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Suggested mark scheme

Physics 9702/21 | May/June 2026

Paper 2: AS Level Structured Questions | Total: 60 marks

DISCLAIMER

This AI-assisted document contains independently written suggested answers and marking guidance. It is **not an official Cambridge mark scheme** and has not been issued, approved, endorsed or verified by Cambridge International or Cambridge University Press & Assessment. Answers, creditworthy alternatives, mark allocations, graph tolerances and error-carried-forward rules may differ from an official scheme. Use it for practice and provisional self-assessment; replace or review it if the official scheme becomes available.

Prepared independently for Jimlaoshi on 9 October 2026. The official matching mark scheme was not available in the public archives checked. The question paper and its printed mark totals are the reference for this document.

How to use the suggestions. B1 = one independent physics point; M1 = one valid method step; A1 = one correct result following a valid method. These labels and their allocation here are the author's proposals, not confirmed examiner instructions. Accept equivalent correct methods and wording. For dependent numerical parts, follow a correct method with a student's earlier value when it remains physically meaningful; do not treat this as an official error-carried-forward rule.

Scope and alignment checklist

1 16 marks	Rocket motion, force, momentum flow and energy. 2.1.3/5; 3.1.2/4/6; 3.2.1; 5.2.4. Pages 17-19.
2 12 marks	Random error, spring constant, elastic energy and energy conservation. 1.3.1; 5.1.2; 5.2.2; 6.1.3/4; 6.2.1-4. Pages 16, 19-20.
3 12 marks	Progressive waves, wave graphs, superposition, nodes and antinodes. 7.1.1/2/5/6; 7.2.2; 8.1.1/3/4. Pages 20-22.
4 12 marks	Resistance, resistivity, thermistors, drift speed and SI units. 1.2.2; 9.1.4; 9.3.1/6/8. Pages 16, 23.
5 8 marks	Quark charges, baryons, mesons and leptons. 11.2.2/4/6. Page 25.

Checked against the **Cambridge International AS & A Level Physics 9702 syllabus, 2025-2027, version 1**. Page numbers above are the printed syllabus pages. This document covers this paper only, not the whole AS course. It does not assess A Level-only oscillation theory or reproduce the question paper.

Question 1 | Rockets and momentum

16 marks in total. Parts 1(a)-1(b)(iii) are on this page; the remaining parts continue on the next page.

Part	Answer and independently proposed marking points	Marks
1(a)	Force is the rate of change of momentum : $F = \Delta p / \Delta t$ (or dp/dt). Suggested: B1: correct definition; do not credit only a vague statement such as "a push or pull".	1
1(b)(i)	As fuel burns and exhaust leaves, the rocket's mass decreases. For constant thrust T and negligible drag, $a = T/m - g$, so its acceleration increases as m decreases. The gradient of the speed-time graph increases, giving a curved rather than a straight graph. Suggested: B1: mass decreases as fuel is burnt and expelled. B1: link decreasing mass to increasing acceleration and hence non-linear speed-time variation.	2
1(b)(ii)	Draw a tangent at $t = 0$ to the speed-time curve. Determine its gradient using a large triangle: $\text{acceleration} = \Delta v / \Delta t$. Suggested: B1: tangent at lift-off. B1: gradient of that tangent, not v/t at a later point.	2
1(b)(iii)	Upwards is positive. $T - mg = ma$, so $T = m(a + g)$. $T = 2.83 \times 10^6 \times (2.5 + 9.81)$ $= 3.48373 \times 10^7 \text{ N}$ $T \approx 3.5 \times 10^7 \text{ N}$. Suggested: M1: include both the weight and the resultant force, using $T = m(a + g)$. A1: correct thrust with unit; $3.48 \times 10^7 \text{ N}$ is also suitable.	2

Key distinction: thrust is not the resultant force. Using $T = ma$ alone omits the force needed to oppose the rocket's weight.

Question 1 | Continued

Part	Answer and independently proposed marking points	Marks
1(b)(iv)	<p>Fuel burnt in 60 s = $(2.0 \times 10^4) \times 60 = 1.20 \times 10^6$ kg. $m_{60} = 2.83 \times 10^6 - 1.20 \times 10^6 = 1.63 \times 10^6$ kg. Read $v_{60} \approx 360 \text{ m s}^{-1}$ from Figure 1.1. $E_K = \frac{1}{2}mv^2 = \frac{1}{2} \times 1.63 \times 10^6 \times 360^2 = 1.05624 \times 10^{11} \text{ J}$. $E_K \approx 1.1 \times 10^{11} \text{ J}$.</p> <p>Suggested: M1: subtract burnt fuel to obtain the remaining mass. M1: use $\frac{1}{2}mv^2$ with the speed read at 60 s. A1: result close to $1.1 \times 10^{11} \text{ J}$; allow sensible graph-reading differences.</p>	3
1(b)(v)	<p>Height is the area under the speed-time graph from 0 to 60 s, because the rocket moves upwards throughout. For example, read approximate speeds 0, 30, 70, 120, 180, 260 and 360 m s^{-1} at 10 s intervals. A trapezium estimate is $h \approx 10[\frac{1}{2}(0 + 360) + 30 + 70 + 120 + 180 + 260] = 8400 \text{ m}$. Height $\approx 8.3 \times 10^3 \text{ m}$; the example estimate of $8.4 \times 10^3 \text{ m}$ is reasonable. Smaller strips or grid-square counting improve the estimate.</p> <p>Suggested: M1: identify the area and use a valid estimate. A1: reasonable value around 8.3 km. These are independently checked readings; no official numerical tolerance is claimed.</p>	2
1(c)	<p>The thrust equals the rate of momentum carried by the exhaust relative to the rocket: $T = (\text{mass emitted per second}) \times \text{exhaust speed}$. $u_{\text{ex}} = T/(2.0 \times 10^4) = 3.48373 \times 10^7/(2.0 \times 10^4) = 1741.865 \text{ m s}^{-1}$. $u_{\text{ex}} \approx 1.7 \times 10^3 \text{ m s}^{-1}$.</p> <p>Suggested: M1: thrust = mass flow rate $\times$ exhaust speed. A1: correct result, or consistent use of the student's thrust from 1(b)(iii).</p>	2
1(d)	<p>Acceleration at lift-off: same. Kinetic energy at 60 s: less.</p> <p>At the exact instant of lift-off the rocket starts from rest, so speed-dependent air drag is zero in the usual still-air model. Once moving, drag opposes the motion and the rocket reaches a lower speed. With the same burn schedule its mass at 60 s is unchanged, so its kinetic energy is lower.</p> <p>Suggested: B1: tick "same" for acceleration at lift-off. B1: tick "less" for kinetic energy at 60 s. The table does not require a written explanation.</p>	2

Question 2 | Springs and energy

12 marks. Use $g = 9.81 \text{ m s}^{-2}$ and retain unrounded values until the final answer.

Part	Answer and independently proposed marking points	Marks
2(a)	<p>Spring constant is the force per unit extension, $k = F/x$, for the spring in its linear region.</p> <p>Suggested: B1: ratio of load to extension, not force per unit total length.</p>	1
2(b)(i)	<p>Different viewing positions in repeat ruler readings cause varying parallax error. Alternatively, judgement of the position between ruler divisions may vary between readings.</p> <p>Suggested: B1: a specific source of variation between readings. A fixed ruler zero error is systematic; a fixed viewing-angle bias is not, by itself, a random error.</p>	1
2(b)(ii)	<p>In equilibrium, $kx = mg$. $k = (0.086 \times 9.81)/0.026 = 32.448... \text{ N m}^{-1}$. $k \approx 32 \text{ N m}^{-1}$.</p> <p>Suggested: M1: $k = mg/x$. A1: correct value and unit.</p>	2
2(b)(iii)	<p>$E_{\text{el,eq}} = \frac{1}{2}kx^2 = \frac{1}{2} \times 32.448... \times 0.026^2$ $= 0.01096758 \text{ J} \approx \textbf{0.011 J}$, as required.</p> <p>Suggested: M1: correct elastic-energy expression and substitution. A1: evaluate to show 0.011 J.</p>	2
2(b)(iv)	<p>The extension from the spring's natural length at release is $0.026 + 0.015 = 0.041 \text{ m}$. $\Delta E_{\text{el}} = \frac{1}{2}k(0.041^2 - 0.026^2)$ $= 0.016305... \text{ J} \approx \textbf{0.016 J}$.</p> <p>Suggested: M1: difference between elastic energies at the two extensions. A1: correct additional energy. $\frac{1}{2}k(0.015)^2$ alone is not this additional spring energy.</p>	2
2(b)(v)	<p>As the block rises 0.015 m, it gains gravitational potential energy $mg(0.015) = 0.0126549 \text{ J}$. $E_K = \Delta E_{\text{el}} - mg(0.015)$ $= 0.016305... - 0.0126549$ $= 0.003650... \text{ J} \approx \textbf{0.0037 J}$. After cancellation, the equivalent expression is $E_K = \frac{1}{2}k(0.015)^2$.</p> <p>Suggested: M1: conserve energy, including the gain in gravitational potential energy. A1: correct kinetic energy, or a physically consistent calculation using an earlier value.</p>	2

Question 2 | Plastic deformation and review

Part 2(c): 2 marks. The earlier ideal-spring calculations use the stated Hooke's-law model.

Part	Answer and independently proposed marking points	Marks
2(c)	<p>Suggested qualitative answer: less recoverable elastic potential energy than in the ideal elastic calculation. Plastic deformation means some work is dissipated as internal energy instead of being stored reversibly in the spring.</p> <p>Suggested: B1: suggest a reduction in recoverable elastic energy. B1: explain the effect in terms of plastic deformation and dissipation. This is a provisional interpretation, not confirmed examiner wording.</p>	2

Review note for 2(c): beyond the elastic limit, the ideal linear spring calculation is insufficient to determine an exact stored-energy change. A quantitative result needs the actual loading/unloading behaviour. Work done on the spring must not all be equated to recoverable elastic energy.

Energy audit for the ideal-spring calculation in 2(b)

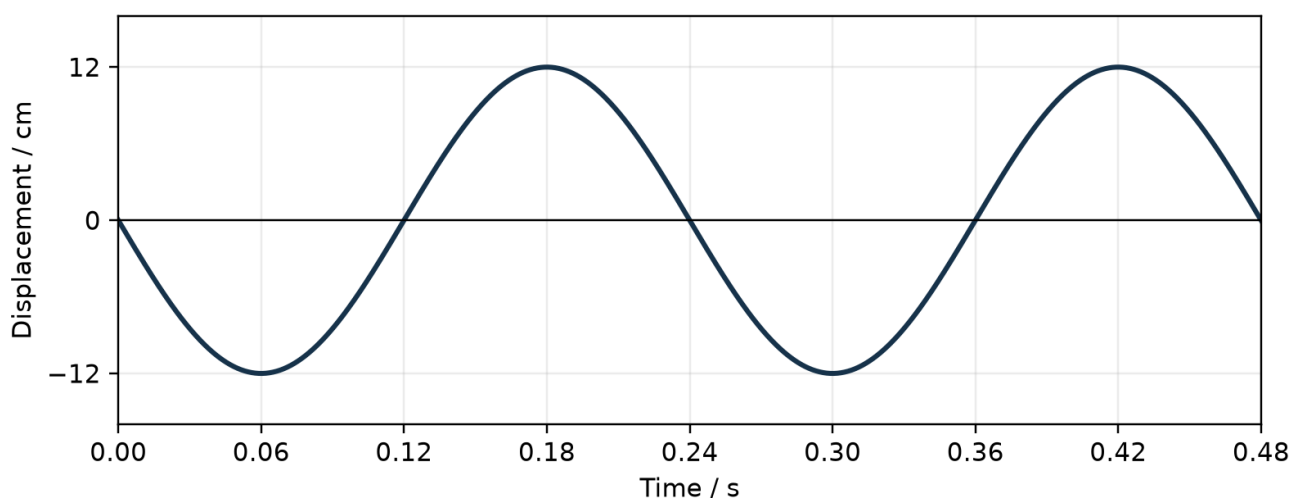
Elastic energy at release, extension 0.041 m	0.02727 J
Elastic energy at equilibrium, extension 0.026 m	0.01097 J
Elastic energy released between those positions	0.01631 J
Gain in gravitational potential energy	0.01265 J
Kinetic energy at the equilibrium position	0.003650 J

The additional spring energy and the kinetic energy are different quantities. The block gains height as it returns upwards, so some of the released spring energy becomes gravitational potential energy. These audit values add no extra marks.

Question 3 | Progressive waves

12 marks in total. Parts 3(a)-3(b)(ii): 6 marks.

Part	Answer and independently proposed marking points	Marks
3(a)	<p>A progressive wave is a travelling disturbance that transfers energy from one place to another without an overall transfer of matter.</p> <p>Suggested: B1: travelling disturbance with energy transfer; equivalent descriptions are acceptable.</p>	1
3(b)(i)	<p>The 36 cm span covers two wavelengths, so $\lambda = 36/2 = 18$ cm. $T = \lambda/v = 18/75 = \mathbf{0.24\text{ s}}$.</p> <p>Suggested: M1: identify $\lambda = 18$ cm. A1: use $T = \lambda/v$ to obtain 0.24 s.</p>	2
3(b)(ii)	<p>Amplitude = $24/2 = \mathbf{12\text{ cm}}$, and the period is 0.24 s. The wave travels from P to Q, so X initially moves downwards: the section just to the left of X has negative displacement. One matching curve is $y = -12 \sin(2\pi t/0.24)$, with y in cm. It shows two full cycles from 0 to 0.48 s.</p> <p>Suggested: B1: amplitude ± 12 cm. B1: period 0.24 s with two cycles. B1: zero initial displacement and correct initial downward direction in a smooth sinusoidal sketch.</p>	3

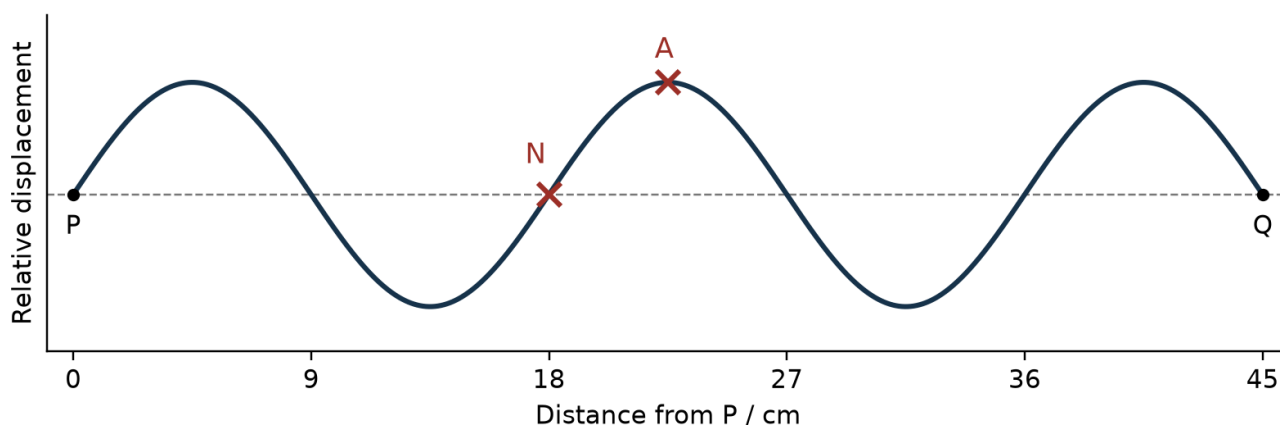


Checkpoints: (0, 0), (0.06, -12), (0.12, 0), (0.18, +12), (0.24, 0), (0.30, -12), (0.36, 0), (0.42, +12), (0.48, 0), with time in s and displacement in cm.

Question 3 | Stationary waves

Parts 3(c)(i)-3(c)(iii): 6 marks.

Part	Answer and independently proposed marking points	Marks
3(c)(i)	<p>A wave on the string is reflected at an end. The incident and reflected waves have the same frequency and travel in opposite directions. Their superposition produces a stationary pattern of fixed nodes and antinodes.</p> <p>Suggested: B1: reflection producing oppositely travelling waves of the same frequency. B1: superposition forming fixed nodes and antinodes.</p>	2
3(c)(ii)	<p>$\lambda = vT = 75 \times 0.24 = 18$ cm. Adjacent nodes are separated by $\lambda/2 = 9$ cm, so 45 cm contains five half-wavelengths.</p> <p>At the instant shown, the string passes through its straight equilibrium position. After 0.060 s = $T/4$, draw five alternating loops at maximum displacement, with zero displacement at P and Q. An inverted version is equally valid.</p> <p>Suggested: B1: five alternating loops between fixed endpoints. B1: maximum-displacement appearance after a quarter period, with the nodes fixed on the equilibrium line. No particular antinode amplitude is specified.</p>	2
3(c)(iii)	<p>Nodes occur at distances 0, 9, 18, 27, 36 and 45 cm from P. Antinodes occur at 4.5, 13.5, 22.5, 31.5 and 40.5 cm.</p> <p>For example, mark N at 18 cm and A at 22.5 cm, as shown. A node is always at zero displacement; an antinode has maximum oscillation amplitude.</p> <p>Suggested: B1: a labelled cross at any node, including either fixed end. B1: a labelled cross at any antinode. Place the crosses on the drawn string at the chosen instant.</p>	2



The vertical amplitude is arbitrary in this illustrative stationary-wave sketch; it must not be inferred from the 24 cm peak-to-trough distance in the earlier progressive-wave figure.

Question 4 | Resistivity and drift speed

12 marks. Graph values below are approximate readings of Figure 4.1.

Part	Answer and independently proposed marking points	Marks
4(a)	Resistance is the potential difference across a component divided by the current through it : $R = V/I$. Suggested: B1: complete ratio definition; do not require constant temperature for this definition.	1
4(b)(i)	$A = \pi(d/2)^2 = \pi(0.60 \times 10^{-3}/2)^2$ $= 2.827... \times 10^{-7} \text{ m}^2 \approx \mathbf{2.8 \times 10^{-7} \text{ m}^2}$. Suggested: B1: correct substitution and shown value; use radius, not diameter, in πr^2 .	1
4(b)(ii)	Read ρ at $20^\circ\text{C} \approx 1.7 \times 10^{-8} \Omega \text{ m}$. $R = \rho L/A = (1.7 \times 10^{-8} \times 2.0)/(2.8 \times 10^{-7}) = 0.121... \Omega$. R $\approx \mathbf{0.12 \Omega}$. Suggested: M1: $R = \rho L/A$ with an appropriate resistivity reading. A1: correct resistance, allowing normal graph-reading and rounding differences.	2
4(b)(iii)	The wire is at a temperature less than 20°C . Since A and R are unchanged but L is larger, $\rho = RA/L$ must be smaller. Figure 4.1 shows that a lower resistivity corresponds to a lower temperature. Suggested: B1: lower temperature. B1: valid link between increased length, reduced resistivity and the graph.	2
4(b)(iv)	A negative-temperature-coefficient thermistor has resistance that decreases as temperature rises, whereas copper wire resistance increases. Alternatively, the thermistor's variation is non-linear rather than approximately linear. Suggested: B1: one correct contrast. The NTC thermistor model is the one specified in this syllabus.	1

Question 4 | Temperature coefficient and drift

Parts 4(c)(i)-4(d): 5 marks.

Part	Answer and independently proposed marking points	Marks
4(c)(i)	<p>The resistivity units cancel, leaving inverse temperature: K^{-1}.</p> <p>Suggested: B1: kelvin inverse, the SI unit; $^{\circ}\text{C}^{-1}$ is not the requested SI-unit notation.</p>	1
4(c)(ii)	<p>At 0 $^{\circ}\text{C}$, read $\rho_0 \approx 1.57 \times 10^{-8} \Omega \text{ m}$. Using a wide span, read ρ at 120 $^{\circ}\text{C} \approx 2.37 \times 10^{-8} \Omega \text{ m}$.</p> $\alpha = (\Delta\rho/\Delta\theta)/\rho_0$ $= [(2.37 - 1.57) \times 10^{-8}/120]/(1.57 \times 10^{-8})$ $= 4.246... \times 10^{-3} \text{ K}^{-1}.$ <p>$\alpha \approx 4.3 \times 10^{-3} \text{ K}^{-1}$.</p> <p>A temperature difference of 120 $^{\circ}\text{C}$ equals a difference of 120 K.</p> <p>Suggested: M1: gradient divided by the resistivity at 0 $^{\circ}\text{C}$. A1: reasonable result near $4.3 \times 10^{-3} \text{ K}^{-1}$. A result near 4.2×10^{-3} using $\rho_0 \approx 1.6 \times 10^{-8}$ and a consistent gradient is reasonable; no official tolerance is claimed.</p>	2
4(d)	<p>$I = Anve$, so $v = I/(Ane)$.</p> $v = 5.6/[(2.8 \times 10^{-7})(8.5 \times 10^{28})(1.60 \times 10^{-19})]$ $= 1.470... \times 10^{-3} \text{ m s}^{-1}.$ <p>$v \approx 1.5 \times 10^{-3} \text{ m s}^{-1}$.</p> <p>Suggested: M1: rearrange and substitute into $I = Anve$. A1: correct speed and unit; using unrounded area gives $1.456... \times 10^{-3} \text{ m s}^{-1}$.</p>	2

Question 5 | Quarks and leptons

8 marks.

Part	Answer and independently proposed marking points	Marks
5(a)	A baryon consists of three quarks . Suggested: B1: three quarks. Three antiquarks describe an antibaryon.	1
5(b)(i)	An up quark has charge $+\frac{2}{3}e$ and an anti-down quark has charge $+\frac{1}{3}e$. A meson containing this pair has total charge $+\frac{2}{3}e + \frac{1}{3}e = +1e$. Suggested: B1: valid quark-antiquark pair with correct constituent charges. B1: correct addition to $+1e$. Equivalent allowed flavour combinations receive the same suggested credit.	2
5(b)(ii)	The other possible charges are 0 and -1e . For charge 0, a quark and its own antiquark have opposite charges that cancel; for example $+\frac{2}{3}e - \frac{2}{3}e = 0$. For charge -1e, a down quark ($-\frac{1}{3}e$) with an anti-up quark ($-\frac{2}{3}e$) gives $-\frac{1}{3}e - \frac{2}{3}e = -1e$. Suggested: B1: 0 with a correct explanation of charge cancellation. B1: -1e with a valid constituent-charge explanation.	2
5(c)	Electron and electron neutrino (or simply neutrino). These are two distinct leptons. Suggested: B1 for each correct distinct lepton. Other scientifically correct named leptons may also be used; this scheme does not require examples beyond the syllabus.	2
5(d)	A lepton is a fundamental particle , whereas a meson is a composite particle containing a quark and an antiquark . Suggested: B1: one explicit valid difference between the two classes. Charge alone is not a difference, as the question states that their possible overall charges overlap.	1

Total suggested marks: 16 + 12 + 12 + 12 + 8 = 60.

Sources and review limits

Question reference: Cambridge International AS & A Level Physics 9702/21, May/June 2026, printed pages 4-6, 8-15. Original filename: 9702_s26_qp_21.pdf. Original source: PapaCambridge session archive. The original question paper is a separate, unchanged file.

Scope reference: Cambridge International Physics 9702 syllabus, 2025-2027, version 1, printed pages 16-25 and 40. Independently checked calculations and answer sketches are included here; this is not a reconstruction of an official examiner document.

Provisional areas: the exact official acceptance ranges for graph readings, alternative responses, partial credit and error-carried-forward rules are unknown. The qualitative interpretation of 2(c) should be reviewed against the official scheme if it becomes available. Any mark obtained using this document is an indicative practice mark, not an official Cambridge result.