Student Number

PENRITH SELECTIVE HIGH SCHOOL

2024 TRIAL HIGHER SCHOOL CERTIFICATE

PHYSICS

Task Weighting: 30 %

General Instructions:

- Reading Time – 5 minutes
- Working time – 180 minutes
- Write using black or blue pen
- Draw diagrams & graphs using a pencil and, where appropriate, ruler or protractor.
- NESA approved calculators may be used.
- Write your student NUMBER at the top of this and every answer page.

Total Marks: 100

Section I
20 marks
Pages 3 - 15
Questions 1 - 20

Section II
80 marks
Pages 16 - 35
Questions 21 - 32

Total pages this exam: 32

TOTAL /100

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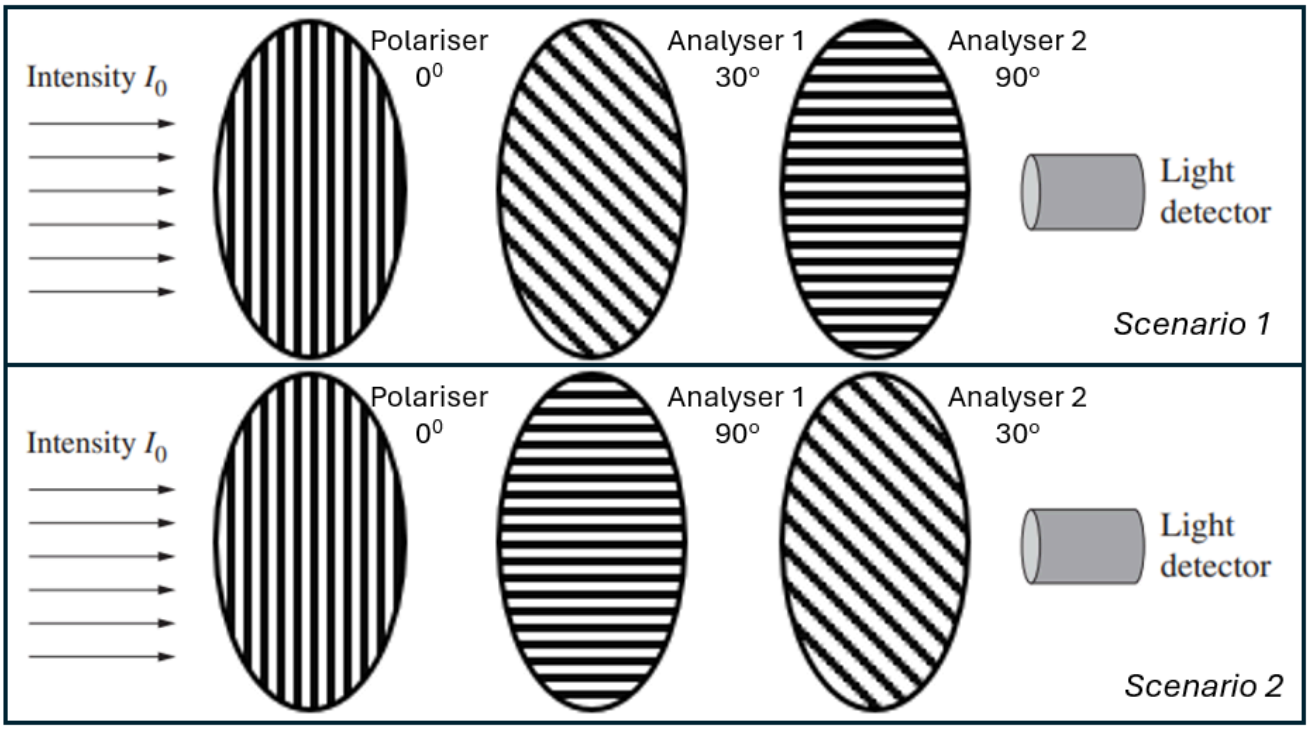
SECTION I : 20 MARKS

1 Light of intensity I_0 is incident on a polariser as shown in the diagram below. There are two analysers placed after the polariser.



Which scenario wil measure some non-zero light intensity at the detector?

A Scenario 1 will detect a light intensity.

B Scenario 2 will detect a light intensity.

C Both scenarios will detect a light intensity.

D Both scenarios will not detect a light intensity.

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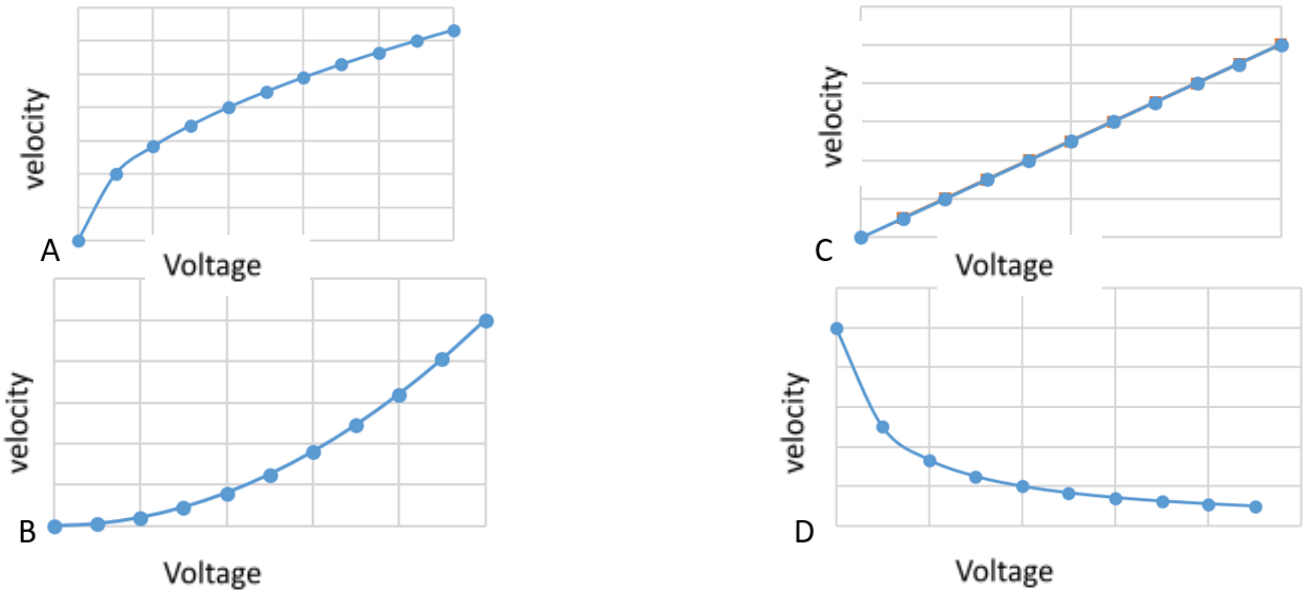
2 Choose the graph below that correctly models how the velocity of a charged particle will change when it is placed between electrical plates and the voltage applied to the plates is increased.



Consider a planet orbiting the Sun in an elliptical path according to Kepler's laws. Which of the following statements correctly applies Kepler's laws and the law of universal gravitation?

A The planet moves fastest when it is farthest from the Sun due to the weaker gravitational pull.

B The gravitational force between the planet and the Sun remains constant throughout the orbit.

C The square of the orbital period of the planet is directly proportional to the cube of the semi-major axis of its orbit.

D The area swept out by a line connecting the planet to the Sun is constant for equal time intervals only if the orbit is circular.

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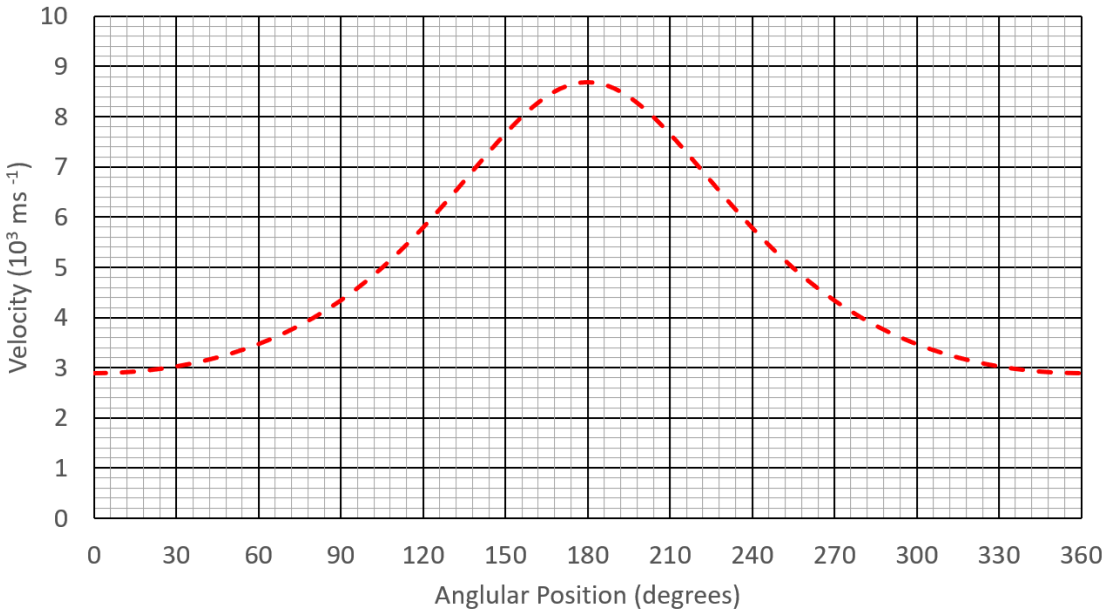
Use the graph below to answer questions 3 and 4

3 The following graph demonstrates the velocity of a planetoid orbiting some star equal to 1 solar mass (2x10^30 Kg)



Which statement best describes the motion of the planetoid?

A Circular orbit

B Elliptical orbit

C Hyperbolic orbit

D Protracting orbit

4 What is distance to the planetoid from the star when it has completed 180 degrees of its orbit.

A 1.8×10^{12} m

B 1.6×10^{13} m

C 1.8×10^{18} m

D 1.6×10^{19} m

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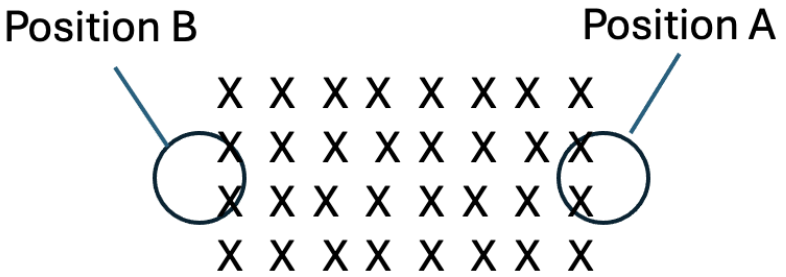
5 A ring-shaped conductor is pulled through an external magnetic field from Position A to Position B. Identify the direction of the induced current as it moves through Position A and Position B.



In what direction will a current flow in the ring at each position?

	Position A	**Position B**
A	Anticlockwise	Anticlockwise
B	Anticlockwise	Clockwise
C	Clockwise	Clockwise
D	Clockwise	Anticlockwise

6 An AC induction motor operates using alternating current to produce mechanical rotation. Which of the following statements correctly describes a key component and its function in an AC induction motor?

A The stator is the rotating part that converts electrical energy into mechanical energy.

B The rotor is a stationary part that creates a magnetic field to induce current in the stator.

C The stator is a stationary part that creates a rotating magnetic field to induce current in the rotor.

D The commutator is used to switch the direction of current in the rotor to maintain continuous rotation.

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7 The Rydberg equation is used to predict the wavelengths of spectral lines in hydrogen.

A spectral line in the hydrogen spectrum is observed at a wavelength of 486 nm. Which electronic transition in the hydrogen atom does this wavelength correspond to?

A $(n_2 = 3)$ to $(n_1 = 2)$

B $(n_2 = 4)$ to $(n_1 = 2)$

C $(n_2 = 2)$ to $(n_1 = 3)$

D $(n_2 = 2)$ to $(n_1 = 4)$

8 In an experiment demonstrating the photoelectric effect, light of a certain frequency is shone onto a metal surface, causing electrons to be emitted. Which of the following statements correctly describes an observation related to the photoelectric effect and its explanation?

A Increasing the intensity of the light increases the kinetic energy of the emitted electrons.

B Decreasing the frequency of the light increases the number of electrons emitted from the metal surface.

C Electrons are emitted from the metal surface only if the frequency of the incident light is above a certain threshold value.

D The photoelectric effect can be explained by the wave theory of light, where light waves transfer energy continuously to the electrons.

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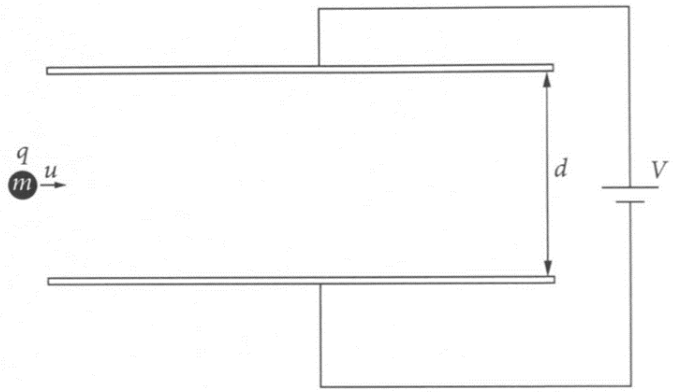
Use this information for questions 9 and 10

A Charged particle having a charge of 1mC and weighing 1 milli gram is fired with an initial velocity of 2000 m/s through the equidistant point between parallel plates. The parallel plates are separated by 0.05 m, the potential difference between the plates was 1000 V.



9 What horizontal distance is travelled by the proton?

A 0.1 m

B 0.31 m

C 0.5 m

D 3.16 m

10 What strength of a magnetic field would have to be directed perpendicular into the page to allow for the charge to travel a straight path?

A 1 T

B 5 T

C 10 T

D 15 T

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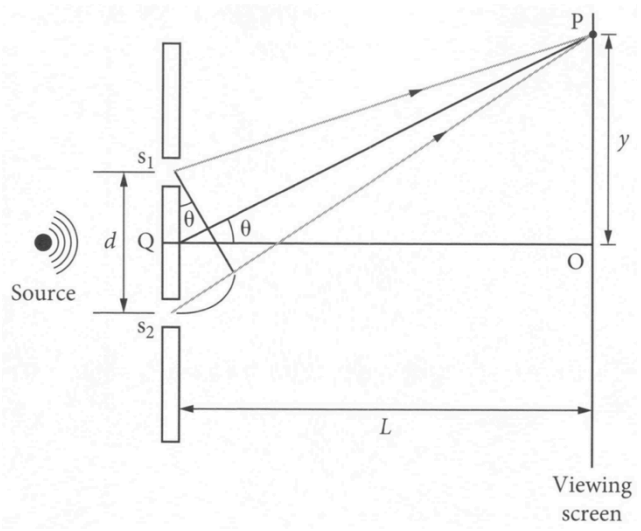
Below is a simplified diagram of the double slit experiment for the interference of light.

Use this diagram to answer questions 11 and 12



11 Choose the expression that best demonstrates the small angle of approximation relationship.

A $\frac{L}{y} = \frac{d}{m\lambda}$

B $\frac{y}{L} = \frac{d}{m\lambda}$

C $dsin\theta = \frac{L}{y}$

D $tan\theta = \frac{y}{L}$

12 If the light source has a wavelength of 600 nm and the slit width is 100 μm, calculate the value of θ.

A 0.11^{o}

B 0.34^{o}

C 0.87^{0}

D 1^{0}

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14 What is the energy equivalent of 250 mL of water?

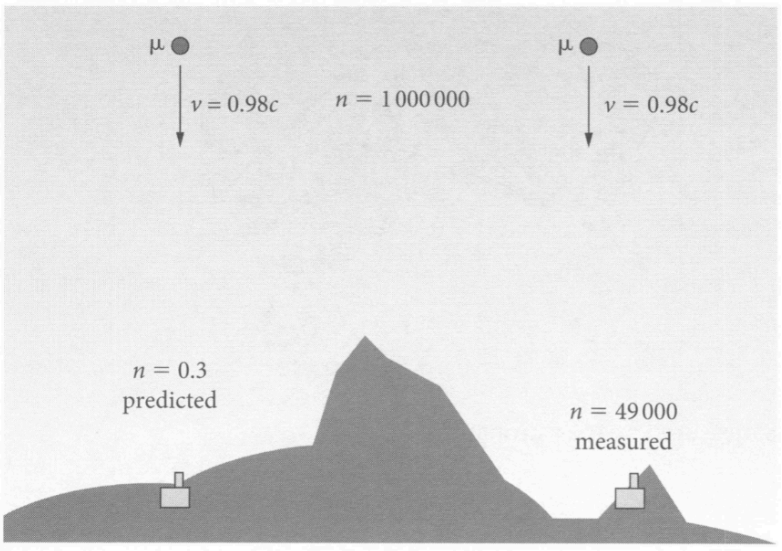
A 75 MJ

B 2.25×10^{9} MJ

C 2.25×10^{10} MJ

D 2.25×10^{12} MJ

13 Muons travel at 0.98 c. What percentage of time do they experience compared to a stationary observer?



A 10 %

B 20 %

C 40 %

D 500 %

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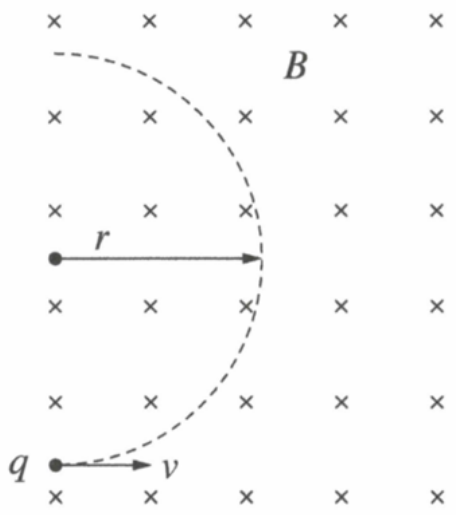
15 A charged particle, q, enters a uniform magnetic field B at velocity v. The particle follows a circular path of radius r as shown.



If the magnitude of the magnetic field were halved, the charge tripled and the velocity increased by 1.5, what would the new radius be?

A $\frac{9}{5}r$

B $3r$

C $\frac{1}{4}r$

D r

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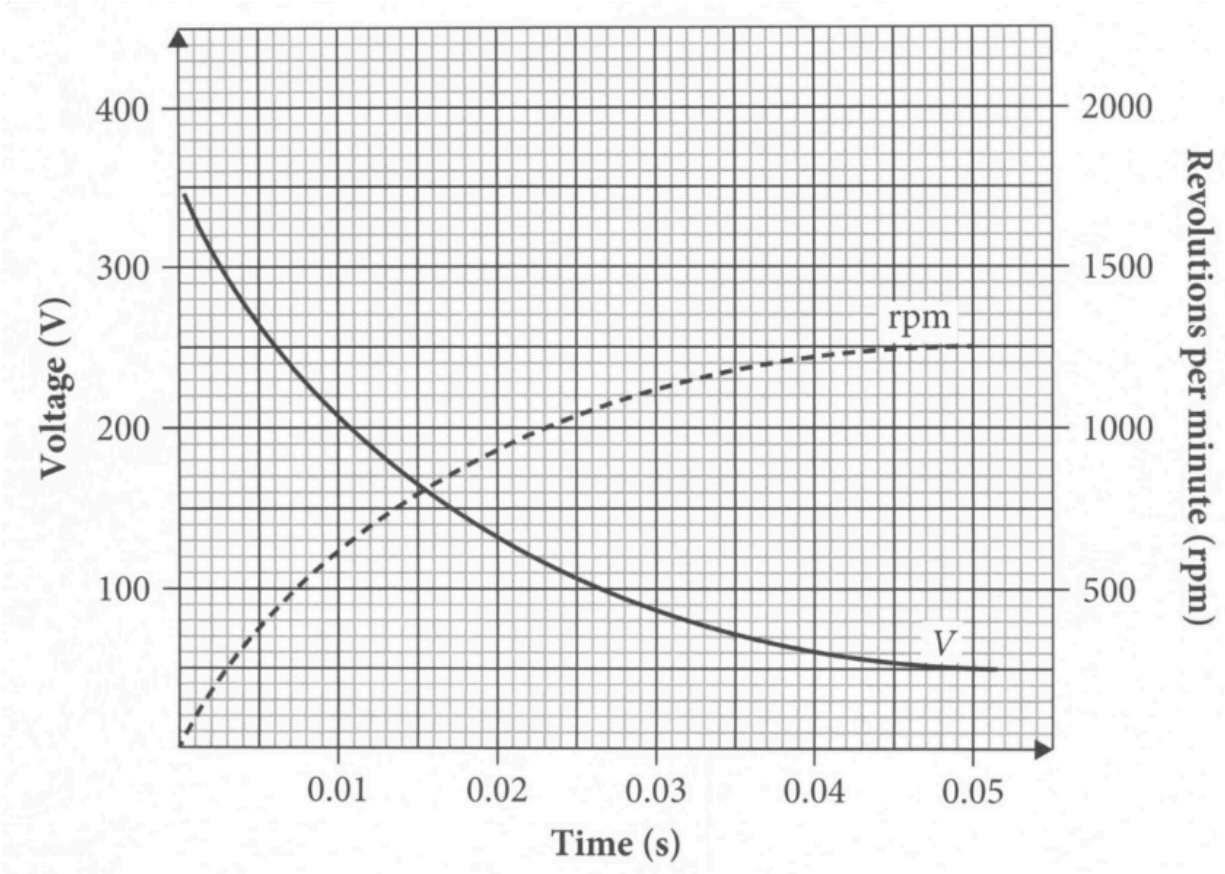
Use the graph below to answer questions 16 and 17

An electric motor was connected to a power source, and the speed and voltage across the motor were recorded as it began to spin. The data shown in the graph below was collected.



16 Which of the following best describes the interactions between the variables in the graph?

A As the motor rotates, back EMF increases, reducing the net voltage and current, decreasing acceleration.

B The motor starts with maximum net voltage; as it spins, back EMF opposes, reducing net voltage and speed.

C Initial net voltage is high; back EMF increases with speed, reducing net voltage and current, decreasing acceleration.

D The motor's rotation induces back EMF, opposing the supplied voltage, reducing net voltage and current, slowing acceleration.

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17 What is the angular velocity for the working speed of the motor?

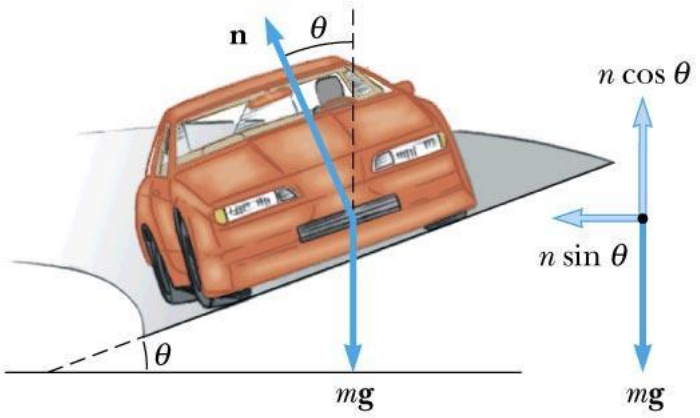
A 20π

B $\frac{100\pi}{3}$

C $\frac{80\pi}{3}$

D $\frac{25\pi}{3}$

18 At what angle should a curve of 200 m radius be banked so that no friction is required when a car travels at 60 kilometres per hour around the curve?



A 1.9º

B 7.9º

C 17.9º

D 23.9

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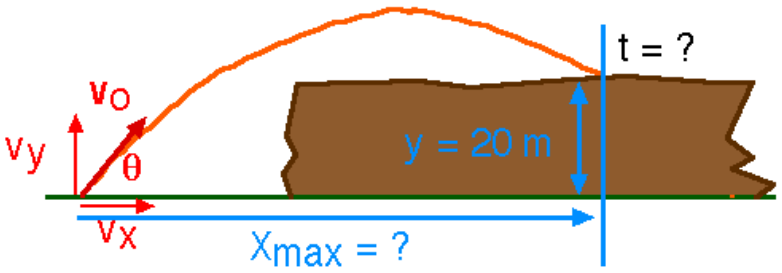
A rock is thrown with an initial speed of 30 ms^{-1} at an angle of 60° above the horizontal. As shown in the diagram it is thrown from below a landing plateau that is elevated by 20 m.



How long is the projectile in the air?

A 0.9 s

B 2.7 s

C 4.4 s

D 5.4 s

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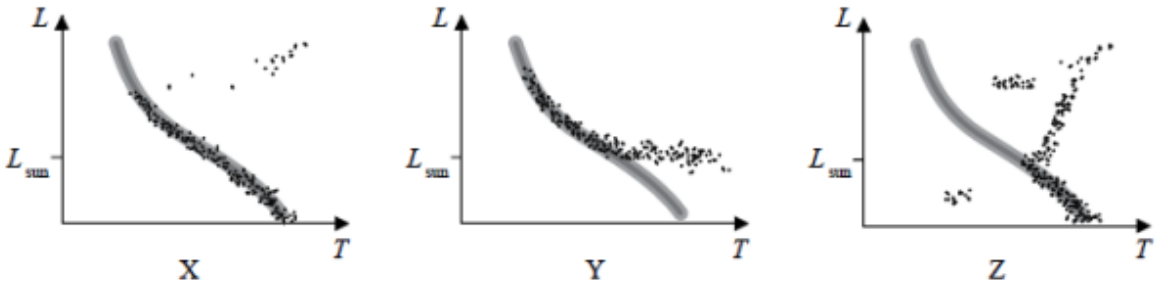
20 Hertzsprung-Russell diagrams are shown for three star clusters, X, Y, and Z.



Choose the row that correctly identifies the ages of the three clusters.

	Youngest	----------□	Oldest
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	X	Y

End of multiple choice section

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2024 PENRITH SELECTIVE HIGH SCHOOL TRIAL HSC EXAMINATION

Physics
SECTION II Answer Booklet

80 MARKS
Attempt Questions 21 – 32
Allow about 2 hours and 25 minutes for this section

Instructions

- Write your student number the top of each page
- Answer the questions in the spaces provided.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

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Question 21 (8 marks)

A small town is supplied with electrical energy from a power plant located 50 kilometres away. The power plant generates electricity at 11 kV, which is then stepped up to 220 kV for transmission through high-voltage power lines. At a substation near the town, the voltage is stepped down to 33 kV before being further reduced to 240 V for use in homes.

A The primary coil of the step-up transformer at the power plant has 500 turns, calculate the number of turns in the secondary coil to achieve the 220 kV transmission voltage. **2**

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B If the step-down transformer at the substation reduces the voltage from 33 kV to 240 V and the primary coil has 3300 turns, calculate the number of turns in the secondary coil. **2**

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C Explain the importance of using high-voltage transmission lines for long-distance electrical energy distribution. **2**

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D Describe how a factor that can affect the efficiency of transformers is mitigated in practical applications. **2**

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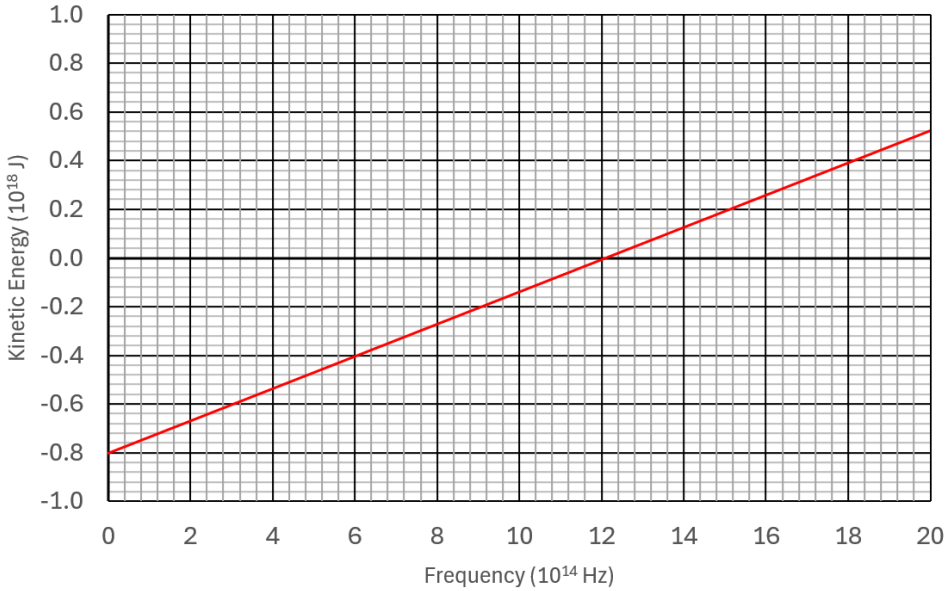
Question 22 (3 marks)

A series of light sources in the blue to ultraviolet range are shone on a gold electrode. The maximum energy of the ejected electrons was measured. The results of the experiment are represented in the graph below.



A What is the work function of gold? **1**

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B A light source with a frequency of 14 x 10^{14} Hz is shone on the gold surface. Determine the velocity of the photoelectron be released? **2**

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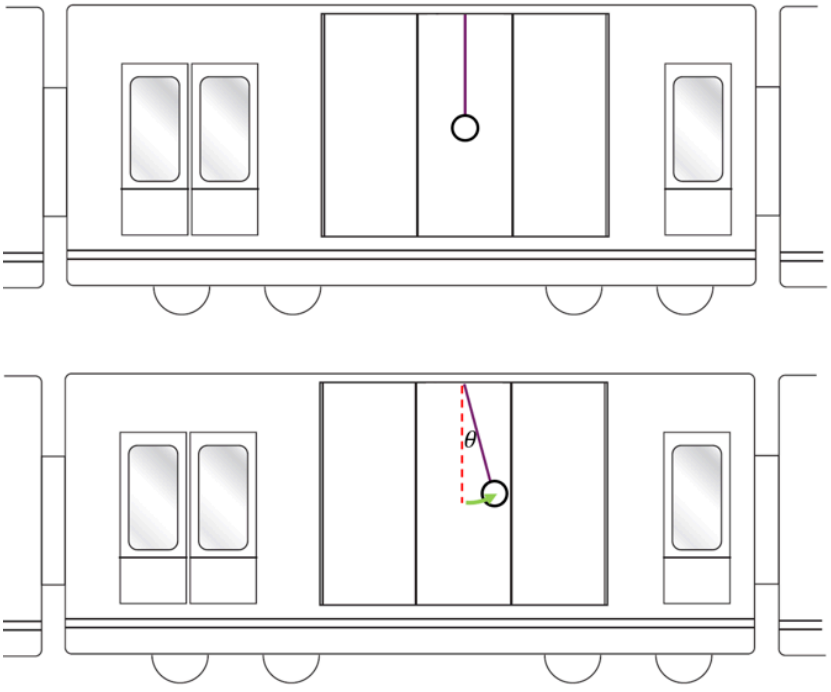
Question 23 (7 marks)

A pendulum is suspended from the centre of the roof of a stationary train carriage. The mass hangs vertically so that it is perpendicular to the roof of the train.

When the train begins to move, an observer inside the train witnesses the pendulum subtend an angle of 2.921° with the vertical plane for 44.44 seconds.



A Show that the acceleration of the train during this time is 0.5 ms^{-2}. **3**

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B Calculate the final velocity of the train. **1**

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C The average length of one of these carriages is 20 m. At what velocity should the train travel so that it appears as half the size to a stationary observer on the platform? **3**

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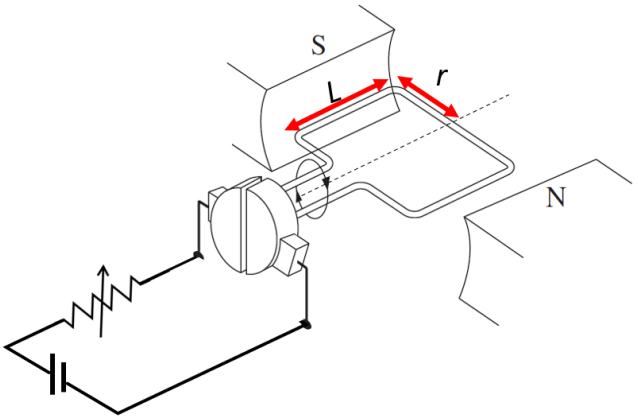
Question 24 (5 marks)

The following motor contains a coil 100 turns enclosed by a 0.5 T radial magnetic field. Dimension "L" is equal to 0.1 m and "r" is equal to 0.05 m. The motor is attached to a power source that has a variable resistor connected in series.



A If the current flowing through the circuit was 10 A. Calculate the expected torque output of the motor. **2**

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B Explain the purpose of variable resistor in controlling the speed of the motor and the back emf it produces **3**

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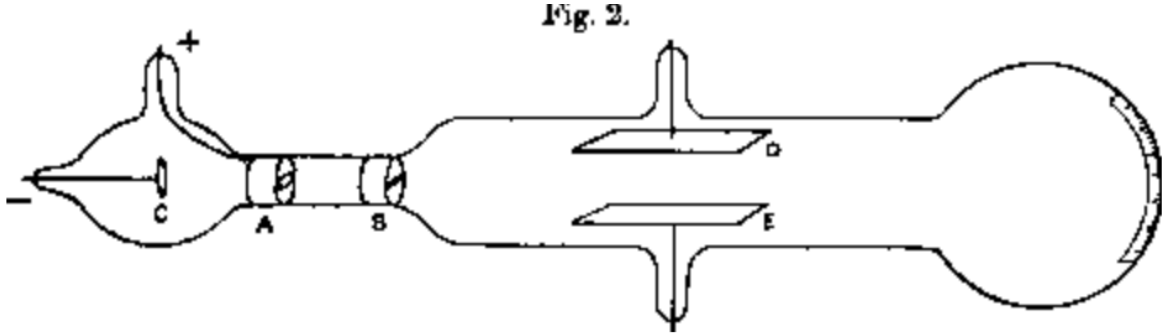
Question 25 (9 marks)

J.J. Thomson conducted an experiment to explore the nature of cathode rays. In this experiment he first set up an apparatus as shown below. The image is taken from his research paper from 1897, *Cathode Rays*.

Cathode rays were emitted from plate C, then accelerated toward the anodes A and then B. They then travelled to the fluorescent screen at the opposite end of the tube where they produced a well-defined phosphorescent patch

Fig. 2.



A In his paper, Thomson described how he could deflect the cathode rays with voltages as low as 2 V between plates D and E separated 1.5 cm. **2**

Determine the Electric field strength between these plates.

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He explored how changing the voltage between plates D and E would alter the deflection of the cathode ray. He used values up to 200 V between the plates.

B Use the modern understanding of cathode rays, to describe how changing the value of the voltage and the polarity of plates would change the deflection of the cathode ray. **3**

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Thomson collected data to determine the velocity of the cathode rays. He used an external magnetic field provided by electric coils to make the cathode ray travel in a straight path to the fluorescent screen. He did this for different values of the electric field between plates D and E. Data about the fields was collected and graphed. A sample of this data is shown below

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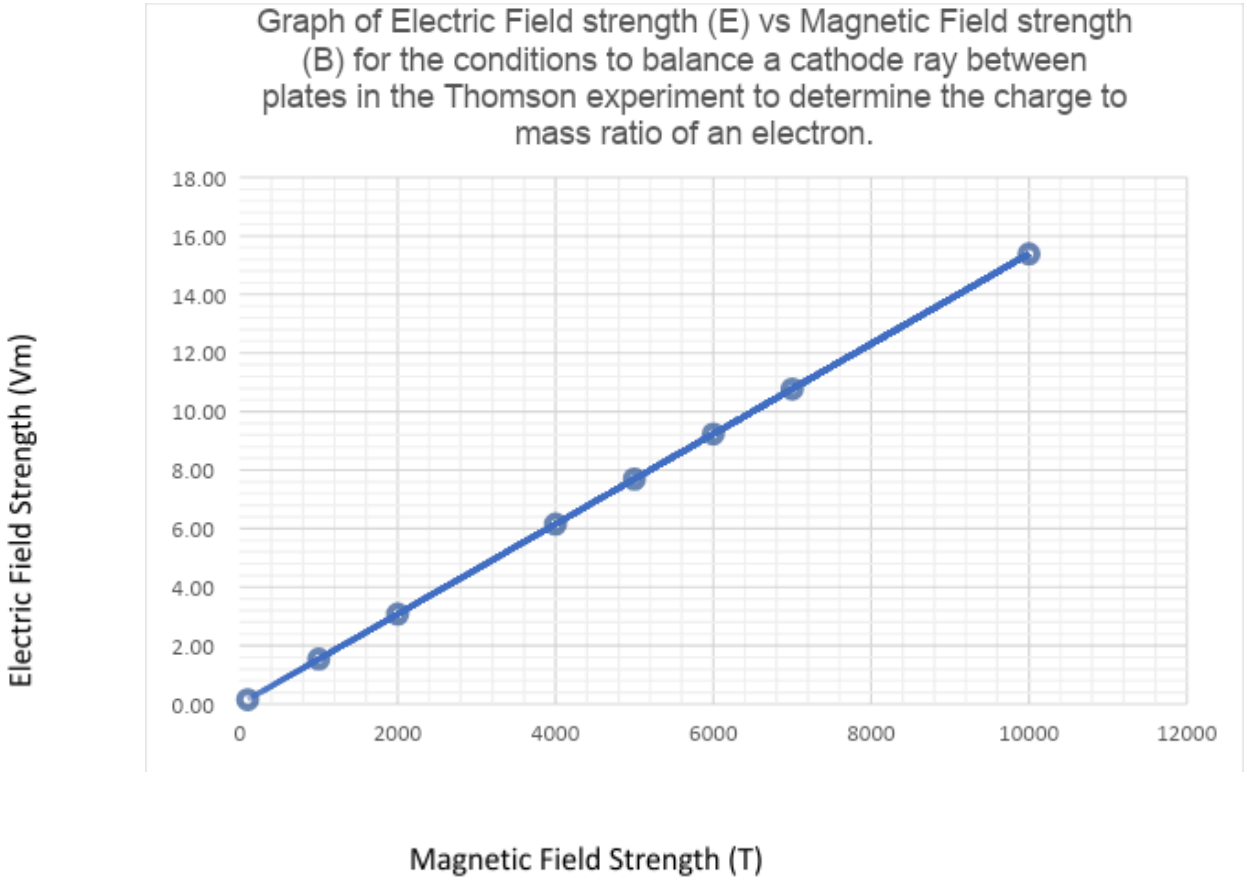

C Use this graph to determine the velocity of the cathode rays as they enter the parallel plates D and E in the experiment. **2**

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D For the case of using an electric field, E, alone with plates D and E of length, L = 5 cm, show that the final vertical velocity, v_y, of the cathode ray particle travelling between the plates is: **2**

$$v_y = \frac{(5x10^{-2})q_e E}{mv_x}$$

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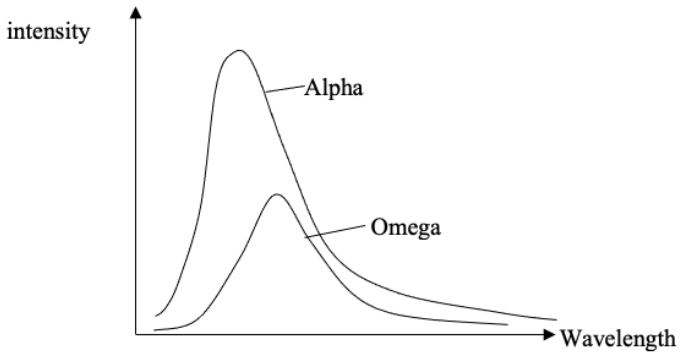
Question 26 (7 marks)

The black body curves for two Main-Sequence stars are plotted below.



A Compare the colour and surface temperature of Alpha and Omega. **2**

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B These curves do not represent the complete, observed, spectra for the stars Alpha and Omega. **2**
Describe how the composition of the surface of the star would contribute to the observed spectrum.

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C Once nuclear fusion commences in the core of a young star, new elements begin to be synthesised. **3**
Compare the synthesis of new elements in the cores of Main-Sequence and post Main-Sequence stars.

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Question 27 (4 marks)

A student claimed that once they knew about electric fields, the same laws can apply to gravitational fields.

Discuss the validity of this claim **4**

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Question 28 (5 mnarks)

A gymnast performs a giant swing on a horizontal high bar. The diagram below was taken from a research paper, it shows the motion of the gymnast.

Hiley M and Yeadon M R 2000, Swinging around the high bar, Physics Education, 36(1):14 36(1):14 accessed 19 July 2024, https://www.researchgate.net/publication/230966159_Swinging_around_the_high_bar

The gymnast's body follows a circular path with a constant radius of 2.5 m. At a certain point in the swing, the gymnast's speed is 6.0 ms^{-1}.

Calculate the centripetal acceleration of the gymnast at this point in the swing. **2**

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Determine the force exerted by the bar on the gymnast if the gymnast has a mass of 50 kg. **3**

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Question 29 (6 marks) **6**

Consider the following statement.

> *The development and application of electromagnetic theories and technologies have revolutionised our ability to understand and manipulate the natural world, leading to significant advancements in communication, medical imaging, and energy production.*

Justify this statement with reference to specific theories, observations, and experiments that have contributed to these advancements. Discuss the impact of these developments on our daily lives and how they have shaped modern living/society

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Question 30 (12 marks)
A long, straight conductor carries a current of 5.0 A and is placed in a uniform magnetic field of strength 0.20 T. The conductor is oriented perpendicular to the magnetic field.

A Identify the direction of the magnetic force acting on the conductor **1**

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B Calculate the magnitude of the magnetic force acting on a 0.50 m length of the conductor. **2**

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C Explain what would happen to the magnetic force if the current in the conductor is doubled, keeping the magnetic field strength and length of the conductor constant. **3**

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D A square coil is attached to an axel oriented in the magnetic field in same direction as the initial straight conductor. It has 10 turns and carries a current of 2.0 A. The length of the conductor within the coil in the magnetic field is 1m. Calculate the total magnetic force acting on the coil **3**

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E Discuss the effects on the magnitude and direction of the induced electromotive force (emf) in the coil if the magnetic field strength is increased to 0.40 T and the current is alternated with a frequency of 50 Hz. **3**

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Question 31 (9 marks)

In a special scenario, a room is hoisted above a vertical position of 4.615 m by a crane, is used to investigate the motion of projectiles in inertial and non-inertial frames of references.

The projectile in the launcher located at coordinates 0,0, and is set to launch with an initial velocity of 5 ms^{-1} at angle of 72^{o}.

The building was initially held static in the air for the first part of the experiment. The inside of the building is presented in the graph below – it contains a person sitting inside it.

A Calculate the projectiles apex and range and then **sketch** on the grid over page the path the projectile will take along the coordinate axis provided, include relevant labels **4**

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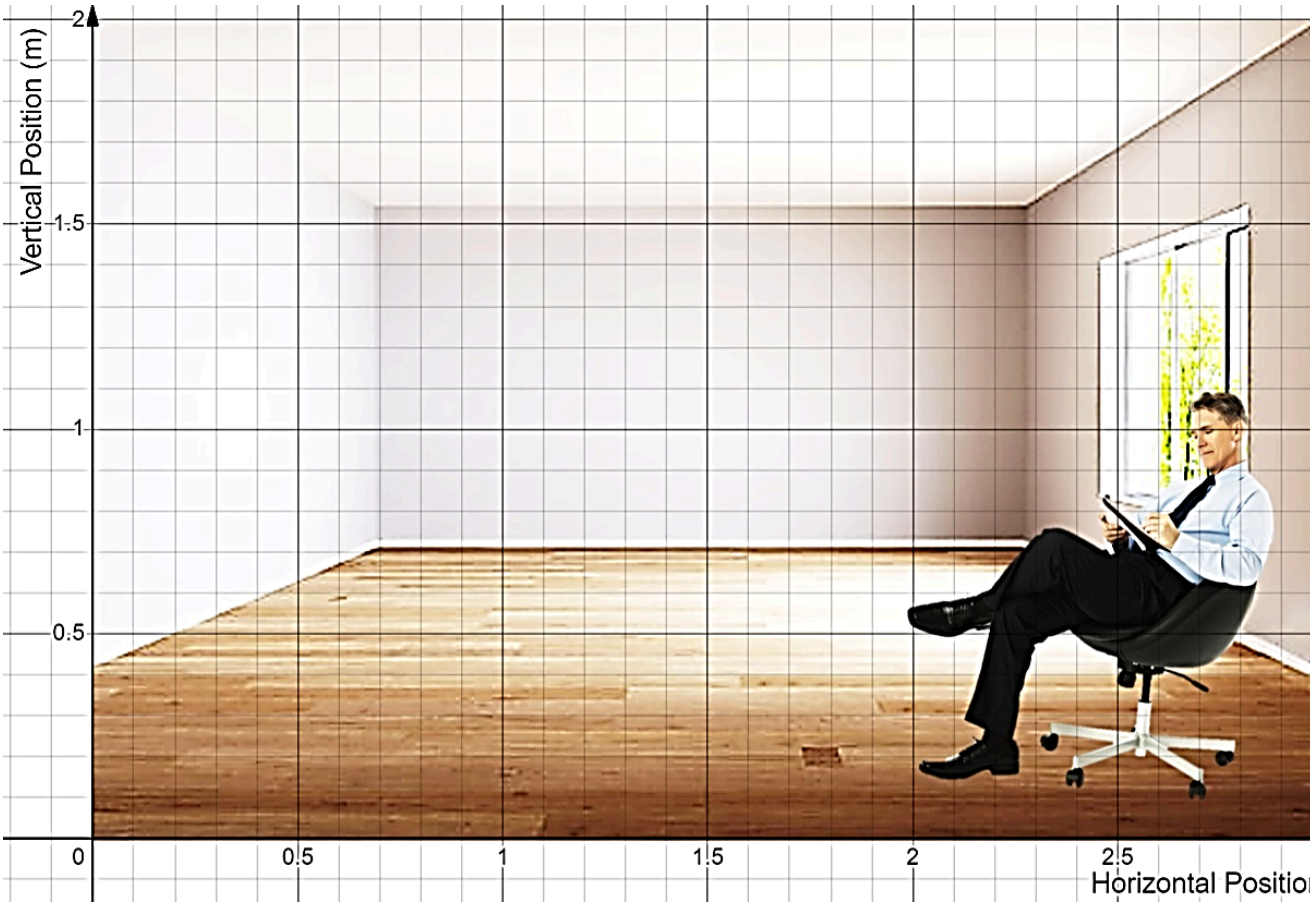

For the second part of the experiment the building was dropped while the projectile was launched. The person was again sitting inside of the building.

B Explain how the position of the person would change as the building begins to descent **3**

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C Use a ruler and or protractor to **sketch** on the grid the path the projectile will take as the building begins its descent. **2**

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Question 32 (8 marks)

Francium-223 is a radioactive element that readily undergoes alpha decay. The most Francium-223 that has been produced in a laboratory is 300 x 10^3 atoms. The following table summarises the atomic masses of the Francium-223, the daughter nucleus and alpha particle.

Element	Mass (u)
$87223Fr$	223.0197
$86219Rn$	219.0095
$24He$	4.0026

Calculate the mass defect of the nuclear reaction. **1**

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Calculate the binding energy of the nuclear reaction. **2**

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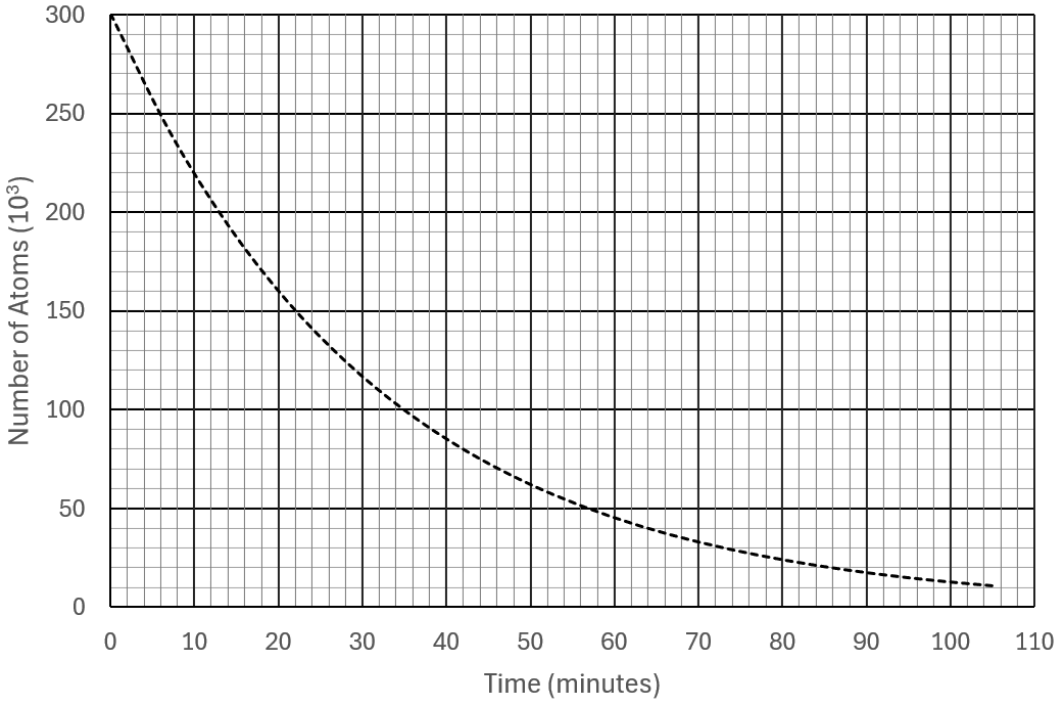
The following curve illustrates the decay of a sample of 300 x 10^3 Francium-223 atoms.



Show that decay constant for Francium-223 is 0.0315 min^{-1} **2**

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