Neap

Trial Examination 2023

HSC Year 12 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
Total Marks: 100	**Section I – 20 marks (pages 2–9)** • Attempt Questions 1– 20 • Allow about 35 minutes for this section **Section II – 80 marks (pages 11–32)** • Attempt Questions 21– 32 • 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 Polonium-214 undergoes decay according to the equation

$$^{214}_{84}\text{Po} \rightarrow {}^{X}_{Y}\text{Pb} + {}^{4}_{2}\text{He}.$$

Which row of the table identifies the values of X and Y and describes the decay?

	X	*Y*	*Description of decay*
A.	210	82	alpha decay with a positive alpha particle
B.	212	80	beta decay with a positive beta particle
C.	212	80	alpha decay with a negative alpha particle
D.	214	82	beta decay with a negative beta particle

2 The table shows the energy levels in a hydrogen atom.

Energy level	*Energy of electron (J)*
$n = 1$	0
$n = 2$	1.63×10^{-18}
$n = 3$	1.94×10^{-18}
$n = 4$	2.04×10^{-18}

An electron in the $n = 4$ level transitions to the $n = 3$ level.

How does the energy change as the electron moves between levels?

A. 1.00×10^{-19} J absorbed

B. 1.00×10^{-19} J emitted

C. 2.04×10^{-18} J absorbed

D. 2.04×10^{-18} J emitted

3 Which row of the table identifies the quark compositions of protons and neutrons?

	Protons	*Neutrons*
A.	2 up quarks, 1 down quark	1 up quark, 2 down quarks
B.	1 up quark, 2 down quarks	2 up quarks, 1 down quark
C.	2 up quarks, 1 top quark	2 top quarks, 1 up quark
D.	1 down quark, 2 top quarks	2 down quarks, 1 top quark

4 The primary coil in a transformer has 50 turns and a voltage of 168 V. The secondary coil has a voltage of 4200 V.

What is the ratio of primary turns to secondary turns in the transformer?

A. 1 : 25

B. 1 : 1250

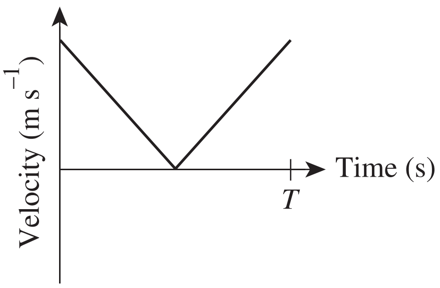
C. 25 : 1

D. 1250 : 1

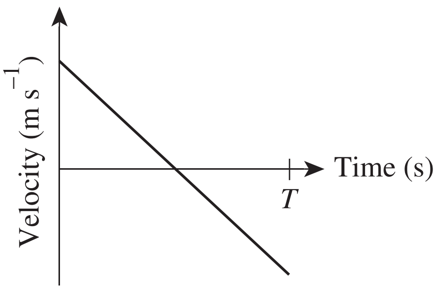
5 A tennis player launches a tennis ball vertically upwards. At time *T*, the tennis player catches the ball when it returns to its starting position.

Which of the following graphs shows the tennis ball's velocity over time?

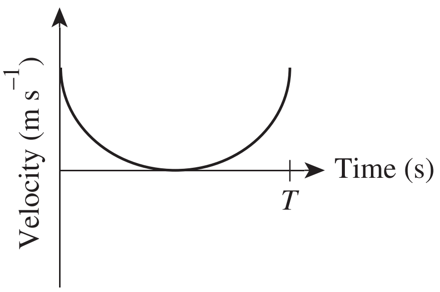
A.



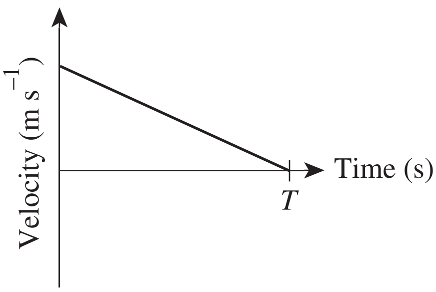
B.



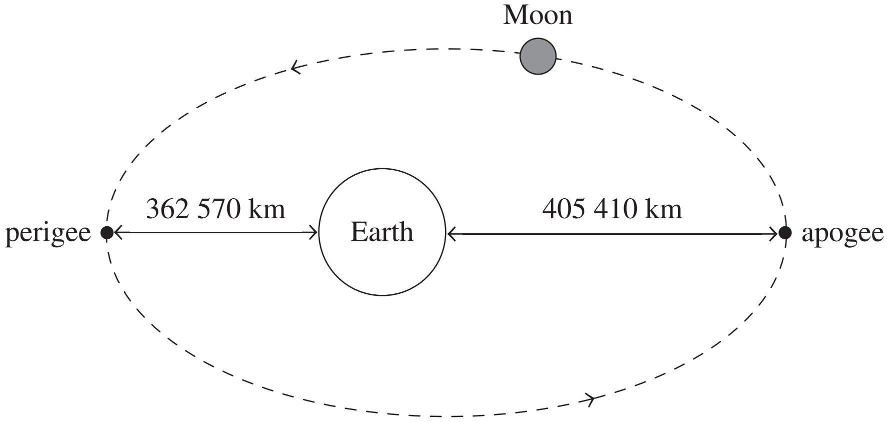
C.



D.



6 The diagram shows the perigee and apogee of the Moon – two points in the Moon's elliptical orbit around Earth.



Which of the following statements is correct?

A. When the Moon reaches the apogee, its gravitational potential energy and kinetic energy will be at minimums. It will move at a low velocity.

B. When the Moon reaches the apogee, its gravitational potential energy and kinetic energy will be at maximums. It will move at a high velocity.

C. When the Moon reaches the perigee, its gravitational potential energy will be at a minimum and its kinetic energy will be at a maximum. It will move at a high velocity.

D. When the Moon reaches the perigee, its gravitational potential energy and kinetic energy will be at maximums. It will move at a low velocity.

7 A student with a mass of 65 kg is asked to determine their weight while they travel in an elevator. The elevator goes through three stages of movement.

- During stage 1, the elevator moves upwards at a constant velocity of 9.8 m s^{-1}.
- During stage 2, the elevator accelerates upwards at 5 m s^{-2}.
- During stage 3, the elevator accelerates downwards at 5 m s^{-2}.

Which row of the table identifies the student's weight during the different stages of the elevator's movement?

	Stage 1	*Stage 2*	*Stage 3*
A.	65 kg	115 kg	15 kg
B.	65 kg	15 kg	115 kg
C.	637 N	312 N	962 N
D.	637 N	962 N	312 N

8 Two current-carrying wires are parallel to each other and separated by a distance of 0.05 m. They carry currents of 0.5 A and 0.3 A in opposite directions.

If the distance between the wires were increased to 0.1 m, the force acting on the 0.3 A wire would be

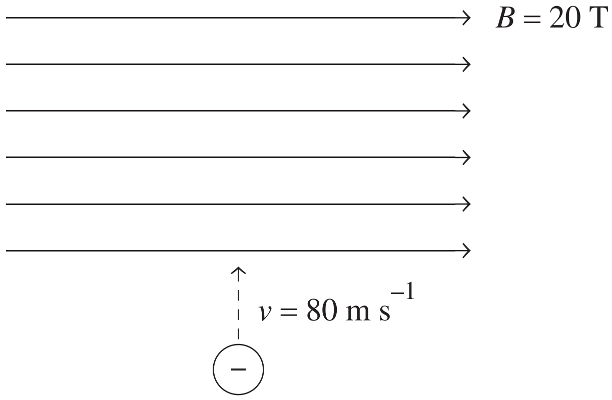
A. a quarter of the original value.

B. half of the original value.

C. 0.6 of the original value.

D. double the original value.

9 An electron travels into a uniform magnetic field as shown.



What is the force acting on the electron?

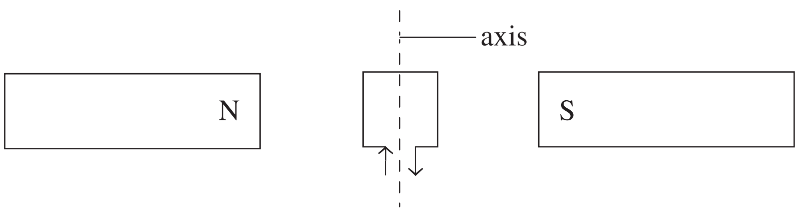
A. 0.4×10^{-20} N up the page

B. 4.0×10^{-20} N out of the page

C. 2.6×10^{-16} N out of the page

D. 2.6×10^{-16} N into the page

10 A rectangular coil has the dimensions 3.0 cm × 4.0 cm and carries a current of 15.0 mA in a uniform magnetic field of 3.0 T. The coil has 20 turns of wire and is free to rotate about the axis as shown.



If the coil is rotated by 25°, what is the torque acting on the coil?

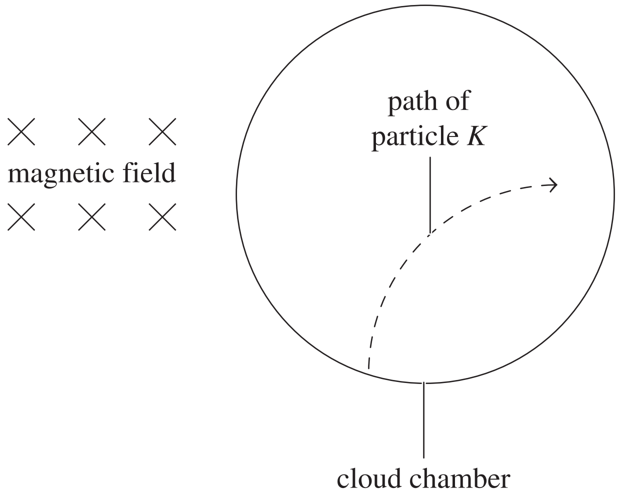
A. 9.79×10^{-4} Nm clockwise

B. 9.79×10^{-4} Nm anticlockwise

C. 4.56×10^{-4} Nm clockwise

D. 4.56×10^{-4} Nm anticlockwise

11 Particle K was accelerated to a velocity of 2.5×10^4 m s^{-1} in a particle accelerator. It then entered a cloud chamber placed in a uniform magnetic field directed into the page with a strength of 1.8×10^{-6} T. The radius of particle K's arc was found to be 5.0 cm.



Which row of the table is correct?

	Charge-to-mass ratio of particle K	*Charge of particle K*
A.	2.8×10^9 C kg^{-1}	negative
B.	2.8×10^9 C kg^{-1}	positive
C.	2.8×10^{11} C kg^{-1}	negative
D.	2.8×10^{11} C kg^{-1}	positive

12 A scientist finds that the frequency of incident light on a piece of metal is greater than the threshold frequency.

The scientist decides to investigate how changing the light may affect the photoelectrons emitted by the piece of metal. They apply the following two conditions as part of their investigation.

1. The intensity of the light is decreased, and the frequency is kept constant.
2. The frequency of the light is increased, and the intensity is kept constant.

The scientist records the maximum kinetic energy of the photoelectrons and the number of photoelectrons emitted under each condition, and compares these results to the initial observation.

Which row of the table best describes the results of the scientist's investigation?

	Maximum kinetic energy of the photoelectrons	*Number of photoelectrons emitted*
A.	increases under conditions 1 and 2	increases under conditions 1 and 2
B.	increases under condition 1 and remains constant under condition 2	decreases under condition 1 and remains constant under condition 2
C.	remains constant under condition 1 and increases under condition 2	decreases under condition 1 and remains constant under condition 2
D.	remains constant under condition 1 and decreases under condition 2	decreases under conditions 1 and 2

13 Galaxies X and Y are on opposite sides of Earth and are moving away from Earth at a speed approaching the speed of light, which is approximately $0.95c$.

Which of the following statements is correct?

A. Light from galaxy Y will hit Earth and galaxy X at a speed of 3.00×10^8 m s^{-1} as the speed of light is constant relative to all observers.

B. Light from galaxy Y will hit Earth at a speed of 3.00×10^8 m s^{-1} and galaxy X at a speed of $0.95c$.

C. Light from galaxy Y will hit galaxy X at a speed of 3.00×10^8 m s^{-1} and Earth at a speed of $0.95c$.

D. Light from galaxy Y will hit Earth and galaxy X at a speed of $0.95c$.

14 In 2224, there is an space race from the Ultima space station to the Extrema space station. Ren and Annika are two competitors in this race. After a collision with space junk, Ren experiences issues with her navigation system. While waiting for the system to reboot, she observes Annika race past her. Annika moves straight ahead on a path parallel to Ren's.

While observing Annika, Ren considers the following conclusions about their positions.

1. She and Annika are both moving towards the Extrema space station; however, Annika is moving faster.
2. She is moving backwards towards the Ultima space station, and Annika is stationary.
3. She is moving faster than Annika, and they are both moving backwards towards the Ultima space station.

Which of Ren's conclusions could be correct?

A. conclusion 1 only

B. conclusions 1 and 3 only

C. conclusions 1, 2 and 3

D. none of the conclusions

15 Students plotted the radiation of stars against their wavelengths.

If a star has a surface temperature of 4000 K, what is the maximum wavelength of the radiation emitted by the star?

A. 0.725×10^{-7} m

B. 7.25×10^{-6} m

C. 725×10^{-7} nm

D. 725 nm

16 Enriched uranium is made up of 2% uranium-235 by mass, and the remaining 98% is uranium-238. Pressurised water reactors use uranium-235 to produce energy. A fission reaction that could occur in a pressurised water reactor is as follows.

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{140}_{56}\text{Ba} + ^{93}_{36}\text{Kr} + 3^{1}_{0}\text{n}$$

The table shows the masses of the reactants and products in the reaction.

Product/reactant	*Mass (amu)*
uranium-235	235.044
barium-140	139.91061
krypton-93	92.93127
neutron	1.00866

Assuming that all of the uranium-235 nuclei undergo fission, how much energy would be released if 1 kg of enriched uranium was used in a pressurised water reactor?

A. 3.00×10^{-11} J

B. 1.42×10^{12} J

C. 1.98×10^{16} J

D. 1.08×10^{42} J

17 In a Physics class, students conduct three experiments in which they observe various light sources through a spectroscope.

- Experiment 1 uses an incandescent lamp.
- Experiment 2 uses a sodium lamp.
- Experiment 3 uses an incandescent lamp and passed the light through sodium vapour.

Which row of the table identifies what the students would observe through the spectroscope in each experiment?

	Experiment 1	*Experiment 2*	*Experiment 3*
A.	continuous spectrum of colours	two yellow lines on a dark background	fully coloured background with two black lines
B.	continuous spectrum of colours	fully coloured background with two black lines	two yellow lines on a dark background
C.	two yellow lines on a dark background	full spectrum of colours	fully coloured background with two black lines
D.	fully coloured background with two black lines	two yellow lines on a dark background	full spectrum of colours

18 An electron is accelerated from rest in an evacuated glass tube with a voltage of 3200 V through a uniform magnetic field of 2.2×10^{-3} T at right angles to the electron's path.

What is the speed of the electron?

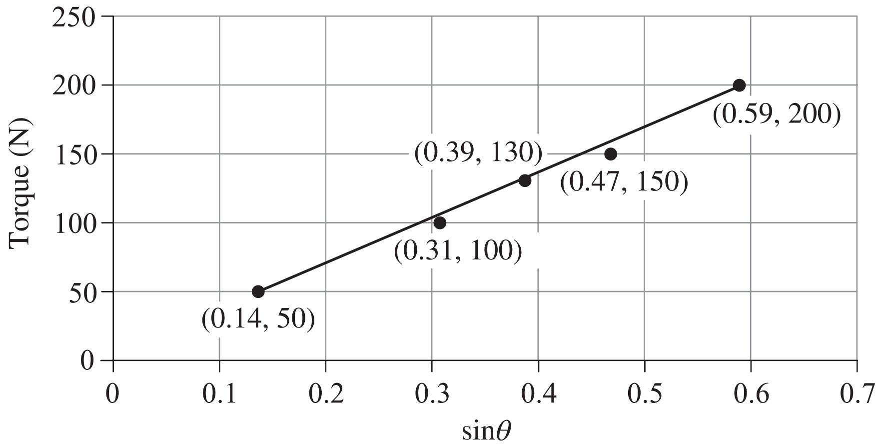
A. 2.56×10^{-16} m s^{-1}

B. 5.13×10^{-16} m s^{-1}

C. 3.35×10^{7} m s^{-1}

D. 1.12×10^{15} m s^{-1}

19 An engineer turns a nut by applying a constant force to a 25.00 cm spanner. They applied this force at different angles and measured the torque. The graph shows the data collected by the engineer.



What is the magnitude of the force applied to the nut?

A. 14.8 N

B. 84.8 N

C. 339 N

D. 1333 N

20 Ella has a mass of 65.00 kg and boards a ride at an amusement park. The ride has a central structure with four 15.00 m steel arms extending from it. Each arm is attached to a steel carriage that has a mass of 550.0 kg and can carry one occupant. When the ride is activated, the arms rotate around the central structure, completing 10 full rotations per minute.

What is the magnitude of the force that the steel arm needs to apply to Ella's carriage so that it continues to move in uniform circular motion?

A. 6744 N

B. 9037 N

C. 10 116 N

D. 363 819 N

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HSC Year 12 Physics

Section II Answer Booklet

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

Instructions	
	• 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 (6 marks)

Kai is a team-based ball game from the the Torres Strait. The traditional balls, known as 'kai', such as those made by the Meriam people from Mer Island, were formed out of plaited strips from pandanus plants.

A kai is thrown at a speed of 25.0 m s^{-1} at 30° above the surface of Earth and lands on Earth a certain time later. Assume that there is no air resistance.

(a) Determine the maximum height of the kai above the surface of Earth. **2**

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(b) Determine the flight time of the kai. **2**

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(c) Determine the horizontal range of the kai. **2**

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Question 22 (8 marks)

A 1300 kg car makes a turn on a circular bend of road at a speed of 80 km per hour. The bend is not banked and has a radius of 40 m.

(a) What is the magnitude of the centripetal force required for the car to make this turn? **2**

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(b) What is the magnitude of the centripetal acceleration of the car around the bend? **2**

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(c) If the bend were banked at an angle of 8°, calculate the magnitude of the centripetal force exerted by the road on the car. Support your answer with a diagram that identifies the relevant forces and vector components. **4**

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Question 23 (8 marks)

A satellite of mass 250 kg is launched from Earth's surface and enters a uniform circular orbit at 5.0×10^5 m above Earth's surface.

(a) Calculate the orbital velocity of the satellite. **2**

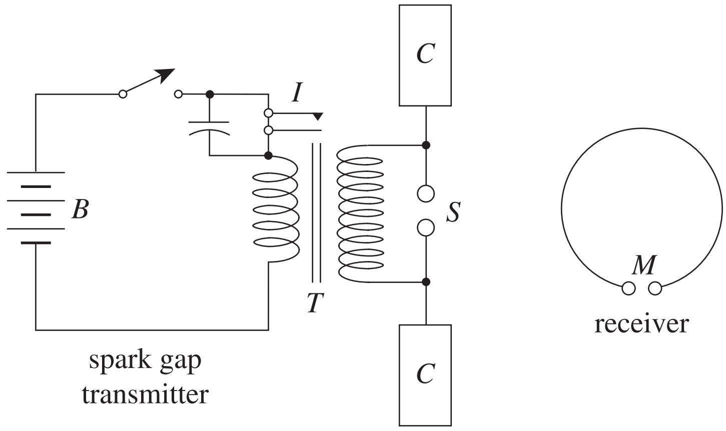
(b) Calculate the magnitude of the gravitational potential energy of the satellite. **2**

(c) Calculate the escape velocity of the satellite from its current position in orbit. **2**

(d) If the satellite were lifted into a higher orbit, explain why work would need to be done by the satellite's engines to change its orbital path. **2**

Question 24 (5 marks)

In 1888, Heinrich Hertz produced and detected radio waves using the apparatus shown in the diagram. The transmitting antenna (*C*) oscillated electrons up and down at a known frequency when a spark was present in the spark gap (*S*). Hertz conducted his work in a dark room so he could observe this spark easily.



Source: Based on Chetvorno (2018), *Hertz transmitter and receiver – English* [diagram]. Accessed December 2022. https://commons.wikimedia.org/wiki/File:Hertz_transmitter_and_receiver_-_English.svg. Licensed under CC BY-SA 3.0, https://creativecommons.org/licenses/by-sa/3.0/legalcode.

(a) Using a diagram, describe how radio waves are propagated. **3**

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Question 24 continues on page 16

Question 24 (continued)

(b) Hertz was able to demonstrate that radio waves have many wave properties including polarisation. Explain how Hertz could have used the receiver to determine if radio waves were polarised. **2**

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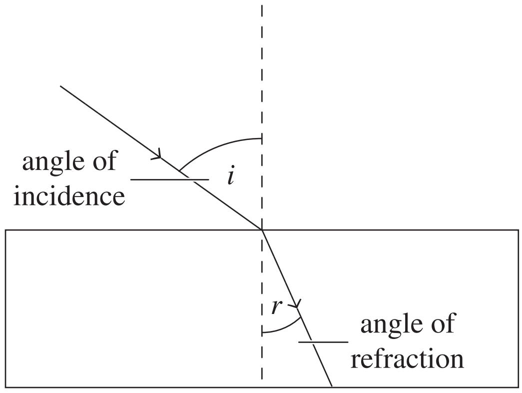
End of Question 24

Question 25 (5 marks)

The diagram shows light moving through a glass prism. **5**



Compare how Huygens's and Newton's models would explain the movement of light through the glass prism.

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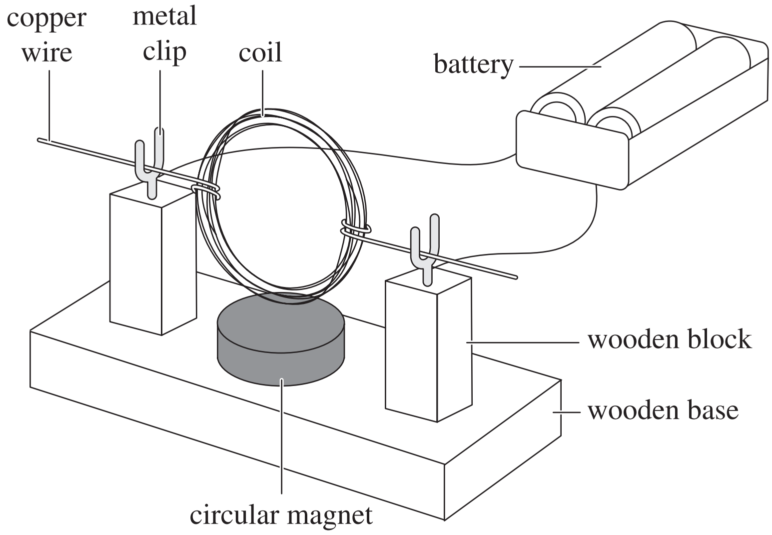
Question 26 (9 marks)

In a Physics class, students are investigating the use of models. Their teacher sets up a series of models in the classroom. The diagram shows model 1, which is a working motor. The students observe the coil rotating about its central axis when it is connected to the batteries. **9**



Model 2 is a plate of plum pudding labelled as ‘an early atomic model’.

Assess the effectiveness of models 1 and 2 in improving the students’ understanding of the concepts represented by the models.

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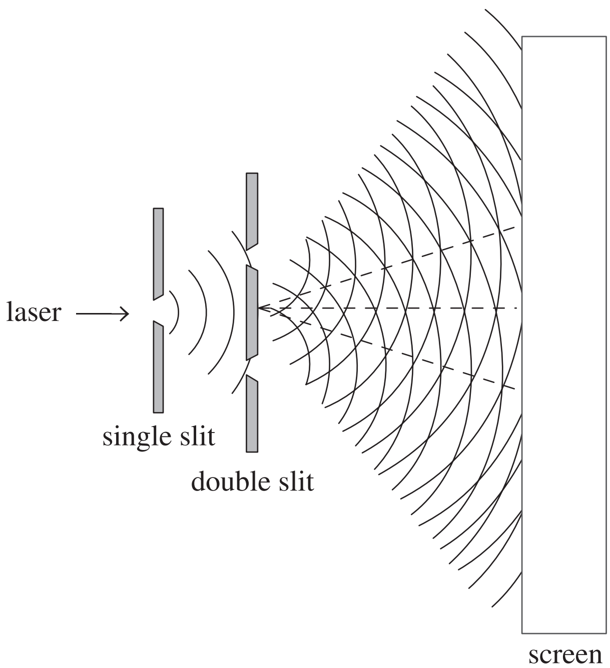
Question 27 (6 marks)

A group of students conducted an experiment in which they directed a red laser of wavelength 633 nm at a screen through a piece of equipment with a double slit in it.

(a) Complete the table by conducting a risk assessment for this experiment. Provide relevant headings for each column. **2**

(b) Consider the experiment shown in the diagram. **2**



Sketch the bands that would be expected to appear on the screen.

Question 27 continues on page 21

Question 27 (continued)

(c) If the students directed the red laser onto a double slit separated by 0.42 mm, what would be the distance between the bright bands that are shown on a screen 1.2 m away? **2**

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End of Question 27

Question 28 (4 marks)

One of Einstein's thought experiments involved a train, lights and mirrors. **4**

A student conducts a similar thought experiment in which an observer inside a train carriage directs light so that it bounces off a mirror and reaches a detector. Diagram 1 shows the path of the light in the frame of reference of the observer inside the train, and diagram 2 shows the path of the light in the frame of reference of the observer outside the train.

Diagram 1: Frame of reference of observer inside the train

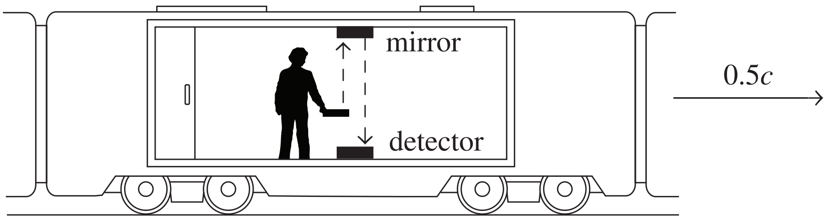
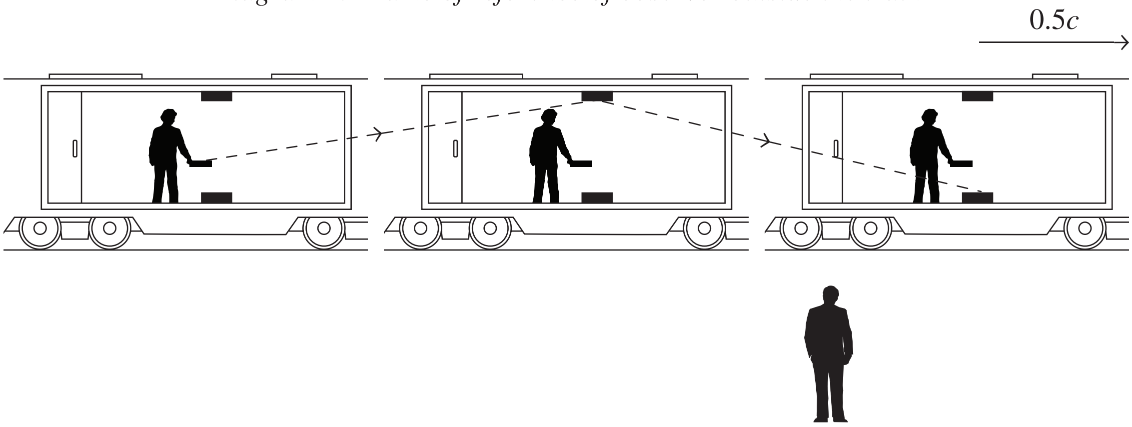


Diagram 2: Frame of reference of observer outside the train



Analyse the diagrams and explain the differences between what the two observers see.

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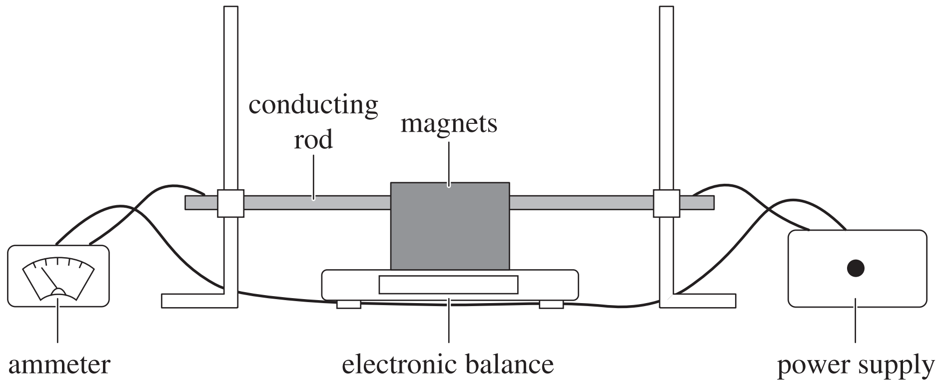
Question 29 (7 marks)

A group of students were conducting an experiment and set up a current balance.



The conducting rod was positioned between two magnets. The balance was initially set at zero. When the students changed the current flowing through the apparatus, the readings on the balance changed due to the force acting up or down.

The students steadily increased the current, which was measured using the ammeter, and recorded the mass displayed on the balance. They then used the measured current and mass to calculate the force acting on the magnets. Their results are shown in the table.

Current (A)	*Mass (kg)*	*Force (N)*
1.1	-0.55×10^{-3}	5.61×10^{-5}
2.1	-1.02×10^{-3}	1.04×10^{-4}
2.9	-1.43×10^{-3}	1.46×10^{-4}
3.6	-1.86×10^{-3}	1.90×10^{-4}
4.3	-2.15×10^{-3}	2.19×10^{-4}

(a) Plot a graph of force versus current. Include a line of best fit. **3**

Question 29 continues on page 24

Question 29 (continued)

(b) Identify the relationship between force and current shown in the graph from part (a) and state TWO assumptions that must be made for this relationship to exist. **2**

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(c) Calculate the gradient of the graph from part (a) and identify what the gradient represents. In your response, include any relevant equation(s). **2**

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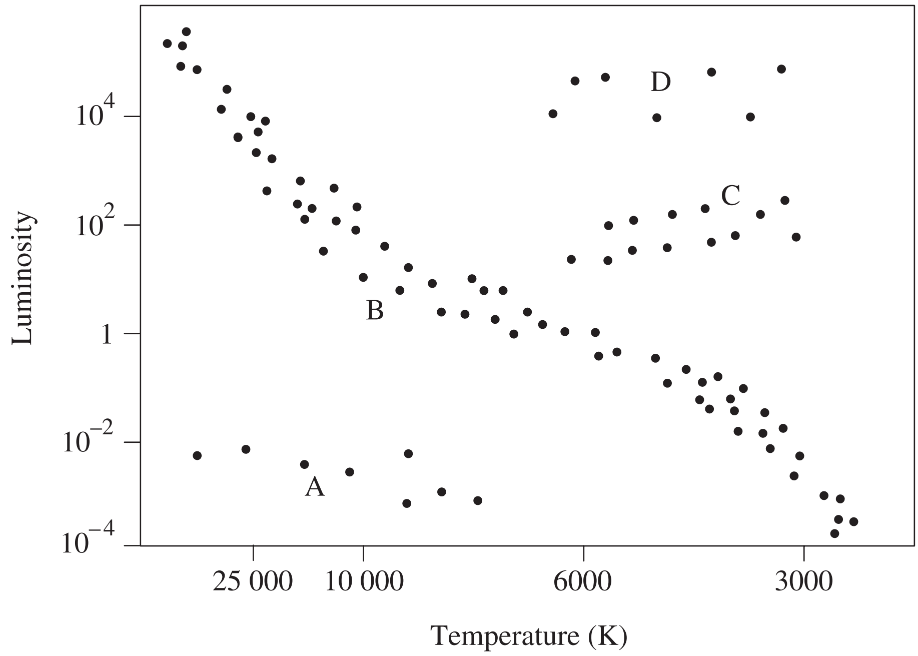
End of Question 29

Question 30 (8 marks)

The Hertzsprung–Russell diagram shows data about the stars in the solar neighbourhood. **8**



Explain how this data may be used to understand the evolution of stars in the solar neighbourhood. In your response, identify the type of stars located in areas A–D and refer to the relevant nucleosynthesis reactions that occur in the identified stars.

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Question 31 (5 marks)

A popular theme park ride is the 'giant drop'. This ride often uses large, permanent magnets under the seats on the ride as a brake. The seats are attached to cables that are used to raise the seats to the top of a tower. The seats are released and as they fall, the magnets pass the bottom section of the tower, which has copper fins that cause the seats to slow down.

A teacher demonstrates this concept to their Physics class using a bar magnet and two pipes made of different materials. They drop the magnet through a PVC pipe and record the time it takes for the magnet to hit the floor, then repeat the action with a copper pipe of the same length and diameter.

The teacher makes the following comment about the giant drop.

> 'The ride is moving quite fast, so the occupants in the seats stop quickly but smoothly. They do not feel a rough jolt. This is much better than if the ride used conventional brakes applied by an operator.'

(a) Using Lenz's law, explain the expected results of the experiment and how they relate to the giant drop. **3**

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(b) Is the teacher's comment correct? Explain your answer. **2**

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Question 32 (9 marks)

In the late nineteenth and early twentieth centuries, experimental discoveries revolutionised the accepted understanding of the nature of matter on an atomic scale.

(a) Describe the nuclear model of the atom developed by Rutherford. **2**

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(b) Atomic models have evolved over time as new technology and discoveries improve our understanding. **4**

Explain how de Broglie's atomic model overcame ONE limitation of Bohr's atomic model.

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(c) The distance between protons in a nucleus is 1.0×10^{-15} m. At this distance, the gravitational force is -2.2×10^{-34} N and the electrostatic force is 230 N. **3**

Explain why these forces cannot account for nuclear stability and describe the properties of the force that holds the nucleus together. In your response, refer to the data provided.

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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 ms^{-1}
Earth's gravitational acceleration, g	9.8 ms^{-2}
Speed of light, c	3.00×10^{8} ms^{-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

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

$v = u + at$

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

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

$\Delta U = mg\Delta h$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Waves and thermodynamics

$v = f\lambda$

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

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

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

$d\sin\theta = m\lambda$

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

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

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

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

$I_1r_1^2 = I_2r_2^2$

$Q = mc\Delta T$

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

FORMULAE SHEET (CONTINUED)

Electricity and magnetism

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

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

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

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

$$W = qV$$

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

$$W = qEd$$

$$V = IR$$

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

$$P = VI$$

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

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

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

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

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

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

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

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

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

Quantum, special relativity and nuclear

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

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

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

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

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

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

$$E = mc^2$$

$$E = hf$$

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

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

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

PERIODIC TABLE OF THE ELEMENTS

KEY

atomic number symbol standard atomic weight name	79 **Au** 197.0 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.

Neap

Trial Examination 2023

HSC Year 12 Physics

DIRECTIONS:

Write your name in the space provided.

Write your student number in the boxes provided below. Then, in the columns of digits below each box, fill in the oval which has the same number as you have written in the box. Fill in **one** oval only in each column.

Read each question and its suggested answers. Select the alternative A, B, C, or D that best answers the question. Fill in the response oval completely, using blue or black pen. Mark only **one** oval per question.

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and draw an arrow as follows.

A ⊗ B ⊗ (*correct* ↓) C ○ D ○

STUDENT NAME: ______________________________

STUDENT NUMBER:

1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9
0	0	0	0	0	0	0	0	0

SECTION I
MULTIPLE-CHOICE ANSWER SHEET

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

STUDENTS SHOULD NOW CONTINUE WITH SECTION II

Neap

Trial Examination 2023

HSC Year 12 Physics

Solutions and Marking Guidelines

SECTION I

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 1 **A** Polonium-214 undergoes alpha decay and emits a helium nucleus. As X is the mass number of Pb: $X = 214 - 4$ $= 210$ As Y is the atomic number of Pb: $Y = 84 - 2$ $= 82$ The alpha particle is the helium nucleus, which is composed of two protons, each with a positive charge, and two neutrons, each with no charge. Thus, the alpha particle has a +2 charge.	Mod 8 From the Universe to the Atom PH12–5, 12–6, 12–7, 12–15 Bands 3–6
Question 2 **B** photon energy $= E_{n=4} - E_{n=3}$ $= 2.04 \times 10^{-18} - 1.94 \times 10^{-18}$ $= 1.00 \times 10^{-19}$ Thus, 1.00×10^{-19} J of energy is emitted as the electron is falling from a higher energy level to a lower energy level.	Mod 8 From the Universe to the Atom PH12–5, 12–6, 12–15 Bands 3–6
Question 3 **A** Protons have a +1 charge with 2 up quarks and 1 down quark; that is, uud. Neutrons have no charge with 1 up quark and 2 down quarks; that is, udd.	Mod 8 From the Universe to the Atom PH12–15 Bands 2–6
Question 4 **A** $\frac{V_p}{V_s} = \frac{N_p}{N_s}$ $\frac{168}{4200} = \frac{50}{N_s}$ $N_s = \frac{4200 \times 50}{168}$ $= 1250$ $N_p : N_s = 50 : 1250$ $= 1 : 25$	Mod 6 Electromagnetism PH12–5, 12–13 Bands 4–6

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 5 **B** **B** is correct and **D** is incorrect. The tennis ball's journey has two parts. Initially, it travels upwards after being launched by the tennis player, so the graph must begin above the *x*-axis. The ball travels upwards at a decreasing velocity, so it approaches the *x*-axis until it reaches its maximum height. After this, the ball travels downwards (that is, below the *x*-axis) at a decreasing velocity until it is caught by the tennis player at time *T*. **A** is incorrect. This graph accurately depicts the first part of the tennis ball's journey, but shows the second part of the journey as an upwards motion with increasing velocity. **C** is incorrect. This graph is parabolic, which does not represent the tennis ball's journey.	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–12 Bands 3–6
Question 6 **C** **C** is correct and **D** is incorrect. When a satellite that has an elliptical orbit, such as the Moon, returns to its closest point to Earth (the perigee), its gravitational potential energy will be at its lowest and its kinetic energy will be at its highest. Thus, the Moon will be moving at a high velocity. **A** is incorrect. At the furthest point in its orbit (the apogee), the Moon's gravitational potential energy will be at a maximum, not a minimum. **B** is incorrect. At the apogee, the Moon's kinetic energy will be at a minimum, not a maximum, and, as a result, it will move at a low velocity.	Mod 5 Advanced Mechanics PH12–4, 12–6, 12–12 Bands 4–6
Question 7 **D** During stage 1, the elevator moves at a constant velocity. Therefore: $\text{weight} = mg$ $= 65 \times 9.8$ $= 637\text{ N}$ During stage 2, the elevator accelerates upwards. Therefore: $\text{weight} = mg + ma$ $= 65 \times 9.8 + 65 \times 5$ $= 962\text{ N}$ During stage 3, the elevator accelerates downwards. Therefore: $\text{weight} = mg - ma$ $= 65 \times 9.8 - 65 \times 5$ $= 312\text{ N}$	Mod 5 Advanced Mechanics PH12–6, 12–12 Bands 4–6

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 8 **B** According to $\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$, doubling the distance between the wires (from 0.05 m to 0.1 m) would reduce the acting force by half of its original value.	Mod 6 Electromagnetism PH12–4, 12–5, 12–13 Bands 3–6
Question 9 **C** $F = qvB$ $= -1.602 \times 10^{-19} \times 80 \times 20$ $= 2.6 \times 10^{-16}$ N The magnetic field, *B*, is directed to the right of the page and the negative charge is entering the field up the page. Thus, the force is out of the page. *Note: When applying the right-hand rule, the thumb points in the direction of the velocity of the charge (up the page), the index finger points in the direction of the magnetic field (right of the page) and the middle finger points in the direction of the force acting on the particle (into the page). As this is a negative particle, the force is in the opposite direction; thus, it is out of the page.*	Mod 6 Electromagnetism PH12–4, 12–5, 12–13 Bands 4–6
Question 10 **B** Using the right-hand rule for the top and bottom of the coil, the current, *I*, is up the page and the magnetic field, *B*, is to the right of the page. Thus, the palm indicates a force into the page, which means that the coil rotates in an anticlockwise direction. $\tau = nIAB\sin\theta$ $= 20 \times (15 \times 0.001) \times (0.03 \times 0.04) \times 3 \times \sin(65°)$ $= 20 \times 0.015 \times 0.0012 \times 3 \times 0.9063\ldots$ $= 9.79 \times 10^{-4}$ Nm	Mod 6 Electromagnetism PH12–4, 12–5, 12–13 Bands 4–6

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 11 **C** **C** is correct and **D** is incorrect. Using the right-hand rule, the magnetic field is into the page; thus, the direction of particle *K*'s movement indicates that it is negatively charged. Given that $F = qvB$: $F = \frac{mv^2}{r}$ $r = \frac{mv^2}{F}$ $r = \frac{mv^2}{qvB}$ $r = \frac{mv}{qB}$ $\frac{q}{m} = \frac{v}{rB}$ $= \frac{2.5 \times 10^4}{0.05 \times 1.8 \times 10^{-6}}$ $= 2.8 \times 10^{11}\ \text{C kg}^{-1}$ **A** and **B** are incorrect. These options do not convert the radius of particle *K*'s arc from centimetres to metres.	Mod 6 Electromagnetism Mod 8 From the Universe to the Atom PH12–5, 12–6, 12–13, 12–15 Bands 5–6
Question 12 **C** The intensity of the light refers to the rate at which the photons in the light are incident on a surface; in this case, the piece of metal. The frequency of the light refers to the energy of each photon, according to $E = hf$. Under condition 1, the maximum kinetic energy of the photoelectrons (K_{max}) would remain constant because the frequency of the light is kept constant, and the number of photoelectrons emitted would decrease because the intensity of light decreased. Under condition 2, the increased frequency of the light means that the photon energy is increased, according to $K_{max} = hf - \phi$. As ϕ is constant, this also increases the kinetic energy of the photoelectrons. As the intensity of the light is kept constant, the number of photons, and thus photoelectrons, also remains constant.	Mod 7 The Nature of Light PH12–2, 12–4, 12–14 Band 5

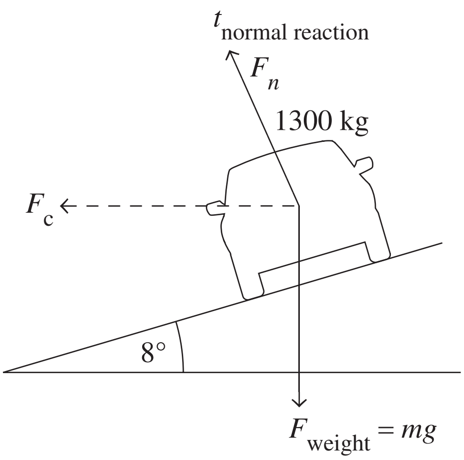
Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 13 **A** **A** is correct. The speed of light is constant relative to all observers. **B**, **C** and **D** are incorrect. These statements do not account for the speed of light being constant.	Mod 7 The Nature of Light PH12–4, 12–14 Band 4
Question 14 **C** Ren and Annika are moving on the same path. Therefore, they could both be moving towards the Extrema space station, with Annika travelling at a faster speed. Thus, conclusion 1 could be correct. While her navigation system is rebooting, Ren could go off course and start moving backwards towards the Ultima space station while Annika remains stationary. Thus, conclusion 2 could be correct. Both Ren and Annika could go off course and start moving backwards towards the Ultima space station, with Ren moving faster than Annika. Thus, conclusion 3 could be correct.	Mod 7 The Nature of Light PH12–4, 12–14 Bands 4–6
Question 15 **D** Using Wien's law gives: $\lambda_{\text{max}} = \frac{b}{T}$ $= \frac{2.898 \times 10^{-3}}{4000}$ $= 7.245 \times 10^{-7}$ m $= 725$ nm	Mod 7 The Nature of Light PH12–4, 12–14 Band 4

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 16 **B** $^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{140}_{56}\text{Ba} + ^{93}_{36}\text{Kr} + 3^{1}_{0}\text{n}$ The mass of the reactants in the fission reaction is: 235.044 + 1.00866 = 236.05266 amu The mass of the products in the fission reaction is: 139.91061 + 92.93127 + (3 × 1.00866) = 235.86786 amu Therefore, the mass lost during the reaction is: 236.05266 – 235.86786 = 0.1848 amu Given that 1 amu = 1.661×10^{-27} kg, the energy released per nucleus is: $E = mc^2$ $= (0.1848 \times 1.661 \times 10^{-27}) \times (3.00 \times 10^8)^2$ $= 2.7625\ldots \times 10^{-11}$ J Given that 2% of 1 kg is 0.02 kg, the mass of uranium-235 is: $\dfrac{0.02}{1.661 \times 10^{-27}} = 1.2040\ldots \times 10^{25}$ amu number of uranium-235 nuclei $= \dfrac{1.2040\ldots \times 10^{25}}{235.044}$ $= 5.1228\ldots \times 10^{22}$ nuclei total energy released $= (2.7625\ldots \times 10^{-11}) \times (5.1228\ldots \times 10^{22})$ $= 1.4168\ldots \times 10^{12}$ $= 1.42 \times 10^{12}$ J	Mod 8 From the Universe to the Atom PH12–4, 12–5, 12–15 Bands 5–6
Question 17 **A** In experiment 1, the students would observe a continuous visible spectrum due to the heated filament of the incandescent lamp, which produces heat and light and emits photons across the entire visible spectrum. In experiment 2, the students would observe an emission spectrum. The yellow lines on the black background are caused by the photons of light released by excited electrons returning to the ground state from a higher energy level and correspond to the differences in these energy levels. In experiment 3, the students would observe an absorption spectrum. The incandescent lamp produces photons of all colour frequencies; however, the sodium vapour would absorb photons that cause electrons to jump to higher energy levels. As these electrons return to the ground state, the photons released would be equivalent to the wavelengths of the energy absorbed. Thus, these wavelengths would appear as black lines on the coloured background.	Mod 8 From the Universe to the Atom PH12–5, 12–6, 12–15 Bands 4–6

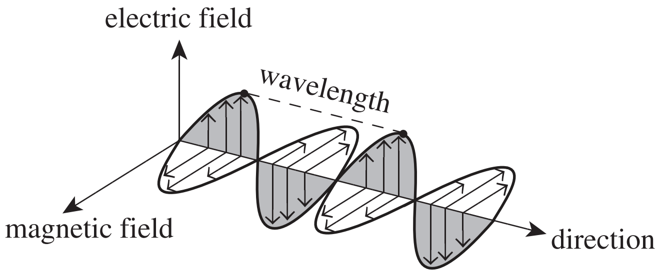
Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 18 **C** $qV = \frac{1}{2}mv^2$ $v = \sqrt{\frac{2qV}{m}}$ $= \sqrt{\frac{2\times(1.602\times10^{-19})\times3200}{9.109\times10^{-31}}}$ $= 3.35\times10^7 \text{ m s}^{-1}$	Mod 8 From the Universe to the Atom PH12–6, 12–15 Band 5
Question 19 **D** $\tau = rF\sin\theta$ Given that $m = rF$, using points from the graph to find m gives: $m = \frac{200-50}{0.59-0.14}$ $= 333.3333\ldots$ Therefore: $m = rF$ $333.3333\ldots = 0.25\times F$ $F = 1333 \text{ N}$	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–6, 12–12 Bands 5–6
Question 20 **C** $T = \frac{60}{10}$ $= 6 \text{ s}$ $v = \frac{2\pi r}{T}$ $= \frac{2\pi\times15.00}{6}$ $= 15.7079\ldots \text{ m s}^{-1}$ $F = \frac{mv^2}{r}$ $= \frac{(550.0+65.00)\times15.7079\ldots^2}{15.00}$ $= 10\,116 \text{ N}$	Mod 5 Advanced Mechanics PH12–4, 12–6, 12–12 Bands 5–6

SECTION II

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 21	
(a) $s = h_{max}$ $v = 0$ $u = 25\sin(30°)$ $= +12.5 \text{ m s}^{-1}$ $a = -9.8 \text{ m s}^{-2}$ Substituting these values into the formula gives: $v^2 = u^2 + 2as$ $0 = 12.5^2 + 2\times -9.8 \times h_{max}$ $-12.5^2 = 2\times -9.8\times h_{max}$ $h_{max} = -\frac{12.5^2}{2\times -9.8}$ $= +7.97 \text{ m}$	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–12 Bands 4–6 • Identifies the appropriate data and formulae. AND • Calculates the maximum height of the kai using appropriate units . . . . 2 • Provides some relevant working . . . 1
(b) $v = -12.5 \text{ m s}^{-1}$ $u = +12.5 \text{ m s}^{-1}$ $a = -9.8 \text{ m s}^{-2}$ Substituting these values into the formula gives: $v = u + at$ $-12.5 = 12.5 + -9.8\times t$ $t = \frac{25}{9.8}$ $= 2.55 \text{ s}$	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–12 Bands 4–6 • Identifies the appropriate data and formulae. AND • Calculates the flight time of the kai using appropriate units. . . . . 2 • Provides some relevant working . . . 1
(c) $v = 25\cos(30°)$ $= 21.6506 \text{ m s}^{-1}$ $t = 2.55 \text{ s}$ Substituting these values into the formula gives: $v = \frac{s}{t}$ $21.6506 = \frac{s}{2.55}$ $s = 21.6506\times 2.55$ $= 55.2091$ $= 55.2 \text{ m}$ *Note: Consequential on answer to **Question 21(b)**.*	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–12 Bands 4–6 • Identifies the appropriate data and formulae. AND • Calculates the horizontal range of the kai using appropriate units . . . . 2 • Provides some relevant working . . . 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 22	
(a) $F_c = \frac{mv^2}{r}$ $= 1300 \times \frac{\left(\frac{80}{3.6}\right)^2}{40}$ $= 16\,049$ N	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–6, 12–12 Bands 4–6 • Identifies the appropriate data and formulae. AND • Calculates the magnitude of the centripetal force using appropriate units. . . . . 2 • Provides some relevant working . . . 1
(b) $a = \frac{v^2}{r}$ $= \frac{\left(\frac{80}{3.6}\right)^2}{40}$ $= 12 \text{ m s}^{-2}$	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–6, 12–12 Bands 4–6 • Identifies the appropriate data and formulae. AND • Calculates the magnitude of the centripetal acceleration using appropriate units. . . . . 2 • Provides some relevant working . . . 1
(c)  $F_c = F_{net}(x)$ $\tan(8°) = \frac{F_{net}(x)}{1300 \times 9.8}$ $F_{net}(x) = \tan(8°) \times 12\,740$ $= 1790$ N OR 2×10^3 N (to 1 significant figure)	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–6, 12–12 Bands 4–6 • Draws a relevant diagram that shows the vector components. AND • Labels the reaction force AND weight force. AND • Identifies $F_{net}(x)$ as the centripetal force. AND • Calculates the magnitude of the centripetal force using appropriate units. . . . . 4 • Any THREE of the above points. . . 3 • Any TWO of the above points. . . . . 2 • Any ONE of the above points 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 23	
(a) Finding the formula for orbital velocity gives: $\frac{GMm}{r^2}=\frac{mv^2}{r}$ $v=\sqrt{\frac{GM}{r}}$ Substituting into the formula gives: $v=\sqrt{\frac{GM}{r}}$ $=\sqrt{\frac{(6.67\times10^{-11})\times(6.0\times10^{24})}{6.371\times10^{6}+5.0\times10^{5}}}$ $=7632\text{ m s}^{-1}$	Mod 5 Advanced Mechanics PH12–6, 12–12 Bands 4–6 • Calculates the orbital velocity using appropriate units. . . . . 2 • Derives the formula for orbital velocity. OR • Calculates the orbital velocity without appropriate units 1
(b) $E_p=-\frac{Gm_1m_2}{r}$ $=-\frac{(6.67\times10^{-11})\times(6.0\times10^{24})\times250}{6.371\times10^{6}+5.0\times10^{5}}$ $=-1.4561\ldots\times10^{10}\text{ J}$ $=-1.5\times10^{10}\text{ J}$	Mod 5 Advanced Mechanics PH12–6, 12–12 Bands 4–6 • Calculates the magnitude of the gravitational potential energy using appropriate units. . . . . 2 • Calculates the magnitude of the gravitational potential energy without appropriate units. OR • Calculates the magnitude of the gravitational energy without including the radius of Earth 1
(c) $\frac{1}{2}mv^2=\frac{GMm}{r}$ $v=\sqrt{\frac{2GM}{r}}$ $=\sqrt{\frac{2\times(6.67\times10^{-11})\times(6.0\times10^{24})}{6.371\times10^{6}+5.0\times10^{5}}}$ $=10\ 793\text{ m s}^{-1}$	Mod 5 Advanced Mechanics PH12–6, 12–12 Bands 5–6 • Identifies the relationship between kinetic energy and potential energy. AND • Identifies the appropriate data and formulae. AND • Calculates the escape velocity of the satellite using appropriate units. . . . . 2 • Any TWO of the above points. 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(d) As the satellite goes to a higher altitude, its gravitational potential energy increases. The work done on the satellite will equal the change in its gravitational potential energy.	Mod 5 Advanced Mechanics PH12–6, 12–12 Bands 4–6 • Identifies the change in the satellite's gravitational potential energy. AND • Explains how the work done is equal to the change in gravitational potential energy . . . . . 2 ——— • Any ONE of the above points 1
Question 24	
(a)  A radio wave, which is an electromagnetic wave, is propagated when a changing electric field induces a changing magnetic field at right angles, which in turn induces a changing electric field.	Mod 7 The Nature of Light PH12–2, 12–7, 12–14 Bands 3–6 • Draws an electromagnetic wave. AND • Labels all THREE of: – electric field – magnetic field – direction of propagation. AND • Describes how radio waves are propagated . . . . 3 ——— • Draws an electromagnetic wave. AND • Labels any TWO of: – electric field – magnetic field – direction of propagation. AND • Describes how radio waves are propagated . . . . 2 ——— • Draws a recognisable electromagnetic wave without labels. OR • Describes how radio waves are propagated 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(b) Hertz could have changed the orientation of the receiver and observed whether a spark occured as he changed the angle. If the sparks were only observed when the receiver was in a particular orientation, then the radio waves would be polarised in that orientation. This is because the vibrations of a polarised transverse wave are restricted to only one direction.	Mod 7 The Nature of Light PH12–2, 12–7, 12–14 Band 6 • Explains a suitable method that could have been used to determine if radio waves were polarised. AND • Demonstrates an understanding of polarisation . . . . 2 • Provides some relevant information 1
Question 25	
The diagram shows the refraction, or bending, of light. Both Huygens's and Newton's models can be used to explain how the light changes direction as it leaves the air and enters the glass prism. Huygens proposed the wave model of light, which stated that every point on the wavefront was a source of secondary wavelets that then travelled forwards at the same speed and wavelength as the original wave. When the wave encounters the glass prism, it slows down and refracts because the wavelength changes; thus, the wave also changes direction. Newton's corpuscular model of light assumes that the speed of light increases as it enters the glass prism because the light and glass particles are attracted to each other. The light particles are accelerated along the normal of the prism due to this attraction. When light exits the prism, the attraction is the same, though it opposes the direction of the light's motion. Thus, the speed of the particles decreases and the light moves away from the normal, changing direction. (continues on next page)	Mod 7 The Nature of Light PH12–1, 12–7, 12–14 Bands 4–6 • Identifies that the diagram shows refraction. AND • Outlines Huygens's wave model. AND • Outlines Newton's corpuscular model. AND • Explains how Huygens's model can be used to explain refraction. AND • Explains how Newton's model can be used to explain refraction . . . 5 • Identifies that the diagram shows refraction. AND • Outlines Huygens's wave model OR Newton's corpuscular model. AND • Explains how Huygens's model can be used to explain refraction. AND • Explains how Newton's model can be used to explain refraction . . . 4

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(continued)	• Identifies that the diagram shows refraction. AND • Identifies that Huygens proposed the wave model. AND • Identifies that Newton proposed the corpuscular model. AND • Explains how Huygens's OR Newton's model can be used to explain refraction. 3
	• Identifies that diagram shows refraction. AND • Identifies that Huygens proposed the wave model. AND • Identifies that Newton proposed the corpuscular model 2
	• Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 26	
Model 1 is effective in demonstrating the motor effect by showing the basic principle behind a simple DC motor. In the model, current flowing through the copper coil is supplied by the battery. The current induces a magnetic field around the coil that interacts with the magnetic field produced by the stationary magnet on the wooden base. These forces are perpendicular to the coil's magnetic field and act on opposite sides of the coil, producing torque and causing the coil to rotate. Thus, this model effectively shows the motor effect. However, there are some elements of a DC motor that model 1 does not represent. In a DC motor, the coil is often wound around a soft iron core to increase the magnetic field, and the core and coil are usually placed in an armature. Model 1 also lacks a split ring commutator, which changes the direction of the current through the coil relative to the external circuit in a DC motor. The plum pudding in model 2 represents Thomson's theory of the atom, which demonstrated the negative charge of electrons and showed that, overall, atoms are neutral. Though this theory is no longer accepted, model 2 is an effective visualisation of the theory. Electrons are represented by the pieces of dried plum that are dispersed throughout the plum pudding; the pudding between the pieces of plums is designated as being positive. Thomson proposed this theory before the nuclear model of the atom was created; thus, it was rejected once the Geiger–Marsden experiments showed that an atom has a very small positive nucleus. Models can help the students to visualise physics concepts, but without explaining experimental evidence, they can lead to misconceptions and oversimplification of these concepts. Model 1 demonstrates the motor effect, but does not include all the parts of a DC motor, and model 2 represents an early atomic model that ultimately could not explain later findings. While each model has some limitations, models 1 and 2 are effective in representing the concepts and would aid the students' overall understanding. (continues on next page)	Mod 6 Electromagnetism Mod 8 From the Universe to the Atom PH12–1, 12–4, 12–5, 12–6, 12–7, 12–13, 12–15 Bands 4–6 • Explains in detail how model 1 demonstrates the motor effect. AND • Identifies the features of a DC motor that model 1 represents. AND • Identifies the features of a DC motor that model 1 does not represent. AND • Explains in detail how model 2 demonstrates Thomson's theory of the atom. AND • Identifies the elements of Thomson's theory that model 2 represents. AND • Outlines why Thomson's theory is no longer accepted. AND • Judges summatively the effectiveness of models 1 and 2. AND • Provides a logical and coherent response . . . . 8–9 --- • Explains in detail how model 1 demonstrates the motor effect. AND • Identifies the features of a DC motor that model 1 represents. AND • Identifies the features of a DC motor that model 1 does not represent. AND • Explains in detail how model 2 demonstrates Thomson's theory of the atom. AND

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(continued)	• Identifies the elements of Thomson's theory that model 2 represents. AND • Outlines why Thomson's theory is no longer accepted. AND • Judges the effectiveness of models 1 and 2. 6–7
	• Explains how model 1 demonstrates the motor effect. AND • Identifies the features of a DC motor that model 1 represents. AND • Explains how model 2 demonstrates Thomson's theory of the atom. AND • Identifies the elements of Thomson's theory that model 2 represents. AND • Judges the effectiveness of models 1 and 2. 4–5
	• Outlines how model 1 demonstrates the motor effect. AND • Outlines how model 2 demonstrates Thomson's theory of the atom. AND • Judges the effectiveness of models 1 and 2 2–3
	• Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide

Question 27

(a)

Identify risk	*Control risk*	*Evaluate risk*
Lasers can damage the eyes.	Point laser away from students.	The risk is low, if students follow directions.

Mod 7 The Nature of Light
PH12–2, 12–7 Bands 2–6

- Provides relevant headings for each column.

AND

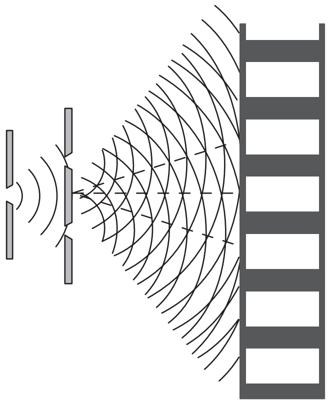
- Conducts a risk assessment for the experiment 2

- Any ONE of the above points.

OR

- Provides some relevant information 1

(b)



Note: Three light bands must be positioned at the three dotted lines where constructive (anti-nodal) interference has occurred. The dark bands represent destructive (nodal) interference and must be positioned between the light bands.

Mod 7 The Nature of Light
PH12–2, 12–3, 12–4, 12–7, 12–14
Bands 4–6

- Sketches alternating light and dark bands.

AND

- Positions the light bands in relation to the wavefronts 2

- Sketches alternating light and dark bands. 1

(c) As this is a first order diffraction, $m = 1$.

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

$$\theta = \sin^{-1}\left(\frac{633\times10^{-9}}{0.42\times10^{-3}}\right)$$

$$= 0.0864°$$

$$\tan\theta = \frac{x}{L}$$

$$x = \tan(0.0864°)\times1.2$$

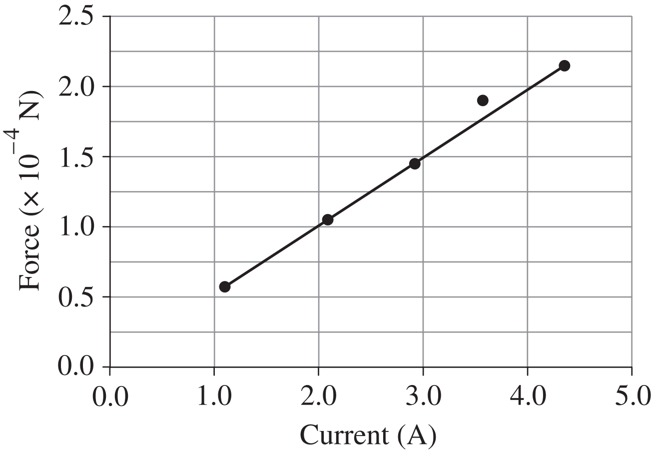
$$= 1.8\times10^{-3}\ \text{m}$$

Mod 7 The Nature of Light
PH12–4, 12–14 Band 4

- Calculates the distances between the bright bands 2

- Provides some relevant working . . . 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 28	
The speed of light is constant for all observers in inertial frames of reference. In diagram 1, light is bounced off a mirror on the ceiling onto a detector on the floor. To the observer inside the train, the light moves up and down over a short distance in a short period of time. However, as shown in diagram 2, the observer outside the train sees the light appear to bounce off the mirror at an angle and travel a longer path. The time interval in the observer's frame of reference is longer (time dilation occurs) and the lengths in the system moving relative to the observer appear to be shorter (length contraction occurs).	Mod 7 The Nature of Light PH12–4, 12–7, 12–14 Band 5 • Explains how time dilation occurs in the thought experiment. AND • Explains how length contraction occurs in the thought experiment. . . 4 • Outlines how time dilation occurs in the thought experiment. AND • Outlines how length contraction occurs in the thought experiment. . . 3 • Outlines how time dilation occurs in the thought experiment. AND • Identifies that length contraction occurs in the thought experiment. OR • Identifies that time dilation occurs in the thought experiment. AND • Outlines how length contraction occurs in the thought experiment. . . 2 • Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 29	
(a) 	Mod 6 Electromagnetism PH12–2, 12–5, 12–13 Band 4 • Identifies the y-axis as force and the x-axis as current. AND • Labels the axes, including correct units. AND • Plots the data. AND • Draws a line of best fit. . . . . 3 • Any THREE of the above points . . . 2 • Any TWO of the above points. 1
(b) *For example:* The graph shows that as current increases, there is a proportional increase in the upwards net force acting on the system, assuming that the magnetic field and current are kept constant. *Note: Responses can also refer to the angle being kept constant. Consequential on answer to **Question 29(a)**.*	Mod 6 Electromagnetism PH12–2, 12–5, 12–13 Band 4 • Identifies the relationship shown in the graph. AND • States TWO assumptions. . . . . 2 • Any ONE of the above points 1
(c) $\text{gradient} = \frac{\text{rise}}{\text{run}}$ $= \frac{1.5\times10^{-4} - 1.0\times10^{-4}}{3.0-2.0}$ $= 0.5\times10^{-4}$ $F = lIB\sin\theta$ $\frac{F}{l} = \frac{0.5\times10^{-4}}{1}$ $= 0.5\times10^{-4}\ \text{N m}^{-1}$ $\therefore \frac{F}{l} = BI\sin\theta$	Mod 6 Electromagnetism PH12–2, 12–5, 12–13 Band 6 • Calculates the gradient. AND • Uses relevant equations to identify what the gradient represents. . . . . 2 • Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 30	
This Hertzsprung–Russell diagram graphs the luminosity of stars against their surface temperature. Matching luminosity and surface temperature helps to determine the size/mass of a star; for example, stars with a low temperature but a high luminosity are very large (super giants). A star is found in a particular region of a Hertzsprung–Russell diagram depending on its evolutionary stage. These stages are controlled by the nucleosynthesis reactions occurring in the star's core. White dwarfs are found in area A; these stars are cooling down as they have stopped all nuclear reactions. Main sequence stars are found in area B; this is where the Sun would be found, as it is approximately halfway through its life cycle and is undergoing hydrogen fusion at its centre. Red giants are found in area C; these stars have used up most of the hydrogen in their cores and are now fusing helium, meaning that they are nearing the end of their lives. Supergiants are found in area D; these massive stars have very high temperatures and other fusion reactions occurring in their core. The life cycle of a star begins when the gas inside huge interstellar clouds condenses due to gravitational attraction. In the core of the new star, hydrogen is converted into helium, which releases large amounts of energy; this occurs in main sequence stars. As a main sequence star increases in size, it consumes hydrogen more quickly and burns hotter and brighter; thus, it appears higher in area B of the diagram. The proton–proton cycle is most common in main sequence stars with a small mass, such as the Sun, while the carbon–nitrogen–oxygen (CNO) cycle takes place in stars with a large mass, such as supergiants. As stars evolve and move up the main sequence, they burn hydrogen faster. This causes the stars to form helium, which then collapses and forms heavier elements with large releases of energy; thus, the outer hydrogen shell expands. This outer surface is cooler and appears red, so the star moves off the main sequence and becomes a red giant. When stars with a small or medium mass burn out, they collapse and form white dwarfs made mainly of carbon, nitrogen and oxygen. These white dwarfs are not as luminous as and have much smaller surface areas than main sequence stars. (continues on next page)	Mod 8 From the Universe to the Atom PH12–5, 12–6, 12–7, 12–15 Bands 4–6 • Explains the relationship between luminosity and surface temperature. AND • Identifies the stars in areas A–D. AND • Describes the life cycle of stars with small mass and stars with large mass. AND • Identifies all THREE of: – stars with a small mass use the proton–proton cycle – stars with a large mass use the CNO cycle – stars release a large amount of energy as they burn fuel. AND • Provides a logical and coherent response .... 7–8 • Explains the relationship between luminosity and surface temperature. AND • Identifies the stars in areas A–D. AND • Outlines the life cycle of stars with small mass and stars with large mass. AND • Identifies any TWO of: – stars with a small mass use the proton–proton cycle – stars with a large mass use the CNO cycle – stars release a large amount of energy as they burn fuel 5–6

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(continued)	• Explains the relationship between luminosity and surface temperature. AND • Identifies the stars in areas A–D. OR • Outlines the life cycle of stars with small mass and stars with large mass. AND • Identifies any ONE of: – stars with a small mass use the proton–proton cycle – stars with a large mass use the CNO cycle – stars release a large amount of energy as they burn fuel 3–4
	• Explains the relationship between luminosity and surface temperature. AND • Identifies the stars in areas A–D. OR • Identifies any ONE of: – stars with a small mass use the proton–proton cycle – stars with a large mass use the CNO cycle – stars release a large amount of energy as they burn fuel 1–2

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 31	
(a) Lenz's law states that the induced electromotive force (emf) in a conductor is in a direction that opposes the energy change that induced it. Thus, it would be expected that the magnet falls through the PVC pipe much faster than the copper pipe. Copper is metallic and therefore a conductor. As the magnet falls, the magnetic field in the copper pipe would change and the movement of the electrons in the copper atoms would induce a current. As a result, eddy currents would form in a direction opposite to the changing external magnetic field. As the falling magnets under the giant drop's seats reach the copper fins, eddy currents and magnetic forces are induced in the copper. The interaction between the magnetic forces causes electromagnetic braking to occur and slow down the seats.	Mod 6 Electromagnetism PH12–2, 12–13 Bands 4–6 • Uses Lenz's law to explain why the magnet falls much slower through the copper pipe. AND • Explains eddy currents. AND • Explains how electromagnetic braking occurs in the giant drop . . . 3 • Any TWO of the above points. . . . . 2 • Any ONE of the above points. OR • Provides some relevant information 1
(b) The teacher's comment is correct. The size of the eddy currents is proportional to the speed of the falling seats. As the induced magnetic field interacts with the external magnetic field, the seats slow, the eddy currents reduce proportionally and the induced magnetic field decreases, resulting in a smooth deceleration. Conversely, conventional braking relies on an operator responding to the falling seats and the change in speed would be felt more suddenly by the occupants. Thus, electromagnetic brakes are smoother and more reliable.	Mod 6 Electromagnetism PH12–12 Bands 5–6 • States that the teacher's comment is correct. AND • Explains why electromagnetic braking is smoother than conventional braking . . . . 2 • Any ONE of the above points 1
Question 32	
(a) The nuclear model of the atom has a positive nucleus surrounded by electrons. Rutherford's atomic model demonstrated that the mass of an atom was concentrated in a tiny, positively charged nucleus and electrostatic forces kept the negatively charged electrons in orbit around the nucleus. This force of attraction provided the centripetal force needed to maintain stable orbits.	Mod 8 From the Universe to the Atom PH12–5, 12–7, 12–15 Bands 3–6 • Outlines the nuclear model of the atom. AND • Describes the specific features of Rutherford's model . . . . 2 • Any ONE of the above points 1

	Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(b)	*For example:* One limitation of Bohr's atomic model was that it showed a single electron spiraling into the nucleus, emitting radiation and thus making the atom unstable. Bohr's model was only applicable to hydrogen atoms and ions with one electron. De Broglie proposed that electrons show wave properties such that their orbits are standing waves; thus, no energy would be lost during orbit. For example, the first orbit at $n = 1$ has a circumference of one wavelength. An electron could not be closer to the nucleus than this as the electron's wave amplitude would be less than zero. Thus, de Broglie's matter waves explained electron orbits and provided stability to the atom. De Broglie's model overcame the limitation of Bohr's model by showing that an electron could not exist closer to the nucleus than the first orbit, as only part of a single wavelength of the electron wave would fit. *Note: Other limitations of Bohr's model could include its inability to predict the brightness of spectral lines and the presence of hyperfine spectral lines; or its inability to explain the splitting of spectral lines (stark and Zeeman effects).*	Mod 8 From the Universe to the Atom PH12–5, 12–7, 12–15 Bands 4–6 • Outlines ONE limitation of Bohr's atomic model. AND • Explains how de Broglie overcame the limitation. AND • Describes de Broglie's atomic model. AND • Provides a logical and coherent response . . . . 4 • Outlines ONE limitation of Bohr's atomic model. AND • Outlines how de Broglie overcame the limitation. AND • Outlines de Broglie's atomic model . . . . 3 • Identifies ONE limitation of Bohr's atomic model. AND • Outlines de Broglie's atomic model . . . . 2 • Provides some relevant information 1
(c)	The electrostatic force of repulsion (230 N) is much greater than the gravitational force of attraction (-2.2×10^{-34} N); the difference prevents these forces from making the nucleus stable. The strong nuclear force holds the nucleus together and only acts over short distances (1.0×10^{-15} m). It is carried by gluons and attracts nucleons to each other within the nucleus.	Mod 8 From the Universe to the Atom PH12–7, 12–15 Bands 5–6 • Explains why the forces cannot account for nuclear stability. AND • Describes the properties of the strong nuclear force. AND • Refers to the data . . . . 3 • Any TWO of the above points. . . . . 2 • Any ONE of the above points 1