SCIENCE EDUCATION

Centre Number

Student Number

Sigma Science Education

2026 **MOCK HIGHER SCHOOL CERTIFICATE EXAMINATION – PAPER 2**

Physics

General Instructions

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

Total marks: 100

Section I – 20 marks (pages 2–11)

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

Section II – 80 marks (pages 13–34)

- Attempt Questions 21–34
- Allow about 2 hours and 25 minutes for this section

Σ **Revision edition.** The Σ tags in the right margin list past HSC Physics questions (year and question number, 2019–2025) that test similar content or skills. Use them for targeted practice after attempting each question.

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 Aircraft that map bushfires carry infrared scanners. One scanner is most sensitive to radiation of wavelength 3.9 μm. At what temperature would a black body have its peak emission at this wavelength?

SIMILAR
2021 Q11
2022 Q9
2023 Q9

A. 470 K

B. 743 K

C. 1016 K

D. 7.43×10^5 K

2 A skateboarder moves in a straight line at a constant 4.0 m s^{-1} east. She throws a ball vertically upwards, relative to herself, at 6.0 m s^{-1} and keeps moving at the same velocity. Air resistance is negligible.

SIMILAR
2021 Q34(a)
2022 Q8
2024 Q9

Which row correctly describes where the ball lands and the speed of the ball at the top of its flight, as measured by an observer standing beside the path?

	Where the ball lands	*Speed at top of flight (m s^{-1})*
A.	Back in her hands	0
B.	About 4.9 m behind her	0
C.	Back in her hands	7.2
D.	Back in her hands	4.0

3 In the first step of the proton–proton chain in the Sun, two protons fuse to form a deuteron, which consists of one proton and one neutron. Two leptons are also emitted.

SIMILAR
2019 Q12
2020 Q25
2022 Q5

Which row correctly identifies the quark change and the leptons emitted?

	Quark change	*Leptons emitted*
A.	u ⟶ d	positron and electron neutrino
B.	d ⟶ u	electron and electron antineutrino
C.	u ⟶ d	positron and electron antineutrino
D.	u ⟶ d	electron and electron neutrino

4 An older-style mobile-phone charger contains a step-down transformer. Its primary coil is connected to the 240 V mains supply, and its secondary coil delivers a current of 2.0 A at 5.0 V to the rest of the charger. The transformer is 85% efficient.

SIMILAR
2019 Q24(a)
2021 Q7
2023 Q28(b)

What is the current in the primary coil?

A. 0.035 A

B. 0.042 A

C. 0.049 A

D. 96 A

5 At Earth's magnetic equator, Earth's magnetic field is horizontal and points north. A cosmic-ray proton there is moving vertically downwards towards the ground.

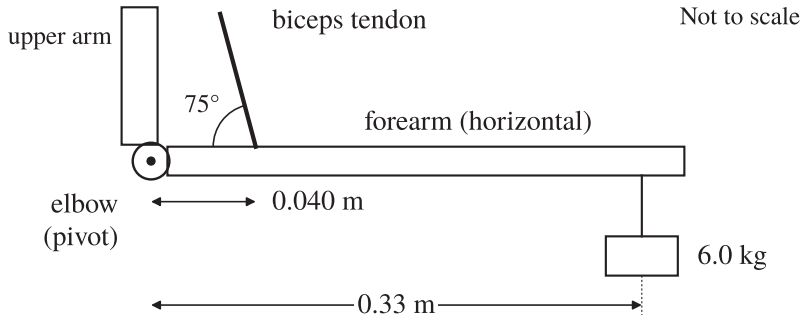
SIMILAR
2020 Q10
2021 Q20
2022 Q12

Which row correctly describes the direction of the magnetic force on the proton and the effect of this force on the proton's speed?

	Direction of force	*Effect on speed*
A.	West	No change
B.	East	Increases
C.	West	Increases
D.	East	No change

6 The diagram shows a forearm held horizontal with a 6.0 kg dumbbell in the hand, 0.33 m from the elbow joint. The biceps tendon is attached to the forearm 0.040 m from the elbow and pulls at 75° to the forearm. Neglect the mass of the forearm.

SIMILAR
2023 Q17
2024 Q21(a)
2025 Q23(a)



What is the magnitude of the force exerted by the biceps on the forearm while the forearm is held still?

A. 51 N

B. 485 N

C. 502 N

D. 1.87×10^3 N

7 Ionisation smoke detectors contain a small sealed source of americium-241, which emits alpha particles and has a half-life of 432 years. The alpha particles ionise the air between two electrodes in the detector so that a small current flows.

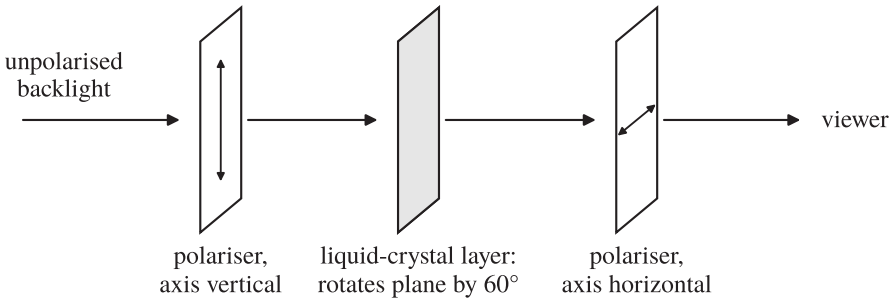
SIMILAR
2021 Q19
2021 Q35(b)
2023 Q4

Which row gives the percentage decrease in the activity of the source over 10 years and a correct reason for using an alpha emitter?

	Decrease in activity over 10 years	*Reason for using an alpha emitter*
A.	1.6%	Strongly ionising; stopped by a few centimetres of air
B.	2.3%	Strongly ionising; stopped by a few centimetres of air
C.	1.6%	Highly penetrating; easily crosses the gap between the electrodes
D.	2.3%	Highly penetrating; easily crosses the gap between the electrodes

8 In one type of liquid-crystal display (LCD), unpolarised light from a backlight passes through a polarising filter with a vertical transmission axis, then through a liquid-crystal layer, and then through a second polarising filter with a horizontal transmission axis, as shown.

SIMILAR
2021 Q15
2022 Q17
2025 Q12



Model the liquid-crystal layer as rotating the plane of polarisation of the light, without absorbing any light, by an angle that depends on the voltage applied. For one pixel the plane of polarisation is rotated by 60°.

What fraction of the intensity of the backlight is transmitted through this pixel?

A. 0.094

B. 0.38

C. 0.43

D. 0.75

9 Astronomers record the spectrum of a Sun-like star every night for two weeks. All of the absorption lines in its spectrum shift together, first slightly towards longer wavelengths and then slightly towards shorter wavelengths, with the pattern repeating every 4.2 days. The widths and relative strengths of the lines and the brightness of the star do not change.

SIMILAR
2019 Q2
2019 Q22
2024 Q22(b)

Which conclusion is best supported by these observations?

A. The star's surface temperature rises and falls with a period of 4.2 days.

B. The star rotates on its axis once every 4.2 days.

C. The star's chemical composition changes in a cycle lasting 4.2 days.

D. The star moves alternately away from and towards Earth every 4.2 days, as would be caused by an orbiting planet.

10 In transcranial magnetic stimulation (TMS), a coil held against a patient's head produces a brief magnetic pulse in the brain. During one pulse, the magnetic field in a region of the brain increases uniformly from zero to 1.5 T in 0.10 ms. Model a small region of brain tissue as a single conducting loop of radius 1.0 cm, with its plane perpendicular to the field.

SIMILAR
2020 Q19
2024 Q15
2025 Q17

What is the magnitude of the average emf induced around the loop?

A. 4.7×10^{-3} V

B. 1.5 V

C. 4.7 V

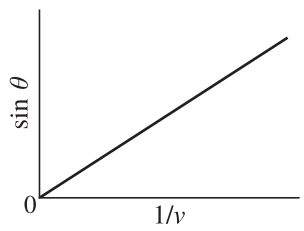
D. 19 V

11 In 1999 researchers showed that a beam of C_{60} molecules (mass 720 u) produces an interference pattern after passing through a diffraction grating. Suppose the angle θ to the first-order maximum is measured for beams of C_{60} molecules travelling at different speeds v.

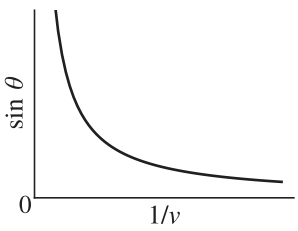
SIMILAR
2023 Q7
2024 Q14
2025 Q4

Which graph best represents the expected relationship between sin θ and $1/v$?

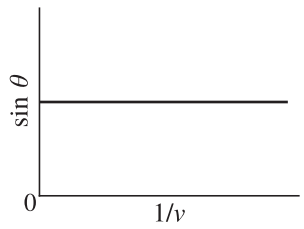
A.



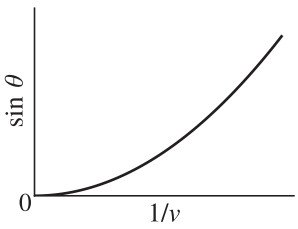
B.



C.

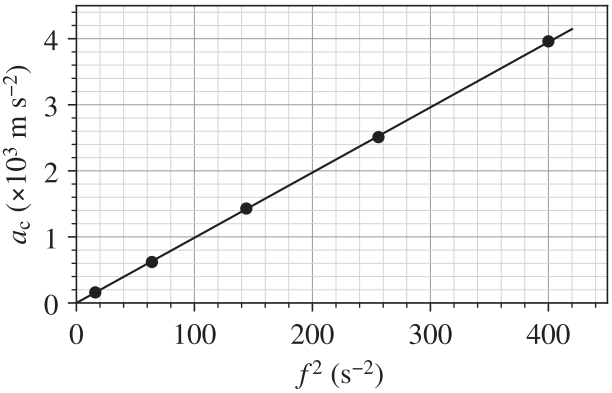


D.



12 A small wireless acceleration sensor is fixed to the inside wall of a washing-machine drum. The centripetal acceleration a_c of the sensor is recorded for different rotation frequencies f (in revolutions per second). The graph shows a_c plotted against f^2.

SIMILAR
2022 Q35
2024 Q17
2025 Q13



What is the radius of the drum?

A. 2.5×10^{-4} m

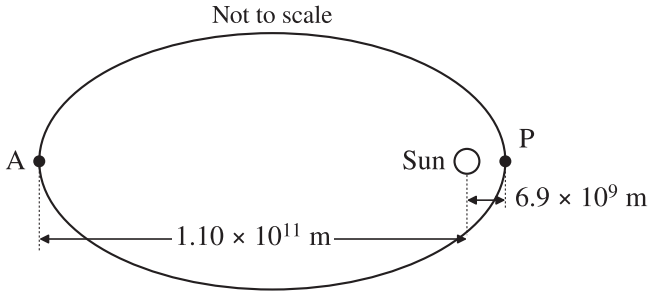
B. 0.25 m

C. 1.6 m

D. 9.9 m

13 The Parker Solar Probe moves around the Sun in an elliptical orbit, as shown. At its closest point to the Sun, P, it is 6.9×10^9 m from the centre of the Sun and travels at 1.90×10^5 m s^{-1}. At its farthest point, A, it is 1.10×10^{11} m from the centre of the Sun.

SIMILAR
2020 Q31(a)
2023 Q5
2025 Q5



What is the speed of the probe at A?

A. 1.2×10^4 m s^{-1}

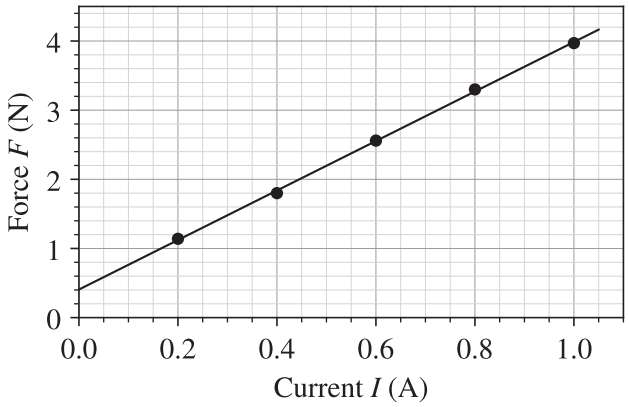
B. 4.8×10^4 m s^{-1}

C. 1.9×10^5 m s^{-1}

D. 3.0×10^6 m s^{-1}

14 An electrodynamic shaker is used to vibration-test spacecraft components. Its drive coil sits in the gap of a permanent magnet. To measure the magnetic field in the gap, a technician passes different direct currents I through the drive coil and measures the force F on the coil using a load cell. The coil has 50 turns of radius 1.5 cm. The magnetic field in the gap is radial, so it is perpendicular to every part of the wire. The graph shows the results and a line of best fit.

SIMILAR
2021 Q27(a)
2023 Q10
2024 Q10



What is the magnetic field strength in the gap?

A. 0.38 T

B. 0.76 T

C. 0.84 T

D. 38 T

15 A student uses a compact disc (CD) as a reflection grating; its tracks act like the lines of a diffraction grating. Laser light strikes the CD at normal incidence, and the angle θ between the central maximum and the first-order maximum is measured for four lasers. The results are shown.

SIMILAR
2022 Q10
2022 Q11
2023 Q3

Wavelength (nm)	405	450	532	650
θ	14.7°	16.3°	41.7°	24.0°

Which statement best describes these results?

A. The 650 nm result is anomalous: its angle is smaller than the angle for 532 nm, so the student probably misread the protractor.

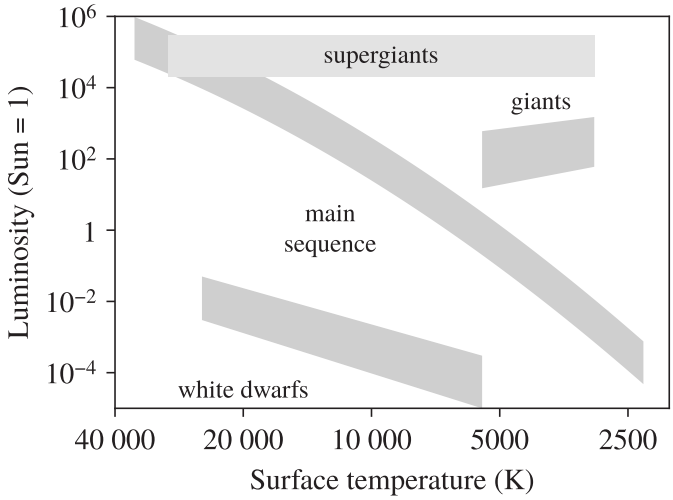
B. The 532 nm result is anomalous: the student probably measured the angle to the first-order maximum on the opposite side of the central maximum.

C. The 532 nm result is anomalous: the student probably measured the angle to the second-order maximum.

D. None of the results is anomalous: the variation in $\lambda/\sin\theta$ is due to random errors in measuring the angles.

16 Proxima Centauri has a surface temperature of 3000 K and a luminosity of 1.7×10^{-3} times that of the Sun. The Hertzsprung–Russell diagram shows the main regions occupied by stars.

SIMILAR
2022 Q21(a)
2023 Q21(a)
2025 Q15



Which row identifies the region in which Proxima Centauri lies and the distance from Proxima Centauri at which a planet would receive radiation of the same intensity as Earth receives from the Sun? (The Earth–Sun distance is 1.0 AU.)

	Region of the H–R diagram	*Distance (AU)*
A.	White dwarfs	0.041
B.	Main sequence	1.7×10^{-3}
C.	White dwarfs	1.7×10^{-3}
D.	Main sequence	0.041

17 A Mars-bound spacecraft of mass 2.6×10^4 kg is in a circular parking orbit 185 km above Earth's surface.

SIMILAR
2022 Q6
2023 Q34(b)
2024 Q13

What is the minimum additional energy needed for the spacecraft to escape from Earth's gravitational field? Ignore the effects of the Sun and the Moon.

A. 7.9×10^{11} J

B. 1.6×10^{12} J

C. 2.4×10^{12} J

D. 2.8×10^{13} J

18 In the Relativistic Heavy Ion Collider, gold nuclei travel at $0.99995c$. At rest, a gold nucleus is approximately a sphere of diameter 14 fm (1 fm = 10^{-15} m). A process inside a nucleus lasts 1.0×10^{-23} s in the nucleus's rest frame.

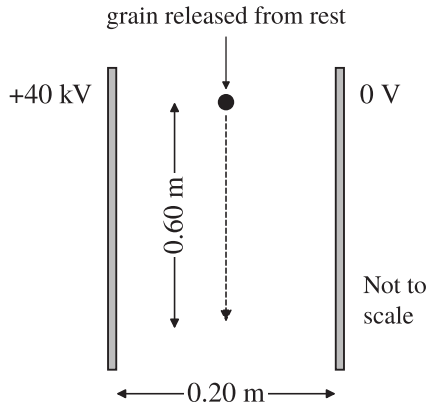
SIMILAR
2023 Q19
2024 Q12
2024 Q20

Which row gives the diameter of one of these moving nuclei along the beam direction and the duration of the process, both as measured in the laboratory?

	Diameter along the beam (fm)	*Duration of the process in the laboratory (s)*
A.	0.14	1.0×10^{-25}
B.	1400	1.0×10^{-21}
C.	1400	1.0×10^{-25}
D.	0.14	1.0×10^{-21}

19 In an electrostatic separator used in the mineral-sands industry, charged mineral grains fall from rest, starting midway between two vertical parallel plates that are 0.20 m apart, with a potential difference of 40 kV between them. One grain has a mass of 1.5×10^{-8} kg and a charge of 6.0×10^{-14} C. Air resistance is negligible.

SIMILAR
2019 Q16
2020 Q34(b)
2024 Q17



What is the horizontal displacement of this grain when it has fallen 0.60 m?

A. 9.8×10^{-3} m

B. 2.4×10^{-2} m

C. 4.9×10^{-2} m

D. 9.8×10^{-2} m

20 Rutherford backscattering spectrometry is used in the semiconductor industry to analyse thin films. A beam of alpha particles, all with the same kinetic energy, strikes a silicon wafer coated with a thin layer of gold. A detector records alpha particles that have been scattered back through nearly 180° by single nuclei. Alpha particles backscattered by gold nuclei return with more kinetic energy than those backscattered by silicon nuclei.

SIMILAR
2019 Q3
2020 Q29(b)
2022 Q31

Which statement best explains this?

A. The repulsive electric force from a gold nucleus does positive net work on the alpha particle over the whole collision.

B. A gold nucleus is much more massive than a silicon nucleus, so it recoils with less kinetic energy, leaving more with the alpha particle.

C. Electrons in the gold layer transfer kinetic energy to the alpha particles as they pass through it.

D. Some of the nuclear binding energy of the gold nucleus is transferred to the alpha particle during the collision.

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2026 MOCK HIGHER SCHOOL CERTIFICATE EXAMINATION – PAPER 2

Centre Number

Student Number

Physics

Section II Answer Booklet

80 marks
Attempt Questions 21–34
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

Do NOT write in this area.

Please turn over

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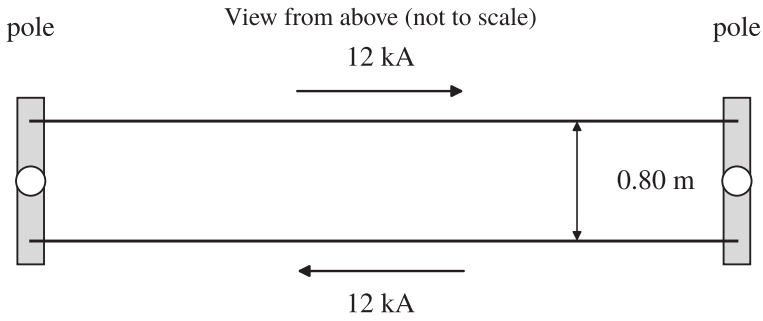
SSE 26P02P2

Question 21 (4 marks)

During a fault on a 33 kV power line, a current of 12 kA flows out along one overhead conductor and returns along the other. The two conductors are parallel and 0.80 m apart, as shown.



(a) Calculate the magnitude of the force on each metre of one conductor at an instant when the current in each conductor is 12 kA. **2**

SIMILAR
2023 Q16
2024 Q29(a)
2024 Q29(b)

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(b) The fault current is alternating. Explain why the force between the conductors is repulsive throughout the fault. **2**

SIMILAR
2021 Q17
2021 Q27(a)
2024 Q29(a)

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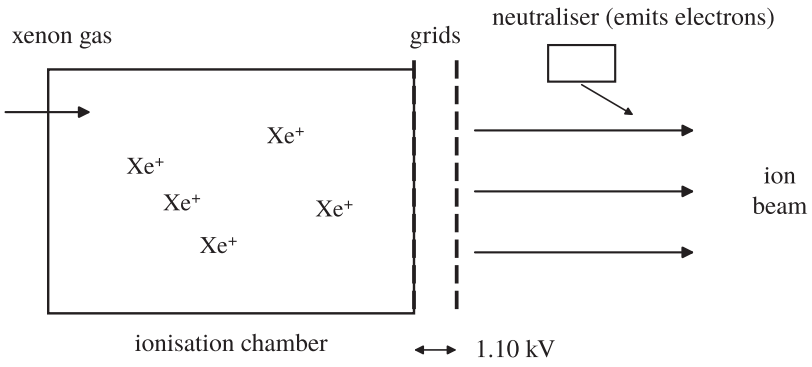
Question 22 (5 marks)

A gridded ion thruster on a deep-space probe turns xenon atoms into singly charged ions, Xe^+, each of mass 131 u. The ions, starting essentially from rest, are accelerated through a potential difference of 1.10 kV between two grids and leave the probe as a beam. A neutraliser adds electrons to the beam so that the probe stays uncharged.



(a) Calculate the speed of the xenon ions as they leave the thruster. **2**

SIMILAR
2021 Q30(a)
2022 Q26(b)
2025 Q30(c)

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(b) The ion beam carries a current of 1.76 A. Calculate the thrust (the forward force) exerted on the probe by the thruster. **3**

SIMILAR
2021 Q30(a)
2022 Q18
2025 Q29(b)

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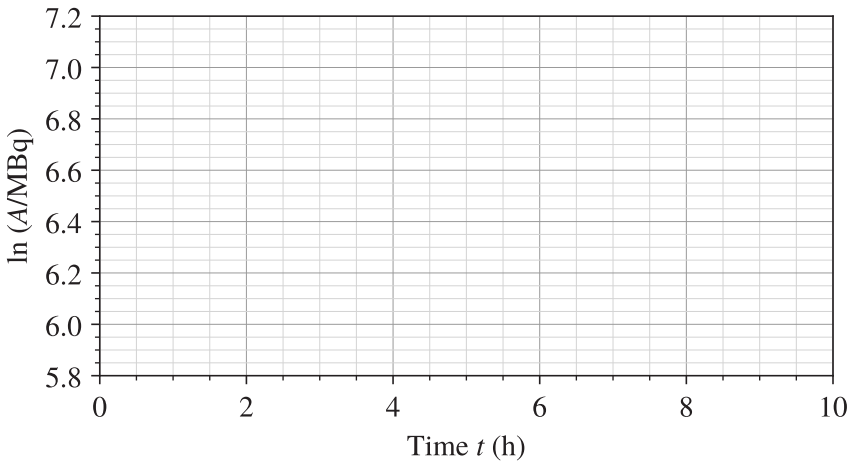
Question 23 (5 marks)

Technetium-99m is used for medical imaging. A hospital's dose calibrator measured the activity A of a sample of technetium-99m every two hours. The results are shown in the table. Since $A = A_0 e^{-\lambda t}$, a graph of ln A against t is a straight line with gradient $-\lambda$.

Time t (h)	0	2	4	6	8	10
Activity A (MBq)	1200	950	760	597	478	376
ln (A/MBq)						

(a) Complete the table, then plot ln A against t on the grid and draw a line of best fit. Hence determine the half-life of technetium-99m. **3**

SIMILAR
2020 Q4
2021 Q35(b)
2022 Q24(a)



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(b) A scan needs 500 MBq at injection at 2:00 pm. The dose is measured out at 9:00 am the same day. Calculate the activity measured out. **2**

SIMILAR
2021 Q35(b)
2022 Q24(b)
2023 Q4

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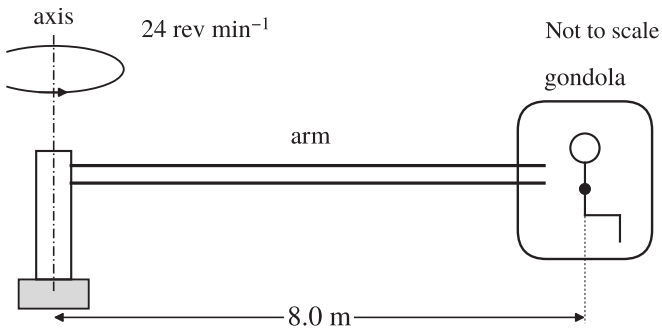
Question 24 (6 marks)

A human centrifuge used to train fighter pilots has a gondola at the end of a horizontal arm that rotates about a vertical axis, as shown. A pilot of mass 75 kg sits in the gondola, with their centre of mass moving in a horizontal circle of radius 8.0 m. The arm rotates at 24 revolutions per minute.



(a) Calculate the magnitude and direction of the force exerted on the pilot by the seat. **3**

SIMILAR
2019 Q35
2024 Q30
2025 Q29(a)

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(b) A trainee says, 'The centrifuge throws me outwards into my seat.' Using Newton's laws of motion, explain why this description is incorrect. **3**

SIMILAR
2019 Q20
2024 Q1
2024 Q30

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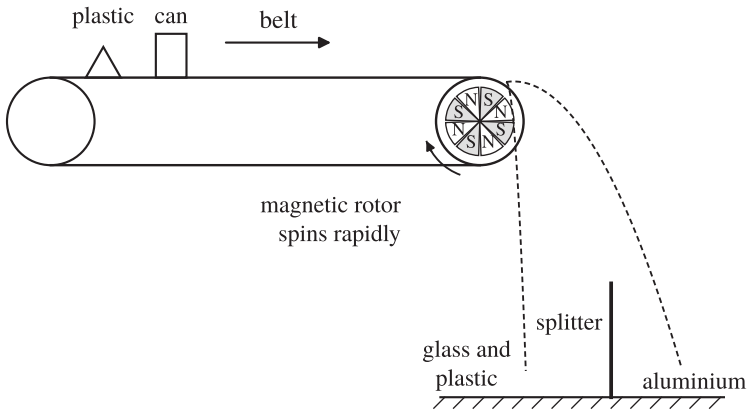
Question 25 (6 marks)

At a recycling plant, mixed waste (with steel already removed) moves along a conveyor belt. Inside the belt's head pulley, a rotor of magnets with alternating north and south poles spins much faster than the pulley. Aluminium cans are thrown beyond a splitter, while glass and plastic fall off the end of the belt, as shown.



(a) Explain how the spinning magnetic rotor causes the aluminium cans to land beyond the splitter. **3**

SIMILAR
2022 Q32(a)
2022 Q32(b)
2025 Q35

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(b) To test how the rotor's rotation rate affects how far cans travel, identify the independent and dependent variables, and justify TWO controlled variables. **3**

SIMILAR
2020 Q33
2023 Q31
2025 Q25(a)

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Question 26 (4 marks)

Radio telescopes detect a faint spectral line from clouds of ionised hydrogen around young stars. It is emitted when electrons in hydrogen atoms make the transition from the $n = 110$ energy level to the $n = 109$ energy level.

Calculate the frequency of this radiation, and explain why this transition produces radio waves whereas the transition from $n = 3$ to $n = 2$ produces visible light.

4

SIMILAR
2022 Q31
2024 Q24(b)
2024 Q24(c)

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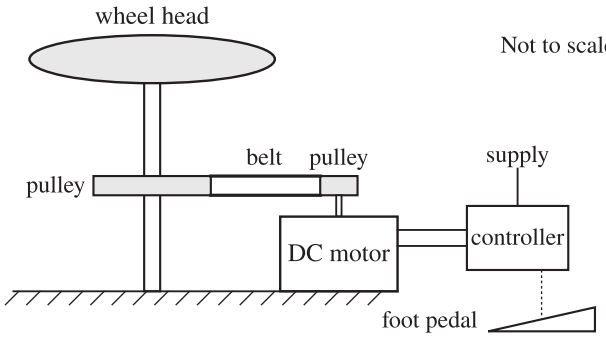
Question 27 (5 marks)

An electric potter's wheel is driven by a DC motor through a belt, as shown, and the potter controls the motor's supply voltage with a foot pedal. The motor's coil has 200 turns, each of area 2.0×10^{-3} m^2, in a radial magnetic field of 0.50 T, so the torque on it is $\tau = nIAB$ in every position. The coil's resistance is 1.2 Ω. While a pot is shaped, the potter's hands and the clay resist the rotation, so at any steady speed the motor must provide a torque of 1.5 N m. Ignore friction in the motor and belt.



(a) With the supply voltage at 48 V, the wheel turns at a steady 240 rev min^{-1}. Calculate the current in the coil and the back emf generated in it. **2**

SIMILAR
2019 Q31(b)
2020 Q32
2023 Q25(b)

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(b) The potter eases off the pedal. The supply voltage falls to 30 V and the wheel settles at a new steady speed. Explain why the current is then the same as in part (a), and calculate the new rotation rate of the wheel. (The back emf is proportional to the motor's rotation rate.) **3**

SIMILAR
2020 Q32
2021 Q21(a)
2024 Q21(b)

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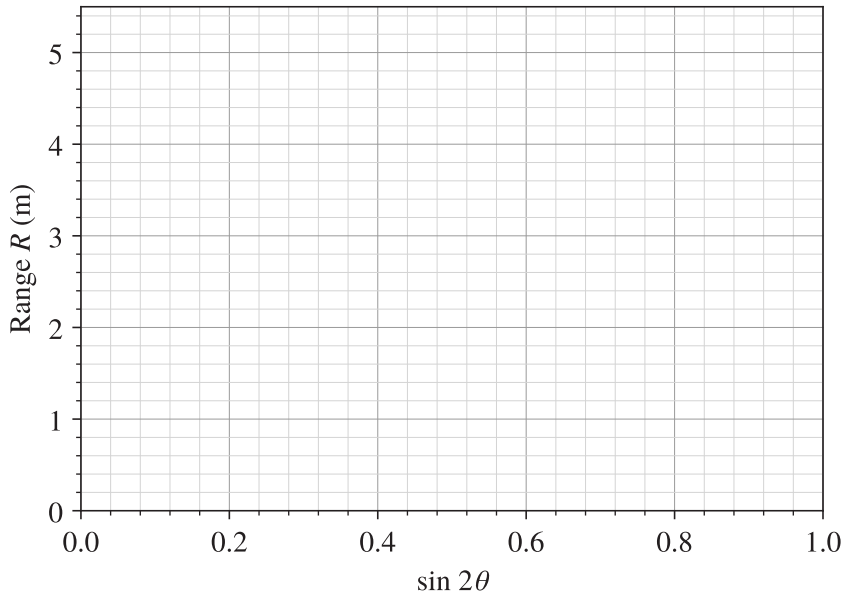
Question 28 (7 marks)

A landscaper calibrates the nozzle of a fountain by measuring the horizontal range R of the water jet on level ground for different launch angles θ. The nozzle delivers the water at the same speed u each time. Air resistance is negligible, and for a projectile that lands at its launch height, $R = (u^2/g) \sin 2\theta$.

Launch angle θ	10°	15°	20°	30°	40°
Range R (m)	1.68	2.55	3.18	4.38	4.90
$\sin 2\theta$					

(a) Complete the table, then plot R against $\sin 2\theta$ on the grid and draw a line of best fit. Use your line to show that u is approximately 7 m s^{-1}. **3**

SIMILAR
2020 Q24
2021 Q34(a)
2025 Q28



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Question 28 continues on page 22

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(b) The landscaper then sets the nozzle at $\theta = 60°$. A raised garden bed 0.80 m high has its near edge 1.5 m and its far edge 4.0 m from the nozzle, as shown. Take $u = 7.0$ m s^{-1}. Determine whether the water lands on the top of the bed.

4

SIMILAR
2021 Q34(b)
2022 Q33(b)
2025 Q28

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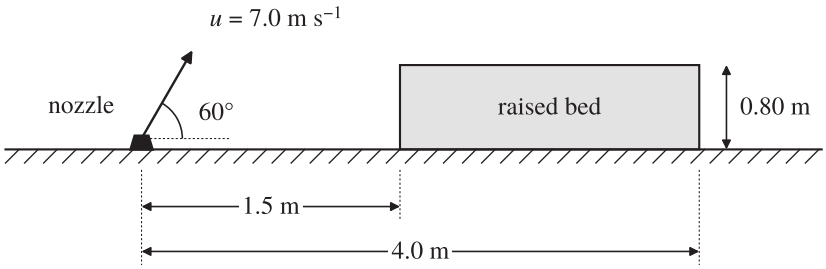

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Question 29 (6 marks)

The outer surface of a spacecraft is coated with aluminium, which has a work function of 4.1 eV. In sunlight, ultraviolet radiation ejects photoelectrons from the coating. Model this ultraviolet radiation as monochromatic, with a wavelength of 121.6 nm, and ignore any effect of the charged particles in the space around the spacecraft.

(a) Calculate the maximum kinetic energy, in electron volts, of the photoelectrons ejected from the coating. **2**

SIMILAR
2023 Q23(b)
2025 Q25(a)
2025 Q25(b)

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(b) The spacecraft is initially uncharged. Explain why its electric potential rises but then stops increasing at a maximum value. In your answer, estimate this maximum potential and explain why it would be the same if the intensity of the ultraviolet radiation were doubled. **4**

SIMILAR
2021 Q33
2022 Q26(b)
2025 Q25(b)

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Question 30 (6 marks)

The Hubble Space Telescope has detected plumes of water vapour rising about 200 km above the surface of Europa, a moon of Jupiter. Europa has a mass of 4.80×10^{22} kg and a radius of 1.561×10^{6} m. Treat Europa as a sphere with no atmosphere, and ignore the gravitational effect of Jupiter.

(a) Using conservation of energy, calculate the minimum speed at which material must leave a vent at the surface to rise 200 km vertically. **3**

SIMILAR
2022 Q25(b)
2023 Q34(b)
2024 Q31

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(b) A student instead modelled Europa's gravitational field as uniform, using the field strength at the surface, and calculated a vent speed of 725 m s^{-1}. Evaluate the validity of the student's model for this situation. **3**

SIMILAR
2021 Q27(a)
2021 Q27(b)
2022 Q35

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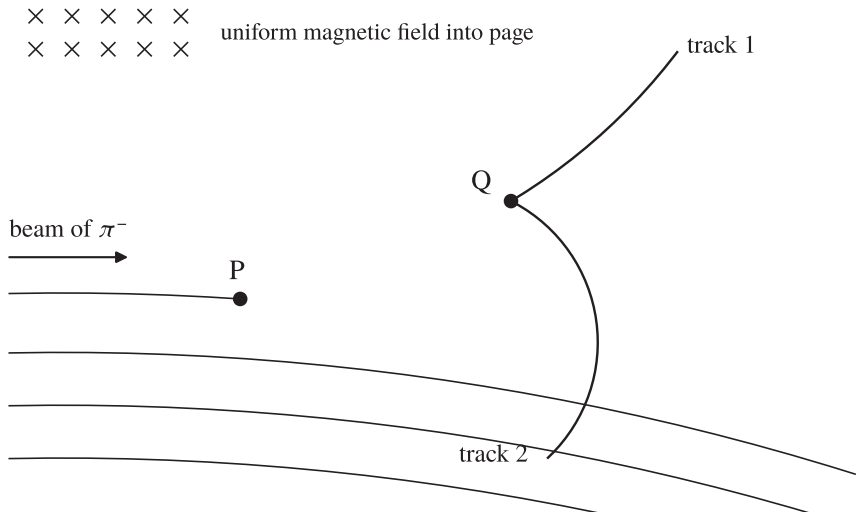
Question 31 (5 marks)

The diagram shows tracks recorded in a liquid-hydrogen bubble chamber placed in a uniform magnetic field directed into the page. Charged particles leave visible tracks of bubbles because they ionise the liquid. A beam of negative pions (π^-, quark composition $d\bar{u}$) enters from the left. At P, a pion interacts with a proton, producing a neutral lambda particle (Λ^0, quark composition uds) and other particles whose tracks are not shown. At Q the lambda decays: $\Lambda^0 \longrightarrow p + \pi^-$.



Explain the features of the tracks shown. In your answer, refer to conservation laws, the Standard Model and the motion of charged particles in magnetic fields. **5**

SIMILAR
2019 Q12
2021 Q3
2025 Q33

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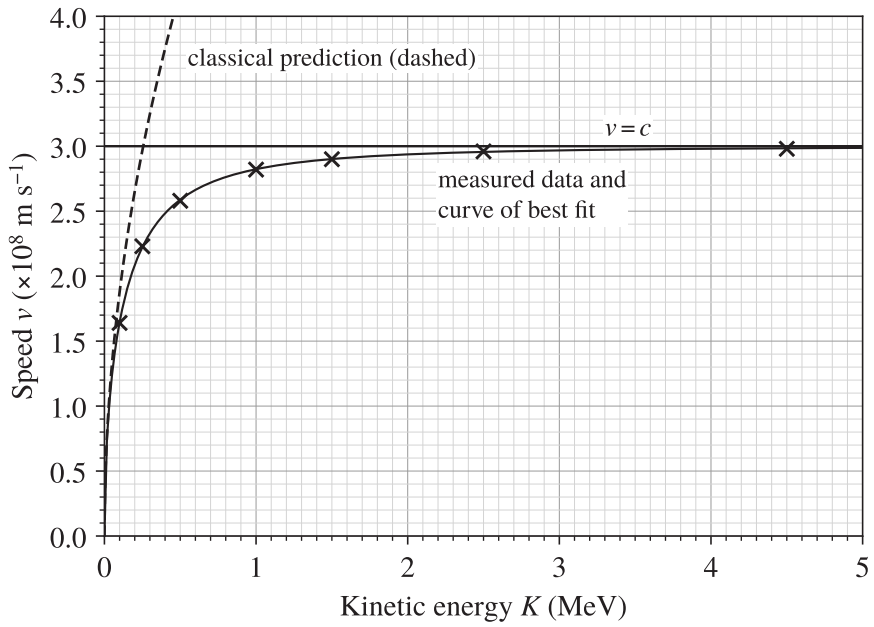
Question 32 (6 marks)

In an experiment similar to Bertozzi's (1964), electrons were accelerated to known kinetic energies K, and their speeds v were found by timing them over a measured distance. The results are shown in the table.

K (MeV)	0.10	0.25	0.50	1.0	1.5	2.5	4.5
v ($\times 10^8$ m s^{-1})	1.64	2.23	2.58	2.82	2.90	2.96	2.98

The graph shows these results with a curve of best fit. It also shows the speeds predicted by classical physics ($K = \frac{1}{2}mv^2$) as a dashed curve, and the line $v = c$.



(a) Using the graph, compare the experimental results with the predictions of classical physics. **2**

SIMILAR
2021 Q28(b)
2023 Q30(b)(ii)
2024 Q27(c)

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Question 32 continues on page 27

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(b) Using the data for $K = 1.0$ MeV, calculate the relativistic momentum of the electron. Compare it with the momentum predicted by classical physics for an electron moving at the same speed, and hence explain why the electrons cannot be accelerated to the speed of light.

4

SIMILAR
2021 Q28(b)
2024 Q27(c)
2025 Q32

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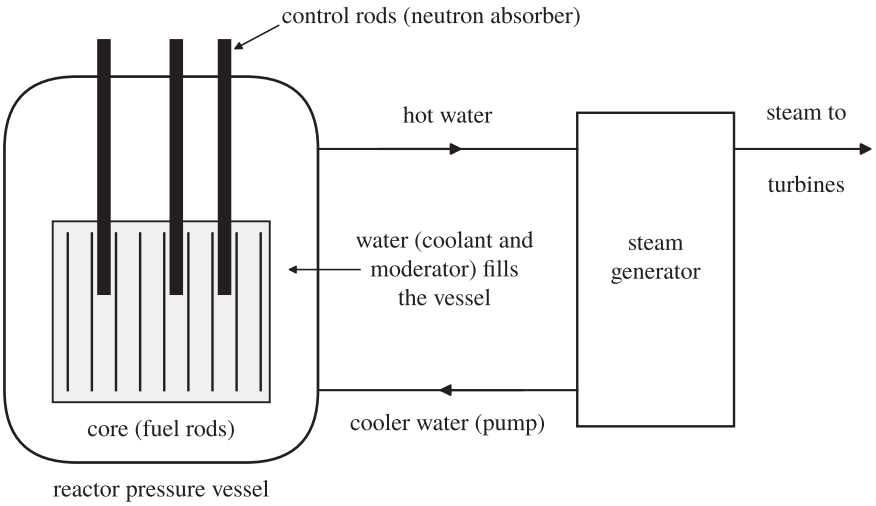
Question 33 (7 marks)

The diagram shows a simplified pressurised-water reactor of the type used to power a submarine. The core contains uranium fuel that is highly enriched in uranium-235. Water flowing through the core acts as both the coolant and the moderator; as the water becomes hotter, its density decreases. Control rods made of a neutron-absorbing material can be moved into and out of the core.



A typical fission reaction in the core is

$$^{235}\text{U} + {}^{1}\text{n} \longrightarrow {}^{141}\text{Ba} + {}^{92}\text{Kr} + 3\ {}^{1}\text{n}$$

Particle	*Mass (u)*
^{235}U	235.043930
^{141}Ba	140.914411
^{92}Kr	91.926156
^{1}n	1.008665

The reactor is designed to run for the submarine's 25-year service life without refuelling, at an average thermal power of 50 MW. Assume that every fission releases the same energy as this reaction. (1 year = 3.16×10^7 s)

Analyse how this reactor releases energy in a controlled way throughout the submarine's service life. In your answer, include a calculation of the mass of uranium-235 that undergoes fission during the 25 years.

7

SIMILAR
2019 Q36
2021 Q35(a)
2023 Q26

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Question 33 (continued)

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Question 33 (continued)

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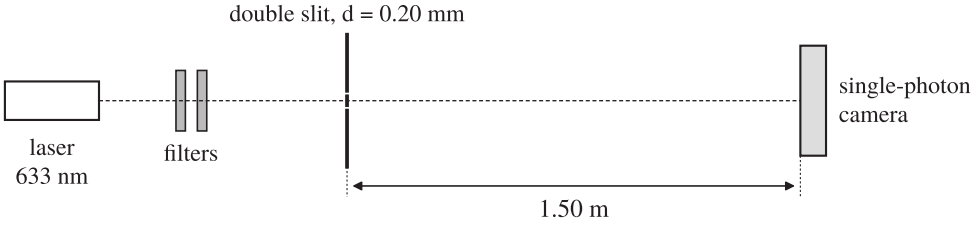
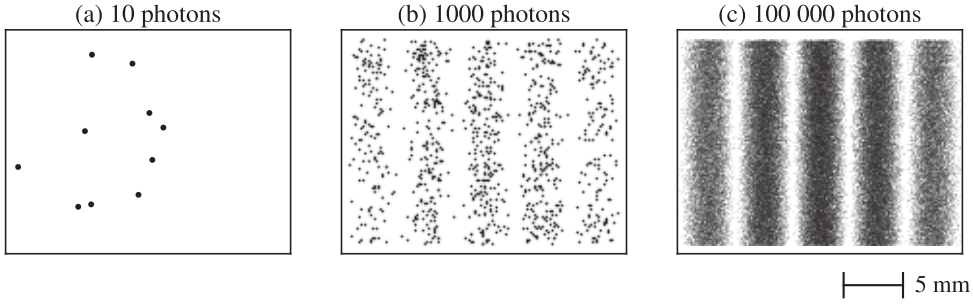
Question 34 (8 marks)

In a modern version of an experiment first carried out by G. I. Taylor in 1909, light from a laser of wavelength 633 nm is dimmed by filters so that the power reaching a double slit is only 1.0×10^{-13} W. The slits are 0.20 mm apart. A single-photon camera 1.50 m beyond the slits records the position of each photon that arrives. Images (a), (b) and (c) show the positions recorded after 10, 1000 and 100 000 photons respectively.





Analyse how these results provide evidence for both the wave model and the particle model of light. Support your answer with relevant calculations. **8**

SIMILAR
2021 Q33
2022 Q27(a)
2024 Q32

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Question 34 (continued)

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