

Cambridge International AS & A Level

PHYSICS**9702/33**

Paper 3 Advanced Practical Skills 1

October/November 2022**MARK SCHEME**Maximum Mark: 40

Published

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Question	Answer	Marks
1(a)	Value of E in the range 2.00–3.50 V.	1
1(b)	Six sets of readings of x and V with the correct trend (V increases as x increases) and without help from the Supervisor scores 3 marks, five sets scores 2 marks etc.	3
	Range: $\Delta x \geq 70.0$ cm.	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. $1/V/V^{-1}$.	1
	Consistency: <u>All</u> values of x must be given to the nearest millimetre.	1
	Significant figures: All values of $1/V$ must be given to the same number of s.f. as (or one more than) the number of s.f. in the raw V values.	1
	Calculation: Values of $1/V$ are correct.	1
1(c)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Axes must be labelled with the quantity that is being plotted. Scale markings must be no more than 2 cm (one large square) apart.	1
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leq$ half a small square. Points must be plotted to an accuracy of half a small square in both x and y directions.	1
	Quality: All points in the table must be plotted (at least 5) on the grid for this mark to be awarded. Trend of points must be negative. It must be possible to draw a straight line that is within ± 5 cm (to scale) on the x axis of <u>all</u> plotted points.	1

Question	Answer	Marks
1(c)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Candidates do not need to identify an anomalous point. However if there is a point off trend, it may be identified as anomalous by circling or labelling it. There must be at least 5 points left after one anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	1
1(c)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the x and y directions. Method of calculation must be correct (not $\Delta x / \Delta y$). Gradient sign on answer line matches graph drawn.	1
	y -intercept: Correct read-off from a point on the line and substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions. or Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square.	1
1(d)	Value of A = candidate's gradient value and value of B = candidate's intercept value. Values must not be written as fractions.	1
1(e)(i)	Value of d in the range 0.290 mm–0.340 mm and <u>all</u> raw values given to either 0.01 mm or <u>all</u> to 0.001 mm with unit.	1
	Measurement of d repeated.	1
1(e)(ii)	ρ correctly calculated.	1
	Correct unit (e.g. Ωm).	1

Question	Answer	Marks
2(a)(i)	Final value L_1 in the range 10.0 cm to 20.0 cm and raw values to the nearest millimetre with unit.	1
2(a)(ii)	Absolute uncertainty in L_1 in the range 2–6 mm. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if working is clearly shown. Correct method of calculation to find percentage uncertainty.	1
2(a)(iii)	k calculated correctly.	1
2(a)(iv)	Justification for number of significant figures in k linked to significant figures in W <u>and</u> $(L_2 - L_1)$.	1
2(b)(i)	Value of M in range $10\text{ g} \leq M \leq 100\text{ g}$ with unit.	1
	Correct calculation of V .	1
2(b)(ii)	Value of L_{oil} with $L_{\text{oil}} < L_{\text{air}}$.	1
2(b)(iii)	Second values of M , L_{air} and L_{oil} .	1
	Second value of L_{air} is larger than first value of L_{air} .	1
2(c)	Two values of Z calculated correctly. The final Z values must not be written as fractions.	1
2(d)	Calculation of percentage difference between candidate's two Z values. Comparison of percentage difference with 5% leading to a consistent conclusion.	1
2(e)	ρ_{oil} calculated with correct unit (e.g. kg m^{-3}).	1

Question	Answer	Marks
2(f)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Difficult to measure any L with a reason e.g. parallax error/hard to judge the end of the spring/hard to hold rule (still)/rule disturbs springs/rule not vertical. C $(L_{\text{air}} - L_{\text{oil}})$ is small so large uncertainty/large <u>percentage</u> uncertainty in $(L_{\text{air}} - L_{\text{oil}})$. D Volume or mass of paper clip not taken into account. E k determined on one result. F Small difference between $(L_{\text{air}} - L_{\text{oil}})$ values for the small and large nuts. <i>1 mark for each point up to a maximum of 4.</i>	4
2(f)(ii)	A Take more readings <u>and</u> plot a graph or take more readings <u>and</u> compare Z values (not “repeat readings” on its own). B Method to improve the measurement of L e.g. use white paper or lined or grid sheet behind spring/clamp rule/use clamped pointers/add marker(s) at the ends of the spring. C Use (vernier) calipers/travelling microscope or use larger (bigger) nuts / more nuts. D Use a thinner or lighter paperclip/use nylon or cotton thread or measure the mass of the paperclip (with or without nuts). E Method to improve determination of spring constant e.g. plot a force–extension graph (and find the gradient). F Extend the range between the size of the nuts or use a spring with a smaller k value/less stiff spring. <i>1 mark for each point up to a maximum of 4.</i>	4

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Paper 3 Advanced Practical Skills 2

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Question	Answer	Marks
1(a)(i)	All values of T to the nearest 0.1 mm or all values to the nearest 0.01 mm, with unit and in the range 2.50–3.50 mm.	1
1(a)(ii)	Value of w with unit in the range 25.0–35.0 cm.	1
1(b)	Evidence of repeated measurements of z .	1
1(c)	Six sets of readings of T and z with correct trend and without help from the Supervisor scores 4 marks, five sets scores 3 marks, etc. Correct trend is z increases as T increases.	4
	Range: $T_{\min} \leq 2.00 \text{ mm}$ and $T_{\max} \geq 9.00 \text{ mm}$.	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate The presentation of quantity and unit must conform to accepted scientific convention e.g. $\theta/^\circ$; $\cos \theta$ must not have a unit.	1
	Consistency: All values of <u>raw</u> z must be given to the nearest mm.	1
	Significant figures: All values of $\cos \theta$ should be to three s.f.	1
	Calculation: Values of $\cos \theta$ calculated correctly.	1

Question	Answer	Marks
1(d)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions Axes must be labelled with the quantity that is being plotted. Scale markings must be no more than 2 cm (one large square) apart.	1
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leq$ half a small square. Points must be plotted to an accuracy of half a small square in both x and y directions.	1
	Quality: All points in the table must be plotted (at least 5) on the grid for this mark to be awarded. Trend of points must be negative. It must be possible to draw a straight line that is within ± 0.5 mm (to scale) on the <i>T</i> axis of <u>all</u> plotted points.	1
1(d)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Candidates do not need to identify an anomalous point. However if there is a point off trend, it may be identified as anomalous by circling or labelling it. There must be at least 5 points left after one anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	1
1(d)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the x and y directions. Method of calculation must be correct (not $\Delta x / \Delta y$). Gradient sign on answer line matches graph drawn.	1
	y-intercept: Correct read-off from a point on the line and substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions. or Intercept read directly from the graph, with read-off at $T = 0$, accurate to half a small square.	1

Question	Answer	Marks
1(e)	Value of a = candidate's intercept and value of b = <u>minus</u> candidate's gradient. Values must not be written as fractions.	1
	Units for a (no unit) and b (mm^{-1} , cm^{-1} or m^{-1}) correct.	1

Question	Answer	Marks
2(a)(i)	Value for h_0 , with unit, to the nearest mm and in the range 30.0–50.0 cm.	1
2(a)(ii)	Value for h , smaller than h_0 .	1
2(a)(iii)	Absolute uncertainty of 2–8 mm. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if working is clearly shown. Correct method of calculation to find percentage uncertainty.	1
2(b)(i)	Correct calculation of S .	1
2(b)(ii)	Justification for number of significant figures in S linked to significant figures in m , g and d_m .	1
2(c)(i)	Value for H .	1
	I obtained without help from the Supervisor and with unit and to the nearest 0.01 A.	1
2(c)(ii)	Second value of H .	1
	Second value of I .	1
	Second value of H (for larger I) smaller than first value.	1
2(d)	Two values of k calculated correctly. The final k values must not be written as fractions.	1
2(e)	Calculation of percentage difference between candidate's two k values. Comparison of percentage difference with 20% leading to a consistent conclusion.	1

Question	Answer	Marks
2(f)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Pointer oscillates. C Difficult to measure height (of pointer) <u>with a reason</u>, e.g. pointer thick/ruler not vertical/ruler (is held by hand so) moves. D Large percentage uncertainty in deflection / d_m or deflection / d_m is (very) small so uncertainty is large. E Change in height due to current / $(h - H)$ is (very) small. F Current/ammeter reading fluctuates/changes. G Magnet hits side of tube. <i>1 mark for each point up to a maximum of 4.</i>	4
2(f)(ii)	A Take more readings <u>and</u> plot a graph or take more readings <u>and</u> compare k values (not “repeat readings” on its own). B Take video with a scale/ruler/grid in view (to estimate mean value) or turn off fans/air-conditioning or use wind shield/close windows/doors or add damping with method. C Improvement for measuring height, e.g. use pointed pointer/thinner pointer/pin or clamp the ruler. D Method to increase deflection d_m, e.g. use <u>heavier</u> magnet/use less stiff spring/use <u>longer</u> spring. E Method to increase $h - H$, e.g. use <u>larger</u> current/use <u>more</u> turns on the coil or use stronger magnet. F Named method of cleaning connections/crocodile clips/end of wire, e.g. wire wool/use soldered connections. G Use wider tube (not “larger”). <i>1 mark for each point up to a maximum of 4.</i>	4

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Question	Answer	Marks
1(a)	Value(s) of raw L to the nearest mm.	1
	Correct calculation of k .	1
1(b)	Six sets of readings of a (different values) and L with the correct trend (L increases as a increases) and without help from the Supervisor scores 4 marks, five sets scores 3 marks etc.	4
	Range: $a_{\min} \leq 20.0 \text{ cm}$ and $a_{\max} \geq 40.0 \text{ cm}$.	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. $\frac{1}{a} / \text{m}^{-1}$, $\frac{1}{a} (\text{cm}^{-1})$, $\frac{1}{e} / 1 / \text{cm}$.	1
	Consistency: <u>All</u> values of a must be given to the nearest 0.1 cm.	1
	Significant figures: All values of $\frac{1}{a}$ must be given to the same number of s.f. as (or one more than) the number of s.f. in the raw a values.	1
	Calculation: Values of $\frac{1}{e}$ calculated correctly.	1

Question	Answer	Marks
1(c)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Axes must be labelled with the quantity that is being plotted. Scale markings no more than 2 cm (one large square) apart.	1
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leq$ half a small square. Points must be plotted to an accuracy of half a small square in both x and y directions.	1
	Quality: All points in the table must be plotted (at least 5) on the grid for this mark to be awarded. Trend of points must be positive. It must be possible to draw a straight line that is within $\pm 0.005 \text{ cm}^{-1}$ ($\pm 0.500 \text{ m}^{-1}$) on the $\frac{1}{a}$ axis (normally x-axis) of all plotted points.	1
1(c)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Candidates do not need to identify an anomalous point. However if there is a point off trend, it may be identified as anomalous by circling or labelling it. There must be at least 5 points left after one anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	1

Question	Answer	Marks
1(c)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the x and y directions. Method of calculation must be correct (not $\Delta x / \Delta y$). Gradient sign on answer line matches graph drawn.	1
	y-intercept: Correct read-off from a point on the line and substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions. or Intercept read directly from the graph, with read-off at $\frac{1}{a} = 0$, accurate to half a small square.	1
1(d)(i)	Value of B = candidate's gradient value and value of C = candidate's y-intercept value. Values must not be written as fractions.	1
	B has no unit and unit for C (mm^{-1} or cm^{-1} or m^{-1}) correct.	1
1(d)(ii)	Correct calculation of R .	1

Question	Answer	Marks
2(a)	Final d value to the nearest mm and raw d to nearest mm and in the range 0.068–0.072 m.	1
2(b)(i)	p in the range 0.055–0.065 m.	1
	All raw time measurements to the nearest 0.1 s or all to the nearest 0.01 s and final T in range $0.50 \text{ s} \leq T \leq 1.00 \text{ s}$.	1
	Repeats: At least two measurements of at least $2T$.	1
2(b)(ii)	Absolute uncertainty in nT in the range 0.2–0.4 s or absolute uncertainty in T in the range $(0.2/n) \text{ s}$ to $(0.4/n) \text{ s}$ where n is the number of oscillations used. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if working is clearly shown. Correct method of calculation to find percentage uncertainty.	1
2(b)(iii)	Correct calculation of p^2 and T^2p .	1
2(b)(iv)	Justification for significant figures in T^2p correctly linked to significant figures in p and raw times.	1
2(b)(v)	Second value of p and second value of T .	1
	Second value of T larger than first value of T .	1
2(c)	Two values of g calculated correctly. The final g values must not be written as fractions.	1
2(d)	Calculation of percentage difference between candidate's two g values. Comparison of percentage difference with 15% leading to a consistent conclusion.	1
2(e)	Correct calculation of g with correct unit (e.g. ms^{-2}).	1

Question	Answer	Marks
2(f)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Difficulty linked to the card e.g. card is not flat/card bends (when making hole at P)/difficult to line up pin with P and cork and press without bending card. C Difficult to judge/decide/determine when to start and/or stop the stop-watch or when oscillation begins and/or ends. D Few/small number of oscillations or oscillations die quickly. E Oscillations not in one plane or card hits stand. <i>1 mark for each point up to a maximum of 4.</i>	4
2(f)(ii)	A Take more readings <u>and</u> plot a graph or take more readings <u>and</u> compare q values (not “repeat readings” on its own). B Method to ensure card remains flat when making hole e.g. mat below triangle or use thicker/stiffer/heavier card. C1 Place a grid behind the apparatus or fiducial mark <u>at the centre of the oscillation</u> or plumb-line at <u>centre</u>. C2 Video/film/record with timer/frame-by-frame. D Use longer pin or named material which has less friction than cork or use larger hole. E Use thicker/stiffer/heavier card (<i>award thicker/stiffer/heavier card only once as B or E</i>) or turn off fans/air conditioning or use a wind-shield. <i>1 mark for each point up to a maximum of 4.</i>	4

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Question	Answer	Marks
1(a)(i)	Value of M_L , with unit, equal to 200 g.	1
1(a)(ii)	Value of T with unit and in range 0.90–1.60 s.	1
	Repeats: at least two measurements of at least $5T$.	1
1(b)	Six sets of readings of M_L and T with correct trend and without help from the Supervisor scores 4 marks, five sets scores 3 marks, etc.	4
	Range: min $M_L \leq 100$ g and max $M_L \geq 500$ g.	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate The presentation of quantity and unit must conform to accepted scientific convention e.g. $\sqrt{M_L} / \text{g}^{\frac{1}{2}}$.	1
	Consistency: All values of raw time must be given to the nearest 0.01 s or all to the nearest 0.1 s.	1
	Significant figures: Values of $\sqrt{M_L}$ given to 3 significant figures.	1
	Calculation: Values of $\sqrt{M_L}$ calculated correctly.	1

Question	Answer	Marks
1(c)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Axes must be labelled with the quantity that is being plotted. Scale markings must be no more than 2 cm (one large square) apart.	1
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leq$ half a small square. Points must be plotted to an accuracy of half a small square in both x and y directions.	1
	Quality: All points in the table must be plotted (at least 5) for this mark to be awarded. General trend of points must be positive. Scatter of plotted points must be no more than $\pm 1 \text{ g}^{\frac{1}{2}}$ from a straight line in the x ($\sqrt{M_L}$) direction. If $\sqrt{M_L}$ has unit $\text{kg}^{\frac{1}{2}}$ then tolerance is $\pm 0.03 \text{ kg}^{\frac{1}{2}}$.	1
1(c)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Candidates do not need to identify an anomalous point. However if there is a point off trend, it may be identified as anomalous by circling or labelling it. There must be at least 5 points left after one anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	1

Question	Answer	Marks
1(c)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the x and y directions. Method of calculation must be correct (not $\Delta x / \Delta y$). Gradient sign on answer line matches graph drawn.	1
	y-intercept: Correct read-off from a point on the line and substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions. or Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square.	1
1(d)	Value of a = candidate's gradient and b = candidate's intercept. Values must not be written as fractions.	1
	Units for a and b correct and consistent with value (e.g. $s\ g^{-\frac{1}{2}}$ for a and s for b).	1

Question	Answer	Marks
2(a)	Value of R to nearest mm, with unit, in range 3.5–6.0 cm.	1
2(b)(i)	Correct calculation of E <u>with no unit</u> .	1
2(b)(ii)	Raw value(s) for d_1 to nearest mm.	1
	Evidence of repeated readings of d_1 .	1
2(b)(iii)	Absolute uncertainty in range 2–8 mm. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if working is clearly shown. Correct method of calculation to find percentage uncertainty.	1
2(b)(iv)	Value for d_2 greater than d_1 .	1
2(c)	Second values of A and B .	1
	Second values of d_1 and d_2 .	1
	Second $d_1 < \text{first } d_1$ and second $d_2 < \text{first } d_2$.	1
2(d)	Two values of k calculated correctly.	1
2(e)	Calculation of percentage difference between candidate's two k values. Comparison of percentage difference with 5% leading to a consistent conclusion.	1
2(f)	Correct calculation of f .	1

Question	Answer	Marks
2(g)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Difficulty in <u>measuring distance between central lines</u> (or A) with reason, e.g. large % uncertainty in A / A is small so uncertainty is large. C Difficult to achieve/judge alignment of lines. D Hard to keep block still in correct position. E Difficult to <u>measure</u> d_1 (or d_2) with reason, e.g. difficult to hold rule still/rule too long/parallax error. F Difficulty in <u>measuring</u> d_2 with reason, e.g. judging lowest point of block. <i>1 mark for each point up to a maximum of 4.</i>	4
2(g)(ii)	A Take more readings <u>and</u> plot a graph or take more readings <u>and</u> compare k values (not “repeat readings” on its own). B Measure <u>line spacing</u> using calipers. C Use thinner ruled lines. D Detail of support method for block, e.g. stand and clamp, support on two adjustable stands or perform the experiment sideways so the paper is against the wall and the block lies on the bench. E Improved instrument to measure d_1 (or d_2), e.g. shorter ruler/clamped ruler/set square <u>instead of ruler</u>/thinner ruler. F Measure to (flat) top of block and subtract radius (for d_2). <i>1 mark for each point up to a maximum of 4.</i>	4