NSW GOVERNMENT

NSW Education Standards Authority

Centre Number

Student Number

2025 **HIGHER SCHOOL CERTIFICATE EXAMINATION**

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and Periodic Table are provided at the back of this paper
- Write your Centre Number and Student Number at the top of this page

Total marks: 100

Section I – 20 marks (pages 2–11)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 13–36)

- Attempt Questions 21–36
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

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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

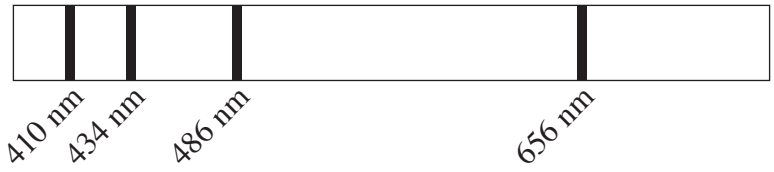
D. Experimental confirmation of light beyond the visible spectrum

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

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

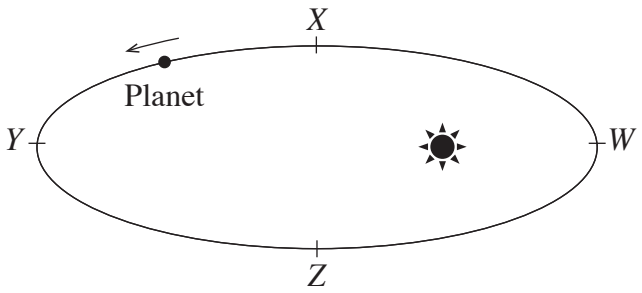
C. Planck

D. Rutherford

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

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?

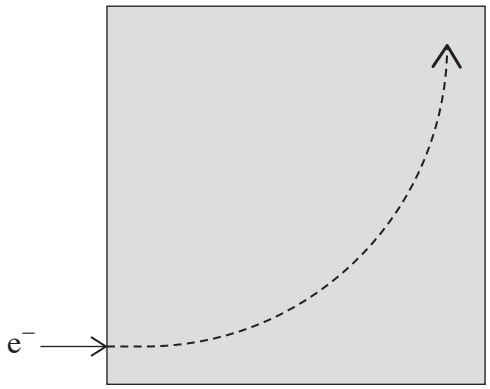
A. *W*

B. *X*

C. *Y*

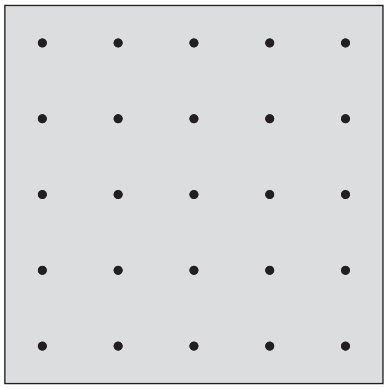
D. *Z*

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.

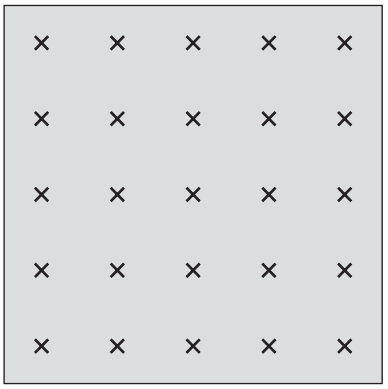


Which magnetic field could produce the motion of the electron shown?

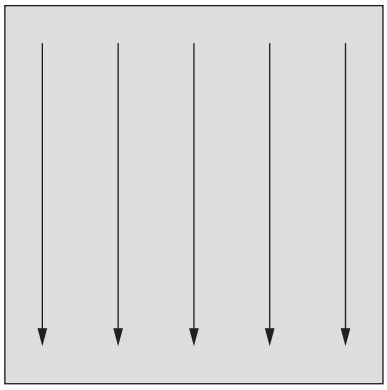
A.



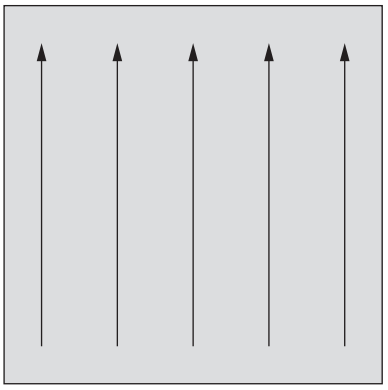
B.



C.



D.



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?

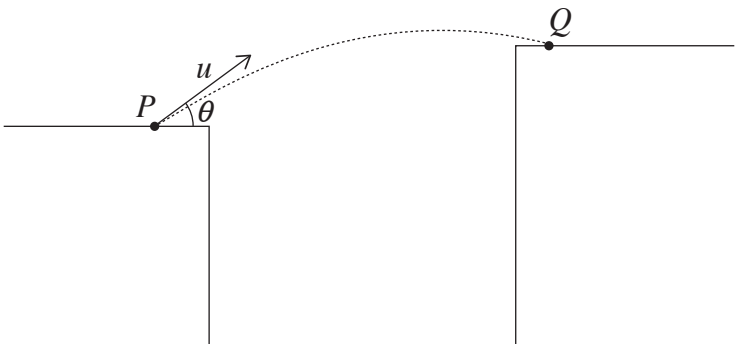
A. Its period is greater, and its acceleration is the same.

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.

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

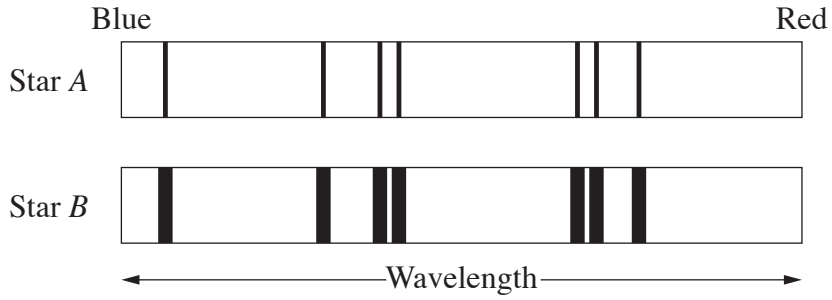


The time of flight of the projectile is t.

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.	$= \frac{t}{2}$	$< u$

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?

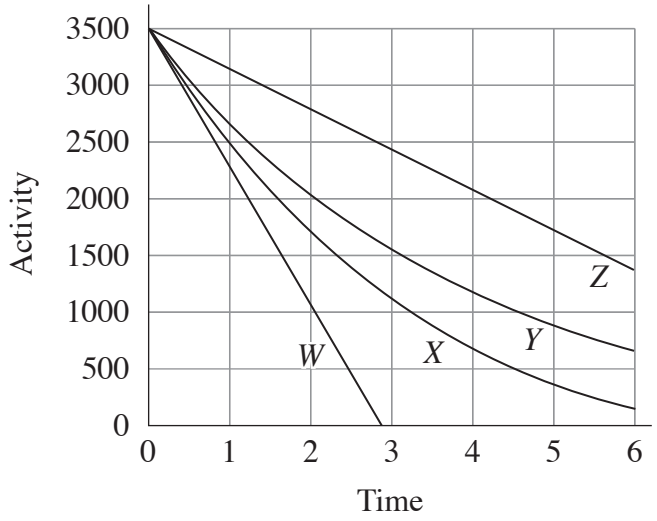
A. Star *A* has a lower density than Star *B*.

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.

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)?

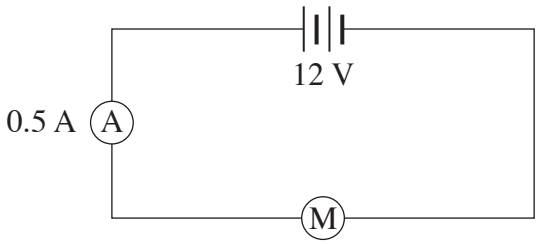
A. *W*

B. *X*

C. *Y*

D. *Z*

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

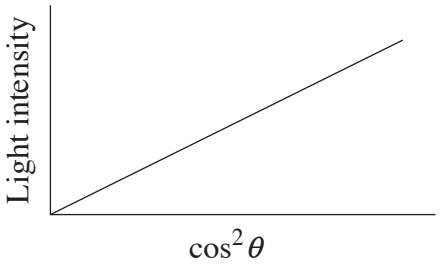
B. Between 0 and 0.5 A

C. 0.5 A

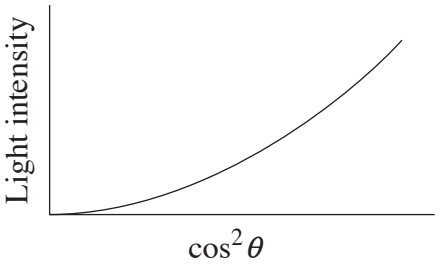
D. Greater than 0.5 A

12 Which graph correctly represents Malus' Law?

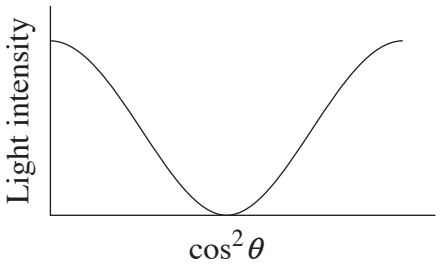
A.



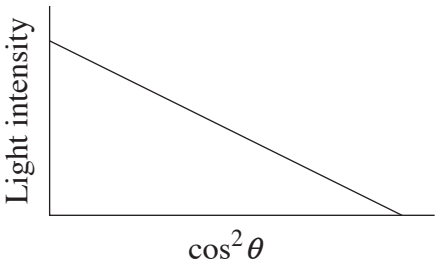
B.



C.

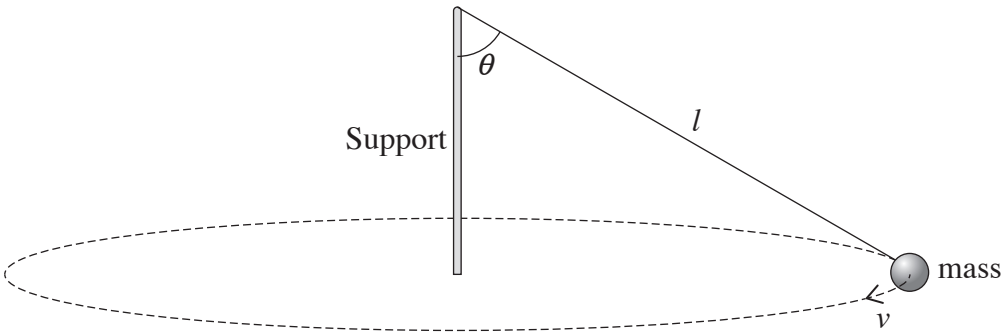


D.



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

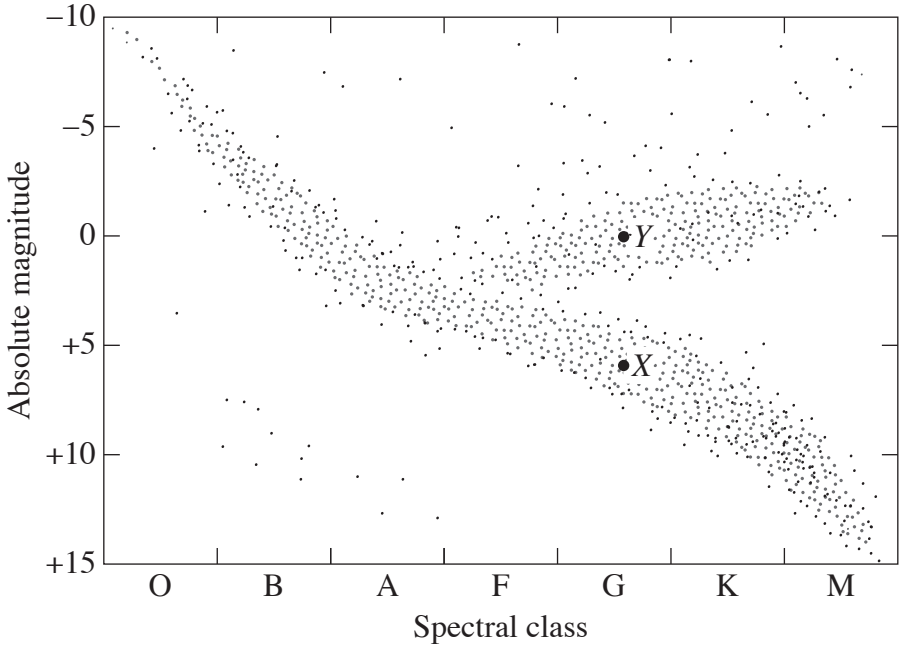
D. $\frac{v^2}{l \cos \theta}$

14 A proton having a velocity of $1 \times 10^6 \text{ m s}^{-1}$ 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

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*.

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

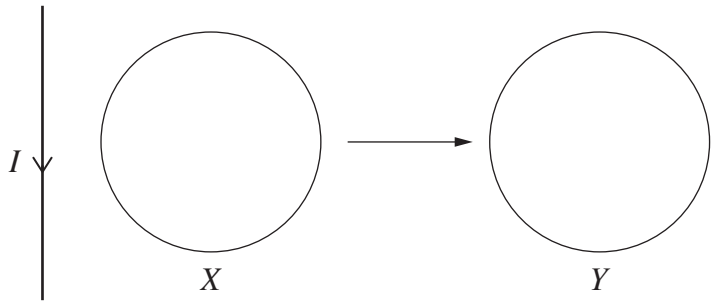
B. Boron-11

C. Lithium-6

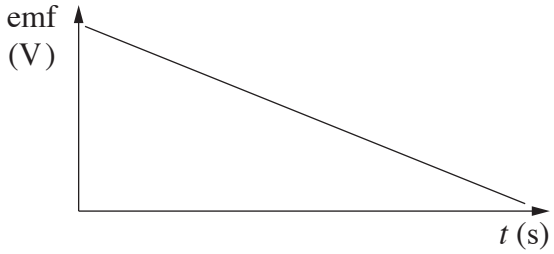
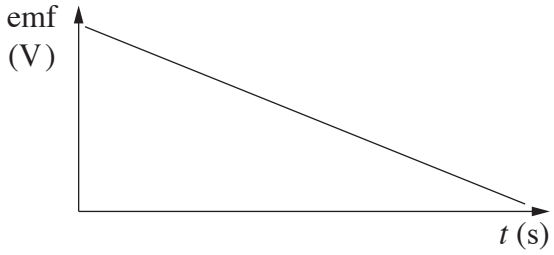
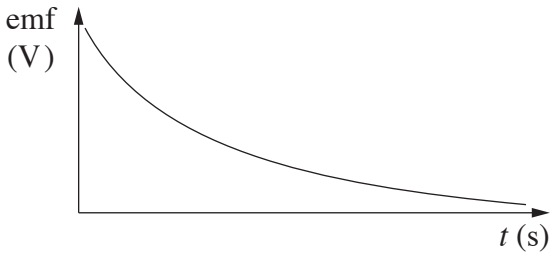
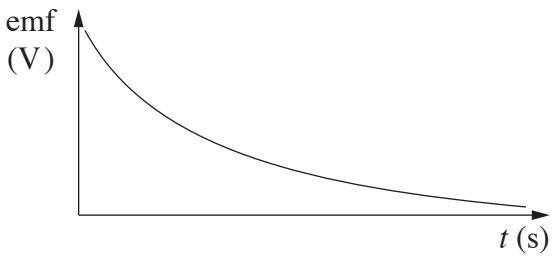
D. Lithium-10

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

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

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.

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.

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2025 HIGHER SCHOOL CERTIFICATE EXAMINATION

Centre Number

Student Number

Physics

Section II Answer Booklet

80 marks
Attempt Questions 21–36
Allow about 2 hours and 25 minutes for this section

Instructions

- Write your Centre Number and Student Number at the top of this page
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response
- 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

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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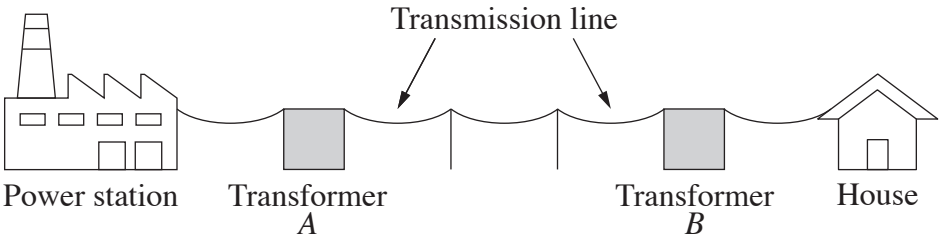
Question 22 (4 marks)

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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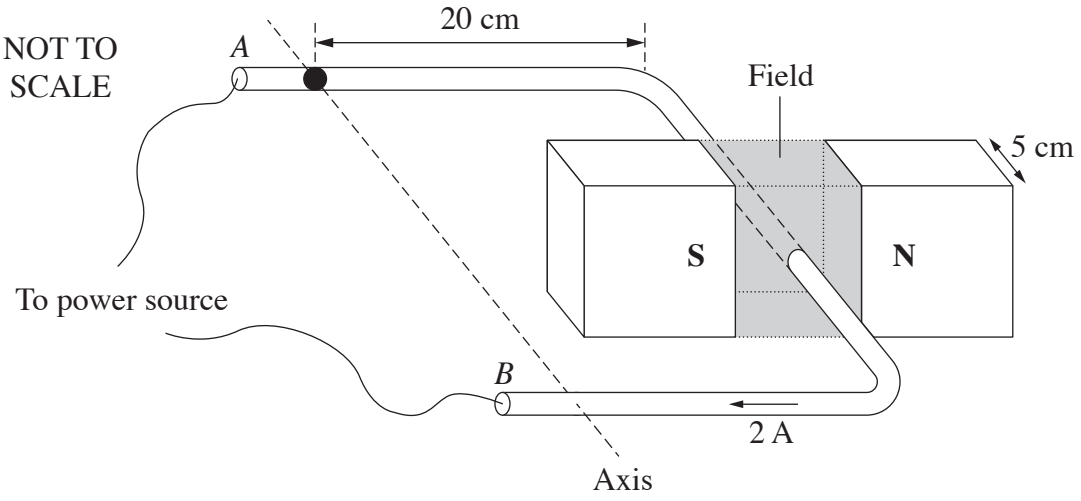
Question 23 (5 marks)

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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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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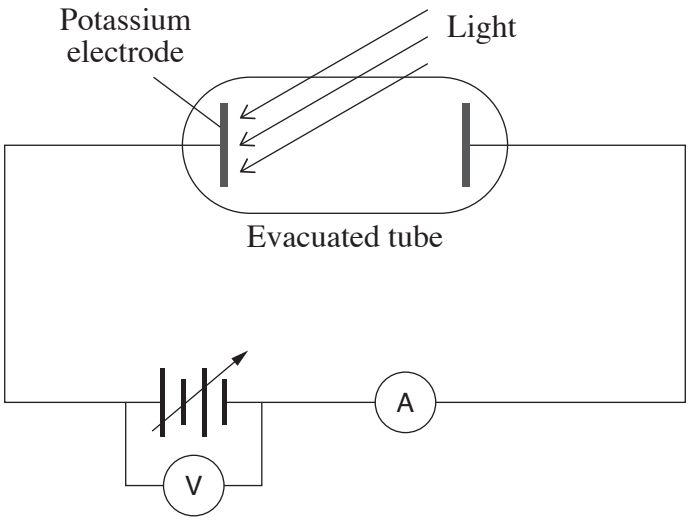
Please turn over

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.



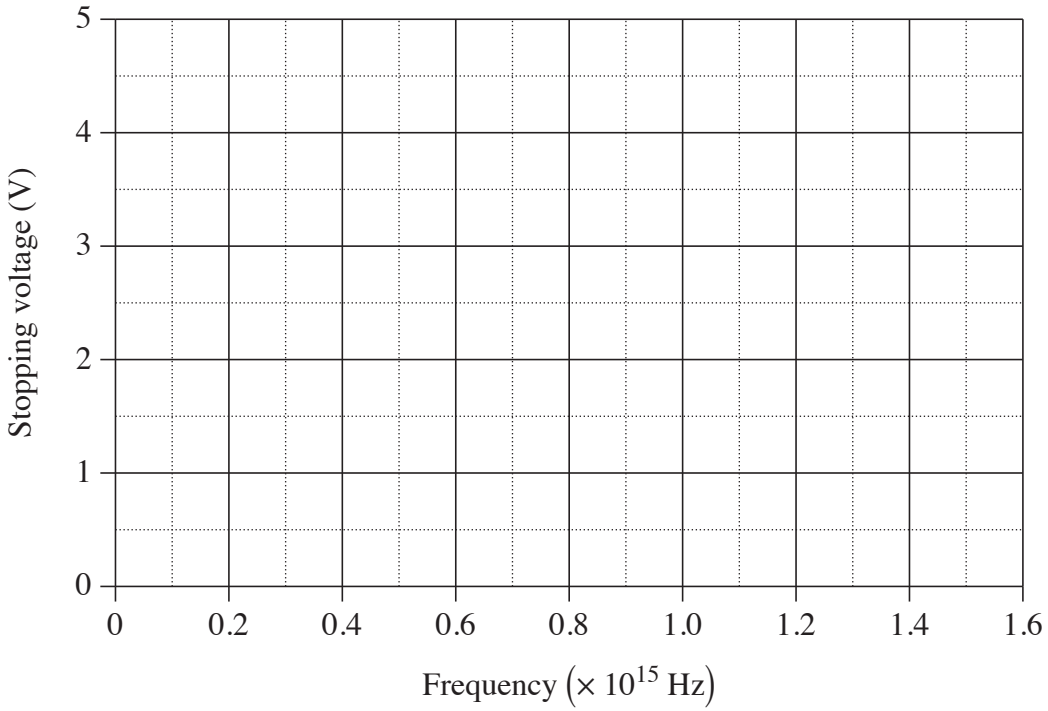
For each frequency of light tested, the voltage in the circuit is varied, and the minimum voltage (called the stopping voltage) required to bring the current in the circuit to zero is recorded.

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

Question 25 (continued)

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



Threshold frequency of potassium: ..... Hz

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

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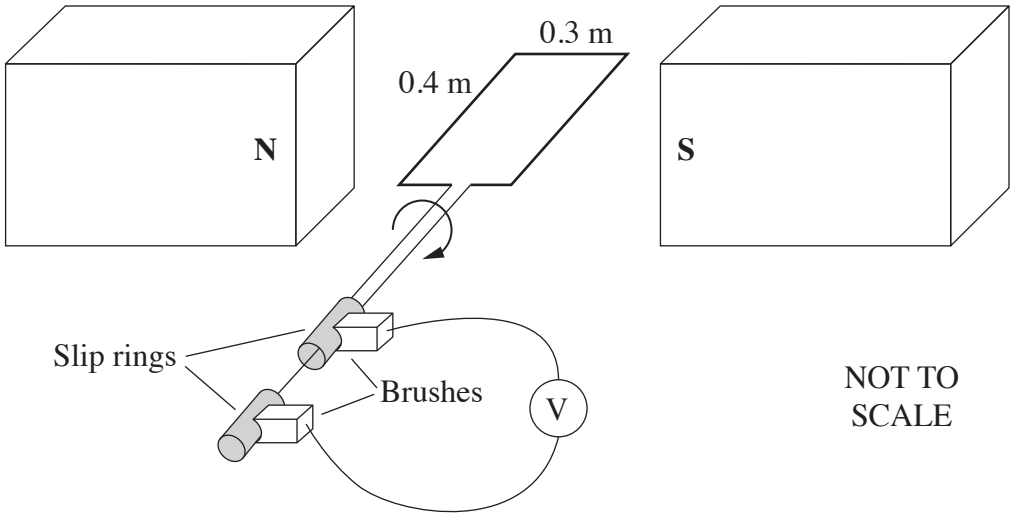
End of Question 25

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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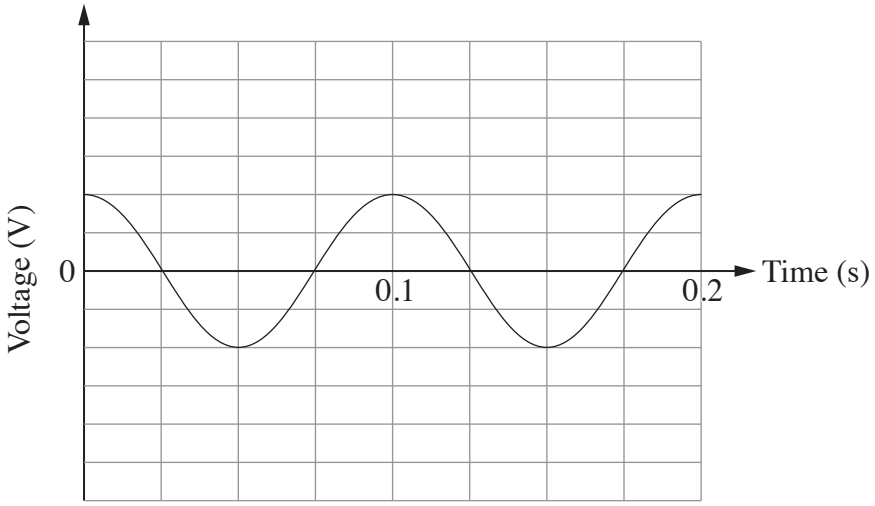
Question 26 continues on page 21

Question 26 (continued)

(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.

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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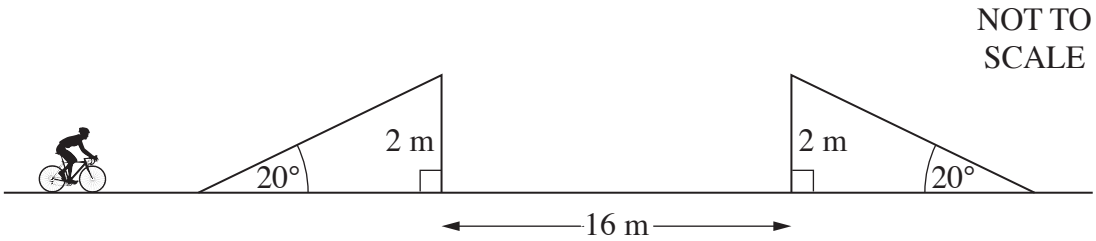
Question 28 (4 marks)

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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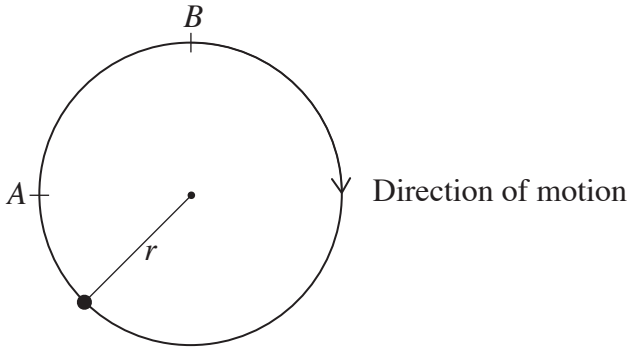
Question 29 (5 marks)

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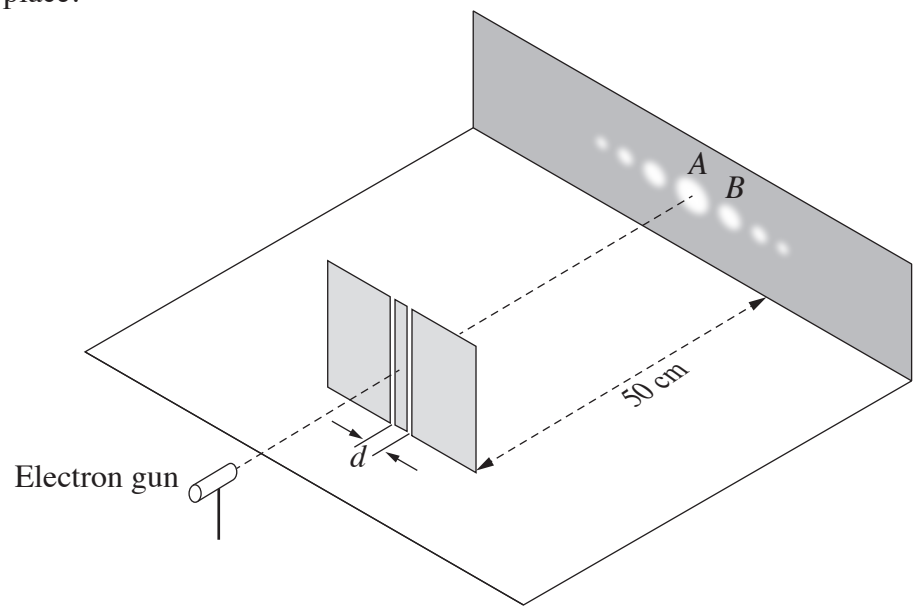
(b) An interference fringe occurs on the screen where constructive interference takes place. **2**



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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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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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**

Question 33 (6 marks)

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

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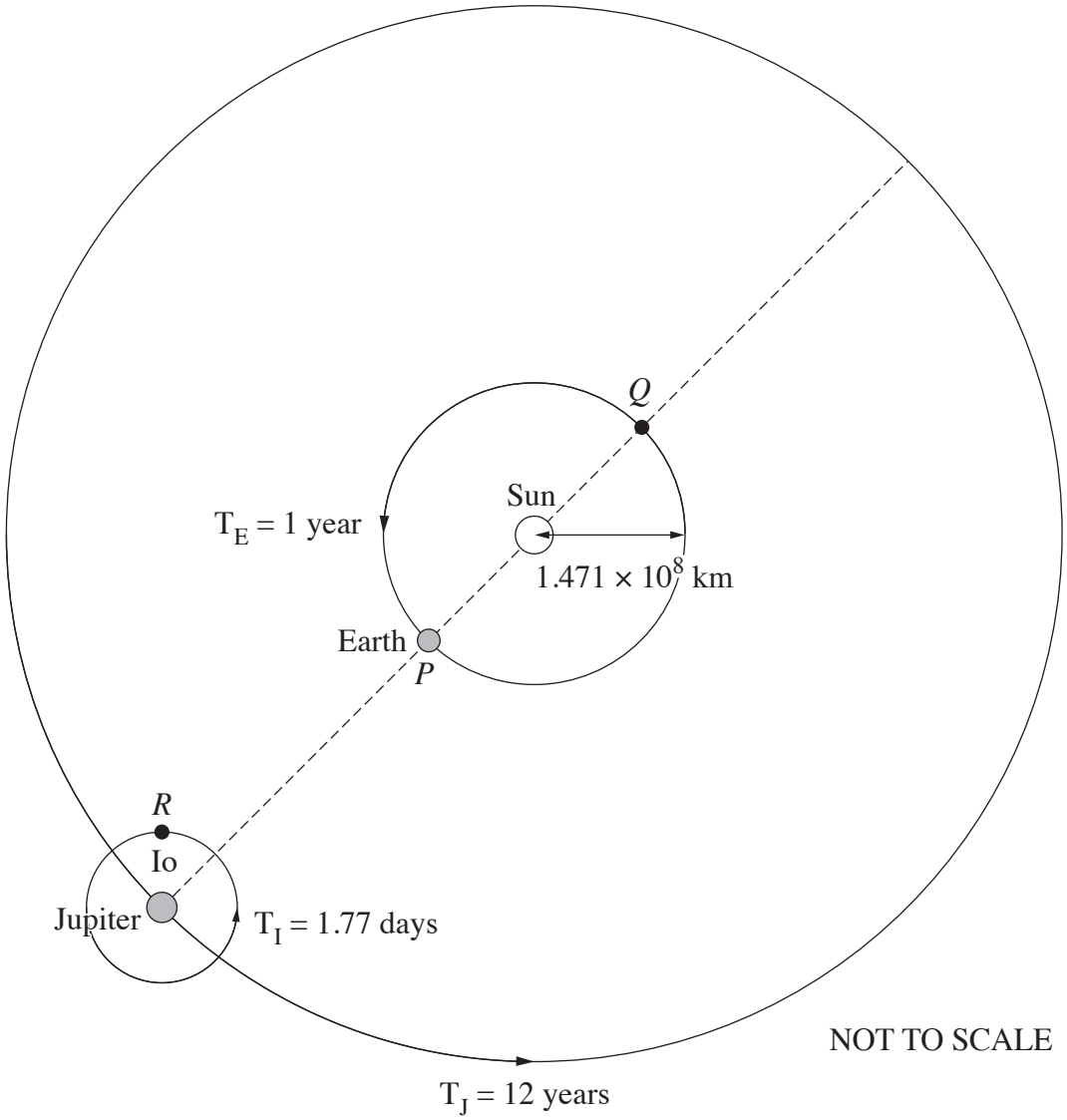
Question 34 (5 marks)

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

Question 34 (continued)

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

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(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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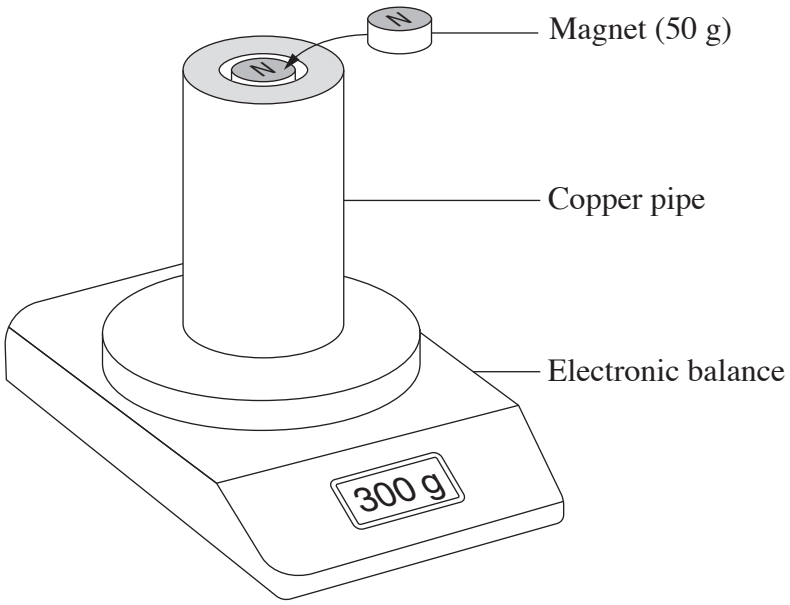
End of Question 34

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**



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)

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

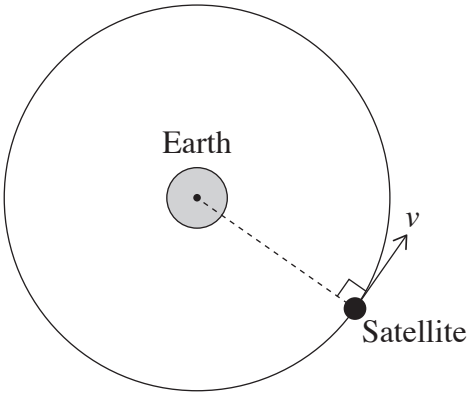

Figure 1

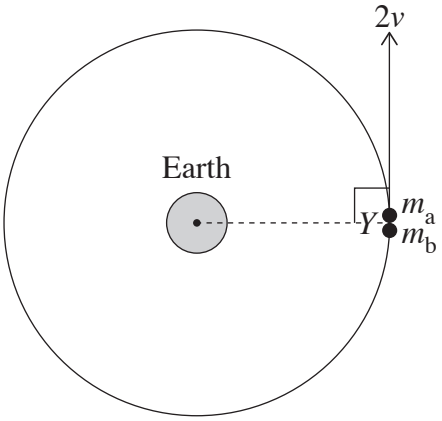

Figure 2

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

Question 36 (continued)

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Physics

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^{8} m s^{-1}
Electric permittivity constant, ε_0	8.854×10^{-12} A^2 s^4 kg^{-1} m^{-3}
Magnetic permeability constant, μ_0	$4\pi \times 10^{-7}$ N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth, M_E	6.0×10^{24} kg
Radius of Earth, r_E	6.371×10^{6} m
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^{7} m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^{3} kg m^{-3}
Specific heat capacity of water	4.18×10^{3} J kg^{-1} K^{-1}
Wien's displacement constant, b	2.898×10^{-3} m K

FORMULAE SHEET

Motion, forces and gravity

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$\Delta U = mg\Delta h$$

$$P = \frac{\Delta E}{\Delta t}$$

$$\sum \frac{1}{2}mv^2_{\text{before}} = \sum \frac{1}{2}mv^2_{\text{after}}$$

$$\Delta \vec{p} = \vec{F}_{\text{net}}\Delta t$$

$$\omega = \frac{\Delta \theta}{t}$$

$$\tau = r_{\perp}F = rF\sin\theta$$

$$v = \frac{2\pi r}{T}$$

$$U = -\frac{GMm}{r}$$

$$v = u + at$$

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$W = F_{||}s = Fs\cos\theta$$

$$K = \frac{1}{2}mv^2$$

$$P = F_{||}v = Fv\cos\theta$$

$$\sum m\vec{v}_{\text{before}} = \sum m\vec{v}_{\text{after}}$$

$$a_{\text{c}} = \frac{v^2}{r}$$

$$F_{\text{c}} = \frac{mv^2}{r}$$

$$F = \frac{GMm}{r^2}$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

Waves and thermodynamics

$$v = f\lambda$$

$$f = \frac{1}{T}$$

$$d\sin\theta = m\lambda$$

$$n_{\text{x}} = \frac{c}{v_{\text{x}}}$$

$$I = I_{\text{max}}\cos^2\theta$$

$$Q = mc\Delta T$$

$$f_{\text{beat}} = \left| f_2 - f_1 \right|$$

$$f' = f\frac{\left(v_{\text{wave}} + v_{\text{observer}}\right)}{\left(v_{\text{wave}} - v_{\text{source}}\right)}$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$\sin\theta_{\text{c}} = \frac{n_2}{n_1}$$

$$I_1r_1^2 = I_2r_2^2$$

$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

Electricity and magnetism

$$E = \frac{V}{d}$$

$$V = \frac{\Delta U}{q}$$

$$W = qV$$

$$W = qEd$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{\mu_0 NI}{L}$$

$$\Phi = B_{||}A = BA\cos\theta$$

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

$$\frac{V_\mathrm{p}}{V_\mathrm{s}} = \frac{N_\mathrm{p}}{N_\mathrm{s}}$$

$$\vec{F} = q\vec{E}$$

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$I = \frac{q}{t}$$

$$V = IR$$

$$P = VI$$

$$F = qv_\perp B = qvB\sin\theta$$

$$F = lI_\perp B = lIB\sin\theta$$

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

$$\tau = nIA_\perp B = nIAB\sin\theta$$

$$V_\mathrm{p} I_\mathrm{p} = V_\mathrm{s} I_\mathrm{s}$$

Quantum, special relativity and nuclear

$$\lambda = \frac{h}{mv}$$

$$K_\mathrm{max} = hf - \phi$$

$$\lambda_\mathrm{max} = \frac{b}{T}$$

$$E = mc^2$$

$$E = hf$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_\mathrm{f}^2} - \frac{1}{n_\mathrm{i}^2}\right)$$

$$t = \frac{t_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$$

$$p_\mathrm{v} = \frac{m_0 v}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$N_\mathrm{t} = N_0 e^{-\lambda t}$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY	
Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.