A LEVEL · PHYSICS 9702 · FOR EXAMINATION IN 2025, 2026 AND 2027

Cambridge International AS & A Level Physics

Two practice papers, one for each half of Cambridge 9702 — AS topics 1–11 and A Level topics 12–25 — written in the format the board sets: multiple choice, structured questions, and a planning-and-analysis question of the kind Paper 5 asks and nothing else on the syllabus prepares you for.

PAPERS	QUESTIONS	TOTAL MARKS	FIGURES
2	**23**	**156**	**12**

EVERY PAPER IN THIS FILE

1 AS · Topics 1–11 — 11 questions · 74 marks · 75 minutes

Physical quantities, kinematics, dynamics, forces and pressure, work and energy, deformation of solids, waves, superposition, electricity, d.c. circuits and particle physics.

2 A Level · Topics 12–25 — 12 questions · 82 marks · 100 minutes

Circular motion and gravitational fields, temperature, ideal gases and thermodynamics, oscillations, electric fields and capacitance, magnetic fields and alternating currents, quantum and nuclear physics.

ASSESSMENT — Paper 1 is 40 multiple-choice items on AS content. Paper 2 is AS structured questions. Paper 3 is a practical exam taken in a laboratory. Paper 4 is A Level structured questions, 100 marks in two hours, and carries the largest single share of the qualification. Paper 5 is planning, analysis and evaluation — 30 marks, no recall, and the paper on which candidates most often underperform. A data sheet is provided in Papers 1, 2 and 4.

DEMAND — *Written to the real level of Paper 4, which is a hard paper. Multi-step calculations where nothing tells you which equation comes first; "show that" parts with the answer given so that partial credit depends on the working; explanations marked for the mechanism, not the name of the effect. The last question on each paper is in Paper 5's format, where the marks are for the design and the uncertainty treatment rather than for physics recall.*

> *Written by GioPhysics from the published syllabus. These are practice papers in the style of Cambridge International AS & A Level Physics 9702; they are not Cambridge papers, contain no past-paper questions, and the official syllabus and specimen materials remain the authority.*
>
> Cambridge International AS & A Level Physics 9702 syllabus — https://www.cambridgeinternational.org/Images/664565-2025-2027-syllabus.pdf

AS · Topics 1–11

Physical quantities, kinematics, dynamics, forces and pressure, work and energy, deformation of solids, waves, superposition, electricity, d.c. circuits and particle physics.

SUGGESTED TIME	TOTAL MARKS	QUESTIONS	MULTIPLE CHOICE
75 minutes	**74**	**11**	**6**

SECTION **AS · AS Level foundations**

IN THE FORMAT OF Paper 1 (multiple choice) and Paper 2 (AS structured questions), closing in the style of Paper 5

DEMAND **Recall 1 · Routine 3 · Demanding 5 · Discriminating 2**

Written to the real level of Paper 4, which is a hard paper. Multi-step calculations where nothing tells you which equation comes first; "show that" parts with the answer given so that partial credit depends on the working; explanations marked for the mechanism, not the name of the effect. The last question on each paper is in Paper 5's format, where the marks are for the design and the uncertainty treatment rather than for physics recall.

SYLLABUS POINTS 1 · 2 · 3 · 4 · 5 · 6 · 7 · 8 · 9 · 10 · 11

INSTRUCTIONS

— Answer all questions in the spaces provided.

— Show your working. Method marks are awarded even where the final answer is wrong.

— Give your answers to a sensible number of significant figures, with a unit.

— The mark scheme for this paper follows the last question.

> *Written by GioPhysics from the published syllabus. These are practice papers in the style of Cambridge International AS & A Level Physics 9702; they are not Cambridge papers, contain no past-paper questions, and the official syllabus and specimen materials remain the authority.*
>
> Cambridge International AS & A Level Physics 9702 syllabus — https://www.cambridgeinternational.org/Images/664565-2025-2027-syllabus.pdf

THE PAPER

AS · Topics 1–11

Answer all questions. 74 marks in 75 minutes.

---

1 AS

MULTIPLE CHOICE · ROUTINE · 1 **[1]**

What is the Young modulus expressed in SI base units?

A kg m s^{-2}

B kg m^{-1} s^{-2}

C kg m^{-1} s^{-1}

D kg m^{2} s^{-2}

Answer

---

2 AS

MULTIPLE CHOICE · DEMANDING · 2 **[1]**

A stone is thrown horizontally at 12 m s^{-1} from the top of a cliff 45 m high. Air resistance is negligible. How far from the base of the cliff does it land?

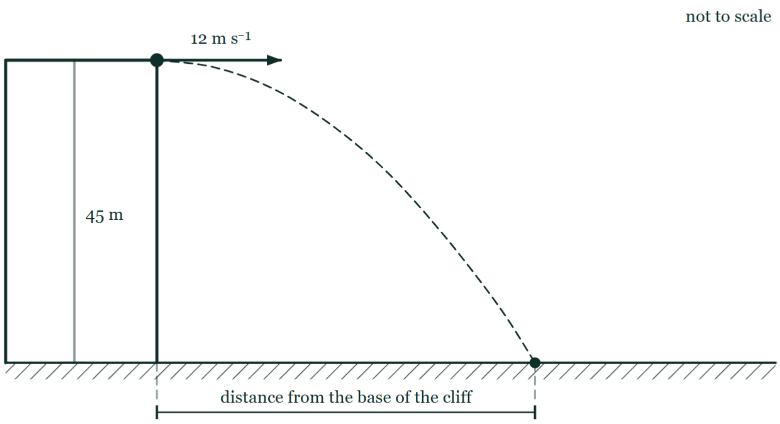

Fig. 2.1 *A cliff of height 45 m rises vertically from level ground. A stone leaves the very edge of the cliff top moving horizontally, its initial velocity shown by an arrow labelled 12 m s^{-1} pointing away from the cliff, and a dashed curve traces its path down to the ground. The height of the cliff is marked 45 m; the horizontal distance from the base of the cliff to the point where the stone lands is marked by a dimension line but is given no value. The figure is not to scale.*

A 27 m

B 36 m

C 45 m

D 110 m

Answer

---

3 AS

MULTIPLE CHOICE · DEMANDING · 3 **[1]**

A ball of mass 0.20 kg strikes a wall at right angles with a speed of 8.0 m s^{-1} and rebounds along the same line at 6.0 m s^{-1}. The ball is in contact with the wall for 0.050 s. What is the magnitude of the average force exerted on the ball?

A 8.0 N

B 24 N

C 56 N

D 112 N

Answer

---

4 AS

MULTIPLE CHOICE · ROUTINE · 8 **[1]**

A stationary wave is set up on a stretched string of length 1.2 m fixed at both ends. Four loops are seen between the fixed ends and the frequency is 150 Hz. What is the speed of the progressive waves on the string?

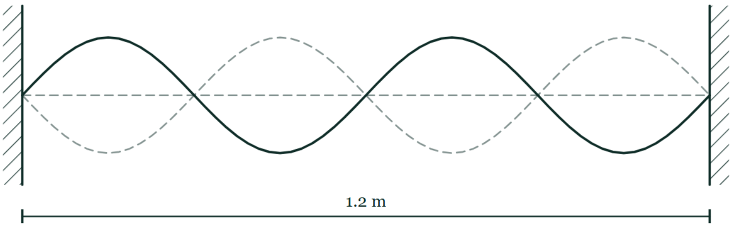

Fig. 4.1 *A string is stretched horizontally between two fixed supports drawn as hatched blocks, with the distance between them marked 1.2 m. The stationary wave on the string is drawn as a solid curve showing four loops between the supports, and the opposite extreme of the motion is drawn dashed over it, so the string is still at the two fixed ends and at three points in between while the loops vibrate.*

A 22.5 m s^{-1}

B 45 m s^{-1}

C 90 m s^{-1}

D 180 m s^{-1}

Answer

---

5 AS

MULTIPLE CHOICE · ROUTINE · 10 **[1]**

A battery of e.m.f. 9.0 V and internal resistance 1.5 Ω is connected to a resistor of resistance 6.0 Ω. What is the potential difference across the 6.0 Ω resistor?

A 1.8 V

B 6.0 V

C 7.2 V

D 9.0 V

Answer

---

6 AS

MULTIPLE CHOICE · RECALL · 11 **[1]**

Which combination of quarks forms a neutron?

A up, up, down

B up, down, down

C up, up, strange

D down, down, down

Answer

---

7 AS

STRUCTURED · DEMANDING · 2 · 3 · 4 **[14]**

A skydiver of total mass 85 kg falls from rest from a stationary balloon. The drag force F on the skydiver is related to her speed v by $F = kv^2$, where k is a constant. She reaches a terminal velocity of 55 m s^{-1} before opening her parachute.

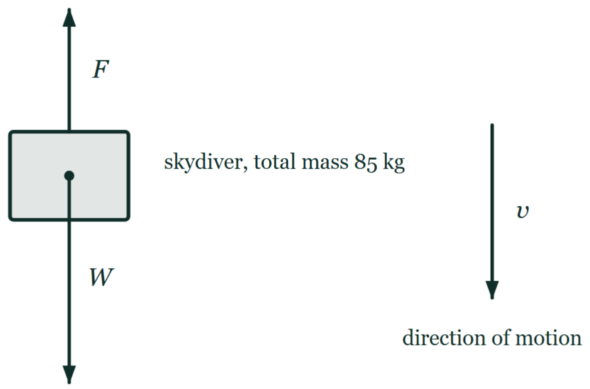

Fig. 7.1 *The falling skydiver is drawn as a block with a dot at her centre of mass, labelled as having a total mass of 85 kg. A long arrow labelled W starts at that dot and points vertically downwards. A shorter arrow labelled F starts at her upper surface and points vertically upwards. To one side, a separate arrow labelled v points downwards to show her direction of motion.*

(a) STATE **[2]**

State what is meant by terminal velocity.

(b) EXPLAIN **[3]**

Explain, with reference to Newton's laws, why the acceleration of the skydiver decreases as her speed increases.

(c) DETERMINE **[3]**

Determine the value of k, and state its SI base units.

(d) CALCULATE **[3]**

Calculate the acceleration of the skydiver at the instant when her speed is 30 m s^{-1}.

(e) EXPLAIN **[3]**

The skydiver opens her parachute while travelling at the terminal velocity of 55 m s^{-1}. Explain what happens to her motion immediately afterwards, and describe the new terminal velocity she reaches.

8 STRUCTURED · DISCRIMINATING · 5 · 6 **[13]**

AS

A vertical steel wire of original length 2.50 m and diameter 0.56 mm hangs from a fixed support. A load of 45 N is attached to its lower end. The Young modulus of steel is 2.0×10^{11} Pa and the wire does not exceed its limit of proportionality.

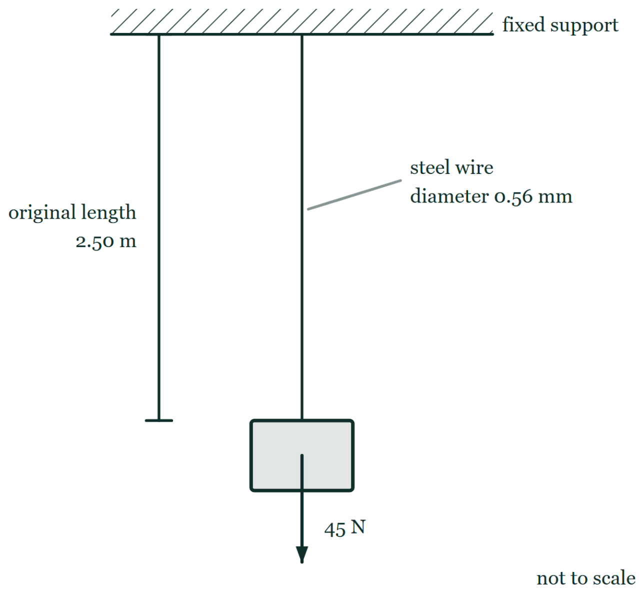

Fig. 8.1 *A steel wire hangs vertically from a rigid support drawn as a hatched ceiling, and a block is attached to its lower end. An arrow starting at the centre of that block points vertically downwards and is labelled 45 N. A dimension line to the left of the wire marks its original length as 2.50 m, and a leader line to the wire labels it as a steel wire of diameter 0.56 mm. The figure is not to scale.*

(a) DEFINE **[2]**

Define the Young modulus.

(b) CALCULATE **[4]**

Calculate the extension of the wire produced by the 45 N load.

(c) CALCULATE **[2]**

Calculate the elastic potential energy stored in the wire under this load.

(d) DETERMINE **[3]**

The diameter is measured with a micrometer as 0.56 ± 0.01 mm. Determine the percentage uncertainty this contributes to the calculated extension.

(e) EXPLAIN **[2]**

The load is increased until the wire is stretched beyond its elastic limit and then removed. Explain how the wire's behaviour differs from that described above.

---

9 AS

STRUCTURED · DEMANDING · 7 · 8 **[11]**

Coherent light of wavelength 590 nm is incident normally on a diffraction grating with 500 lines per millimetre. The diffracted light is observed on a screen a long way from the grating.

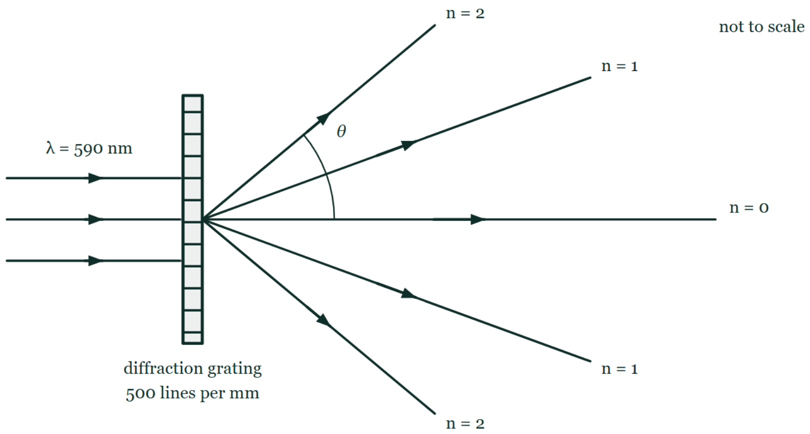

Fig. 9.1 *A parallel beam of light of wavelength 590 nm travels from the left and meets a diffraction grating at normal incidence; the grating is drawn edge-on as a narrow ruled strip and labelled 500 lines per mm. On the far side five beams spread from the grating: one continues straight through and is labelled n = 0, and above and below it lie beams labelled n = 1 and, at larger angles, n = 2. An arc marks the angle θ between the straight-through direction and the upper second-order beam. The angles drawn are not to scale.*

(a) STATE **[2]**

State what is meant by coherent.

(b) CALCULATE **[3]**

Calculate the angle between the second-order maximum and the straight-through direction.

(c) DETERMINE **[3]**

Determine the highest order of maximum that can be observed with this grating and this light.

(d) EXPLAIN **[3]**

The grating is replaced by one with 300 lines per millimetre. Explain, without calculation, how this changes the pattern observed.

---

10 AS STRUCTURED · DEMANDING · 9 · 10 **[13]**

A battery of e.m.f. 12.0 V and internal resistance r is connected in series with a variable resistor R and an ammeter of negligible resistance. When R is set to 4.0 Ω, the ammeter reads 2.0 A.

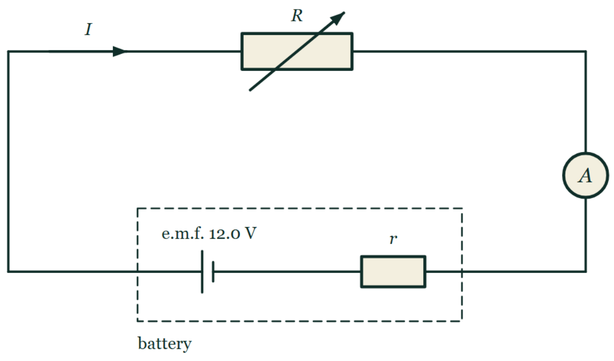

Fig. 10.1 *A single series loop. Along the bottom, a cell with its long plate on the left and a small resistor labelled r sit together inside a dashed rectangle labelled battery, the cell marked e.m.f. 12.0 V. From the dashed box the wire runs to the left, up the left-hand side and along the top through a resistor labelled R that has an arrow drawn across it to show that it is variable, then down the right-hand side through a circle marked A, and back along the bottom into the box. An arrow on the top wire labelled I shows the direction of the conventional current.*

(a) DEFINE **[2]**

Define the electromotive force of a source.

(b) DETERMINE **[3]**

Determine the internal resistance r of the battery.

(c) CALCULATE **[3]**

Calculate the ratio of the power dissipated inside the battery to the total power produced by the battery.

(d) DETERMINE **[3]**

R is now increased to 12.0 Ω. Determine the new terminal potential difference of the battery.

(e) EXPLAIN **[2]**

Explain why the terminal potential difference increased when R was increased, even though the e.m.f. of the battery did not change.

11 AS **[17]**

A student investigates how the period T of the vertical oscillations of a mass m hanging from a spring depends on m. The student suggests that T and m are related by $T = km^p$, where k and p are constants. She measures T for five values of m and calculates lg(T/s) and lg(m/kg).

The student's processed results

m / kg	0.100	0.200	0.400	0.600	0.800
T / s	0.397	0.562	0.795	0.973	1.124
lg (m / kg)	−1.000	−0.699	−0.398	−0.222	−0.097
lg (T / s)	−0.401	−0.250	−0.100	−0.012	0.051

(a) STATE **[3]**

State the independent variable, the dependent variable, and two quantities that must be kept constant in this investigation.

(b) DESCRIBE **[3]**

Describe how the student should measure T so that the uncertainty in each value is as small as possible.

(c) EXPLAIN **[4]**

Explain why a graph of lg T against lg m tests the suggested relationship, and state what the gradient and the y-intercept of that graph represent.

(d) DETERMINE **[4]**

Use the first and last data points to determine values for p and for k. Give k to two significant figures.

(e) DEDUCE **[3]**

Theory predicts $T = 2\pi\sqrt{m/k_s}$, where k_s is the spring constant. Deduce a value for k_s and comment on whether the student's results support the theory.

MARK SCHEME

AS · Topics 1–11 — mark scheme

One line per mark, as an examiner would award them. A note under a part is the error that part is set to catch.

---

1 AS

MULTIPLE CHOICE · ROUTINE · 1 **[1]**

What is the Young modulus expressed in SI base units?

KEY **B** **kg m^{-1} s^{-2}**

The Young modulus is a stress, so it has the base units of pressure. A is a force and D is an energy. C is Pa s, the unit of viscosity, and catches candidates who lose one power of time.

AO2

---

2 AS

MULTIPLE CHOICE · DEMANDING · 2 **[1]**

A stone is thrown horizontally at 12 m s^{-1} from the top of a cliff 45 m high. Air resistance is negligible. How far from the base of the cliff does it land?

KEY **B** **36 m**

D takes $t = 2h/g$ without the square root — the single commonest projectile slip. C is the height of the cliff itself, offered to candidates who lose track of which quantity they are finding. The horizontal velocity never changes, so the only work in the question is finding the time of the fall: $t = \sqrt{(2 \times 45 / 9.81)} = 3.03$ s.

AO2

---

3 AS

MULTIPLE CHOICE · DEMANDING · 3 **[1]**

A ball of mass 0.20 kg strikes a wall at right angles with a speed of 8.0 m s^{-1} and rebounds along the same line at 6.0 m s^{-1}. The ball is in contact with the wall for 0.050 s. What is the magnitude of the average force exerted on the ball?

KEY **C** **56 N**

A subtracts the speeds instead of recognising that the velocity has reversed, so the change in momentum is 0.20×14 and not 0.20×2. That one sign is the whole item, and it costs more marks across a real Paper 1 than any other single idea.

AO2

---

4 AS

MULTIPLE CHOICE · ROUTINE · 8 **[1]**

A stationary wave is set up on a stretched string of length 1.2 m fixed at both ends. Four loops are seen between the fixed ends and the frequency is 150 Hz. What is the speed of the progressive waves on the string?

KEY **C** **90 m s^{-1}**

Each loop is half a wavelength, so four loops make two wavelengths and $\lambda = 0.60$ m. D treats each loop as a whole wavelength; B and A halve again.

AO2

---

5 AS

MULTIPLE CHOICE · ROUTINE · 10 **[1]**

A battery of e.m.f. 9.0 V and internal resistance 1.5 Ω is connected to a resistor of resistance 6.0 Ω. What is the potential difference across the 6.0 Ω resistor?

KEY **C** **7.2 V**

A is the lost volts across the internal resistance. D is the answer of a candidate who treats e.m.f. and terminal p.d. as the same thing, which they are only when no current flows.

AO2

---

6 AS

MULTIPLE CHOICE · RECALL · 11 **[1]**

Which combination of quarks forms a neutron?

KEY **B** **up, down, down**

A is the proton. The check is the charge: $(+2/3) + (-1/3) + (-1/3) = 0$, and D would give -1.

AO1

---

7 AS

STRUCTURED · DEMANDING · 2 · 3 · 4 **[14]**

A skydiver of total mass 85 kg falls from rest from a stationary balloon. The drag force F on the skydiver is related to her speed v by $F = kv^2$, where k is a constant. She reaches a terminal velocity of 55 m s^{-1} before opening her parachute.

(a) STATE · AO1 **[2]**

State what is meant by terminal velocity.

1. the constant (maximum) velocity reached by a falling body
2. when the drag force has grown to equal the weight, so the resultant force and the acceleration are zero

(b) EXPLAIN · AO1 **[3]**

Explain, with reference to Newton's laws, why the acceleration of the skydiver decreases as her speed increases.

1. the weight is constant, but the drag force increases as the speed increases
2. so the resultant force, weight minus drag, decreases
3. and by Newton's second law $a = F/m$, so the acceleration decreases while the speed still increases

The mark most often lost is the last: candidates state that the acceleration falls but then say the skydiver slows down. She does not — she is still speeding up, just less quickly.

(c) DETERMINE · AO2 **[3]**

Determine the value of k, and state its SI base units.

1. at terminal velocity, $kv^2 = mg$, so $k = 85 \times 9.81 / 55^2$
2. $k = 0.276$
3. units kg m^{-1}

(d) CALCULATE · AO2 **[3]**

Calculate the acceleration of the skydiver at the instant when her speed is 30 m s^{-1}.

1. drag $F = 0.276 \times 30^2 = 248$ N
2. resultant $= 834 - 248 = 586$ N
3. $a = 586 / 85 = 6.9$ m s^{-2}

(e) EXPLAIN · AO2 **[3]**

The skydiver opens her parachute while travelling at the terminal velocity of 55 m s^{-1}. Explain what happens to her motion immediately afterwards, and describe the new terminal velocity she reaches.

1. opening the parachute increases k sharply, so at 55 m s^{-1} the drag now greatly exceeds the weight
2. the resultant force acts upwards, so she decelerates
3. the drag falls as she slows until it again equals the weight, giving a new, much lower terminal velocity

A deceleration produced by an upward resultant force, not by "the parachute pushing her up" as a separate agent. Candidates who never say the resultant force reverses direction cannot earn the second mark.

---

8 STRUCTURED · DISCRIMINATING · 5 · 6 **[13]**

AS

A vertical steel wire of original length 2.50 m and diameter 0.56 mm hangs from a fixed support. A load of 45 N is attached to its lower end. The Young modulus of steel is 2.0×10^{11} Pa and the wire does not exceed its limit of proportionality.

(a) DEFINE · AO1 **[2]**

Define the Young modulus.

1 the ratio of tensile stress to tensile strain

2 for a material obeying Hooke's law / below the limit of proportionality

(b) CALCULATE · AO2 **[4]**

Calculate the extension of the wire produced by the 45 N load.

1 $A = \pi(0.28 \times 10^{-3})^2 = 2.46 \times 10^{-7}$ m²

2 stress = F/A = 45 / 2.46×10^{-7} = 1.83×10^{8} Pa

3 strain = stress / E = 1.83×10^{8} / 2.0×10^{11} = 9.14×10^{-4}

4 e = strain × L = $9.14 \times 10^{-4} \times 2.50 = 2.3 \times 10^{-3}$ m (2.3 mm)

Halving the diameter to get the radius is worth a mark on its own, and is the step that quarters a candidate's area when they miss it.

(c) CALCULATE · AO2 **[2]**

Calculate the elastic potential energy stored in the wire under this load.

1 E = ½Fe = ½ × 45 × 2.3×10^{-3}

2 E = 0.051 J

The factor of a half is the mark. The load was not 45 N throughout the stretching — it rose from zero — so the work done is the area under the force–extension line, not Fe.

(d) DETERMINE · AO3 **[3]**

The diameter is measured with a micrometer as 0.56 ± 0.01 mm. Determine the percentage uncertainty this contributes to the calculated extension.

1 percentage uncertainty in d = (0.01 / 0.56) × 100 = 1.8%

2 e is inversely proportional to d^2, so the percentage uncertainty is doubled

3 percentage uncertainty in e = 3.6%

The discriminating part of the paper. A power in a formula multiplies the percentage uncertainty by that power; candidates who carry the 1.8% straight through have not registered that the diameter enters squared.

(e) EXPLAIN · AO1 **[2]**

The load is increased until the wire is stretched beyond its elastic limit and then removed. Explain how the wire's behaviour differs from that described above.

1 the wire no longer returns to its original length when the load is removed

2 it retains a permanent (plastic) extension, because layers of atoms have slipped past one another rather than simply being pulled further apart

9 AS

STRUCTURED · DEMANDING · 7 · 8 **[11]**

Coherent light of wavelength 590 nm is incident normally on a diffraction grating with 500 lines per millimetre. The diffracted light is observed on a screen a long way from the grating.

(a) STATE · AO1 **[2]**

State what is meant by coherent.

1 the waves have a constant phase difference

2 which requires them to have the same frequency (and, in practice, the same wavelength)

(b) CALCULATE · AO2 **[3]**

Calculate the angle between the second-order maximum and the straight-through direction.

1 $d = 1 / (500 \times 10^3) = 2.0 \times 10^{-6}$ m

2 $\sin\theta = n\lambda/d = 2 \times 590 \times 10^{-9} / 2.0 \times 10^{-6} = 0.590$

3 $\theta = 36.2°$

(c) DETERMINE · AO2 **[3]**

Determine the highest order of maximum that can be observed with this grating and this light.

1 the maximum possible value of $\sin\theta$ is 1, so $n \le d/\lambda$

2 $d/\lambda = 2.0 \times 10^{-6} / 590 \times 10^{-9} = 3.39$

3 n must be a whole number, so the highest order observed is the third

Answering 3.39 scores two of the three marks. An order is a count of whole wavelengths of path difference and cannot be fractional — the physics is in rounding down, not in the division.

(d) EXPLAIN · AO2 **[3]**

The grating is replaced by one with 300 lines per millimetre. Explain, without calculation, how this changes the pattern observed.

1 the slit separation d is larger

2 so for each order $\sin\theta = n\lambda/d$ is smaller and every maximum moves closer to the centre

3 and because d/λ is larger, more orders can be seen

10 STRUCTURED · DEMANDING · 9 · 10 **[13]**

AS

A battery of e.m.f. 12.0 V and internal resistance r is connected in series with a variable resistor R and an ammeter of negligible resistance. When R is set to 4.0 Ω, the ammeter reads 2.0 A.

(a) DEFINE · AO1 **[2]**

Define the electromotive force of a source.

1 the energy transferred from chemical (or other non-electrical) form to electrical form

2 per unit charge driven through the source

"The voltage of the battery" earns nothing. E.m.f. and potential difference are both energy per unit charge; what distinguishes them is the direction of the transfer.

(b) DETERMINE · AO2 **[3]**

Determine the internal resistance r of the battery.

1 $E = I(R + r)$, so $12.0 = 2.0 \times (4.0 + r)$

2 $4.0 + r = 6.0$

3 $r = 2.0\ \Omega$

(c) CALCULATE · AO2 **[3]**

Calculate the ratio of the power dissipated inside the battery to the total power produced by the battery.

1 power in r = $I^2r = 2.0^2 \times 2.0 = 8.0$ W

2 total power = $EI = 12.0 \times 2.0 = 24$ W

3 ratio = 8.0 / 24 = 0.33 (33%)

(d) DETERMINE · AO2 **[3]**

R is now increased to 12.0 Ω. Determine the new terminal potential difference of the battery.

1 $I = 12.0 / (12.0 + 2.0) = 0.857$ A

2 $V = IR = 0.857 \times 12.0$

3 $V = 10.3$ V

(e) EXPLAIN · AO2 **[2]**

Explain why the terminal potential difference increased when R was increased, even though the e.m.f. of the battery did not change.

1 increasing R decreases the current in the circuit

2 so the lost volts Ir across the internal resistance are smaller, and $V = E - Ir$ is closer to E

11 AS

PRACTICAL SKILLS · PLANNING, ANALYSIS AND EVALUATION – PAPER 5 STYLE · DISCRIMINATING · 1 · 5 **[17]**

A student investigates how the period T of the vertical oscillations of a mass m hanging from a spring depends on m. The student suggests that T and m are related by $T = km^p$, where k and p are constants. She measures T for five values of m and calculates lg(T/s) and lg(m/kg).

(a) STATE · AO3 **[3]**

State the independent variable, the dependent variable, and two quantities that must be kept constant in this investigation.

1. independent variable: the mass m hanging from the spring
2. dependent variable: the period T of the oscillations
3. constants: the same spring (same spring constant) and the same amplitude of oscillation — accept also the same support and no additional damping

(b) DESCRIBE · AO3 **[3]**

Describe how the student should measure T so that the uncertainty in each value is as small as possible.

1. time a number of complete oscillations — at least 10 or 20 — and divide by that number
2. start and stop the timing at the centre of the oscillation, where the mass moves fastest, using a fiducial marker
3. repeat the timing and take a mean

Timing at the centre rather than at the extremes is a real marking point on Paper 5 and comes up rarely in teaching: at the extremes the mass is momentarily at rest, so the eye cannot judge the instant.

(c) EXPLAIN · AO3 **[4]**

Explain why a graph of lg T against lg m tests the suggested relationship, and state what the gradient and the y-intercept of that graph represent.

1. taking logarithms of $T = km^p$ gives $\lg T = p \lg m + \lg k$
2. this has the form $y = mx + c$, so if the relationship holds the points lie on a straight line
3. the gradient of the line is p
4. the y-intercept is lg k, so $k = 10^{(\text{intercept})}$

(d) DETERMINE · AO2 **[4]**

Use the first and last data points to determine values for p and for k. Give k to two significant figures.

1. gradient $p = (0.051 - (-0.401)) / (-0.097 - (-1.000)) = 0.452 / 0.903$
2. $p = 0.50$
3. intercept: $\lg k = -0.401 - 0.50 \times (-1.000) = 0.099$
4. $k = 10^{0.099} = 1.3$ (accept 1.26)

(e) DEDUCE · AO3 **[3]**

Theory predicts $T = 2\pi\sqrt{m/k_s}$, where k_s is the spring constant. Deduce a value for k_s and comment on whether the student's results support the theory.

1. the theory predicts p = 0.5, which matches the gradient found, so the form of the relationship is supported
2. comparing constants, $k = 2\pi/\sqrt{k_s}$, so $k_s = (2\pi/k)^2 = (2\pi/1.26)^2$
3. $k_s = 25\ \text{N m}^{-1}$

The last question on Paper 5 almost always asks for a judgement, not just a number. A comment that names the agreement in the exponent as the reason for the conclusion earns the mark; "yes it supports it" on its own does not.

A Level · Topics 12–25

Circular motion and gravitational fields, temperature, ideal gases and thermodynamics, oscillations, electric fields and capacitance, magnetic fields and alternating currents, quantum and nuclear physics.

SUGGESTED TIME	TOTAL MARKS	QUESTIONS	MULTIPLE CHOICE
100 minutes	**82**	**12**	**6**

SECTION **A2 · A Level extension**

IN THE FORMAT OF Paper 4 (A Level structured questions), closing in the style of Paper 5

DEMAND **Recall 1 · Routine 2 · Demanding 6 · Discriminating 3**

Written to the real level of Paper 4, which is a hard paper. Multi-step calculations where nothing tells you which equation comes first; "show that" parts with the answer given so that partial credit depends on the working; explanations marked for the mechanism, not the name of the effect. The last question on each paper is in Paper 5's format, where the marks are for the design and the uncertainty treatment rather than for physics recall.

SYLLABUS POINTS 12 · 13 · 14 · 15 · 16 · 17 · 18 · 19 · 20 · 21 · 22 · 23

INSTRUCTIONS

- Answer all questions in the spaces provided.
- Show your working. Method marks are awarded even where the final answer is wrong.
- Give your answers to a sensible number of significant figures, with a unit.
- The mark scheme for this paper follows the last question.

> *Written by GioPhysics from the published syllabus. These are practice papers in the style of Cambridge International AS & A Level Physics 9702; they are not Cambridge papers, contain no past-paper questions, and the official syllabus and specimen materials remain the authority.*
>
> Cambridge International AS & A Level Physics 9702 syllabus — https://www.cambridgeinternational.org/Images/664565-2025-2027-syllabus.pdf

THE PAPER

A Level · Topics 12–25

Answer all questions. 82 marks in 100 minutes.

---

1 A LEVEL

MULTIPLE CHOICE · ROUTINE · 13 **[1]**

A satellite is in a circular orbit at a height above the Earth's surface equal to the radius R of the Earth. The gravitational field strength at the Earth's surface is g. What is the acceleration of the satellite?

A g

B g/2

C g/4

D g/8

Answer

---

2 A LEVEL

MULTIPLE CHOICE · DEMANDING · 15 **[1]**

An ideal gas is at a thermodynamic temperature of 300 K. To what temperature must it be raised to double the root-mean-square speed of its molecules?

A 424 K

B 600 K

C 1200 K

D 2400 K

Answer

---

3 A LEVEL

MULTIPLE CHOICE · ROUTINE · 17 **[1]**

A body moves with simple harmonic motion of amplitude 2.0 cm and frequency 5.0 Hz. What is the magnitude of its maximum acceleration?

A 0.63 m s^{-2}

B 3.1 m s^{-2}

C 20 m s^{-2}

D 200 m s^{-2}

Answer

---

4 MULTIPLE CHOICE · DEMANDING · 19 **[1]**

A LEVEL

A capacitor of capacitance 470 μF, charged to a potential difference V_0, is discharged through a resistor of resistance 22 kΩ. After what time has the charge on the capacitor fallen to 25% of its initial value?

A 3.6 s

B 7.2 s

C 14 s

D 21 s

Answer

---

5 MULTIPLE CHOICE · RECALL · 20 **[1]**

A LEVEL

An electron enters a uniform magnetic field with its velocity perpendicular to the field. What is its subsequent path within the field?

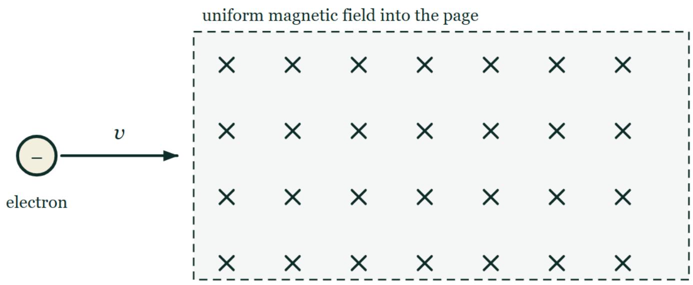

Fig. 5.1 *An electron, drawn as a small circle marked with a negative sign, travels horizontally to the right, and an arrow labelled v gives its velocity. Ahead of it lies a large rectangular region with a dashed boundary, filled with a regular array of crosses and labelled as a uniform magnetic field directed into the page. The electron is shown outside that region, at the instant before it crosses the boundary, with its velocity lying in the plane of the page.*

A a straight line at constant speed

B a straight line with increasing speed

C a circular arc at constant speed

D a parabolic arc with increasing speed

Answer

---

6 A LEVEL

MULTIPLE CHOICE · DEMANDING · 22 **[1]**

Light of wavelength 450 nm is incident on a metal surface of work function 2.0 eV. What is the maximum kinetic energy of the emitted photoelectrons?

A 0.76 eV

B 2.0 eV

C 2.8 eV

D 4.8 eV

Answer

---

7 A LEVEL

STRUCTURED · DISCRIMINATING · 12 · 13 **[12]**

A satellite is in a circular geostationary orbit about the Earth. The product GM for the Earth is 3.99×10^{14} m^3 s^{-2}, and one day may be taken as 24 hours.

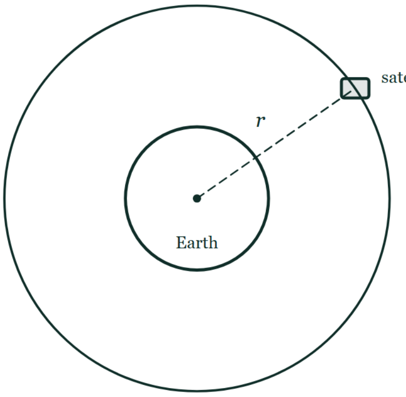

Fig. 7.1 *The Earth is drawn as a circle, labelled, with a dot marking its centre. A second, larger circle drawn concentric with it is the satellite's circular orbit. The satellite itself is a small block sitting on that larger circle, above and to the right of the Earth, and a dashed straight line runs from the dot at the centre of the Earth out to the satellite, labelled r. The figure is marked not to scale.*

(a) EXPLAIN **[3]**

Explain what is meant by a geostationary orbit.

(b) SHOW (THAT) **[4]**

The gravitational force provides the centripetal force. Show that the radius of a geostationary orbit is approximately 4.2×10^7 m.

(c) CALCULATE **[2]**

Calculate the linear speed of the satellite in this orbit.

(d) EXPLAIN **[3]**

A student suggests placing a geostationary satellite in orbit above London. Explain why this is not possible.

8 STRUCTURED · DEMANDING · 15 · 16 **[12]**

A LEVEL

A sealed cylinder contains an ideal gas of volume 2.0×10^{-3} m^3 at a pressure of 1.5×10^5 Pa and a temperature of 290 K. The Boltzmann constant is 1.38×10^{-23} J K^{-1}.

(a) CALCULATE **[3]**

Calculate the number of molecules of gas in the cylinder.

(b) DETERMINE **[3]**

Determine the total kinetic energy of the molecules in the cylinder.

(c) DEDUCE **[4]**

The gas is now compressed slowly at a constant temperature of 290 K. During the compression, 120 J of work is done on the gas. Deduce the change in internal energy of the gas and the thermal energy transferred to or from it.

(d) EXPLAIN **[2]**

Explain why the internal energy of an ideal gas depends only on its temperature, whereas that of a real gas does not.

9 STRUCTURED · DEMANDING · 17 [12]

A LEVEL

A mass suspended from a spring oscillates vertically with simple harmonic motion of amplitude 4.0 cm and period 0.80 s.

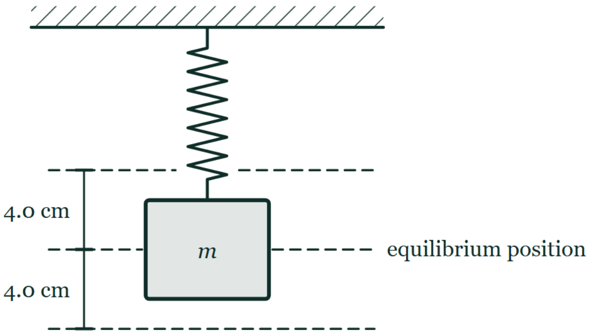

Fig. 9.1 *A spring hangs vertically from a rigid horizontal support drawn with hatching above it, and a block labelled m is attached to the lower end of the spring. A dashed horizontal line level with the centre of the block is labelled equilibrium position. Two further dashed horizontal lines, one above it and one below it, mark the highest and lowest positions the block reaches, and the distance from the equilibrium line to each of them is marked 4.0 cm.*

(a) DEFINE [2]

Define simple harmonic motion.

(b) CALCULATE [3]

Calculate the maximum speed of the mass.

(c) CALCULATE [3]

Calculate the speed of the mass when its displacement from the equilibrium position is 2.0 cm.

(d) EXPLAIN **[4]**

The mass is now made to oscillate by a driver whose frequency can be varied, and the system is lightly damped. Describe how the amplitude of the oscillations varies with the driving frequency, and explain what happens to the response curve if the damping is increased.

10 STRUCTURED · DEMANDING · 18 · 19 · 20 **[11]**

A LEVEL

Two large parallel metal plates are 5.0 mm apart in a vacuum. A potential difference of 2.0 kV is maintained between them. A separate circuit contains a capacitor of capacitance 22 μF charged to a potential difference of 12 V.

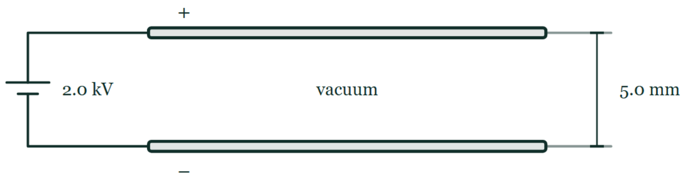

Fig. 10.1 *Two long horizontal metal plates are drawn one directly above the other and connected by wires at their left-hand ends to a battery labelled 2.0 kV; the upper plate carries a plus sign and the lower plate a minus sign. The space between the plates is empty and labelled vacuum, and a dimension at the right-hand end gives the separation of the plates as 5.0 mm. No field lines are drawn between the plates.*

(a) CALCULATE **[2]**

Calculate the magnitude of the electric field strength between the parallel plates.

(b) EXPLAIN **[3]**

Compare the field between the parallel plates with the field around an isolated point charge, and explain the difference in how each varies with position.

(c) CALCULATE **[2]**

Calculate the energy stored in the 22 μF capacitor.

(d) DETERMINE **[4]**

The charged capacitor is discharged through a 150 kΩ resistor. Determine the time taken for the potential difference across it to fall to 3.0 V.

11 A LEVEL

STRUCTURED · DISCRIMINATING · 22 · 23 **[14]**

Electrons are accelerated from rest through a potential difference of 250 V. Separately, a nucleus of $^{56}_{26}Fe$ has a nuclear mass of 55.9206 u. The mass of a proton is 1.00728 u, the mass of a neutron is 1.00867 u, and 1 u is equivalent to 931.5 MeV.

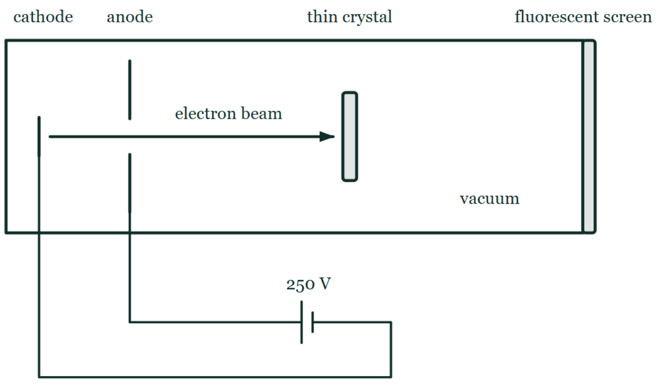

Fig. 11.1 *An evacuated tube is drawn as a long horizontal rectangle, closed at its right-hand end by a bar labelled fluorescent screen. Near the left-hand end is a short vertical cathode, and beyond it a vertical anode plate with a gap at its centre; leads from both pass out of the tube to a cell labelled 250 V, whose positive terminal is joined to the anode. An arrow along the axis shows a beam of electrons passing through the gap in the anode and travelling to a thin crystal mounted upright across the middle of the tube. The screen is drawn blank.*

(a) CALCULATE **[4]**

Calculate the de Broglie wavelength of the accelerated electrons.

(b) EXPLAIN **[3]**

Explain how the diffraction of a beam of such electrons by a thin crystal provides evidence for the wave nature of matter.

(c) DETERMINE **[4]**

Determine the binding energy per nucleon of $^{56}_{26}Fe$, in MeV.

(d) EXPLAIN **[3]**

Iron-56 lies near the peak of the binding energy per nucleon curve. Explain why energy is released both when light nuclei fuse and when heavy nuclei undergo fission.

---

12 DATA ANALYSIS · ANALYSIS, CONCLUSIONS AND EVALUATION — PAPER 5 STYLE · DISCRIMINATING · 19 · 23 **[15]**

A LEVEL

A student investigates the discharge of a capacitor of capacitance C through a resistor of resistance R = 100 kΩ. The potential difference V across the capacitor is recorded at intervals, and ln(V/V) is calculated. The student expects $V = V_0e^{(-t/RC)}$.

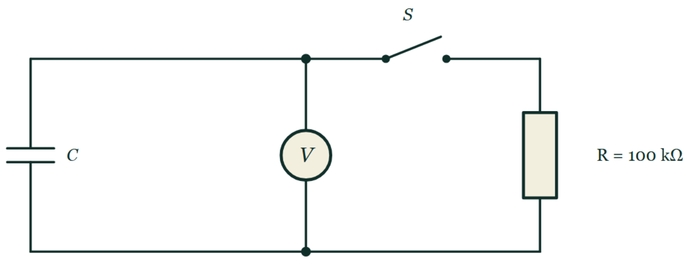

Fig. 12.1 *A circuit with three branches between an upper and a lower horizontal wire. On the left is a capacitor labelled C; in the middle is a voltmeter connected permanently across it, with junction dots where its branch joins each of the two wires; on the right is a resistor labelled R = 100 kΩ. An open switch S lies in the upper wire between the voltmeter branch and the resistor branch, so that closing it connects the resistor across the capacitor.*

The student's processed results

t / s	0.0	10.0	20.0	30.0	40.0
V / V	9.00	6.05	4.07	2.73	1.84
ln (V / V)	2.197	1.800	1.404	1.004	0.610

(a) EXPLAIN **[4]**

Explain why a graph of ln V against t should be a straight line if the discharge is exponential, and state what its gradient and intercept represent.

(b) DETERMINE **[4]**

Use the first and last data points to determine the gradient of the line, and hence determine the capacitance C.

(c) DETERMINE **[4]**

The resistance is quoted as 100 ± 2 kΩ, and the uncertainty in the gradient is ±1.5%. Determine the percentage uncertainty in C, and state the value of C with its absolute uncertainty.

(d) SUGGEST **[3]**

The voltmeter used has a finite resistance connected across the capacitor throughout the experiment. Suggest how this affects the value obtained for C, and suggest an improvement.

MARK SCHEME

A Level · Topics 12–25 — mark scheme

One line per mark, as an examiner would award them. A note under a part is the error that part is set to catch.

1 A LEVEL

MULTIPLE CHOICE · ROUTINE · 13 **[1]**

A satellite is in a circular orbit at a height above the Earth's surface equal to the radius R of the Earth. The gravitational field strength at the Earth's surface is g. What is the acceleration of the satellite?

KEY **C** **g/4**

B halves rather than squaring — the error of a candidate who remembers that the distance has doubled but not that the field follows an inverse square law. The distance from the centre, not from the surface, is what enters the law, and it has gone from R to 2R.

AO2

---

2 A LEVEL

MULTIPLE CHOICE · DEMANDING · 15 **[1]**

An ideal gas is at a thermodynamic temperature of 300 K. To what temperature must it be raised to double the root-mean-square speed of its molecules?

KEY **C** **1200 K**

B doubles the temperature, which doubles the mean kinetic energy but multiplies the r.m.s. speed by only $\sqrt{2}$ — and A is that $\sqrt{2}$ factor applied to the temperature instead. Since $\frac{1}{2}m\langle c^2\rangle \propto T$, the speed goes as $\sqrt{T}$, so doubling the speed needs four times the temperature.

AO2

---

3 A LEVEL

MULTIPLE CHOICE · ROUTINE · 17 **[1]**

A body moves with simple harmonic motion of amplitude 2.0 cm and frequency 5.0 Hz. What is the magnitude of its maximum acceleration?

KEY **C** **20 m s^{-2}**

B uses f rather than $\omega = 2\pi f$, which loses a factor of $(2\pi)^2 \approx 39$. The amplitude must also be converted to metres; leaving it in centimetres gives D.

AO2

---

4 A LEVEL

MULTIPLE CHOICE · DEMANDING · 19 **[1]**

A capacitor of capacitance 470 μF, charged to a potential difference V_0, is discharged through a resistor of resistance 22 kΩ. After what time has the charge on the capacitor fallen to 25% of its initial value?

KEY **C** **14 s**

D is two time constants, which is the answer of a candidate who assumes the charge falls to $1/e^2$ rather than to a quarter. The time constant is 10.3 s and $t = RC \ln 4 = 14.3$ s.

AO2

---

5 A LEVEL

MULTIPLE CHOICE · RECALL · 20 **[1]**

An electron enters a uniform magnetic field with its velocity perpendicular to the field. What is its subsequent path within the field?

KEY **C** **a circular arc at constant speed**

D is the path in a uniform electric field, and is the answer of a candidate who has not separated the two cases. The magnetic force is always perpendicular to the velocity, so it does no work: the speed cannot change, only the direction.

AO1

---

6 A LEVEL

MULTIPLE CHOICE · DEMANDING · 22 **[1]**

Light of wavelength 450 nm is incident on a metal surface of work function 2.0 eV. What is the maximum kinetic energy of the emitted photoelectrons?

KEY **A** **0.76 eV**

C is the photon energy itself, hc/λ = 2.76 eV, offered to candidates who stop before subtracting the work function. D adds the work function instead of subtracting it.

AO2

---

7 A LEVEL

STRUCTURED · DISCRIMINATING · 12 · 13 **[12]**

A satellite is in a circular geostationary orbit about the Earth. The product GM for the Earth is 3.99×10^{14} $m^3\ s^{-2}$, and one day may be taken as 24 hours.

(a) EXPLAIN · AO1 **[3]**

Explain what is meant by a geostationary orbit.

1. the satellite has a period of 24 hours, equal to the Earth's period of rotation
2. it orbits in the same direction as the Earth's rotation, in the plane of the equator
3. so it remains vertically above the same point on the Earth's surface

All three conditions are required, and the equatorial plane is the one candidates omit. An orbit of 24-hour period inclined to the equator does not stay above one point.

(b) SHOW (THAT) · AO2 **[4]**

The gravitational force provides the centripetal force. Show that the radius of a geostationary orbit is approximately 4.2×10^7 m.

1. $GMm/r^2 = mr\omega^2$, so $GM = r^3\omega^2$
2. $\omega = 2\pi/T = 2\pi/86400 = 7.27 \times 10^{-5}$ rad s^{-1}
3. $r^3 = GM/\omega^2 = 3.99 \times 10^{14} / (7.27 \times 10^{-5})^2 = 7.55 \times 10^{22}$
4. $r = 4.2 \times 10^7$ m

A "show that" with the answer printed: every line of the working has to be there, because a candidate who writes only the final number earns one mark at most.

(c) CALCULATE · AO2 **[2]**

Calculate the linear speed of the satellite in this orbit.

1. $v = 2\pi r/T = 2\pi \times 4.2 \times 10^7 / 86400$
2. $v = 3.1 \times 10^3$ m s^{-1}

(d) EXPLAIN · AO2 **[3]**

A student suggests placing a geostationary satellite in orbit above London. Explain why this is not possible.

1. the centre of a circular orbit must be at the centre of the Earth, because that is where the gravitational force is directed
2. an orbit whose plane passes above London at a fixed latitude would have its centre away from the Earth's centre
3. so the satellite would have to be held up by some force other than gravity, which there is none to provide

The hardest three marks on the paper, and worth setting: the geometry of the orbit follows from the direction of the force, which is a point candidates rarely have to use explicitly.

---

8 STRUCTURED · DEMANDING · 15 · 16 [12]

A LEVEL

A sealed cylinder contains an ideal gas of volume 2.0×10^{-3} m³ at a pressure of 1.5×10^5 Pa and a temperature of 290 K. The Boltzmann constant is 1.38×10^{-23} J K⁻¹.

(a) CALCULATE · AO2 **[3]**

Calculate the number of molecules of gas in the cylinder.

1 $pV = NkT$

2 $N = pV/kT = (1.5 \times 10^5 \times 2.0 \times 10^{-3}) / (1.38 \times 10^{-23} \times 290)$

3 $N = 7.5 \times 10^{22}$

(b) DETERMINE · AO2 **[3]**

Determine the total kinetic energy of the molecules in the cylinder.

1 mean kinetic energy per molecule = $(3/2)kT = 1.5 \times 1.38 \times 10^{-23} \times 290 = 6.0 \times 10^{-21}$ J

2 total = $N \times 6.0 \times 10^{-21}$

3 total = 4.5×10^2 J (450 J)

Also obtainable as (3/2)pV, and a candidate who spots that earns full marks in one line.

(c) DEDUCE · AO2 **[4]**

The gas is now compressed slowly at a constant temperature of 290 K. During the compression, 120 J of work is done on the gas. Deduce the change in internal energy of the gas and the thermal energy transferred to or from it.

1 the temperature is unchanged, so the mean kinetic energy per molecule is unchanged

2 the internal energy of an ideal gas is entirely kinetic, so $\Delta U = 0$

3 first law: $\Delta U = q + w$, so $0 = q + 120$

4 $q = -120$ J: 120 J of thermal energy is transferred out of the gas to the surroundings

(d) EXPLAIN · AO1 **[2]**

Explain why the internal energy of an ideal gas depends only on its temperature, whereas that of a real gas does not.

1 an ideal gas is defined to have no forces between its molecules except during collisions, so there is no potential energy contribution and the internal energy is the total random kinetic energy alone

2 a real gas has intermolecular forces, so its internal energy also includes potential energy, which depends on the separation of the molecules and hence on the volume

9 STRUCTURED · DEMANDING · 17 **[12]**

A LEVEL

A mass suspended from a spring oscillates vertically with simple harmonic motion of amplitude 4.0 cm and period 0.80 s.

(a) DEFINE · AO1 **[2]**

Define simple harmonic motion.

1 motion in which the acceleration is proportional to the displacement from a fixed point

2 and is always directed towards that point (opposite in direction to the displacement)

(b) CALCULATE · AO2 **[3]**

Calculate the maximum speed of the mass.

1 $\omega = 2\pi/T = 2\pi/0.80 = 7.85$ rad s^{-1}

2 $v_{max} = \omega x_0 = 7.85 \times 0.040$

3 $v_{max} = 0.31$ m s^{-1}

(c) CALCULATE · AO2 **[3]**

Calculate the speed of the mass when its displacement from the equilibrium position is 2.0 cm.

1 $v = \omega\sqrt{(x_0^2 - x^2)}$

2 $v = 7.85 \times \sqrt{(0.040^2 - 0.020^2)} = 7.85 \times 0.0346$

3 $v = 0.27$ m s^{-1}

(d) EXPLAIN · AO2 **[4]**

The mass is now made to oscillate by a driver whose frequency can be varied, and the system is lightly damped. Describe how the amplitude of the oscillations varies with the driving frequency, and explain what happens to the response curve if the damping is increased.

1 the amplitude is small at low driving frequencies, rises to a sharp maximum when the driving frequency equals the natural frequency of the system, then falls again

2 this maximum is resonance, and at it the driver transfers energy to the system most efficiently

3 increasing the damping lowers the peak amplitude and makes the peak broader (flatter)

4 and the peak occurs at a slightly lower frequency than the undamped natural frequency

The shift of the peak to a lower frequency is the fourth mark and is regularly omitted from teaching. The first three are available to any candidate who has drawn the curve.

10 A LEVEL

STRUCTURED · DEMANDING · 18 · 19 · 20 **[11]**

Two large parallel metal plates are 5.0 mm apart in a vacuum. A potential difference of 2.0 kV is maintained between them. A separate circuit contains a capacitor of capacitance 22 μF charged to a potential difference of 12 V.

(a) CALCULATE · AO2 **[2]**

Calculate the magnitude of the electric field strength between the parallel plates.

1. $E = V/d = 2000 / 5.0 \times 10^{-3}$
2. $E = 4.0 \times 10^{5}$ V m^{-1}

(b) EXPLAIN · AO1 **[3]**

Compare the field between the parallel plates with the field around an isolated point charge, and explain the difference in how each varies with position.

1. the field between the plates is uniform — the field lines are parallel and equally spaced, so E has the same magnitude and direction everywhere between them
2. the field of a point charge is radial, with lines spreading out from the charge
3. so the point-charge field falls off as $1/r^2$, while the field between the plates does not vary with position at all

(c) CALCULATE · AO2 **[2]**

Calculate the energy stored in the 22 μF capacitor.

1. $W = ½CV^2 = ½ \times 22 \times 10^{-6} \times 12^2$
2. $W = 1.6 \times 10^{-3}$ J

(d) DETERMINE · AO2 **[4]**

The charged capacitor is discharged through a 150 kΩ resistor. Determine the time taken for the potential difference across it to fall to 3.0 V.

1. time constant $RC = 150 \times 10^{3} \times 22 \times 10^{-6} = 3.3$ s
2. $V = V_0e$^$(-t/RC)$, so $3.0 = 12e$^$(-t/3.3)$
3. $t = RC \ln(V_0/V) = 3.3 \times \ln 4$
4. $t = 4.6$ s

11 STRUCTURED · DISCRIMINATING · 22 · 23 **[14]**

A LEVEL

Electrons are accelerated from rest through a potential difference of 250 V. Separately, a nucleus of $^{56}_{26}Fe$ has a nuclear mass of 55.9206 u. The mass of a proton is 1.00728 u, the mass of a neutron is 1.00867 u, and 1 u is equivalent to 931.5 MeV.

(a) CALCULATE · AO2 **[4]**

Calculate the de Broglie wavelength of the accelerated electrons.

1 kinetic energy = eV = $1.60 \times 10^{-19} \times 250 = 4.0 \times 10^{-17}$ J

2 $p = \sqrt{2mE_k} = \sqrt{2 \times 9.11 \times 10^{-31} \times 4.0 \times 10^{-17}}$

3 $p = 8.5 \times 10^{-24}$ kg m s^{-1}

4 $\lambda = h/p = 6.63 \times 10^{-34} / 8.5 \times 10^{-24} = 7.8 \times 10^{-11}$ m

Candidates who find the speed first and then use $\lambda = h/mv$ reach the same answer and earn the same marks. Those who set $eV = hc/\lambda$ have used the photon relation on a particle with mass and earn nothing.

(b) EXPLAIN · AO1 **[3]**

Explain how the diffraction of a beam of such electrons by a thin crystal provides evidence for the wave nature of matter.

1 the beam produces a pattern of rings or maxima and minima rather than a single spot

2 diffraction and interference are effects that only waves show

3 the spacing of the pattern agrees with the de Broglie wavelength calculated from the electrons' momentum, so the wavelength is a property of the particles themselves

(c) DETERMINE · AO2 **[4]**

Determine the binding energy per nucleon of $^{56}_{26}Fe$, in MeV.

1 total mass of separate nucleons = $26 \times 1.00728 + 30 \times 1.00867 = 56.4494$ u

2 mass defect $\Delta m = 56.4494 - 55.9206 = 0.5288$ u

3 binding energy = $0.5288 \times 931.5 = 492.6$ MeV

4 per nucleon = $492.6 / 56 = 8.8$ MeV

(d) EXPLAIN · AO2 **[3]**

Iron-56 lies near the peak of the binding energy per nucleon curve. Explain why energy is released both when light nuclei fuse and when heavy nuclei undergo fission.

1 energy is released whenever the products have a greater binding energy per nucleon than the reactants, because the nucleons end up more tightly bound and the surplus mass is released as energy

2 light nuclei lie to the left of the peak, so fusing them moves the nucleons up the curve towards iron

3 heavy nuclei lie to the right of the peak, so splitting them also moves the nucleons up the curve towards iron

The argument has to run through the same curve twice, in opposite directions. Answers that treat fusion and fission as unrelated processes with separate explanations do not earn the third mark.

12

A LEVEL

DATA ANALYSIS · ANALYSIS, CONCLUSIONS AND EVALUATION — PAPER 5 STYLE · DISCRIMINATING · 19 · 23 **[15]**

A student investigates the discharge of a capacitor of capacitance C through a resistor of resistance R = 100 kΩ. The potential difference V across the capacitor is recorded at intervals, and ln(V/V) is calculated. The student expects $V = V_0e^{(-t/RC)}$.

(a) EXPLAIN · AO3 **[4]**

Explain why a graph of ln V against t should be a straight line if the discharge is exponential, and state what its gradient and intercept represent.

1. taking natural logarithms of $V = V_0e^{(-t/RC)}$ gives $\ln V = \ln V_0 - t/(RC)$
2. this is of the form y = mx + c with ln V as y and t as x, so the points lie on a straight line if the model holds
3. the gradient is $-1/(RC)$
4. the intercept on the ln V axis is $\ln V_0$

(b) DETERMINE · AO2 **[4]**

Use the first and last data points to determine the gradient of the line, and hence determine the capacitance C.

1. gradient = (0.610 − 2.197) / (40.0 − 0.0) = −1.587 / 40.0
2. gradient = $-0.0397\ s^{-1}$
3. RC = −1/gradient = 25.2 s
4. $C = 25.2 / 100 \times 10^3 = 2.5 \times 10^{-4}$ F (250 μF)

(c) DETERMINE · AO3 **[4]**

The resistance is quoted as 100 ± 2 kΩ, and the uncertainty in the gradient is ±1.5%. Determine the percentage uncertainty in C, and state the value of C with its absolute uncertainty.

1. percentage uncertainty in R = (2/100) × 100 = 2%
2. C is found by dividing by the gradient and by R, so the percentage uncertainties add: 1.5% + 2% = 3.5%
3. absolute uncertainty = 0.035 × 250 = 8.75 ≈ 9 μF
4. C = 250 ± 9 μF

Percentage uncertainties add for a product or a quotient, whichever way round the quantities appear. Candidates who subtract because one quantity is in a denominator lose all four marks, and it is a common enough error that Paper 5 sets it deliberately.

(d) SUGGEST · AO3 **[3]**

The voltmeter used has a finite resistance connected across the capacitor throughout the experiment. Suggest how this affects the value obtained for C, and suggest an improvement.

1. the voltmeter provides a second discharge path in parallel with R, so the effective resistance is less than 100 kΩ
2. the capacitor therefore discharges faster than the model assumes; the measured time constant is too small, and since C is calculated using R = 100 kΩ, the value obtained for C is too small
3. improvement: use a voltmeter (or digital multimeter) of much higher resistance, or a data logger with a high-impedance input

Naming the direction of the systematic error is where the marks are. This is the standard Paper 5 evaluation question and it rewards a candidate who traces the fault all the way through to the final quantity.

THE CHEAPEST MARKS ON ANY PAPER

What the command words are asking for

Every board publishes these and marks to them. A candidate who explains where the question said state has spent four minutes earning one mark; one who states where it said explain has earned none.

Calculate	Work out from given facts, figures or information.
Deduce	Conclude from available information.
Define	Give the precise meaning.
Describe	State the points of a topic; give characteristics and main features.
Determine	Establish an answer using the information available.
Explain	Set out purposes or reasons; make relationships evident; give why and/or how.
Show (that)	Provide structured evidence that leads to a given result.
State	Express in clear terms.
Suggest	Apply knowledge and understanding to situations where there is a range of valid responses in order to make proposals.

WHAT IS BEING TESTED

A Level assessment objectives

Paper 1 is 40 multiple-choice items on AS content. Paper 2 is AS structured questions. Paper 3 is a practical exam taken in a laboratory. Paper 4 is A Level structured questions, 100 marks in two hours, and carries the largest single share of the qualification. Paper 5 is planning, analysis and evaluation — 30 marks, no recall, and the paper on which candidates most often underperform. A data sheet is provided in Papers 1, 2 and 4.

AO1 28 MARKS · 18%	**Knowledge with understanding** Recall and use scientific ideas, terminology, conventions, instruments and apparatus.
AO2 101 MARKS · 65%	**Handling, applying and evaluating information** Select and translate information, manipulate numerical data, solve problems, make predictions and reasoned judgements, and apply physics to unfamiliar contexts.
AO3 27 MARKS · 17%	**Experimental skills and investigations** Plan an investigation, identify and control variables, analyse and evaluate data and methods, handle uncertainties, and draw conclusions.

> *Written by GioPhysics from the published syllabus. These are practice papers in the style of Cambridge International AS & A Level Physics 9702; they are not Cambridge papers, contain no past-paper questions, and the official syllabus and specimen materials remain the authority.*
>
> Cambridge International AS & A Level Physics 9702 syllabus — https://www.cambridgeinternational.org/Images/664565-2025-2027-syllabus.pdf