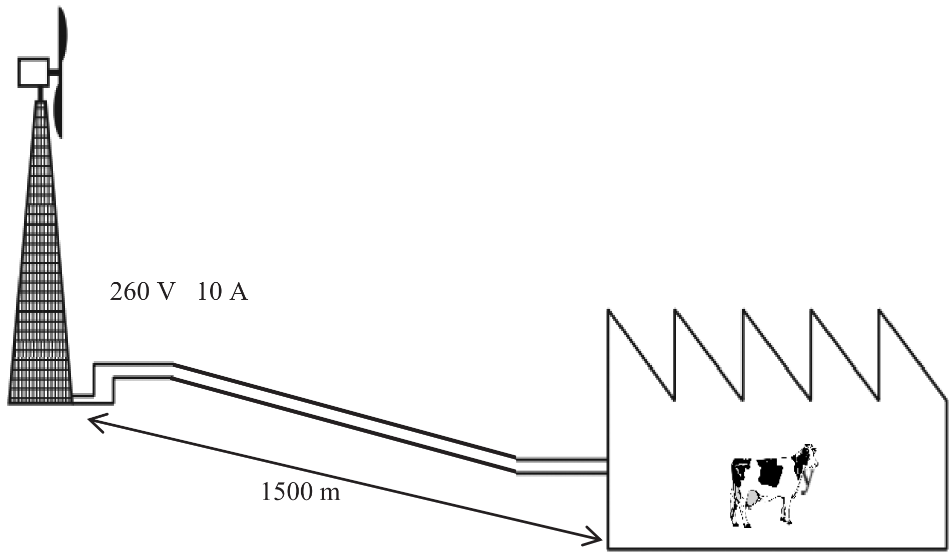
Determine the change in gravitational potential energy of the satellite as it travels from the Earth's surface to its orbital altitude of 500 km above the Earth's surface.
The mass of the satellite is 120 kg.

J

[3 marks]

Question 4. (9 marks)

In order to become less reliant on fossil fuel energy, a farmer installs a wind generator to provide power to run his dairy. The wind generator is located on top of a hill 1500 m away from the dairy. When there is an average wind blowing steadily, the generator produces an RMS voltage of 260 V and an RMS current of 10 A.



a. What RMS power is being produced by the wind generator?

W

[2 marks]

b. If the dairy receives RMS 240 V, what is the total resistance in the transmission wires between the generator and the dairy?

Ω

[2 marks]

c. What is the power lost in the transmission lines?

W

[2 marks]

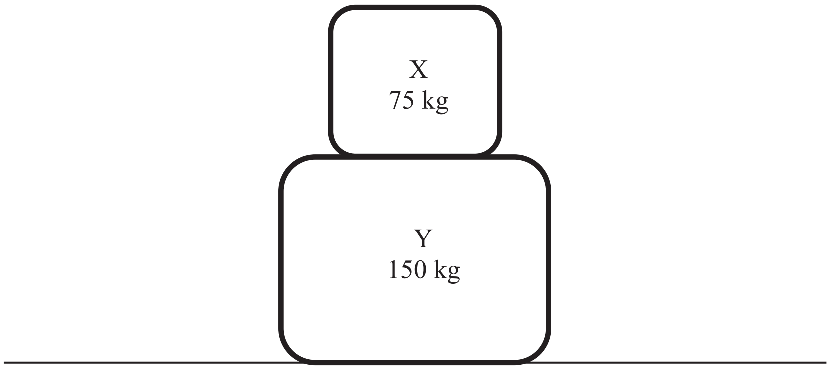
d. In order to improve efficiency, the farmer decides to limit transmission energy loss by installing two transformers: a step-up transformer with a turns ratio of 1:20 at the wind generator and a step-down transformer with a turns ratio of 20:1 at the factory. Each transformer can be considered ideal. With the installation of the transformers, determine the power, in watts, that is now lost in the transmission lines.

W

[3 marks]

Question 5. (6 marks)

Two boxes (X & Y) are placed one on top of the other, stationary on a floor.
Box X has a mass of 75 kg and Box Y a mass of 150 kg.



a. What is the magnitude of the net force acting on box Y?

N

[1 mark]

b. What is the magnitude of the force of the floor acting on Box Y?

N

[2 marks]

c. What is the magnitude of the force of Box X acting on Box Y?

N

[2 marks]

PHYSICS

Trial Examination

FORMULA SHEET

Instructions

This formula sheet is provided for your reference.

Detach this formula sheet before commencing the trial examination.

Motion and related energy transformations

velocity; acceleration	$v = \frac{\Delta s}{\Delta t}$; $a = \frac{\Delta v}{\Delta t}$
equations for constant acceleration	$v = u + a t$ $s = u t + ½ a t^2$ $s = v t - ½ a t^2$ $v^2 = u^2 + 2 a s$ $s = ½ (v + u) t$
Newton's second law	$\Sigma F = m a$
circular motion	$a = \frac{v^2}{r} = \frac{4 \pi^2 r}{T^2}$
Hooke's law	$F = -k \Delta x$
elastic potential energy	$E_s = ½ k (\Delta x)^2$
gravitational potential energy near the surface of Earth	$E_g = m g \Delta h$
kinetic energy	$E_k = ½ m v^2$
Newton's law of universal gravitation	$F = G \frac{M_1 M_2}{r^2}$
gravitational field	$g = G \frac{M}{r^2}$
impulse	$I = F \Delta t$
momentum	$p = m v$
Lorentz factor	$\gamma = \left(1 - \frac{v^2}{c^2}\right)^{-\frac{1}{2}}$
time dilation	$t = t_o \gamma$
length contraction	$L = \frac{L_o}{\gamma}$
rest energy	$E_{rest} = m c^2$
relativistic total energy	$E_{total} = \gamma m c^2$
relativistic kinetic energy	$E_k = (\gamma - 1) m c^2$

Fields and application of field concepts

electric field between charged plates	$E = \frac{V}{d}$
energy transformations of charges in an electric field	$\frac{1}{2} m v^2 = q V$
field of a point charge	$E = \frac{k q}{r^2}$
force on an electric charge	$F = q E$
Coulomb's law	$F = \frac{k q_1 q_2}{r^2}$
magnetic force on a moving charge	$F = q v B$
magnetic force on a current carrying conductor	$F = n I l B$
radius of a charged particle in a magnetic field	$r = \frac{m v}{q B}$

Generation and transmission of electricity

voltage; power	$V = R I$; $P = V I = I^2 R$
resistors in series	$R_T = R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$
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 = $(n - \frac{1}{2}) \lambda$
fringe spacing	$\Delta x = \frac{\lambda L}{d}$
Snell's law	$n_1 \sin \theta_1 = n_2 \sin \theta_2$
refractive index and wave speed	$n_1 v_1 = n_2 v_2$

The nature of light and matter

photoelectric effect	$E_{\text{k max}} = hf - \phi$
photon energy	$E = hf$
photon momentum	$p = \frac{h}{\lambda}$
de Broglie wavelength	$\lambda = \frac{h}{p}$
Heisenberg's uncertainty principle	$\Delta p_x \Delta x \geq \frac{h}{4\pi}$

Data

acceleration due to gravity at Earth's surface	$g = 9.8\ \text{m s}^{-2}$
mass of the electron	$m_e = 9.1 \times 10^{-31}\ \text{kg}$
magnitude of the charge on the electron	$e = 1.6 \times 10^{-19}\ \text{C}$
Planck's constant	$h = 6.63 \times 10^{-34}\ \text{J s}$ $h = 4.14 \times 10^{-15}\ \text{eV s}$
speed of light in a vacuum	$c = 3.0 \times 10^{8}\ \text{m s}^{-1}$
universal gravitation constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
mass of Earth	$M_E = 5.98 \times 10^{24}\ \text{kg}$
radius of Earth	$R_E = 6.37 \times 10^{6}\ \text{m}$
Coulomb constant	$k = 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$

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}	1 tonne = 10^{3} kg

END OF FORMULA SHEET

d. In terms of Newton's 3rd Law what is the action−reaction pair to the force due to the Earth's gravity acting on Box Y?

Explain your answer.

[1 mark]

Question 6. (4 marks)

A ball is carrying a positive charge. The ball is illustrated in the diagram below.

a. An electric field is created in the space surrounding the ball. On the diagram above, carefully draw in at least 6 field lines indicating the shape and strength of the electric field around the charged ball.

[2 marks]

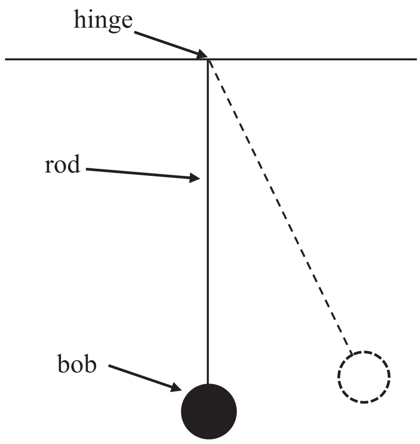
b. What is the magnitude of the electric field at a distance of 6.0 mm from the centre of the charged ball if the charged ball carries a positive charge of 4.8×10^{-19}C?

V m^{-1}

[2 marks]

Question 7. (14 marks)

Some Physics students are given an assignment to investigate the motion of a simple pendulum. This pendulum consists of a thin rod, which can be varied in length, and a 1.0 kg 'bob' (the swinging mass at the end of the rod). The pendulum is hung from a hinge, which is considered friction free, and then pulled to the side and allowed to swing.



To measure the period (T) the students allow the pendulum to make several swings before measuring how long it takes for the pendulum to make a further 20 swings.

a. Suggest why the students allowed the pendulum to make several swings before they started their time measurements.

[1 mark]

b. Apart from the mass of the bob and the length of the pendulum, suggest another possible variable that should be considered in this experiment.

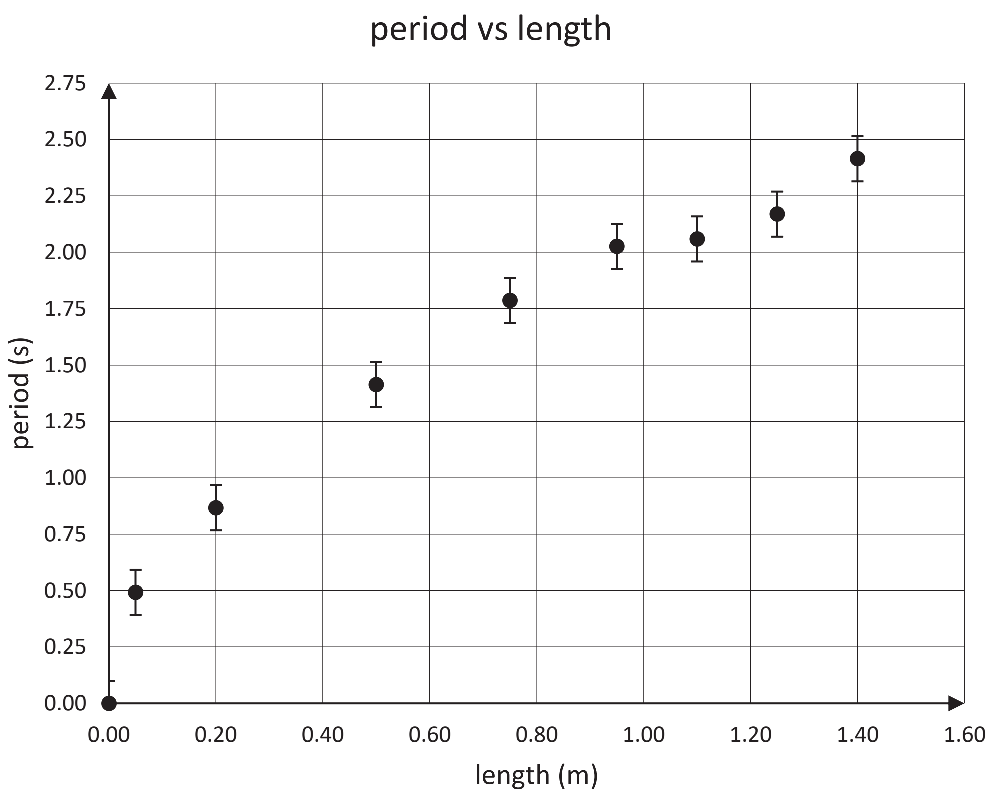
[1 mark]

The following results were obtained by the students.

L (m)	20T (s)	T (s)
0.00	0.0	0.0
0.05	9.8	
0.20	17.3	0.87
0.50	28.3	1.41
0.75	35.7	1.79
0.95	40.5	2.03
1.10	41.2	
1.25	43.4	2.17
1.40	48.3	2.41

c. In the table above, fill in the two missing values for T in the right hand column. [1 mark]

These results were plotted as shown on the following graph.



d. On the graph above, draw in a line or curve of best fit. [2 marks]

From the graph it can be seen that the length measurement was quite accurate compared to the scale but that the Period measurement had some variations as indicated by the uncertainty bars.

e. **Read from the graph** the best estimate of the period of the pendulum for a length of 0.60 m including the appropriate uncertainty range is:

s	±

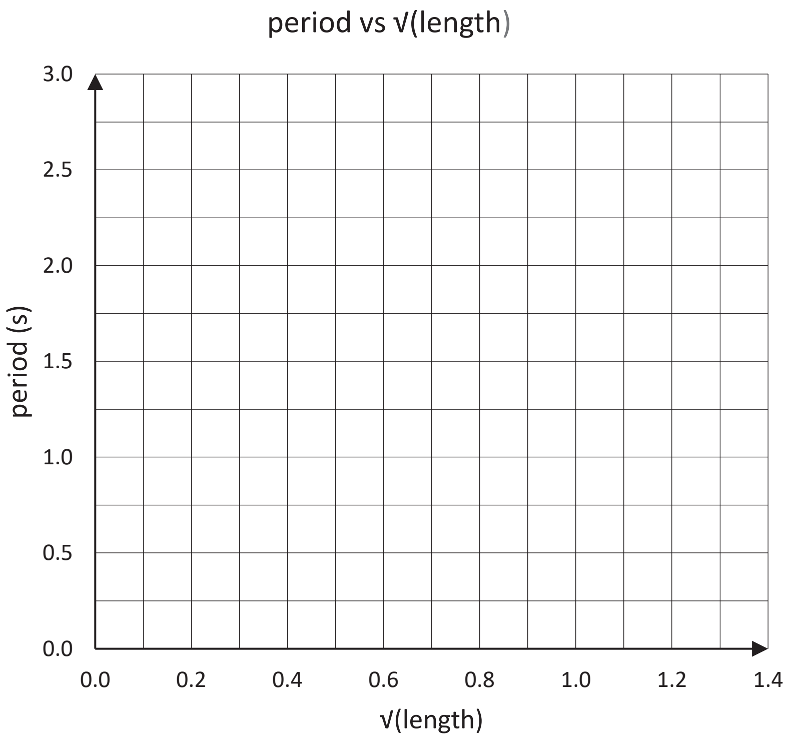
[2 marks]

One of the students completed some research on pendulums and came back to the group with the suggestion that there is a relationship between the pendulum period and the pendulum length. She suggested that the relationship between period and length is $T \propto \sqrt{L}$

To investigate this the students created the following table:

$\sqrt{L}$ ($m^{1/2}$)	T (s)
0.00	0.0
0.2	0.5
0.5	0.9
0.7	1.4
0.9	1.8
1.0	2.0
1.1	2.1
1.2	2.4

f. Plot these points on the following axes **and** draw a **linear** line of best fit. [3 marks]



g. Find the value of the constant of proportionality between T and $\sqrt{L}$.

[2 marks]

h. Hence use this constant value to predict the period of a pendulum of length 2.0 m.

s

[2 marks]

Question 8. (4 marks)

An astronaut has left the Earth and is travelling on a spaceship at 0.600c ($\gamma = 1.25$) directly towards the star known as Proxima Centauri which is 4.25 light-years from the Earth, as measured by observers on Earth. The spaceship has a length of 120 m when measured on Earth prior to the voyage.

a. How long is the ship when measured by the astronaut as it is travelling at 0.600c ?

m

[1 mark]

b. How long will the trip to Alpha Centauri take according to a clock that the astronaut is carrying on his spaceship that can measure years? Show your working.

years

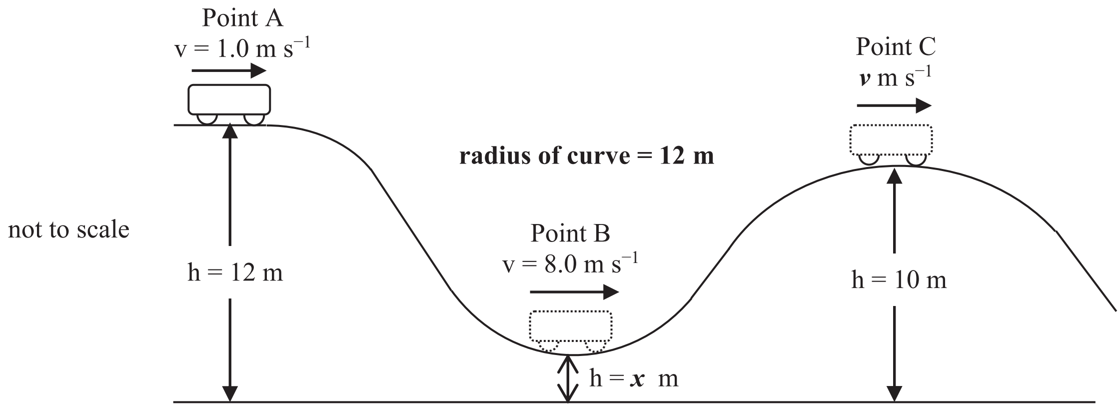
[2 marks]

c. Is the trip time measured by the astronaut considered to be proper time? Explain your reasoning.

[1 mark]

Question 9. (8 marks)

A roller coaster goes over a series of humps. The humps have a circular track at the top and at the bottom joined by straight sections of track. A 75 kg passenger is in the roller coaster car at Point A, travelling at 1.0 ms^{-1} to the right. The radius of the curve is 12 m.



a. What is the height of the track (***x*** m) at point B? (Assume no energy losses.)

m

[3 marks]

b. A 75 kg passenger is at the bottom at Point B, travelling a 8.0 m s^{-1}. What is the magnitude of the force of the roller coaster car seat on the passenger at this point?

N

[2 marks]

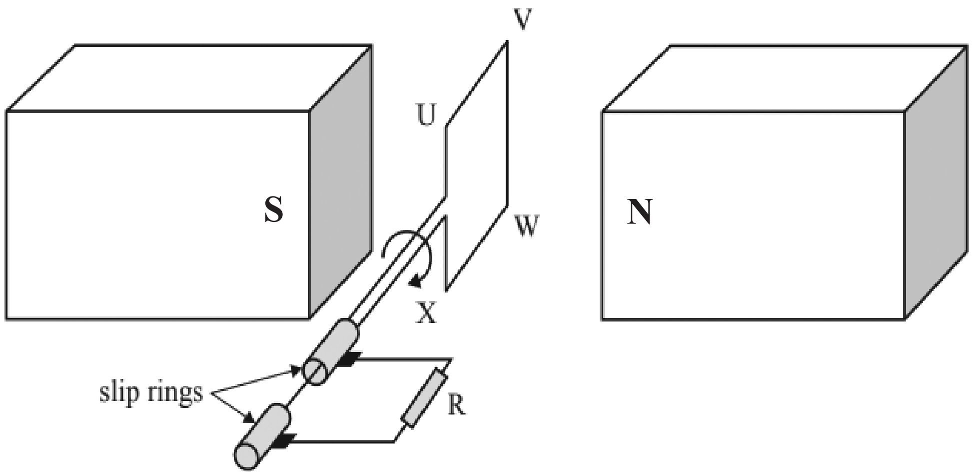
c. What is the speed ***v*** of the roller coaster at point C?

m s^{-1}

[3 marks]

Question 10. (7 marks)

A simple alternator is shown in the diagram below.



When the coil is rotating steadily, it takes 50 ms for each complete rotation and produces a peak EMF of 3.2 V.

a. Calculate the frequency of this voltage.

Hz

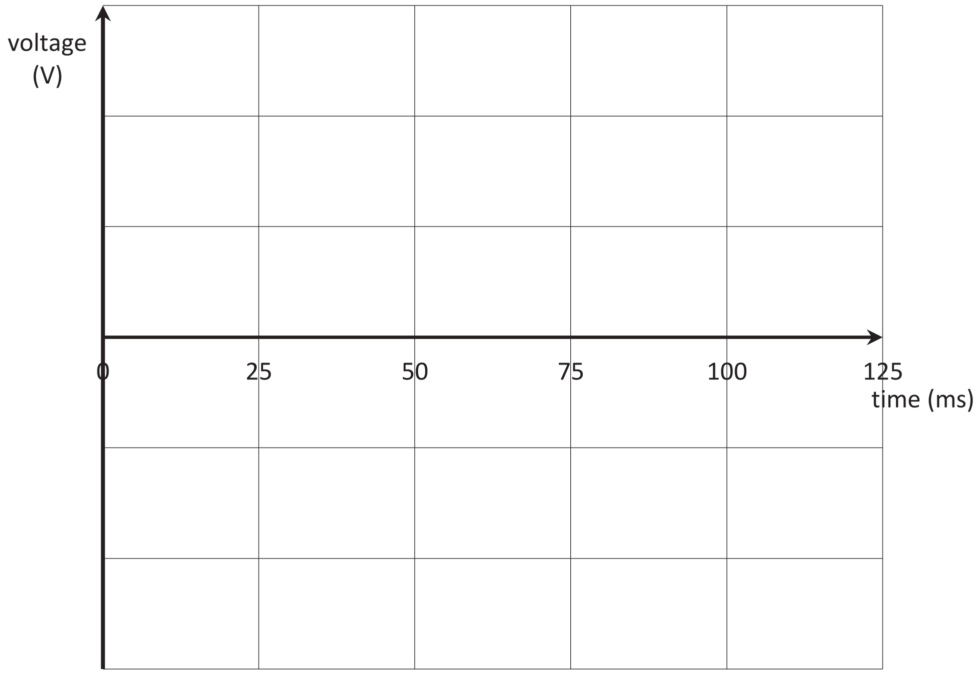
[1 mark]

b. Calculate the RMS value of the AC EMF.

V

[1 mark]

c. On the following axes draw **two** cycles of this rotation starting from the position in the diagram, showing appropriate values on the *y* (voltage) axis.



[3 marks]

d. Suggest **two** ways in which the magnitude of the EMF produced by the alternator can be increased.

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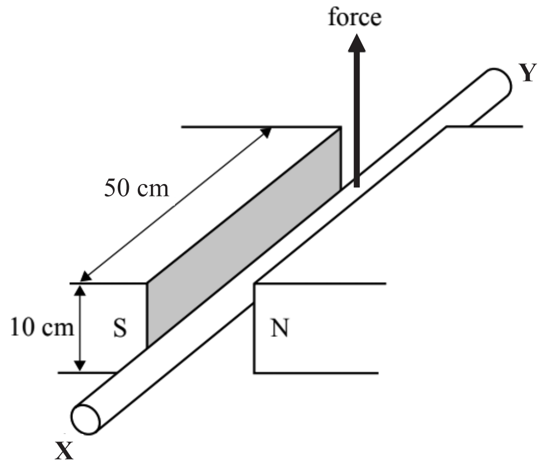
[2 marks]

Question 11. (5 marks)

The diagram below shows a magnet with pole pieces that are each 50 cm × 10 cm. The uniform magnetic field strength between the poles is 2.0×10^{-3} T, and zero outside the poles. A conducting rod, XY, carrying a current of 2.5 A, is placed between the poles as shown in the diagram. The force due to the magnetic field on the rod is upwards.



a. In which direction, X to Y or Y to X, is the current flowing in the rod?

Circle your choice: **X to Y** **Y to X** [1 mark]

b. What is the magnitude of the force on the rod? Show your working.

N

[2 marks]

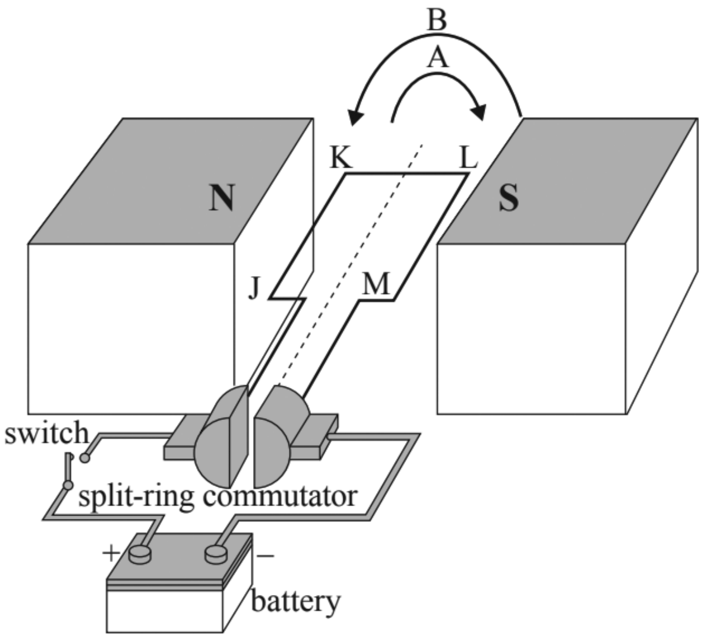
c. What is the total magnetic flux between the pole pieces? Show your working.

Wb

[2 marks]

Question 12. (4 marks)

The following diagram shows a small DC electric motor, powered by a battery through a split-ring commutator.



a. The current is switched on when the coil is stationary in the position shown in the diagram. The coil begins to rotate. Which of the directions of rotation (A or B) will the coil initially move?

***Circle your choice*:** **A** **B**

Explain your choice.

____

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[2 marks]

b. When the coil travels through 90° to the point where side KL is vertical, explain what then happens to the coil **and** why.

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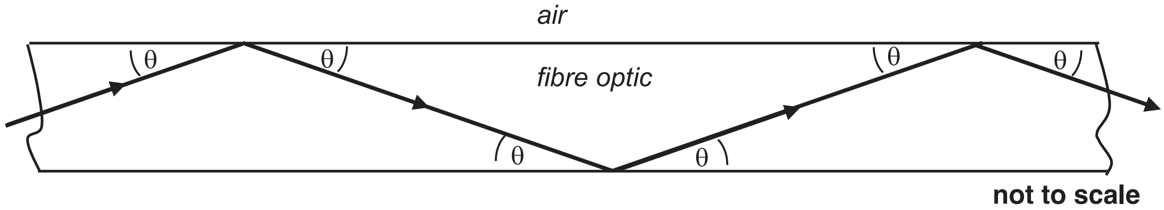
[2 marks]

Question 13. (4 marks)

A simple fibre optic pipe consists of a tube of transparent material as shown below.

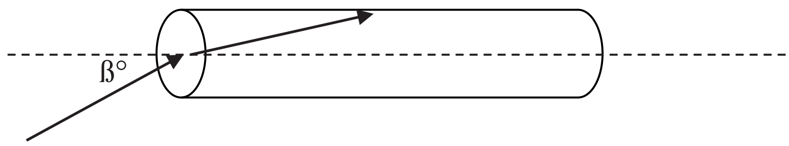


The maximum angle between the light beam and the tube surface for which the beam is contained within the tube is θ = 30°. Take $n_{\text{air}} = 1.0$

a. What is the refractive index for this particular fibre optic material?

[2 marks]

ß° is the acceptance angle for the light entering the fibre optic so that it travels down the pipe.



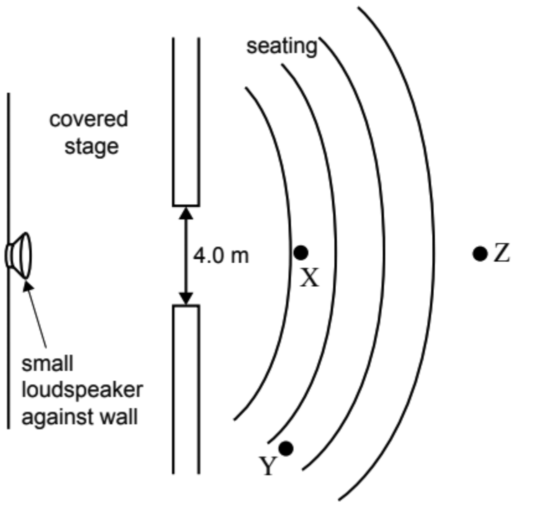
b. What is the maximum possible value for ß°?

°

[2 marks]

Question 14. (5 marks)

Two sound engineers are testing the acoustics of an outdoor performance area. The area consists of a covered stage and an open-air seating area, as shown in the diagram below. The width of the stage opening is 4.0 m.



not to scale

The sound engineers use two signals in turn, one of 200 Hz and one of 5000 Hz, from the small loudspeaker centrally located at the rear of the stage. The sound intensity level at the centre of the seating area (point X) with either of the frequencies is equal.

a. What is the wavelength for each of the two frequencies?
Take the speed of sound to be 340 m s^{-1}.

i) $f = 200$ Hz

m

[1 mark]

ii) $f = 5000$ Hz

m

[1 mark]

The sound engineers then measure the sound intensity level of the 200 Hz and 5000 Hz signals in turn at point Y, and find the levels are different.

b. Which of the frequencies will be louder?

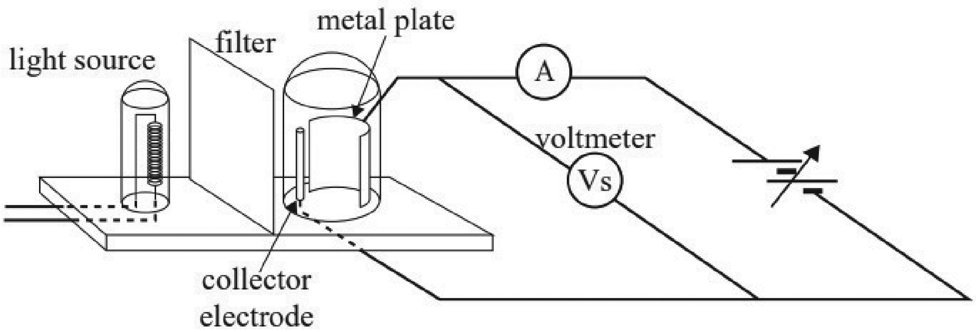
Circle your choice: **200 Hz** **5000 Hz**

Explain your choice.

[3 marks]

Question 15. (7 marks)

Michelle is carrying out photoelectric effect experiments. Her apparatus is shown in the diagram below.



Michelle can choose between two metal plates in the photoelectric cell. One plate is made of zinc and the other is made of aluminium. Michelle uses light of a particular frequency to firstly illuminate the zinc plate and then the aluminium plate but finds that photoelectrons are emitted only by the zinc plate.

It is known that the threshold frequency of zinc for photoelectric emission is 7.40×10^{14} Hz and that of aluminium is 9.90×10^{14} Hz.

a. Calculate the maximum wavelength (in nm) of the light required to eject photoelectrons from the zinc plate.

nm

[2 marks]

In an attempt to eject photoelectrons from the aluminium plate, Michelle increases the intensity of the light beam, but still finds that no photoelectrons are emitted.

b. Explain how this observation supports the particle model of light, but not the wave model of light.

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[2 marks]

In another photoelectric experiment, Michelle uses light with a frequency of 7.50×10^{14} Hz to eject photoelectrons from a sodium surface. The work function of sodium is 2.28 eV.

c. Calculate the maximum kinetic energy (in eV) of these photoelectrons.

eV

[2 marks]

d. Calculate the stopping voltage that would be required to just prevent the most energetic electrons from reaching the collector electrode.

V

[1 mark]

Question 16. (6 marks)

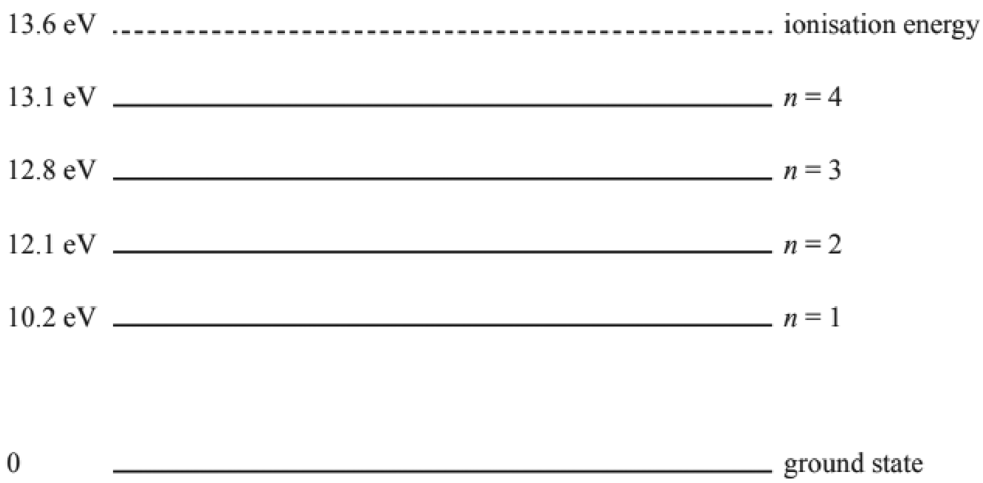
The visible spectrum of the hydrogen atom is observed to emit photons of energy 2.6 eV.

a. Calculate the wavelength of an emission spectral line corresponding to this photon energy.

m

[2 marks]

The energy levels for the hydrogen atom are shown in the diagram below.



not to scale

b. Draw an arrow on the diagram to indicate the transition that could cause the 2.6 eV spectral line.

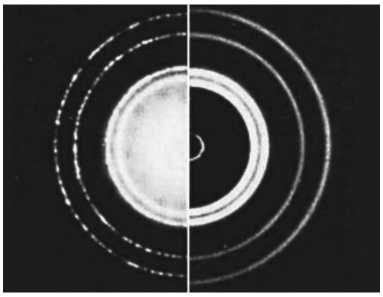
[1 mark]

c. A hydrogen atom is excited to the 12.1 eV energy level. List the possible photon energies (in eV) that could be emitted as it returns to its ground state.

[3 marks]

Question 17. (5 marks)

The diffraction patterns for X-rays and electrons through a thin polycrystalline aluminium foil have been combined in the diagram below, which shows an electron diffraction pattern on the left and an X-ray diffraction pattern on the right. The images are to the same scale.
The X-rays have a wavelength of 0.0123 nm.



a. Calculate the energy of the electrons in keV.
Explain your assumption and show your working.

keV

[3 marks]

b. Explain how this experiment is an example of wave-particle duality, with regard to the electron.

[2 marks]

END OF TRIAL EXAMINATION