Centre Number

Student Number

NSW GOVERNMENT

NSW Education Standards Authority

This sample HSC examination paper is designed to show one way the Physics 11–12 Syllabus (2025) could be examined. It reflects the layout of a formatted HSC examination paper.

Sample **HIGHER SCHOOL CERTIFICATE EXAMINATION**

Physics

General Instructions

- Reading time – 10 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 3–15)

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

Section II – 80 marks (pages 16–38)

- Attempt Questions 21–37
- Allow about 2 hours and 25 minutes for this section

The first HSC examination for the Physics 11–12 Syllabus (2025) will be held in 2028. The structure of the Physics HSC examination is similar to the structure of past Physics HSC examinations. Where they are still relevant, past HSC questions have been used to illustrate different types of questions and how the syllabus can be examined.

The Physics HSC examination specifications can be found in the assessment information for the Physics 11–12 Syllabus (2025).

This sample examination provides examples of some types of questions that may be found in HSC examinations for the Physics 11–12 Syllabus (2025). Each question has been mapped to show how the question relates to syllabus outcomes and content.

Answers for the objective-response questions (Section I) and sample answers and marking guidelines for all other questions (Section II) are provided. The marking guidelines indicate the criteria for each mark.

In the examination, students will record their answers to Section I on a multiple-choice answer sheet and their answers to Section II in the spaces provided in the Section II Answer Booklet.

The sample questions, marking criteria, sample answers, answers could include and annotations provide teachers and students with guidance as to the types of questions to expect and how they may be marked. They are not meant to be prescriptive. Each year the structure of the examination may differ in the number and types of questions, or focus on different syllabus outcomes and content.

Note:

Comments in coloured boxes are annotations that provide information and guidance.

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 In which subatomic particle are quarks found?

A. Electron

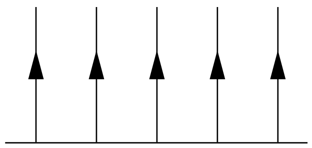
B. Gluon

C. Muon

D. Proton

2 Which diagram best approximates the shape and direction of the Earth's gravitational field for a person standing on its surface?

A.



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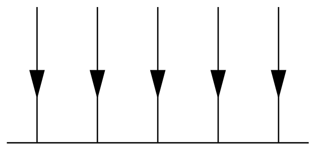

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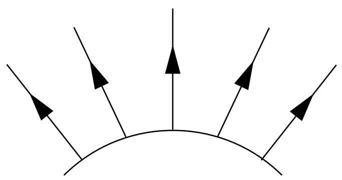

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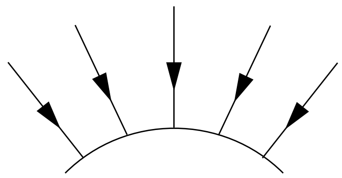


3 Which row of the table correctly describes the properties of a real transformer?

	Flux linkage	*Power loss*
A.	Complete	Yes
B.	Complete	No
C.	Incomplete	Yes
D.	Incomplete	No

4 The photoelectric effect is mathematically modelled by the following relationship:

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

In this model, the symbol ϕ represents the amount of energy

A. supplied by a photon to an electron.

B. retained by an electron after being hit.

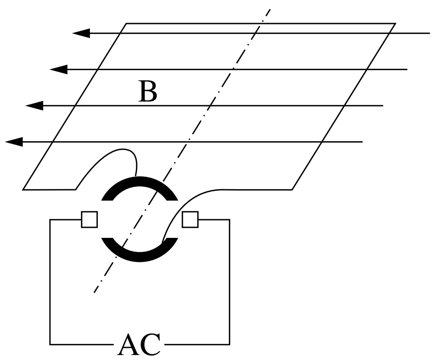
C. required to release an electron from a material.

D. left over after a collision of a photon with an electron.

5 A conducting coil is mounted on an axle and placed in a uniform magnetic field. The diagram shows different ways of connecting the coil to a power source.

Which setup allows the conducting coil to rotate continuously?

A.



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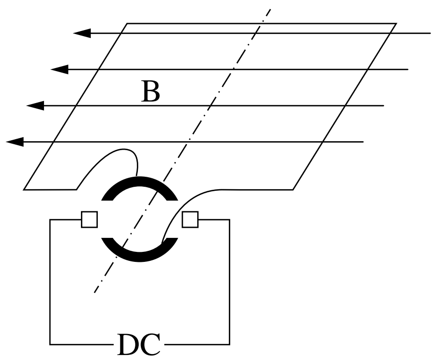

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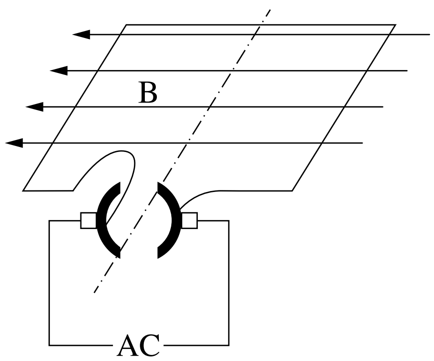

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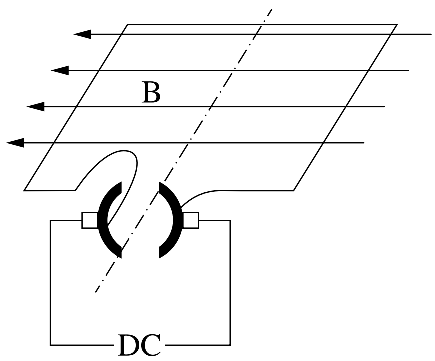
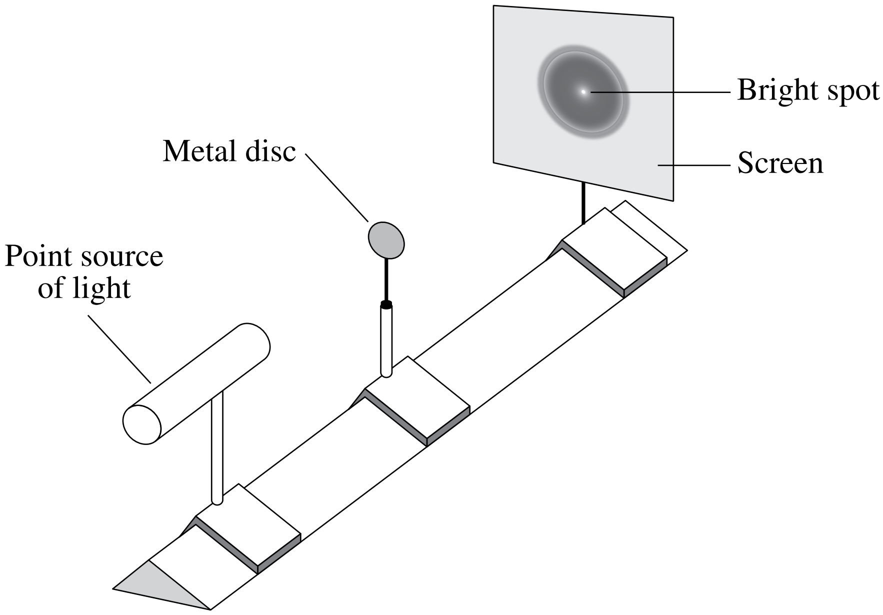


6 Light from a point source is incident upon a circular metal disc, forming a shadow on a screen as shown. A bright spot is observed in the centre of the shadow.



The bright spot is caused by a combination of

A. interference and refraction.

B. refraction and polarisation.

C. polarisation and diffraction.

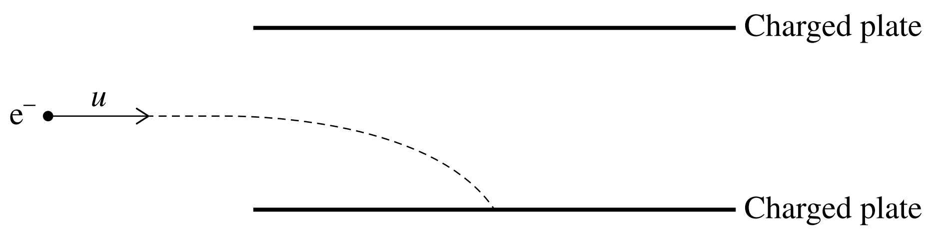
D. diffraction and interference.

7 In a certain ideal transformer, the current in the secondary coil is four times as large as the current in the primary coil.

Which row of the table correctly identifies the type of transformer and the ratio of turns?

	Type of transformer	*Ratio of turns in primary coil to turns in secondary coil*
A.	Step up	4 : 1
B.	Step up	1 : 4
C.	Step down	4 : 1
D.	Step down	1 : 4

8 An electron travelling in a straight line with an initial velocity, u, enters a region between two charged plates in which there is an electric field causing it to travel along the path as shown.

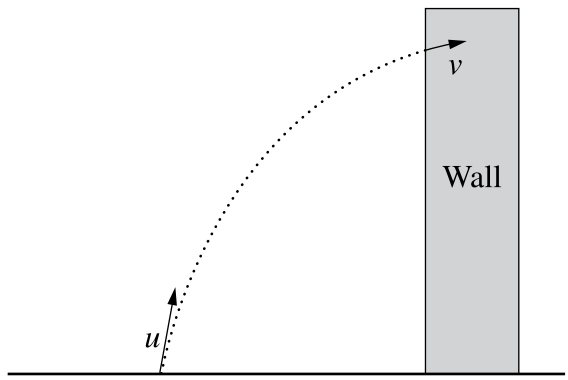


A magnetic field is then applied causing a second electron with the same initial velocity to pass through undeflected.

Which row of the table shows the directions of the electric and magnetic fields when the second electron enters the region between the plates?

	Electric field	*Magnetic field*
A.	Towards top of page	Into page
B.	Towards top of page	Out of page
C.	Towards bottom of page	Into page
D.	Towards bottom of page	Out of page

9 An object is launched with an initial velocity, u, and hits a wall with a final velocity, v.



Which statement correctly compares components of u and v?

A. The vertical component of v is less than the vertical component of u.

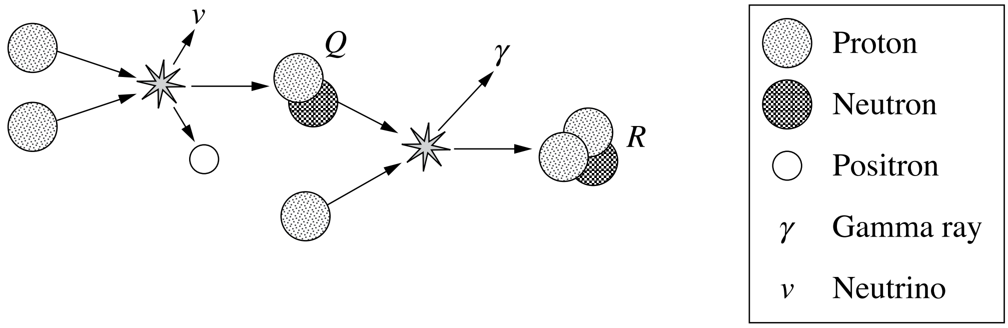
B. The vertical component of v is greater than the vertical component of u.

C. The horizontal component of v is less than the horizontal component of u.

D. The horizontal component of v is greater than the horizontal component of u.

Use the information provided to answer Questions 10 and 11.

The diagram shows part of a nuclear fusion process that occurs in stars.



10 What is the isotope labelled *R*?

A. H-2

B. He-2

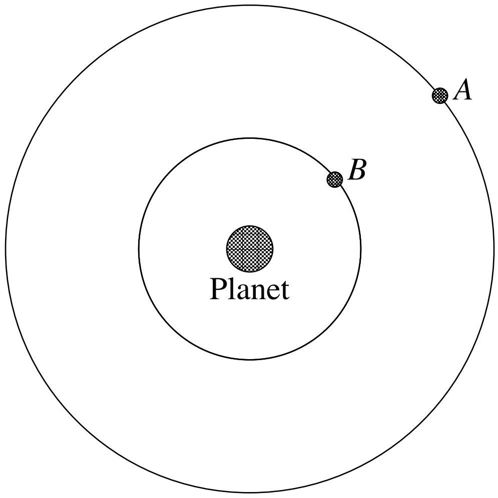
C. H-3

D. He-3

11 Which row of the table shows the process and corresponding quark change during the formation of isotope *Q*?

	Process	*Quark change*
A.	Beta-minus decay	up → down
B.	Beta-minus decay	down → up
C.	Beta-plus transformation	up → down
D.	Beta-plus transformation	down → up

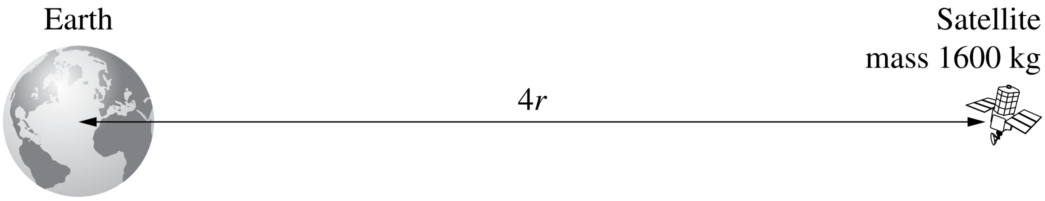
12 The diagram shows two identical satellites, *A* and *B*, orbiting a planet.

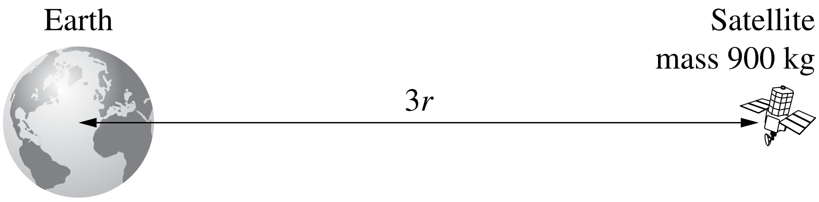


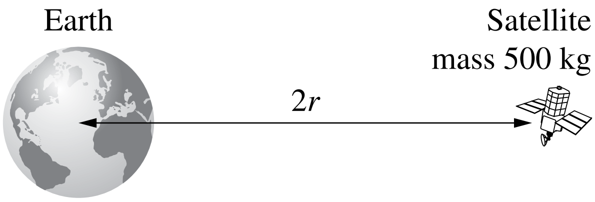
Which row in the table correctly compares the potential energy, U, and kinetic energy, K, of the satellites?

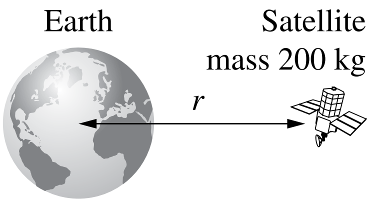
	Potential energy	*Kinetic energy*
A.	$U_A > U_B$	$K_A < K_B$
B.	$U_A < U_B$	$K_A > K_B$
C.	$U_A > U_B$	$K_A > K_B$
D.	$U_A < U_B$	$K_A < K_B$

13 In which of the following would the satellite have the greatest escape velocity from Earth?

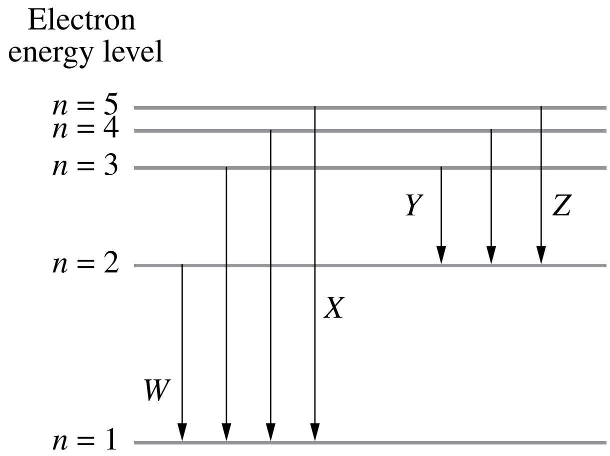
A. 

B. 

C. 

D. 

14 The diagram shows electron transitions in the stationary energy level model of a hydrogen atom.



Which transition would produce the shortest wavelength of light?

A. *W*

B. *X*

C. *Y*

D. *Z*

15 A laser has a power output of 30 mW and emits light with a wavelength of 650 nm.

How many photons does this laser emit per second?

A. 4.6×10^{14}

B. 9.8×10^{16}

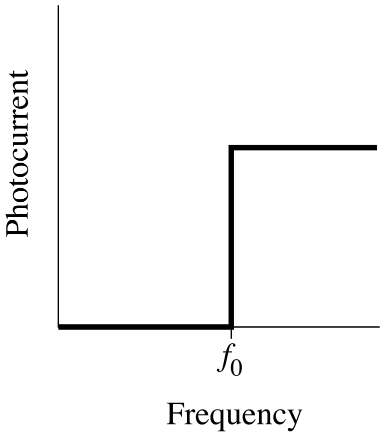
C. 3.1×10^{19}

D. 9.3×10^{21}

16 The threshold frequency (f_0) is the minimum frequency of light required to release an electron from a metal surface.

Which of the following graphs shows the relationship between the photocurrent and light frequency when the intensity of light is constant?

A.



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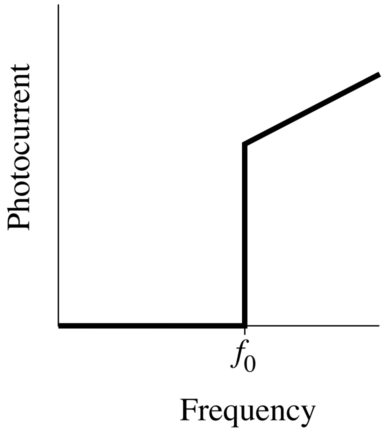

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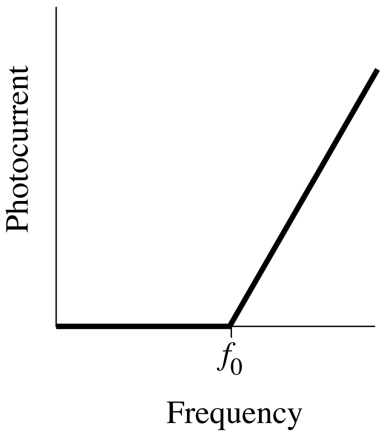

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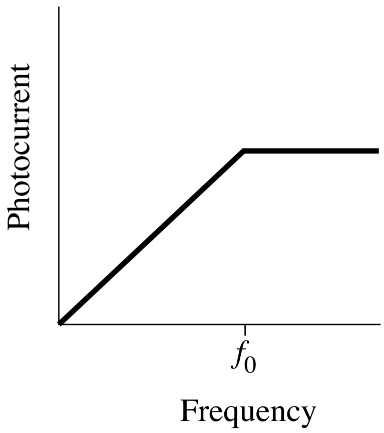
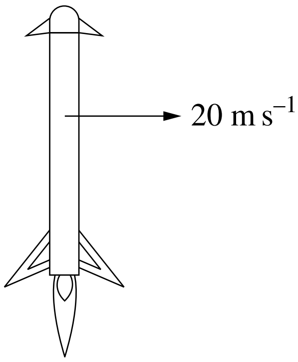


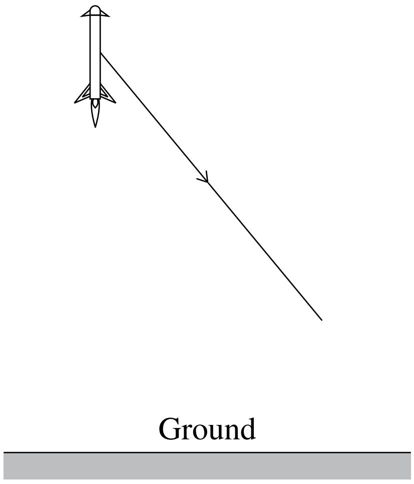
17 A rocket returns to Earth for reuse after launching satellites, using its engines to make a controlled landing.

The rocket having a mass of 7800 kg is on approach to the ground, travelling horizontally at 20 m s^{-1} as shown in the diagram, when the engine thrust is changed to 90 000 newtons.

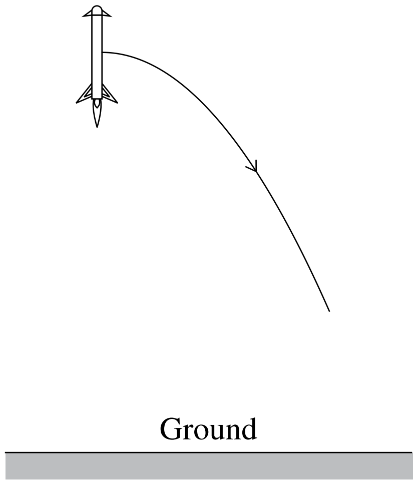


Which diagram shows the trajectory of the rocket following this change of thrust?

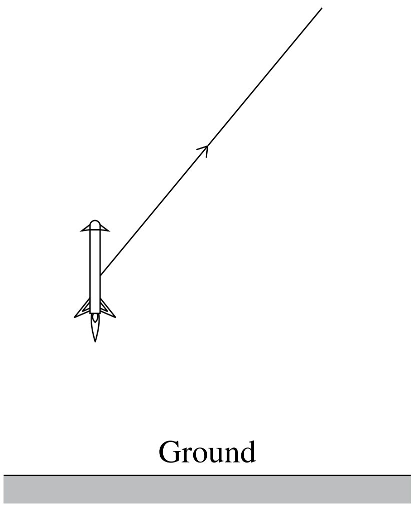
A.



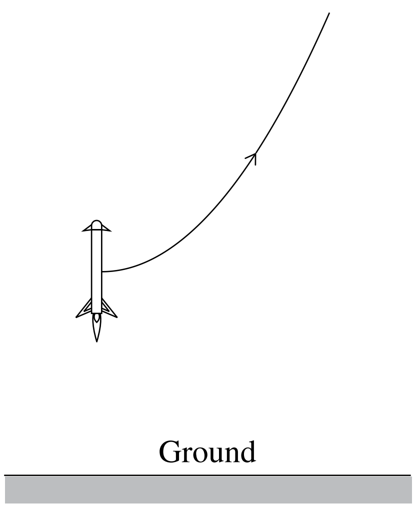
B.



C.

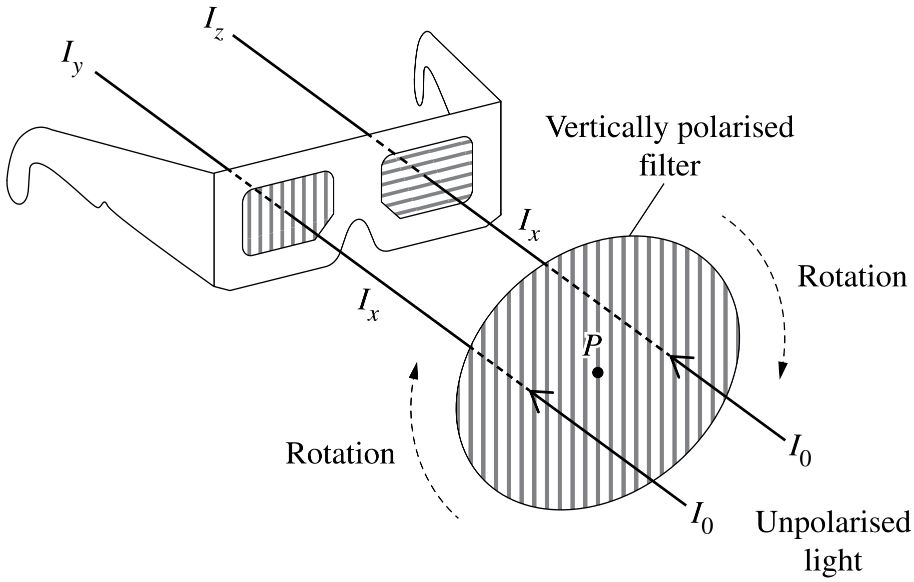


D.



18 Unpolarised light of intensity I_0 is incident upon a vertically polarised filter. The filtered light then passes through a pair of glasses. The glass have polarising filters, with one side polarised vertically and the other horizontally.

The filter undergoes one complete 360° rotation around point P, as shown.



Which of the following correctly compares I_y to the intensity at other positions?

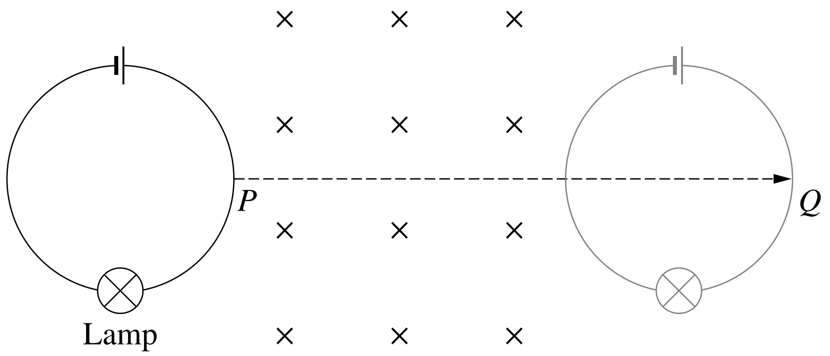
A. I_y never equals I_x

B. I_y never equals I_z

C. I_y sometimes equals I_z

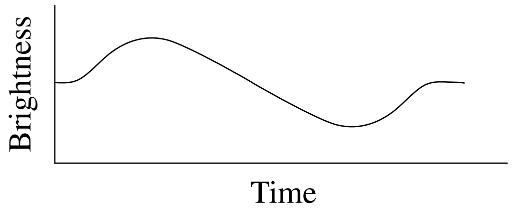
D. I_y sometimes equals I_0

19 A circular loop of wire is connected to a battery and a lamp. The apparatus is moved from *P* to *Q* along the path shown at a constant velocity through a region containing a uniform magnetic field.

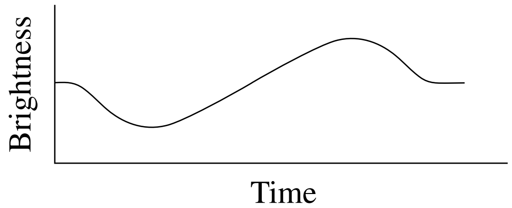


Which graph shows the brightness of the lamp as the apparatus moves between *P* and *Q*?

A.



B.



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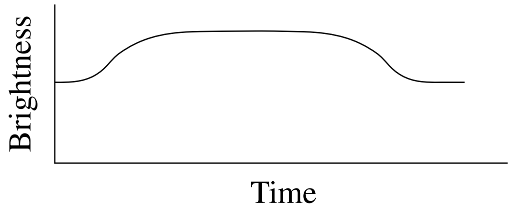
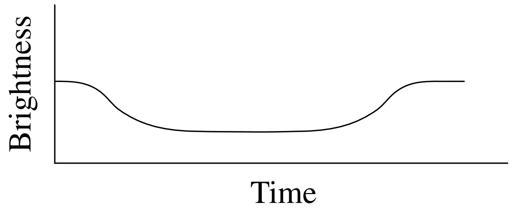
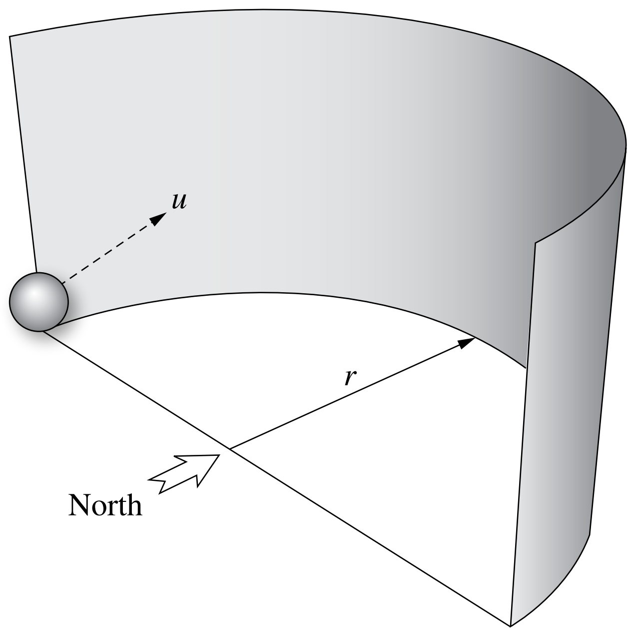


D.



20 The diagram shows a smooth, semi-circular, vertical wall with radius, r.

A ball is launched from the position shown with a velocity u towards north at an angle to the horizontal.



The ball follows a trajectory around the wall before landing on the ground, opposite its starting point. It does not reach the top of the wall.

Assume that there is no friction between the ball and the wall.

Which statement correctly describes the net force acting on the ball during its motion?

A. The magnitude of the net force remains constant.

B. The direction of the net force is vertically downwards.

C. The direction of the net force is perpendicular to the wall.

D. The magnitude of the net force reaches a minimum when the ball is at its highest point.

Sample HIGHER SCHOOL CERTIFICATE EXAMINATION

Centre Number

Student Number

Physics

Section II Answer Booklet

80 marks
Attempt Questions 21–37
Allow about 2 hours and 25 minutes for this section

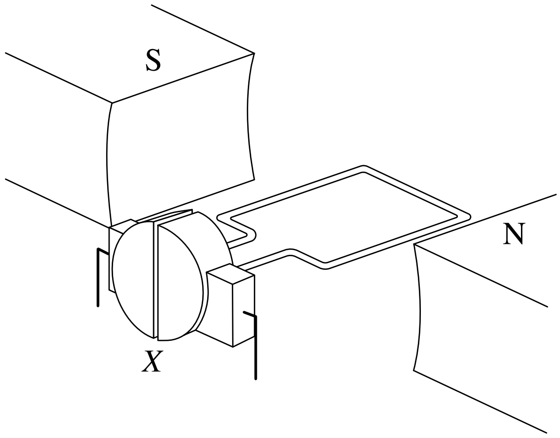
Instructions

- 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 (4 marks)

(a) The diagram represents one type of electric motor. **2**



Describe the function of part *X*.

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(b) Explain why the torque of a DC motor decreases as its rotational speed increases. **2**

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Question 22 (4 marks)

Explain how the composition and surface temperature of a star can be determined from its spectrum. **4**

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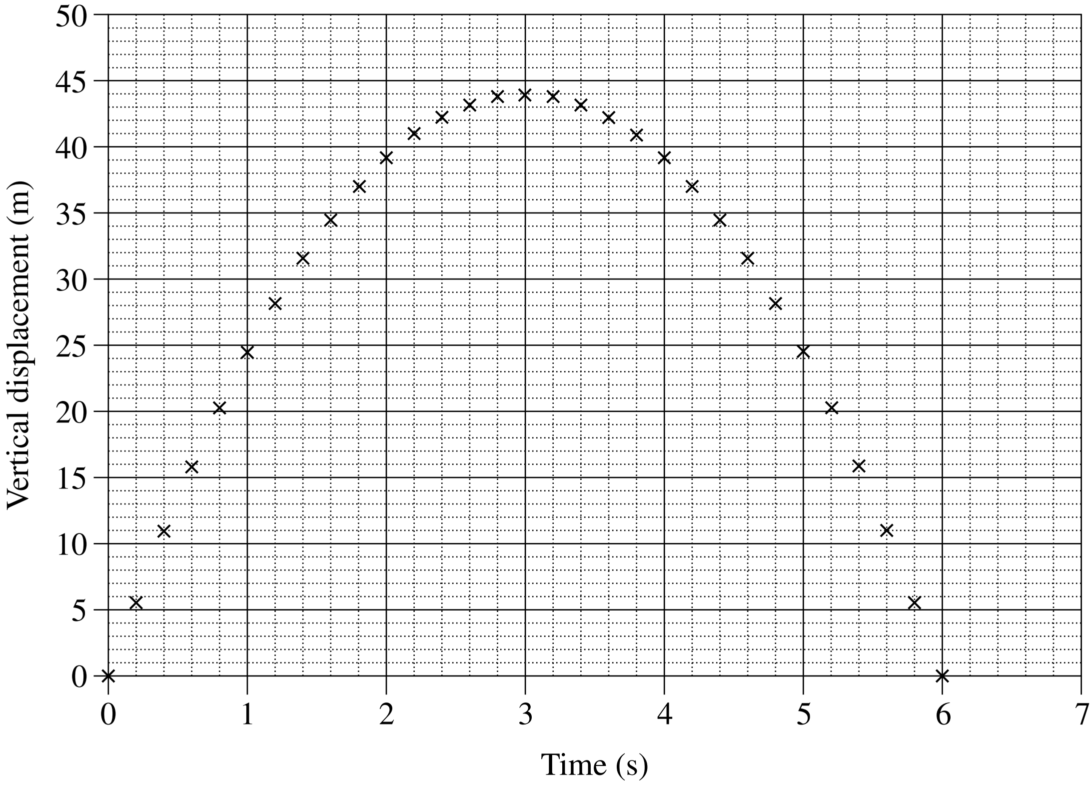
Question 23 (4 marks)

The graph shows the vertical displacement of a projectile throughout its trajectory. The range of the projectile is 130 m. **4**



Calculate the initial velocity of the projectile.

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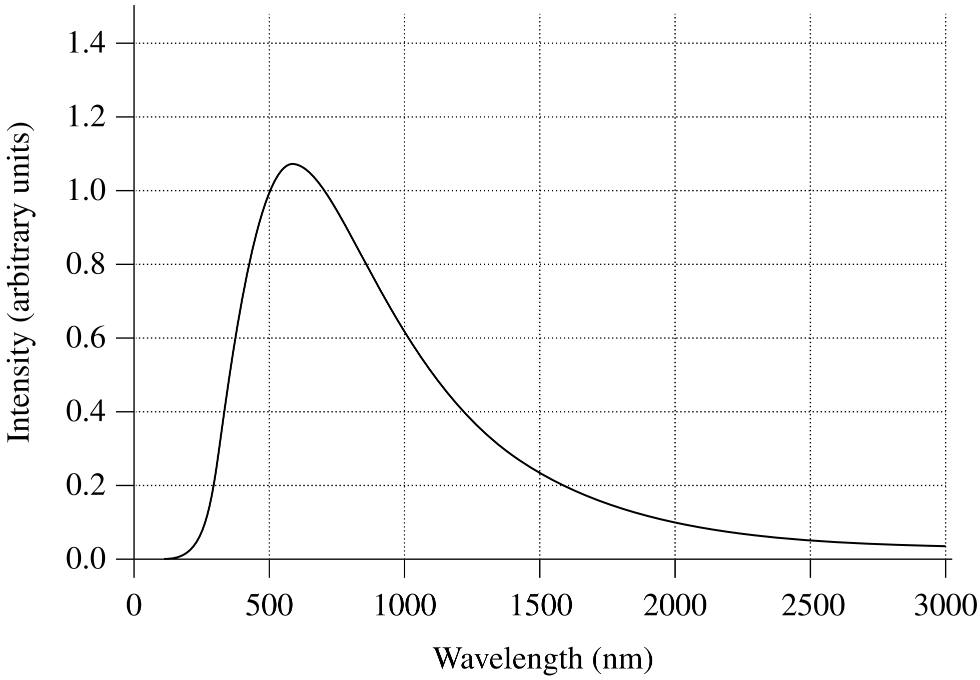
Question 24 (4 marks)

The diagram shows the radiation curve for a black body radiator at a temperature of 5000 K. **4**



On the same diagram, sketch a curve for a black body radiator at a temperature of 4000 K and explain the differences between the curves.

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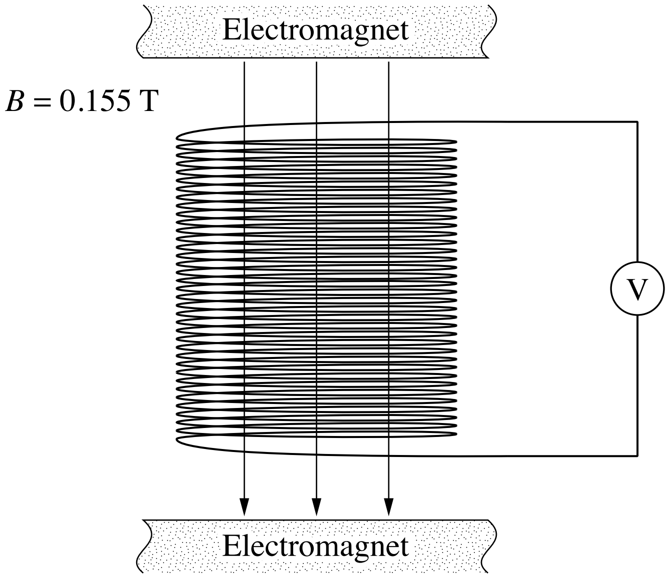
Question 25 (3 marks)

A stationary coil of 35 turns and cross-sectional area of 0.02 m^2 is placed between two electromagnets, and connected to a voltmeter as shown. The electromagnets produce a uniform magnetic field of 0.155 T through the coil. **3**



The magnitude of the magnetic field is then reduced to zero at a constant rate over a period of 0.40 s.

Calculate the magnitude of the emf induced in the coil to two significant figures.

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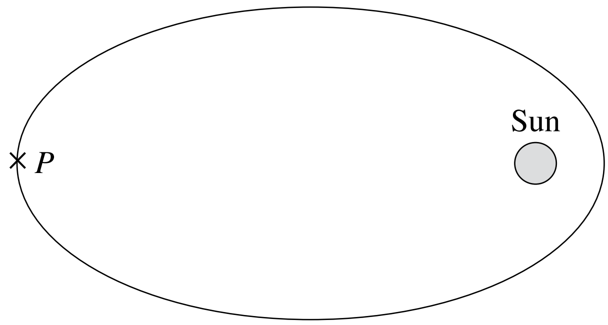
Question 25 is an example of a question that requires students to use appropriate significant figures to express quantitative solutions.

Question 26 (3 marks)

The orbit of a comet is shown. **3**



Account for the changes in velocity of the comet as it completes one orbit from position P.

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Question 27 (5 marks)

An experiment was conducted to determine the speed of light. The experiment involved measuring the electric permittivity constant (ε_0), then using this data to calculate the speed of light.

The experiment was conducted four times, and the results are shown in the table.

	ε_0 ($\times 10^{-11}$ A^2 s^4 kg^{-1} m^{-3})
Trial 1	1.233
Trial 2	1.229
Trial 3	1.236
Trial 4	1.256
Average	1.239

(a) Using the average value of ε_0, show that the calculated speed of light is 2.534×10^8 m s^{-1}. **2**

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(b) Assess the precision and accuracy of the data collected in the experiment. **3**

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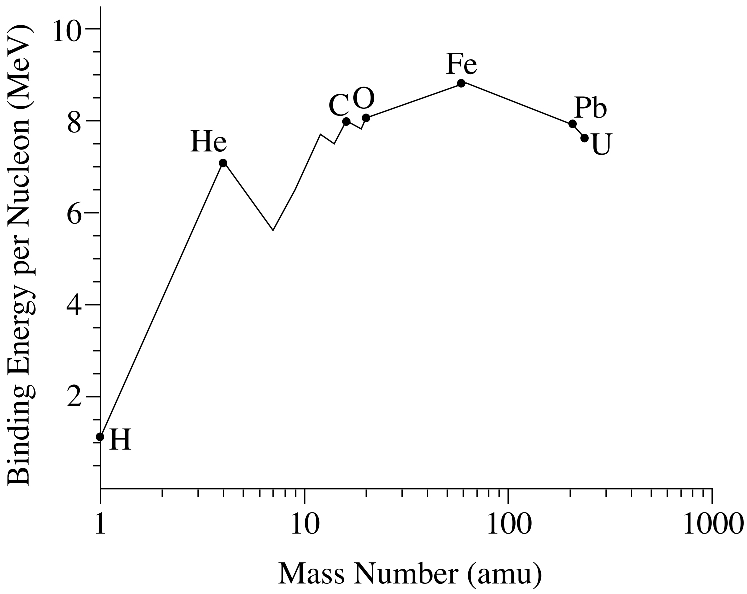
Question 27 (b) shows one way an item could assess Working scientifically outcomes and content.

Question 28 (5 marks)

The graph shows the change in binding energy per nucleon as mass number increases. **5**



Account for the formation of elements in stars using the data from the graph.

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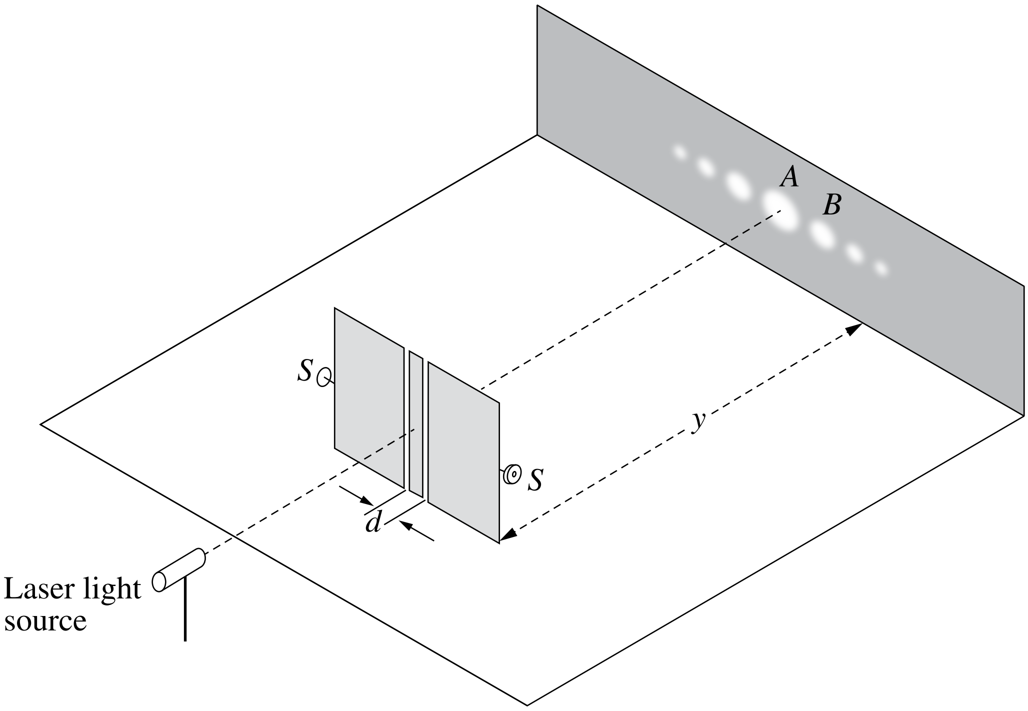
Question 28 shows one way that an item could require the integration of knowledge from more than one syllabus content point.

Question 29 (4 marks)

The following apparatus is used to investigate light interference using a double slit. **4**



The distance, y, from the slits to the screen can be varied. The adjustment screws (S) vary the distance, d, between the slits. The wavelength of the laser light can be varied across the visible spectrum. The diffraction pattern shown is for a specific wavelength of light.

Explain TWO methods of keeping the distance between the maxima at A and B constant when the wavelength of the laser light is reduced.

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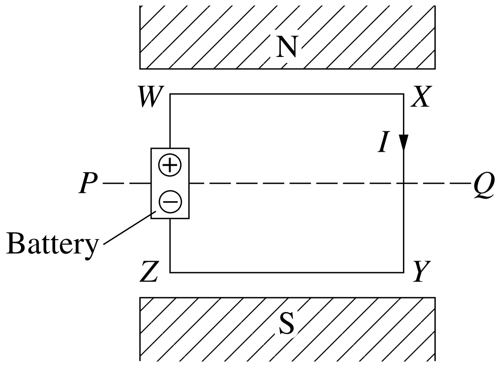
Question 30 (3 marks)

A metal loop, *WXYZ* is connected to a battery and placed in a uniform magnetic field. **3**
A current flows through the loop in the direction shown.



The loop is then allowed to rotate by 90° about the axis *PQ*.

Compare the forces acting on *WX* and *XY* before and after this rotation.

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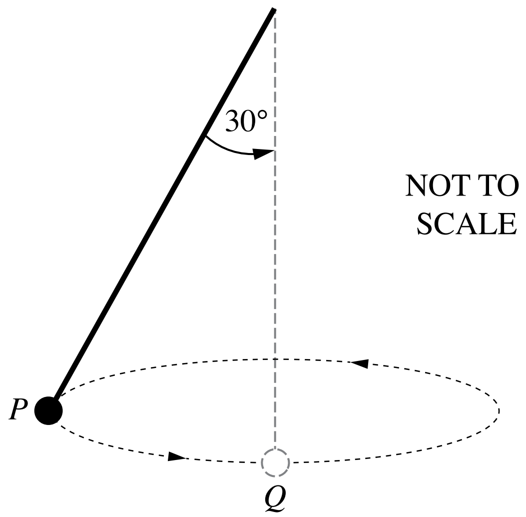
Question 31 (5 marks)

A 2 kg mass connected by a string is undergoing constant horizontal circular motion with a radius of 80 cm.



(a) Show that the magnitude of the centripetal force on the mass is approximately 11 N at position *P*. **2**

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(b) At position *Q*, the string is cut. **3**

Calculate the range of the mass when it has fallen 3 m.

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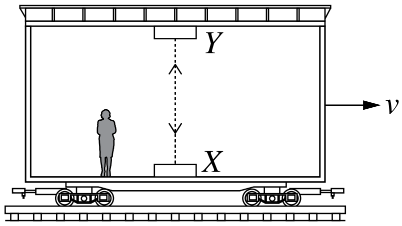
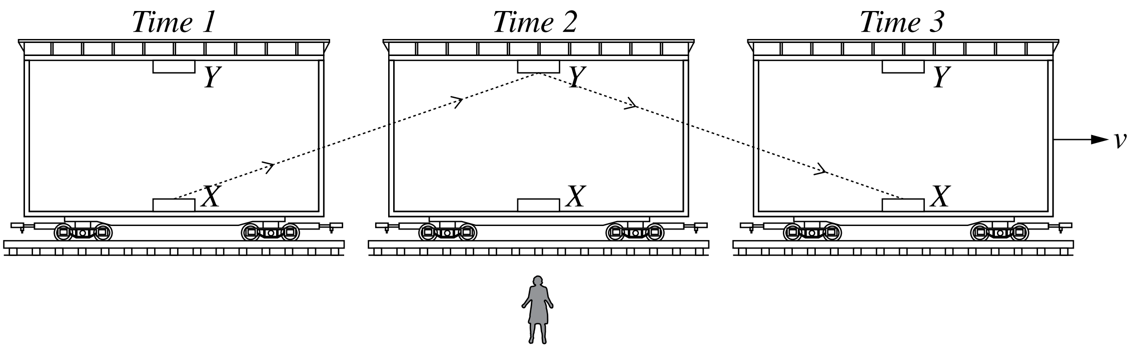
Question 32 (6 marks)

In a thought experiment, light travels from X to a mirror Y and back to X on a moving train carriage. The path of the light relative to an observer on the train is shown.



Relative to an observer outside the train, the path of the light is shown below, at three consecutive times as the train carriage moves along the track.



(a) Describe qualitatively how the constancy of the speed of light and the thought experiment above led Einstein to predict time dilation. **3**

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Question 32 continues on page 29

Question 32 (continued)

(b) The train is travelling with a velocity $v = 0.96c$. To the observer inside the train, the return journey for the light between X and Y takes 15 nanoseconds. **3**

How long would this return journey take according to the observer outside the train?

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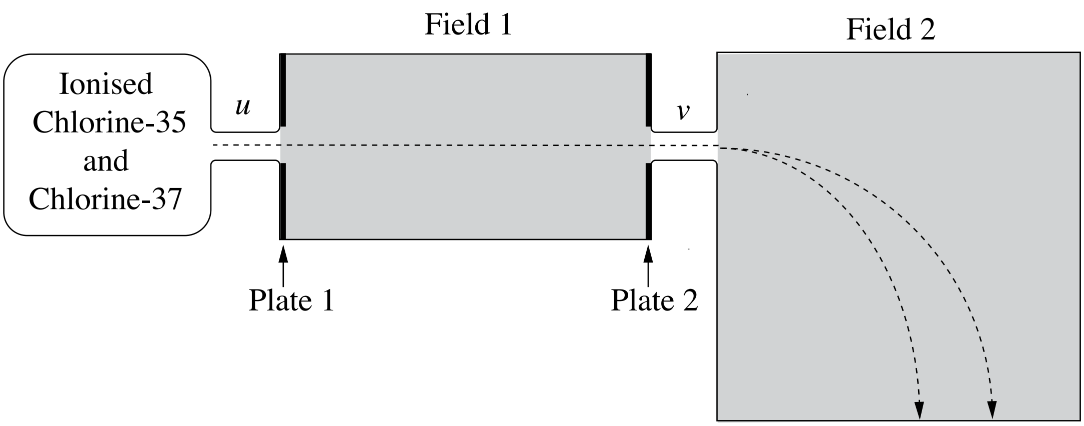
End of Question 32

Please turn over

Question 33 (5 marks)

The diagram shows the path of a mixture of Chlorine-35 and Chlorine-37 through a simplified mass spectrometer. The ions enter Field 1 with velocity *u*. **5**

Assume the ions have the same negative charge, leave Field 1 with the same velocity *v* and the effects of gravity are negligible.



Explain how Field 1 and Field 2 contribute to the separation of the chlorine ions.

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Question 33 shows one way that an item could require the integration of knowledge from more than one syllabus focus area.

Question 34 (5 marks)

Describe the role of annihilation and the photoelectric effect in the production of a positron emission tomography (PET) scan. In your answer, refer to the law of conservation of energy. **5**

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Question 35 (6 marks)

The mathematical model below shows the relationship between the orbital radius of a satellite and its period.

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

(a) By considering gravitational force, show how this model can be derived. **2**

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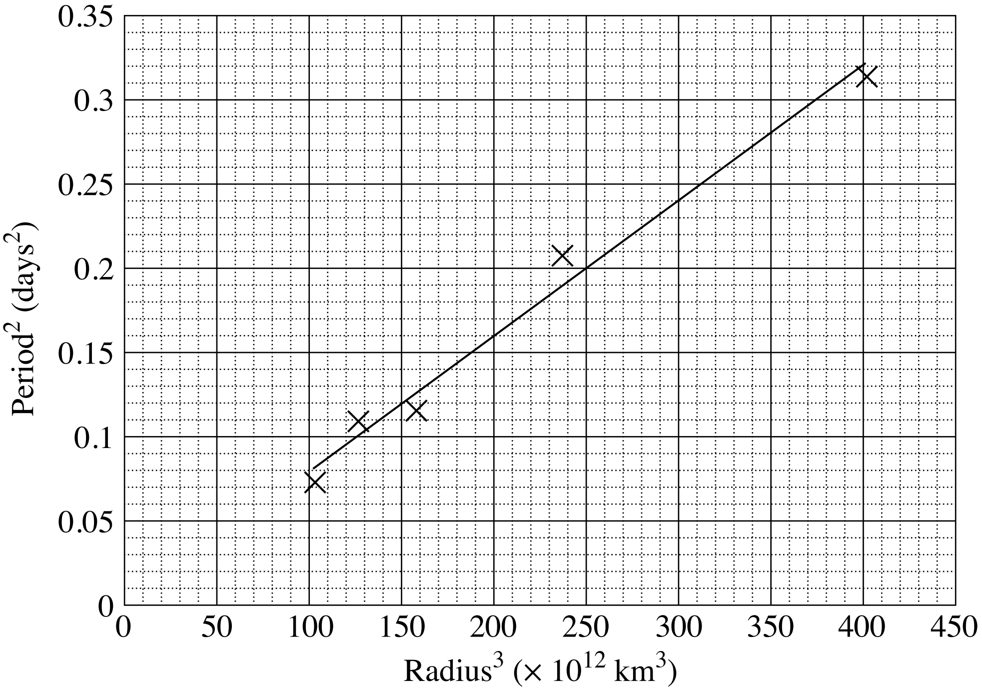
Question 35 continues on page 33

Question 35 (continued)

(b) A planet with five moons is discovered. The following graph is produced from observations of the orbital radius of the moons and their orbital periods, measured in Earth days. **4**



Use the graph to calculate the mass of the planet.

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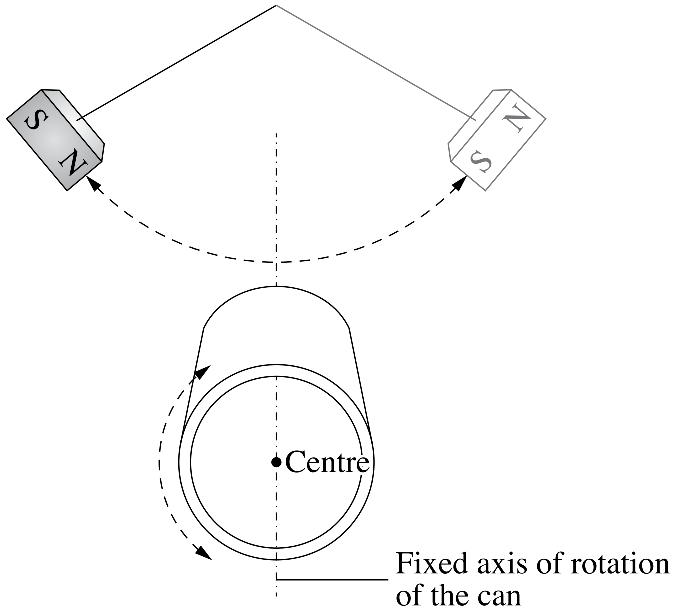
End of Question 35

Question 36 (7 marks)

A magnet is swinging as a pendulum. Close below it is an aluminium (non-ferromagnetic) can. The can is free to spin around a fixed axis as shown. **7**



Analyse the motion and energy transformations of both the can and the magnet.

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Question 37 (7 marks)

A radon-198 atom, initially at rest, undergoes alpha decay. The masses of the atoms involved are shown in atomic mass units (u). **7**

radon-198	$\longrightarrow$	polonium-194	+	helium-4
197.999 u		193.988 u		4.00260 u

The kinetic energy of the polonium atom produced is 2.55×10^{-14} J.

By considering mass defect, calculate the kinetic energy of the alpha particle, and explain why it is significantly greater than that of the polonium atom.

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End of paper

Section II extra writing space

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If you use this space, clearly indicate which question you are answering.

NSW Education Standards Authority

Sample 2028 **HIGHER SCHOOL CERTIFICATE EXAMINATION**

Physics

The Physics data sheet has been updated. Additions and changes have been highlighted in red boxes below.

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	$3.00 \times 10^{8} \text{ m s}^{-1}$
Electric permittivity constant, ε_0	$8.854 \times 10^{-12} \text{ A}^2 \text{ s}^4 \text{ kg}^{-1} \text{ m}^{-3}$
Magnetic permeability constant, μ_0	$4\pi \times 10^{-7} \text{ N A}^{-2}$
Universal gravitational constant, G	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Mass of Earth, M_E	5.97×10^{24} kg
Radius of Earth, r_E	6.371×10^{6} m
h	6.626×10^{-34} J s
R (hydrogen)	$1.097 \times 10^{7} \text{ m}^{-1}$
Atomic mass unit, u	1.661×10^{-27} kg $931.5 \text{ MeV}/c^2$
1 eV	1.602×10^{-19} J
b	2.898×10^{-3} m K

FORMULAE SHEET

Motion, forces and gravity

$$\boxed{\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2}$$

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

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

$$\boxed{\tau = rF\sin\theta}$$

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

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

$$U \boxed{+ KE} = -\frac{GMm}{2r}$$

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

$$\boxed{KE} = \frac{1}{2}mv^2$$

$$\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$$

$$\vec{v}_{av} = \frac{\Delta \vec{s}}{\Delta t}$$

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

$$F_\perp = mg\cos\theta$$

$$F_{||} = mg\sin\theta$$

$$F_x = F\cos\theta$$

$$F_y = F\sin\theta$$

$$\boxed{\vec{v} = \vec{u} + \vec{a}t}$$

$$\vec{F}_w = m\vec{g}$$

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

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

$$\vec{p} = m\vec{v}$$

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

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

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

$$a_c = \frac{v^2}{r}$$

$$F_c = \frac{mv^2}{r}$$

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

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

$$g = \frac{GM}{r^2}$$

$$W = \Delta U$$

$$f_{\text{friction}} = \mu F_N$$

Waves

$$v = f\lambda$$

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

$$d\sin\theta = m\lambda = \boxed{\frac{dy}{L}}$$

$$n_x = \frac{c}{v_x}$$

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

$$\boxed{I \propto \frac{1}{r^2}}$$

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

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

$$\sin\theta_c = \frac{n_2}{n_1}$$

$$I_1r_1^2 = I_2r_2^2$$

$$E = hf$$

FORMULAE SHEET (continued)

Electricity and magnetism

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

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

$$W = qV = \boxed{\Delta KE}$$

$$W = qEd$$

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

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

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

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

$$\boxed{\begin{aligned} &\Phi = BA\cos\theta \\ &|\varepsilon| = N\left|\frac{\Delta\Phi}{\Delta t}\right| \end{aligned}}$$

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

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

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

$$V = IR$$

$$P = VI$$

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

$$F = lIB\sin\theta$$

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

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

$$\boxed{\begin{aligned} &P = I^2 R \\ &V_\mathrm{series} = V_1 + V_2 + \ldots + V_\mathrm{n} \\ &R_\mathrm{series} = R_1 + R_2 + \ldots + R_\mathrm{n} \\ &\frac{1}{R_\mathrm{parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_\mathrm{n}} \\ &I_\mathrm{parallel} = I_1 + I_2 + \ldots + I_\mathrm{n} \\ &c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} \end{aligned}}$$

Quantum, special relativity and nuclear

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

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

$$\boxed{K_\mathrm{max} = qV_0}$$

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

$$E = mc^2$$

$$\boxed{\Delta m = m_i - m_f}$$

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

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

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

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

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

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.

HSC Physics Sample Examination Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Sample answers are provided for each question in Section II. Sample answers show one way a student may answer a question and there may be alternative responses that are correct. Sample answers show one way maximum marks may be achieved for that question.

Question 21 (a)

Criteria	Marks
• Describes the function of part *X*	2
• Provides some relevant information	1

Sample answer:

Its function is to reverse the current in the loop, so that the loop continues in the same direction.

Question 21 (b)

Criteria	Marks
• Explains why the torque decreases	2
• Provides some relevant information	1

Sample answer:

As the speed increases, the back emf increases reducing the motor current and hence the torque.

Question 22

Criteria	Marks
• Explains how the composition and surface temperature of a star can be determined from its spectrum	4
• Explains how the composition OR surface temperature of a star can be determined by its spectrum	3
• Identifies features of a star's spectrum	2
• Provides some relevant information	1

Sample answer:

Composition can be deduced by looking at the absorption and emission spectra, because the lines present are unique for each element.

Temperature of the surface of the star can be determined from the measurement of the wavelength at which the radiation is at its peak intensity. This is because as a black body, this wavelength is related to its temperature.

Question 23

Criteria	Marks
• Correctly calculates the magnitude and direction of the initial velocity	4
• Provides the main steps for calculating the initial velocity	3
• Provides some steps for calculating the initial velocity	2
• Provides some relevant information	1

Sample answer:

From the graph, max height is 44 m and $v_y = 0$ at max height. Therefore:

$$v_y{}^2 = u_y{}^2 + 2a_y s_y$$

$$0 = u_y{}^2 + 2 \quad (-9.8) \quad 44$$

$$u_y = 29.4 \text{ m s}^{-1}$$

From the graph, time of flight is 6s. Therefore:

$$u_x = \frac{s_x}{t} = \frac{130}{6} = 21.7 \text{ m s}^{-1}$$

$$u^2 = u_x{}^2 + u_y{}^2$$

$$u^2 = 21.7^2 + 29.4^2$$

$$u = 36.5 \text{ m s}^{-1}$$

Calculating angle of launch:

$$\tan\theta = \frac{u_y}{u_x}$$

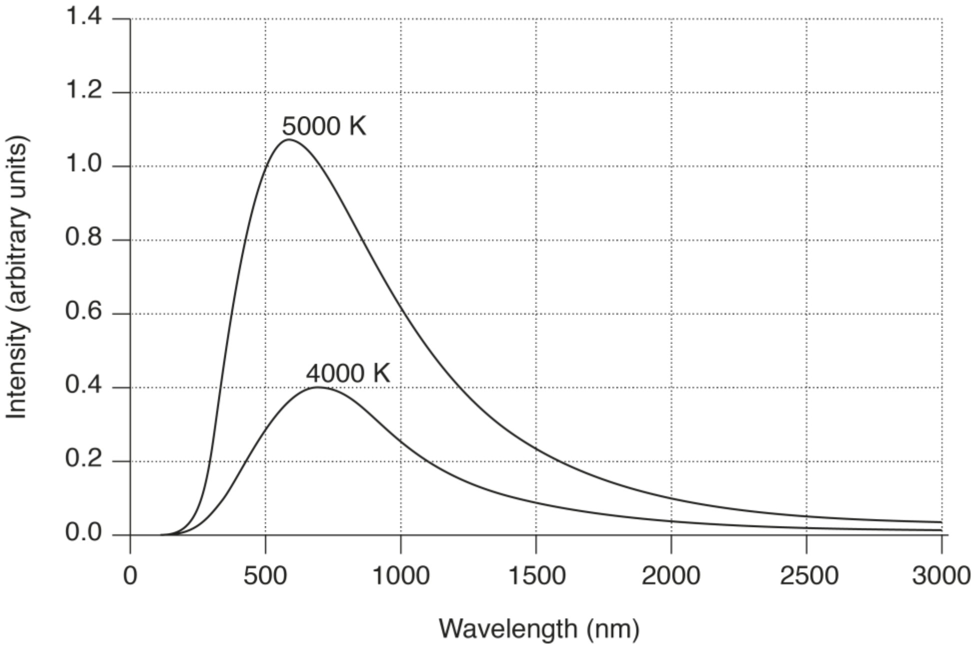
$$\theta = 54$$

Therefore $u = 36.5 \text{ m s}^{-1}$, 54 above the horizontal.

Question 24

Criteria	Marks
• Sketches the correct curve • Explains the differences	4
• Sketches a substantially correct curve • Provides some explanation	3
• Provides correct feature(s) of the curve OR • Shows some understanding of the differences	2
• Provides some relevant information	1

Sample answer:



The 4000 K curve has a peak intensity at a wavelength that is greater than for a body at 5000 K because the wavelength at which a black body reaches peak emissivity is inversely proportional to its absolute temperature.

The area under the curve at 4000 K is less than that for 5000 K because at every wavelength the intensity of the radiation produced at 4000 K is less.

Question 25

Criteria	Marks
• Calculates the magnitude of the induced emf • Expresses answer to two significant figures	3
• Calculates the magnitude of the induced emf	2
• Provides some relevant information	1

Sample answer:

$\Phi = \Delta B \mid\mid A = 0.155 \times 0.02 = 0.031\,\text{Wb}$

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t} = -35\,\frac{(0-0.0031)}{0.4}$$

$$= 0.27125$$

$$= 0.27\text{ V (2 significant figures)}$$

Question 26

Criteria	Marks
• Accounts for the changes in velocity of the comet	3
• Provides a reason for a change in velocity of the comet	2
• Provides some relevant information	1

Sample answer:

As the comet moves toward the sun, its gravitational potential energy (GPE) is converted into kinetic energy (KE) consistent with the law of conservation of energy. The increase in KE results in an increase in velocity as it approaches the sun. As it returns to point P, it loses velocity as its KE is converted into GPE.

Question 27 (a)

Criteria	Marks
• Uses the correct formula to calculate the speed of light	2
• Provides some relevant information	1

Sample answer:

$$c = \frac{1}{\sqrt{\varepsilon_0\,\mu_0}}$$

$$c = \frac{1}{\sqrt{1.239 \times 10^{-11} \times 4\pi \times 10^{-7}}}$$

$c = 2.534 \times 10^{8}\,\text{ms}^{-1}$

Question 27 (b)

Criteria	Marks
• Assesses the precision and accuracy of the data collected	3
• Assesses the precision OR accuracy of the data collected	2
• Provides some relevant information	1

Sample answer:

The precision of the data is high as there is little variation between the measured values of ε_0.

The accuracy of the data is low because the measured values of ε_0 (1.239×10^{-13}) or c (2.534×10^{8}) are not close to the accepted value of ε_0 (8.854×10^{-12}) or c (3×10^{8}).

Question 28

Criteria	Marks
• Accounts for the fusion of elements up to iron in terms of binding energy • Accounts for the synthesis of elements beyond iron in terms of binding energy • Effectively uses data from the graph	5
• Describes how fusion of elements up to iron produces energy • Describes the synthesis of elements beyond iron as requiring energy • Uses data from the graph	4
• Describes the fusion and synthesis of elements • May use data from the graph	3
• Outlines the fusion of elements OR • Outlines the synthesis of elements	2
• Provides some relevant information	1

Sample answer:

Stars to the left of iron fuse smaller elements, such as hydrogen and helium, into larger elements like carbon and oxygen. These reactions release energy because the binding energy per nucleon increases up to iron. For example, the fusion of hydrogen into helium leads to an increase in binding energy from 1 to 7 MeV. Synthesis of larger elements to the right of iron requires energy because the binding energy per nucleon decreases after iron. Elements heavier than iron, such as lead and uranium, are instead formed during energetic events such as supernovae.

Question 29

Criteria	Marks
• Explains TWO methods	4
• Explains ONE method and identifies another OR • Outlines TWO methods	3
• Outlines ONE method OR • Identifies TWO methods	2
• Provides some relevant information	1

Sample answer:

For diffraction $d\sin\theta = m\lambda$, where m = 1 for maxima A, B.

Hence $\sin\theta = \dfrac{\lambda}{d}$ and so decreasing λ decreases θ.

To keep the distance between A and B constant:

1. the slit separation d could be reduced causing θ to increase, compensating for the effect of reducing the wavelength
2. the distance 'y' could be increased sin θ for any angle θ, the distance between A and B increases and 'y' increases and so increasing 'y' would compensate for the reduction in θ due to the shorter wavelength.

Question 30

Criteria	Marks
• Compares the forces acting on WX and XY before and after the rotation	3
• Identifies some features of the forces acting on WX and XY OR • Compares the forces acting on WX or XY before and after the rotation	2
• Identifies a feature of the force acting on WX or XY	1

Sample answer:

The magnitude and direction of the force on WX remains the same when it is rotated. Initially, XY experiences no force, whereas after rotation it experiences a force to the right.

Question 31 (a)

Criteria	Marks
• Shows, using correct formula and calculation, that the magnitude of centripetal force is 11 N	2
• Provides some relevant information	1

Sample answer:

$\tan\theta = \dfrac{F_c}{mg}$

$F_c = \tan 30° \times 9.8 \times 2.0$

$F_c = 11$ N

Question 31 (b)

Criteria	Marks
• Correctly calculates the range of the mass	3
• Provides correct calculation of the horizontal velocity OR • Provides correct calculation of time taken to fall 3 m	2
• Provides some relevant information	1

Sample answer:

Horizontal velocity:

$F_c = \dfrac{mv^2}{r}$

$v = \sqrt{\dfrac{F_c r}{m}}$

$v = \sqrt{\dfrac{11 \times 0.8}{2}}$

$v = 2.1\text{ms}^{-1}$

Time taken to fall:

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

$t = \sqrt{\dfrac{2s}{a}}$

$t = \sqrt{\dfrac{2 \times 3}{9.8}}$

$t = 0.78$ s

Range:

$s = v \times t$

$s = 2.1 \times 0.78$

$s = 1.6$ m

Question 32 (a)

Criteria	Marks
• Describes the process that led to the prediction of time dilation	3
• Outlines parts of the process	2
• Provides some relevant information	1

Sample answer:

The distance travelled by the light, *X* to *Y* to *X*, appears to be greater to the observer outside the train than to the observer in the train. Since both observe the same speed of light, then the return trip must have taken longer for the observer outside the train, since $t = \frac{d}{c}$. This is what Einstein called time dilation.

Question 32 (b)

Criteria	Marks
• Calculates the outside observer's time, includes relevant unit	3
• Provides substantial working to calculate outside observer's time	2
• Provides a correct step in calculation	1

Sample answer:

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

So $$t = \frac{1.5 \times 10^{-8}}{\sqrt{\left(\frac{1 - (0.96)^2 c^2}{c^2}\right)}}$$

$$= \frac{1.5 \times 10^{-8}}{0.28}$$

$$= 5.4 \times 10^{-8} s$$

OR $= 54$ ns

Question 33

Criteria	Marks
• Explains how the electric field (Field 1) accelerates the ions according to the equation $\vec{F} = q\vec{E}$ • Explains how the magnetic field (Field 2) separates the ions based on their different mass according to the equation $r = \frac{mv}{qB}$	5
• Explains the effect of one field • Outlines the effect of the other field	4
• Explains the effect of one field OR • Outlines an effect of both fields	3
• Outlines an effect of a field	2
• Provides some relevant information	1

Sample answer:

Field 1 is an electric field where Plate 1 is negative, and Plate 2 is positive. This accelerates the ions according the equation $\vec{F} = q\vec{E}$. The ions then enter Field 2 which is a magnetic field directed into the range. The magnetic field causes the ions to accelerate according to

$F = qvB$, and in a circular path with a radius given by $r = \frac{mv}{qB}$.

Chlorine-35 has a smaller mass than Chlorine-37 so will deflect with a smaller radius.

Question 34

Criteria	Marks
• Provides a thorough description of the role of annihilation AND the photoelectric effect in the production of a PET scan • Effectively relates the law of conservation of energy to both processes	5
• Provides a description of the role of annihilation AND the photoelectric effect in the production of a PET scan • Outlines how the law of conservation of energy relates to both processes	4
• Demonstrates an understanding of annihilation OR the photoelectric effect in the production of a PET scan • Identifies how the law of conservation of energy relates to annihilation OR the photoelectric effect	3
• Demonstrates an understanding of annihilation OR the photoelectric effect	2
• Provides some relevant information	1

Sample answer:

During a PET scan, positrons emitted from a radioactive tracer undergo annihilation with electrons, producing two gamma ray photons. The gamma ray photons interact with the detector which produces light photons. The light photons strike a photodetector releasing electrons due to the photoelectric effect. The photoelectrons are used to produce an image.

Both the annihilation and the photoelectric effect obey the law of conservation of energy. The energy of the two gamma rays equals the energy of the positron-electron. In the photoelectric effect, the kinetic energy of the photoelectrons is equal to the photon’s energy minus the work function.

Question 35 (a)

Criteria	Marks
• Shows how the mathematical model is derived	2
• Shows some relevant steps	1

Sample answer:

$$F_C = F_G$$

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

$$\left(\frac{2\pi r}{T}\right)^2 = \frac{GM}{r}$$

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

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

Question 35 (b)

Criteria	Marks
• Calculates the mass of the planet using the graph's line of best fit and correct working	4
• Show some steps in calculating the gradient • Relates the gradient to the mathematical model and/or mass of the planet	3
• Show some steps in calculating the gradient OR • Relates the graph to the mathematical model and/or mass of the planet	2
• Provides some relevant information	1

Sample answer:

Using the line of best fit

$$\text{Gradient} = 0.0008 \times \frac{\text{days}^2}{10^{12}\ \text{km}^3} = \frac{0.0008 \times (24 \times 60 \times 60)^2}{10^{12} \times 1000^3}\ \text{s}^2\text{m}^{-3} = 6.0 \times 10^{-15}\ \text{s}^2\text{m}^{-3}$$

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

$$6.0 \times 10^{-15} = \frac{4\pi^2}{6.67 \times 10^{-11} \times M}$$

$$M = 9.9 \times 10^{25}\ \text{kg}$$

Question 36

Criteria	Marks
• Provides a detailed analysis of the motion of the can AND the magnet • Provides a detailed analysis of the energy transformations in the system	7
• Analyses the motion of the can AND the magnet • Provides an analysis of the energy transformations in the system	6
• Describes the motion of the can and/or the magnet • Describes the energy transformations of the magnet AND/OR can	4–5
• Demonstrates some understanding of the motion of the can AND/OR the magnet AND/OR the energy transformations of both magnet and/or can	2–3
• Provides some relevant information	1

Sample answer:

As the magnet swings from a high position towards the can, it loses gravitational potential energy and gains kinetic energy.

The motion of the magnet provides changing magnetic flux through the aluminium can. This change in flux is greatest when the relative motion of the magnet and can is greatest and induces an emf according to $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$.

This emf gives rise to eddy currents in the can, which produces resistive heating as well as a magnetic field that opposes the movement of the magnet.

The interaction of the magnetic fields of the magnet and the can, due to eddy currents, also results in the can rotating clockwise initially.

Over time, this results in a dampening of the magnet's movement, and the interaction of the eddy currents' magnetic field with the magnet results in the rotation of the can backwards and forwards, with diminishing amplitude as the total energy is ultimately converted to heat.

Question 37

Criteria	Marks
• Applies correct method to calculate KE of the alpha particle • Explains the greater KE of the alpha particle using the principle of conservation of momentum	7
• Applies correct method to calculate KE of the alpha particle • Applies the principle of conservation of momentum	6
• Shows the main steps of the calculation of KE AND/OR • Shows a sound understanding of the conservation of momentum	4–5
• Shows step(s) of the calculation of KE AND/OR • Shows some understanding of the conservation of momentum	2–3
• Provides some relevant information	1

Sample answer:

Alpha decay

Mass defect = 197.999 – (193.988 + 4.000260) = 0.0084u
Converting to kilograms = $0.0084 \times 1.661 \times 10^{-27} = 1.395 \times 10^{-29}$ kg

Total energy produced = $mc^2 = 1.395 \times 10^{-29} \times (3 \times 10^8)^2 = 1.256 \times 10^{-12}$ J

KE_{alpha} = total energy produced – $KE_{polonium}$ = $1.256 \times 10^{-12} - 2.44 \times 10^{-14}$
$= 1.23 \times 10^{-12}$ J

Since the radon atom is initially at rest, the decay products move away from each other with equal and opposite momenta. As the alpha particle's mass is significantly less than that of the polonium atom, it therefore has a significantly higher velocity ($p = mv$), and consequently a higher KE. Despite the higher mass of the polonium atom, the higher velocity of the alpha particle has a more significant effect on its KE ($KE = \frac{1}{2}mv^2$).

This mapping grid shows how the Physics Sample HSC Examination allows for appropriate differentiation of student performance at each band on the performance scale. An examination committee uses a mapping grid to ensure the examination is appropriately mapped to the course's syllabus and performance standards.

HSC Physics Sample Examination Mapping Grid

An examination committee uses the 'targeted syllabus outcomes' column of the mapping grid to ensure there is a representative sample of a **range of syllabus outcomes** throughout the examination.

The 'targeted performance bands' column of the mapping grid shows how questions in this sample HSC examination are targeted to **levels of performance** that are described in the bands on the performance scale.

Section I

Question	Marks	Content	Targeted syllabus outcomes	Targeted performance bands
1	1	Matter, energy and the cosmos – Modelling the atom	PY-12-04	2–3
2	1	Advanced mechanics – Motion in gravitational fields	PY-12-01	2–3
3	1	Electromagnetism – Applications of electromagnetic induction	PY-12-02	2–3
4	1	Nature of light – The quantum model of light	PY-12-03	3–4
5	1	Electromagnetism – Applications of electromagnetic induction	PY-12-02	3–4
6	1	Nature of light – The wave model of light	PY-12-03	3–4
7	1	Advanced mechanics – Applications of electromagnetic induction	PY-12-02	3–4
8	1	Electromagnetism – Charged particles in electric and magnetic fields	PY-12-02	3–4
9	1	Advanced mechanics – Projectile motion	PY-12-01	3–4
10	1	Matter, energy and the cosmos – Astrophysics	PY-12-04	3–4
11	1	Matter, energy and the cosmos – Radioactivity	PY-12-04	4–5
12	1	Advanced mechanics – Circular motion	PY-12-01	4–5
13	1	Advanced mechanics – Circular motion	PY-12-01 PY-12WS-05	4–5
14	1	Matter, energy and the cosmos – Modelling the atom	PY-12-04	4–5
15	1	Nature of light – The quantum model of light	PY-12-03	4–5
16	1	Nature of light – The quantum model of light	PY-12-03	4–5
17	1	Advanced mechanics – Projectile motion	PY-12-01	4–5
18	1	Nature of light – The wave model of light	PY-12-03 PY-12WS-06	5–6

Question	Marks	Content	Targeted syllabus outcomes	Targeted performance bands
19	1	Electromagnetism – Electromagnetic induction	PY-12-02 PY-12WS-06	5–6
20	1	Advanced mechanics – Projectile motion and circular motion	PY-12-04 PY-12WS-06	5–6

Section II

Question	Marks	Content	Syllabus outcomes	Targeted performance bands
21 (a)	2	Electromagnetism – Applications of electromagnetic induction	PY-12-02	2–4
21 (b)	2	Electromagnetism – Applications of electromagnetic induction	PY-12-02	2–4
22	4	Matter, energy and the cosmos – Astrophysics	PY-12-04	2–6
23	4	Advanced mechanics – Projectile motion	PY-12-01 PY-12WS-04	2–5
24	4	Nature of light – The quantum model of light	PY-12-03 PY-12WS-05	3–6
25	3	Electromagnetism – Electromagnetic induction	PY-12-02 PY-12WS-05	2–5
26	3	Advanced mechanics – Circular motion	PY-12-01	2–4
27 (a)	2	Nature of light – Electromagnetic waves	PY-12-03	2–4
27 (b)	3	Nature of light – Electromagnetic waves	PY-12-03 PY-12WS-02 PY-12WS-05	2–5
28	5	Matter, energy and the cosmos– Nuclear energy; Astrophysics	PY-12-04 PY-12WS-04	2–6
29	4	Nature of light – The wave model of light	PY-12-03	2–5
30	3	Electromagnetism – The motor effect and electric motors	PY-12-02	2–5
31 (a)	2	Advanced mechanics – Circular motion	PY-12-01	3–5
31 (b)	3	Advanced mechanics – Projectile motion; Circular motion	PY-12-01	2–5
32 (a)	3	Nature of light – Light and special relativity	PY-12-03	4–6
32 (b)	3	Nature of light – Light and special relativity	PY-12-03	3–5
33	5	Electromagnetism – Charged particles in electric and magnetic fields Advanced mechanics – Circular motion Matter, energy and the cosmos – Radioactivity	PY-12-02 PY-12-01 PY-12-04	2–6
34	5	Matter, energy and the cosmos – Radioactivity; Nuclear energy Nature of light – Quantum model of light	PY-12-04 PY-12-03	2–6
35 (a)	2	Advanced mechanics – Motion in gravitational fields	PY-12-01	3–5
35 (b)	4	Advanced mechanics – Motion in gravitational fields	PY-12-01 PY-12WS-04	2–6

Question	Marks	Content	Syllabus outcomes	Targeted performance bands
36	7	Electromagnetism – Applications of electromagnetic induction Advanced mechanics – Circular motion	PY-12-02 PY-12-01 PY-12WS-04 PY-12WS-06	2–6
37	7	Matter, energy and the cosmos– Radioactivity; Nuclear energy	PY-12-04 PY-12WS-06 PY-12WS-07	2–6