2025 HSC Physics Examination

NSW Education Standards Authority

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Exam Overview

Year	2025
Total Marks	100
Section I	20 marks (Questions 1-20, Multiple Choice)
Section II	80 marks (Questions 21-36, Extended Response)

Section I: Multiple Choice

20 marks - Questions 1-20

Allow about 35 minutes for this section

Question 1

1 Which of the following did Maxwell contribute to the understanding of the nature of light?

A. Explanation of atomic emission spectra

B. Prediction of the speed of electromagnetic waves

C. Experimental support for the particle model of light

D. Experimental confirmation of light beyond the visible spectrum

Figure 1: Q1

Question 2

2 An ideal transformer converts 240 V to 2200 V.

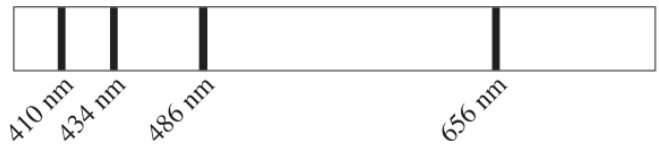
Which row in the table best describes the transformer?

	Type of transformer	*Number of turns in primary coil*	*Number of turns in secondary coil*
A.	Step up	120	1100
B.	Step up	1100	120
C.	Step down	120	1100
D.	Step down	1100	120

Figure 2: Q2

Question 3

3 The diagram shows lines in the emission spectrum of hydrogen.



The production of this spectrum can be explained by applying the atomic model developed by which scientist?

A. Balmer

B. Bohr

C. Planck

D. Rutherford

Figure 3: Q3

Question 4

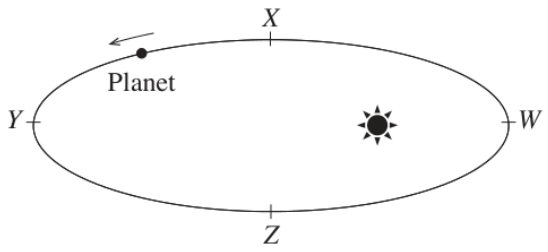
4 Which row in the table identifies the particle with the shortest de Broglie wavelength?

	Particle	*Velocity*
A.	Electron	$0.1c$
B.	Electron	$0.9c$
C.	Proton	$0.1c$
D.	Proton	$0.9c$

Figure 4: Q4

Question 5

5 A planet orbits a star in an elliptical orbit as shown.



At which point in its orbit is the planet's kinetic energy increasing?

A. *W*

B. *X*

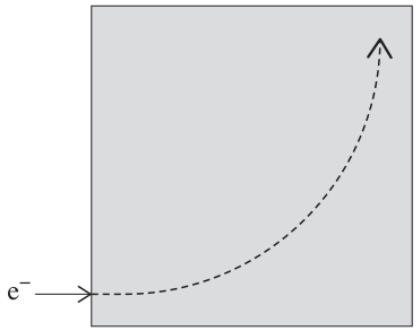
C. *Y*

D. *Z*

Figure 5: Q5

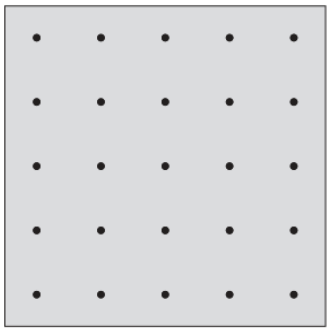
Question 6

6 In the diagram, an electron enters the shaded region where it is subjected to an external magnetic field that causes it to move in a circular arc, as indicated by the dotted line.



Which magnetic field could produce the motion of the electron shown?

A.



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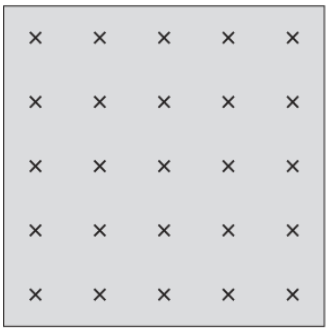
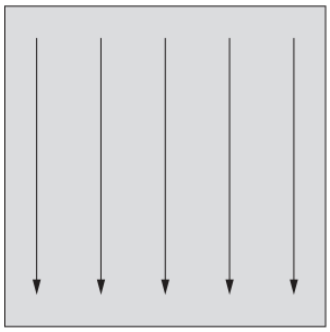


C.



D.

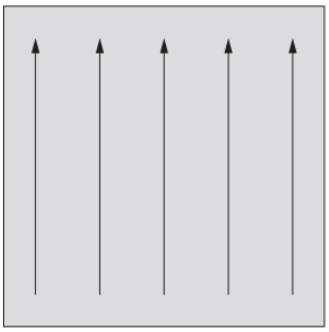


Figure 6: Q6

Question 7

7 A satellite in a circular orbit around Earth at an altitude of 500 km is moved to a new circular orbit at a higher altitude of 35 800 km.

Which statement correctly compares properties of the satellite in the higher orbit with its properties in the lower orbit?

A. Its period is greater, and its acceleration is the same.

B. Its kinetic energy is less, and its acceleration is less.

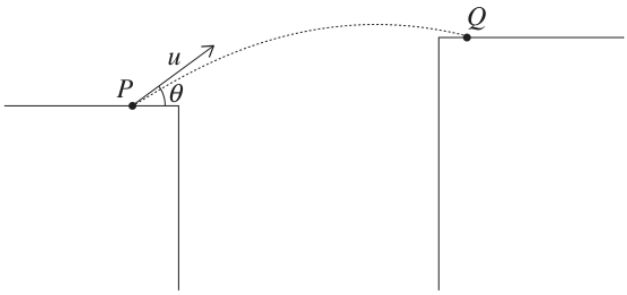
C. Its orbital velocity is less, and its potential energy is positive.

D. Its escape velocity is greater, and the centripetal force is less.

Figure 7: Q7

Question 8

8 A projectile is launched from point P, with speed u, at angle θ to the horizontal. It lands at point Q.



The time of flight of the projectile is t.

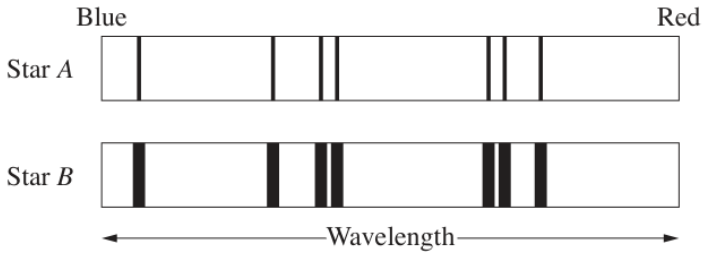
Which row in the table best describes the time to reach maximum height and the speed of the projectile at Q?

	Time to reach maximum height	*Speed of projectile at Q*
A.	$> \frac{t}{2}$	$< u$
B.	$> \frac{t}{2}$	$= u$
C.	$= \frac{t}{2}$	$= u$
D.	$= \frac{t}{2}$	$< u$

Figure 8: Q8

Question 9

9 The diagram shows the absorption spectra of two different stars in the Milky Way galaxy.



Based on the information in the diagram, which of the following statements about the two stars is true?

A. Star *A* has a lower density than Star *B*.

B. Star *A* has a greater rotational velocity than Star *B*.

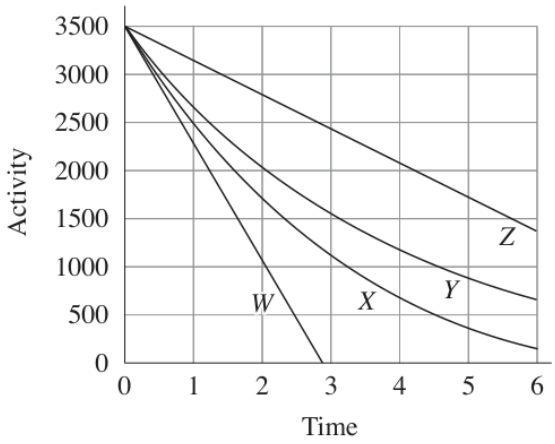
C. Star *A* has a greater translational velocity than Star *B*.

D. Star *A* and Star *B* have different chemical compositions.

Figure 9: Q9

Question 10

10 The diagram shows four lines, W, X, Y and Z, depicting radioactivity varying with time.



Which of the four lines is consistent with a decay graph with the smallest decay constant (λ)?

A. W

B. X

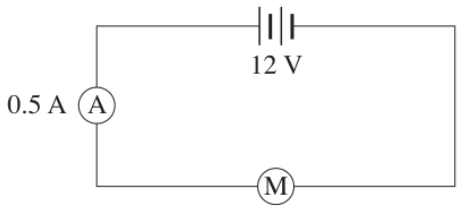
C. Y

D. Z

Figure 10: Q10

Question 11

11 A DC motor connected to a 12 V supply is maintaining a constant rotational speed. An ammeter in the circuit reads 0.5 A.



Some material falls into the running motor, causing it to slow down.

What is the subsequent ammeter reading likely to be?

A. 0

B. Between 0 and 0.5 A

C. 0.5 A

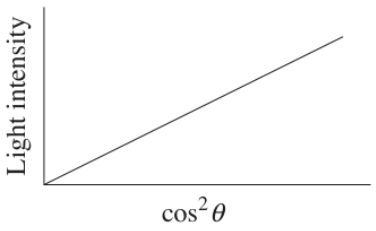
D. Greater than 0.5 A

Figure 11: Q11

Question 12

12 Which graph correctly represents Malus' Law?

A.



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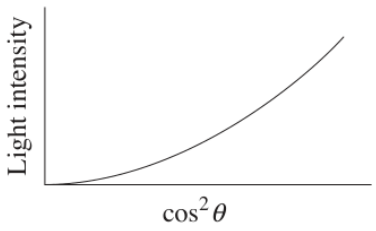
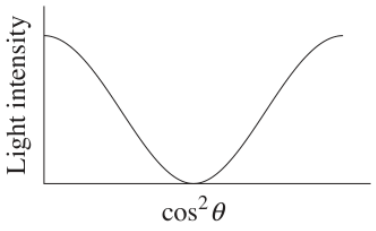


C.



D.

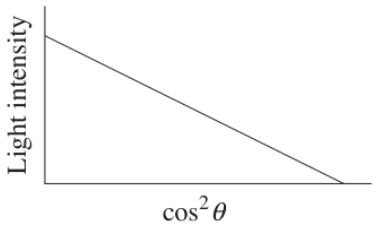
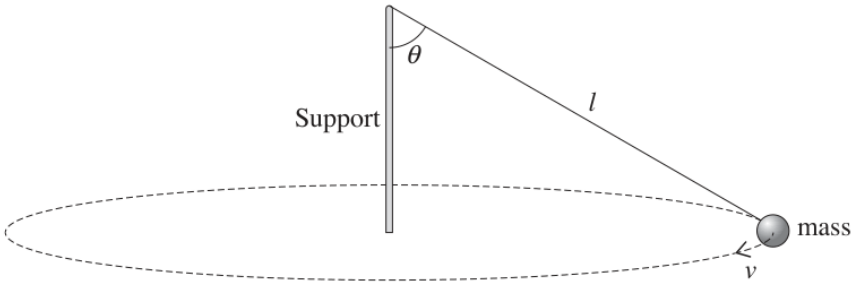


Figure 12: Q12

Question 13

13 A mass is attached by a light, inextensible string of length l to a vertical rigid support.

The mass rotates with uniform speed, v, in a horizontal circle as shown.



What is the acceleration of the mass?

A. g

B. $\frac{v^2}{l}$

C. $\frac{v^2}{l \sin \theta}$

D. $\frac{v^2}{l \cos \theta}$

Figure 13: Q13

Question 14

14 A proton having a velocity of 1×10^6 m s^{-1} enters a uniform field with a trajectory that is initially perpendicular to the field.

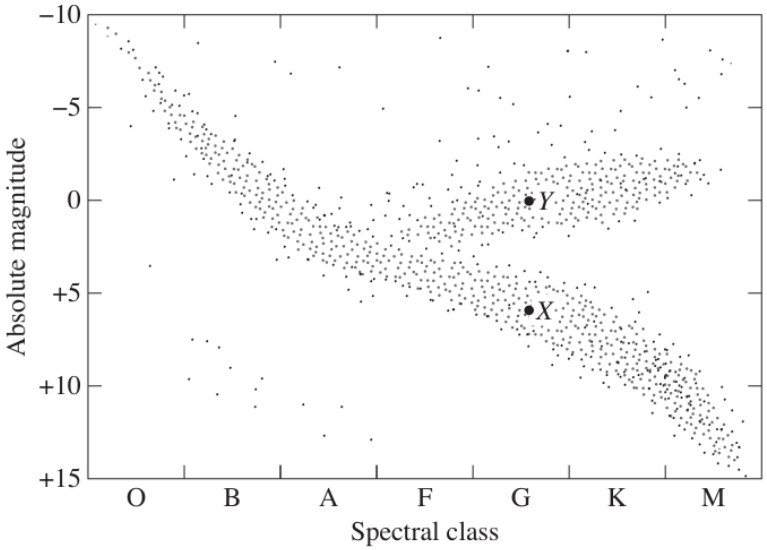
Which row in the table correctly identifies the field, and its effect on the kinetic energy of the proton?

	Type of field	*Effect on kinetic energy*
A.	Electric	Decreases
B.	Electric	Increases
C.	Magnetic	Decreases
D.	Magnetic	Increases

Figure 14: Q14

Question 15

15 Two stars, *X* and *Y*, are identified on the Hertzsprung–Russell diagram.



In what way are these two stars different?

A. *X* has a higher luminosity than *Y*.

B. *X* is a red star, and *Y* is a blue star.

C. *X* has a lower core temperature than *Y*.

D. *X* has a higher surface temperature than *Y*.

Figure 15: Q15

Question 16

16 A neutron is absorbed by a nucleus, X.

The resulting nucleus undergoes alpha decay, producing lithium-7.

What is nucleus X?

A. Boron-10

B. Boron-11

C. Lithium-6

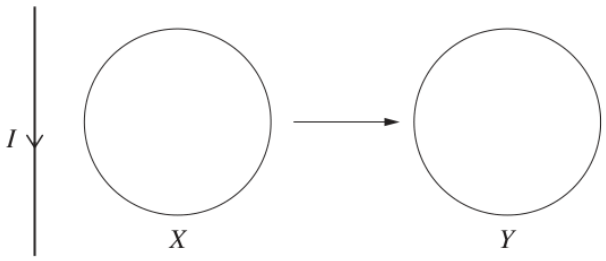
D. Lithium-10

Figure 16: Q16

Question 17

17 A circular loop of wire is placed at position X, next to a straight current-carrying wire with the current direction shown.

The loop is moved to position Y at a constant speed.



Which row in the table best describes the induced electromotive force (emf) in the loop as it moves from X to Y?

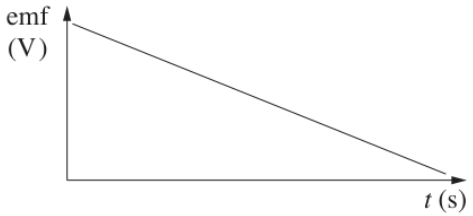
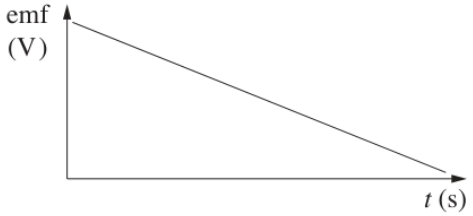
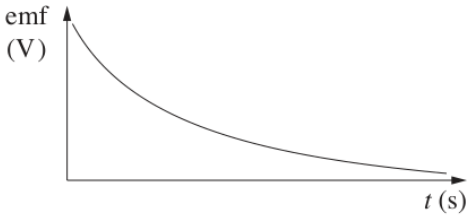
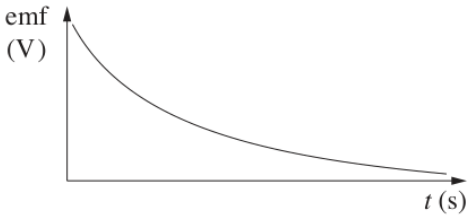
	Induced emf in loop	*Direction of induced emf in loop*
A.		Anticlockwise
B.		Clockwise
C.		Anticlockwise
D.		Clockwise

Figure 17: Q17

Question 18

18 The escape velocity from the surface of a planet, which has no atmosphere, is v. A mass is launched at 45° to the planet's surface at v.

What will be the subsequent motion of the mass?

A. A circular orbit around the planet

B. An elliptical orbit around the planet

C. A parabolic trajectory, returning to land with velocity v

D. A trajectory reaching zero velocity at an infinite distance

Figure 18: Q18

Question 19

19 A system consists of a sealed glass jar containing some oxygen and a small strip of magnesium.

The magnesium reacts with the oxygen to produce magnesium oxide as a product. Energy is released from the system in this reaction.

The mass of the system will

A. increase because oxygen is added to the magnesium.

B. decrease because energy is removed from the system.

C. increase because energy is added to the system by the reaction.

D. decrease because magnesium and oxygen are lost in the reaction.

Figure 19: Q19

Question 20

20 Consider the possibility of an electron and a positron colliding in a particle accelerator to produce a proton and an antiproton, as shown in the equation below.

$$\text{electron} + \text{positron} \longrightarrow \text{proton} + \text{antiproton}$$

Which statement makes the correct conclusion about the possibility of such a reaction, and provides a plausible reason for this conclusion?

A. The reaction is impossible because electrons and positrons will combine to produce a single neutral particle.

B. The reaction is possible because the masses of the proton and antiproton are the result of their relativistic velocities.

C. The reaction is possible because the masses of the proton and antiproton come mainly from energy supplied by the accelerator.

D. The reaction is impossible because protons are much more massive than electrons and hence the reaction violates the law of conservation of mass.

Figure 20: Q20

Section II: Extended Response

80 marks - Questions 21-36

Allow about 2 hours and 25 minutes for this section

Question 21 (3 marks)

Question 21 (3 marks)

A scientist has two unlabelled sources of radiation. One source emits alpha particles and the other emits beta particles. **3**

Outline TWO methods that could be used to determine which source is the alpha emitter, and which source is the beta emitter.

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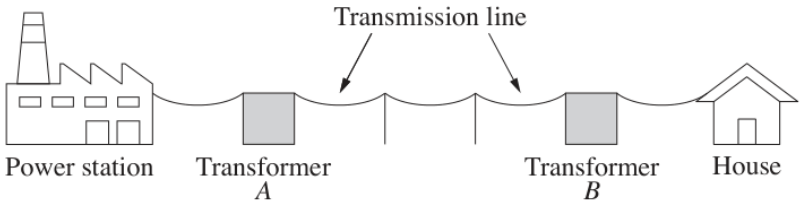
Figure 21: Q21

Question 22 (4 marks)

Question 22 (4 marks)

The diagram represents the parts of the AC system used to transfer energy from a power station to people's houses. **4**



Describe the energy transformations that take place in the transformers, and in the transmission line.

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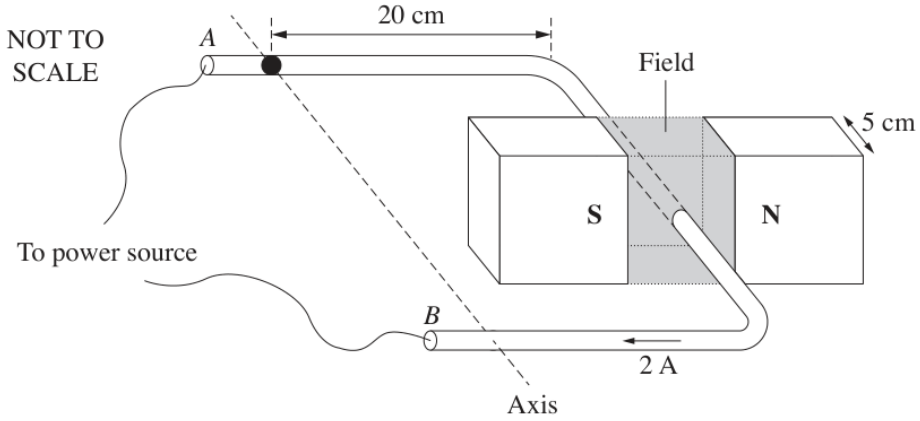
Figure 22: Q22

Question 23 (5 marks)

Question 23 (5 marks)

A wire loop is carrying a current of 2 A from A to B as shown. The length of wire within the magnetic field is 5 cm. The loop is free to pivot around the axis. The magnetic field is of magnitude 3×10^{-2} T and at right angles to the wire.



(a) Determine the torque produced on the wire loop due to the motor effect. **3**

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(b) Both the current and the magnetic field were changed, and the torque was observed to be in the same direction but twice the magnitude. **2**

What changes to the magnitude of BOTH the current and the magnetic field are required to produce this result?

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Figure 23: Q23

Part (a)

(a) Determine the torque produced on the wire loop due to the motor effect. **3**

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Figure 24: Q23a

Part (b)

(b) Both the current and the magnetic field were changed, and the torque was observed to be in the same direction but twice the magnitude. **2**

What changes to the magnitude of BOTH the current and the magnetic field are required to produce this result?

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Figure 25: Q23b

Question 24 (3 marks)

Question 24 (3 marks)

Two satellites, A and B, are in stable circular orbits around the Earth. The radius of satellite A's orbit is three times that of satellite B's orbit. Both satellites have the same kinetic energy. **3**

Show that the mass of A is three times the mass of B.

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Please turn over

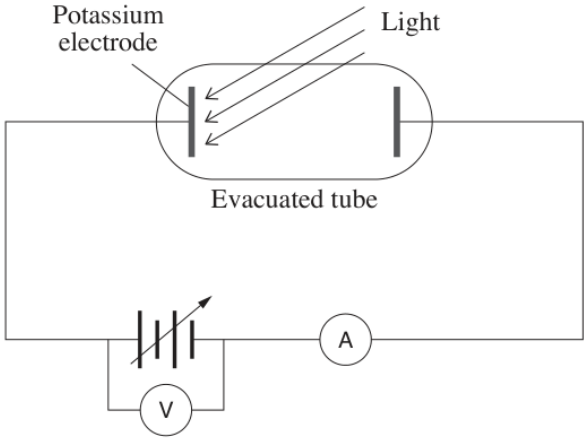
Figure 26: Q24

Question 25 (6 marks)

Question 25 (6 marks)

A student conducts an experiment to determine the work function of potassium.

The following diagram depicts the experimental setup used, where light of varying frequency is incident on a potassium electrode inside an evacuated tube.



For each frequency of light tested, the voltage in the circuit is varied, and the minimum voltage (called the stopping voltage) required to bring the current in the circuit to zero is recorded.

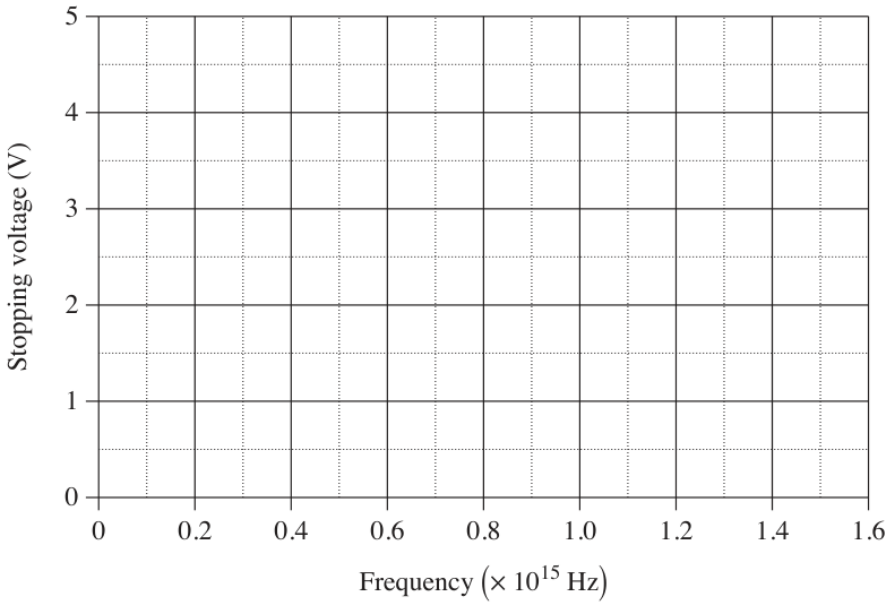
Frequency of incident light $(\times 10^{15}$ Hz)	*Stopping voltage* (V)
0.9	1.5
1.1	2.0
1.2	2.5
1.3	3.0
1.4	3.5
1.5	4.0

Question 25 continues on page 19

Figure 27: Q25

Part (a)

(a) Construct an appropriate graph using the data provided, and from this, determine the threshold frequency of potassium. **3**



Threshold frequency of potassium: ..... Hz

Figure 28: Q25a

Part (b)

(b) Using the particle model of light, explain the features shown in the experimental results. **3**

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End of Question 25

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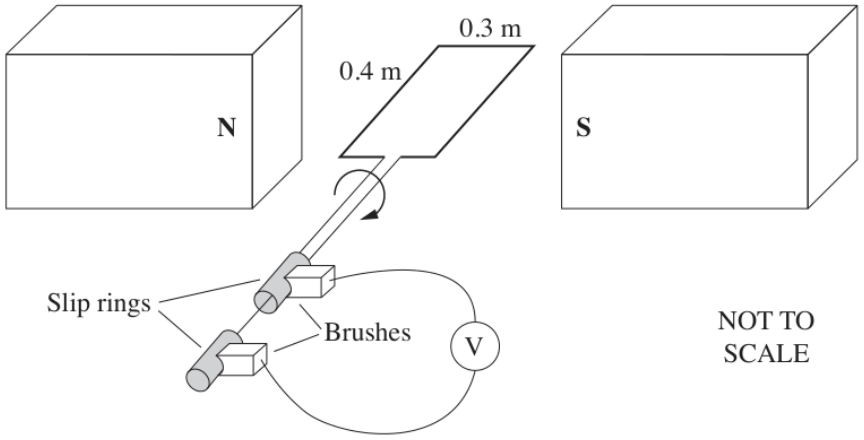
Figure 29: Q25b

Question 26 (5 marks)

Question 26 (5 marks)

The starting position of a simple AC generator is shown. It consists of a single rectangular loop of wire in a uniform magnetic field of 0.5 T. This loop is connected to two slip rings and the slip rings are connected via brushes to a voltmeter.



(a) The loop is rotated at a constant rate through an angle of 90 degrees from the starting position in the direction indicated, in 0.1 seconds. **2**

Calculate the magnitude of the average emf generated during this rotation.

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Question 26 continues on page 21

Figure 30: Q26

Part (a)

(a) The loop is rotated at a constant rate through an angle of 90 degrees from the starting position in the direction indicated, in 0.1 seconds. **2**

Calculate the magnitude of the average emf generated during this rotation.

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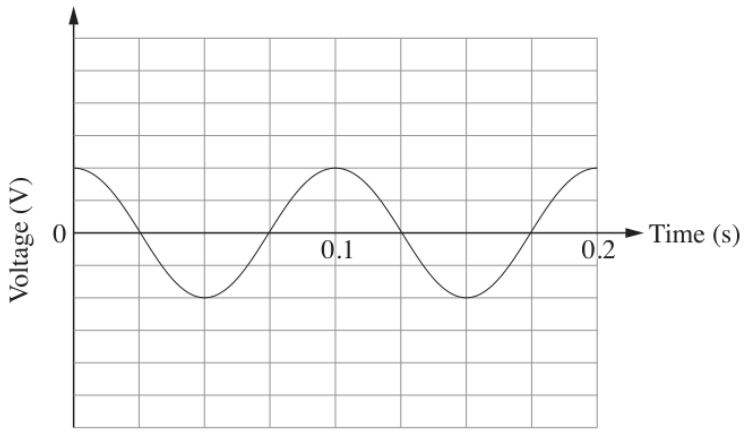
Question 26 continues on page 21

Figure 31: Q26a

Part (b)

in this area.

(b) The same coil was then rotated at 10 revolutions per second from the starting position. The voltage varies with time, as shown in the graph. **3**



On the same axes, sketch a graph that shows the variation of voltage with time if the rotational speed is 20 revolutions per second in the opposite direction, beginning at the original starting position.

Figure 32: Q26b

Question 27 (3 marks)

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Question 27 (3 marks)

Outline TWO ways in which Schrödinger's model of electron behaviour is different from electron behaviour in the atomic models of Rutherford and Bohr. **3**

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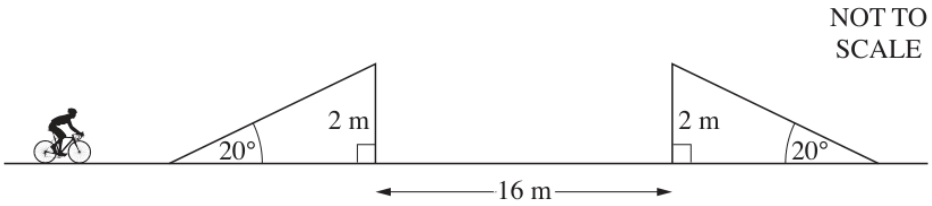
Figure 33: Q27

Question 28 (4 marks)

Question 28 (4 marks)

A bicycle rider jumps from one ramp to a second ramp separated by 16 m as shown. The ramps are inclined at 20° and are 2 m high. **4**



What minimum speed is required for the rider to land on the second ramp?

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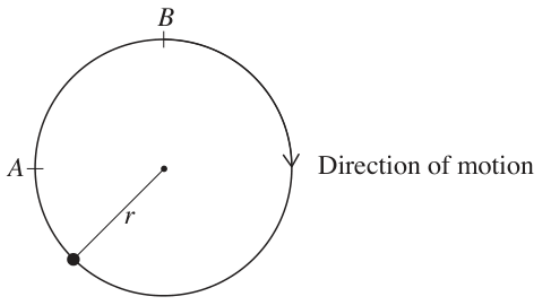
Figure 34: Q28

Question 29 (5 marks)

Question 29 (5 marks)

A mass moves around a vertical circular path of radius r, in Earth's gravitational field, without loss of mechanical energy. A string of length r maintains the circular motion of the mass.

When the mass is at its highest point B, the tension in the string is zero.



(a) Show that the speed of the mass at the highest point, B, is given by $v = \sqrt{rg}$. **2**

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(b) Compare the speed of the mass at point A to that at point B. Support your answer using appropriate mathematical relationships. **3**

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Figure 35: Q29

Part (a)

write in this are

(a) Show that the speed of the mass at the highest point, B, is given by $v = \sqrt{rg}$. **2**

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Figure 36: Q29a

Part (b)

Do NOT

(b) Compare the speed of the mass at point A to that at point B. Support your answer using appropriate mathematical relationships. **3**

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Figure 37: Q29b

Question 30 (6 marks)

Question 30 (6 marks)

A beam of electrons travelling at 4×10^3 m s^{-1} exits an electron gun and is directed toward two narrow slits with a separation, d, of 1 μm. The resulting interference pattern is detected on a screen 50 cm from the slits.

(a) Show that the wavelength of the electrons in this experiment is 182 nm. **2**

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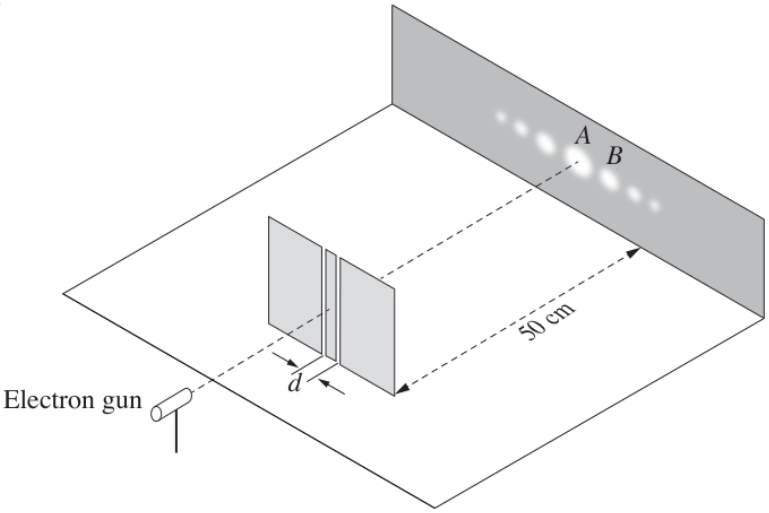
(b) An interference fringe occurs on the screen where constructive interference takes place. **2**



Determine the distance between the central interference fringe A and the centre of the next bright fringe B.

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(c) Determine the potential difference acting in the electron gun to accelerate the electrons in the beam from rest to 4×10^3 m s^{-1}. **2**

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Figure 38: Q30

Part (a)

(a) Show that the wavelength of the electrons in this experiment is 182 nm. **2**

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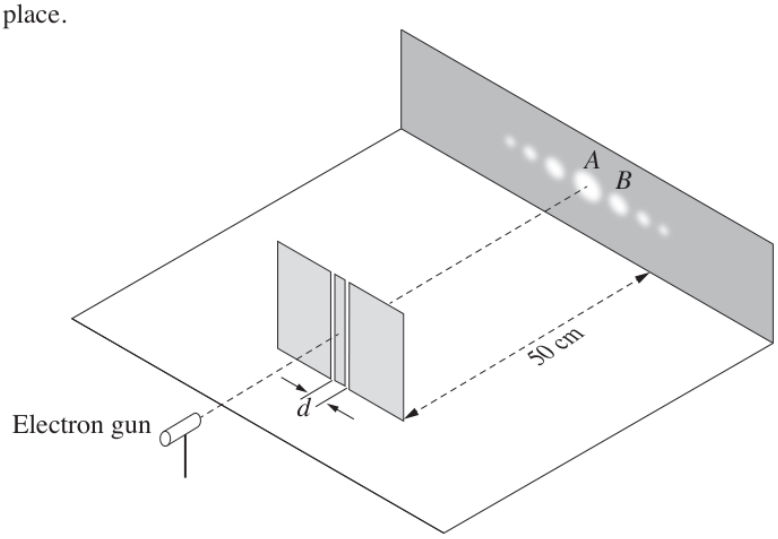
Figure 39: Q30a

Part (b)

(b) An interference fringe occurs on the screen where constructive interference takes place. **2**



Determine the distance between the central interference fringe A and the centre of the next bright fringe B.

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Figure 40: Q30b

Part (c)

(c) Determine the potential difference acting in the electron gun to accelerate the electrons in the beam from rest to 4×10^3 m s^{-1}. **2**

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Figure 41: Q30c

Question 31 (5 marks)

Question 31 (5 marks)

Experiments have been carried out by scientists to investigate cathode rays. **5**

Assess the contribution of the results of these experiments in developing an understanding of the existence and properties of electrons.

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Figure 42: Q31

Question 32 (8 marks)

Question 32 (8 marks)

Analyse the consequences of the theory of special relativity in relation to length, time and motion. Support your answer with reference to experimental evidence. **8**

Figure 43: Q32

Question 33 (6 marks)

Question 33 (6 marks)

Analyse the role of experimental evidence and theoretical ideas in developing the Standard Model of matter. **6**

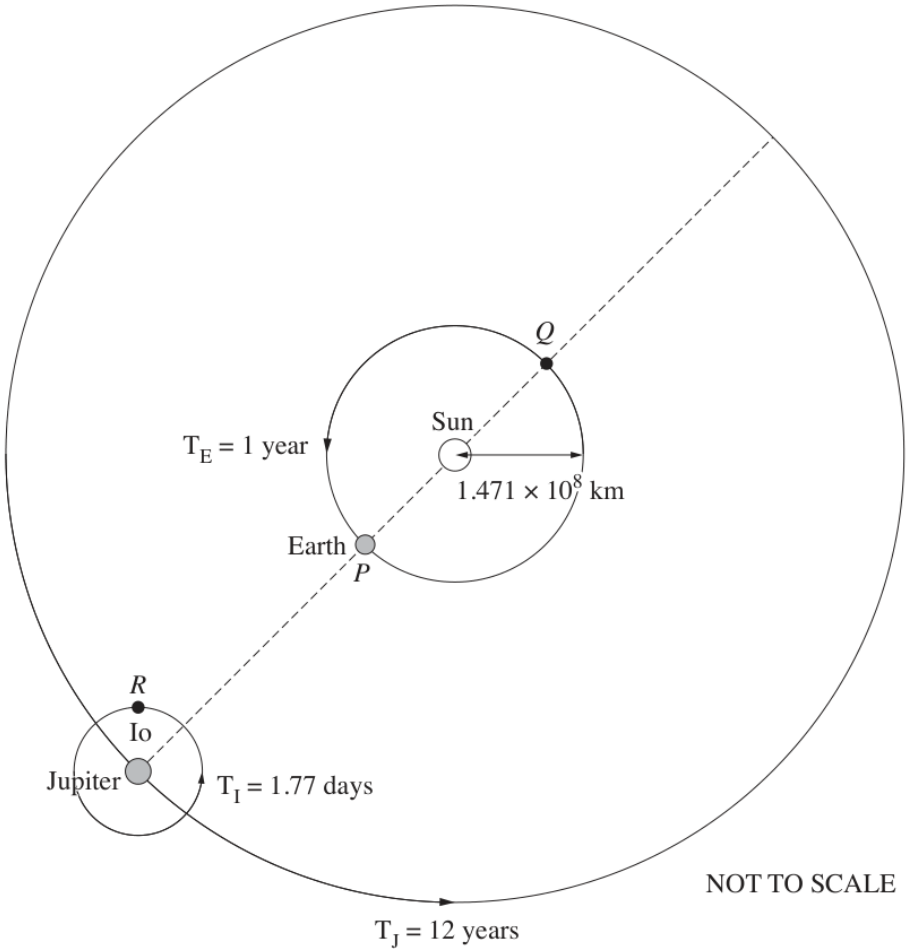
Do NOT write in this area.

Figure 44: Q33

Question 34 (5 marks)

Question 34 (5 marks)

The diagram shows a model of the orbits of Earth, Jupiter and Io, including their orbital direction and periods of orbit. In this model, it is assumed that the orbits of Earth, Jupiter and Io are circular.



A method to determine the speed of light using this model is described below.

When Earth was at position P, the orbital period of Io was measured, and the time that Io was at position R was recorded.

Six months later, Io had orbited Jupiter 103 times, and Earth had reached position Q. The orbital period of Io was used to predict when it would be at position R. Assume that Jupiter has not moved significantly in its orbit around the Sun.

The time for Io to reach position R was measured to be 1.000×10^3 seconds later than predicted, due to the time it takes light to cross the diameter of Earth's orbit from P to Q.

Question 34 continues on page 29

Figure 45: Q34

Part (a)

(a) Use the measurements provided in the model to calculate the speed of light. **2**

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Figure 46: Q34a

Part (b)

(b) Consider a modification to this model in which the Earth's orbit is elliptical. **3**

Explain how this modification will affect the determination of the speed of light.

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End of Question 34

Figure 47: Q34b

Question 35 (4 marks)

Question 35 (4 marks)

A hollow copper pipe is placed upright on an electronic balance, which shows a reading of 300 g. A 50 g magnet is suspended inside the pipe and subsequently released. **4**

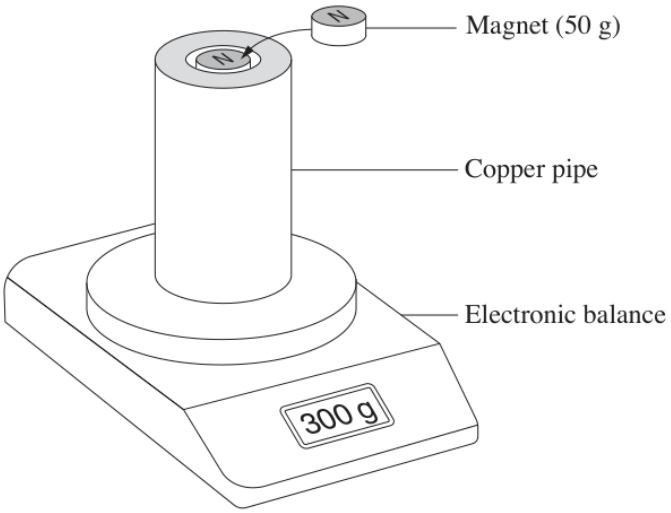

Figure 48: Q35

It was observed that the readings on the balance began to increase after the magnet began to fall, and that the reading reached a constant maximum of 350 g before the magnet reached the bottom of the tube.

Explain these observations.

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Question 36 (8 marks)

Question 36 (8 marks)

A satellite with velocity v, is in a geostationary orbit as shown in Figure 1. **8**

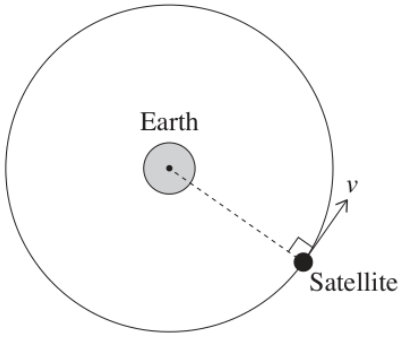

Figure 1

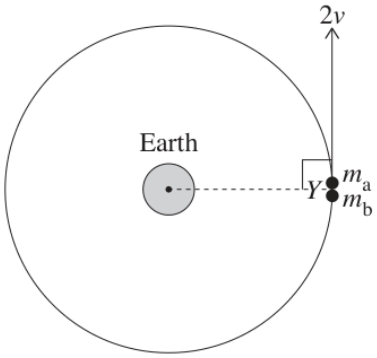

Figure 2

At point Y, the satellite explodes and splits into two pieces m_a and m_b, of identical mass. As a result of the explosion, the velocity of one piece, m_a, changes from v to $2v$ as shown in Figure 2.

Analyse the subsequent motion of BOTH m_a and m_b after the explosion. Include reference to relevant conservation laws and formulae in your answer.

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Question 36 continues on page 32

Figure 49: Q36