



Cambridge International AS & A Level

PHYSICS**9702/33**

Paper 3 Advanced Practical Skills 1

October/November 2021**MARK SCHEME**Maximum Mark: 40

Published

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Question	Answer	Marks
1(a)	Value of I with unit and in the range 20–120 mA.	1
1(b)	Six (or more) I values with different resistance pairings of R_1 , R_2 without help from the Supervisor scores 5 marks, five sets scores 4 marks, etc.	5
	Range: 33 Ω and 47 Ω resistors used as a pair and 68 Ω and 82 Ω resistors used as a pair.	1
	Column headings: Each column heading must contain a quantity and a unit. The presentation of quantity and unit must conform to accepted scientific convention, e.g. $1/I$ /A ⁻¹ , $\left(\frac{R_1 R_2}{R_1 + R_2}\right) / \Omega$.	1
	Consistency: <u>All</u> values of I must be given to the nearest 0.1 mA or <u>all</u> to the nearest 0.01 mA.	1
	Significant figures: All values of $\left(\frac{R_1 R_2}{R_1 + R_2}\right)$ must be given to 2 s.f. or 3 s.f.	1
	Calculation: Values of $1/I$ and $\left(\frac{R_1 R_2}{R_1 + R_2}\right)$ are correct.	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 should be no more than three large squares 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 (at least 5) must be plotted on the grid. Trend of points on graph must be correct. It must be possible to draw a straight line that is within $\pm 1 \Omega$ on the $\left(\frac{R_1 R_2}{R_1 + R_2} \right)$ axis of all plotted points.	1
1(c)(ii)	Line of best fit: Judge by the balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Line 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, e.g. $\Delta y / \Delta x$. 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 must be accurate to half a small square in both x and y directions. or Intercept read directly from the graph at $\left(\frac{R_1 R_2}{R_1 + R_2} \right) = 0$, accurate to half a small square.	1
1(d)(i)	Value of P = candidate's gradient and value of Q = candidate's y-intercept. Values must not be written as fractions.	1
	Unit for P is correct e.g. $\Omega^{-1}A^{-1}$ or $\Omega^{-1}mA^{-1}$ or V^{-1} and unit for Q is correct e.g. A^{-1} or mA^{-1} .	1
1(d)(ii)	E and Z correctly calculated from P and Q using: $E = 1 / P$ and $Z = EQ$ or $Z = Q / P$ and units for E (V) and Z (Ω) correct.	1

Question	Answer	Marks
2(a)(i)	$d = 11.0 \pm 0.5 \text{ cm}$.	1
	Raw value(s) of d recorded to the nearest millimetre.	1
2(a)(ii)	A calculated correctly.	1
2(a)(iii)	Number of significant figures in A is linked to the number of significant figures in d .	1
2(b)(i)	Value of t in the range $0.5 \leq t \leq 1.0 \text{ s}$ and given to 0.1 s or better.	1
	Repeated measurement of t .	1
2(b)(ii)	Percentage uncertainty based on an absolute uncertainty in the range 0.2–0.5 s. 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)	Mass in the range 2.0–10.0 g and measured to the nearest 0.1 g or better and with unit.	1
2(c)(i)	Second value of d .	1
2(c)(ii)	Second value of t is larger than the first value of t .	1
2(d)(i)	Two values of k calculated correctly. The final values must not be written as fractions.	1
2(d)(ii)	Valid comment consistent with the calculated values of k , testing against a criterion stated by the candidate.	1

Question	Answer	Marks
2(e)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Difficulty with filter paper at the start, e.g. paper not horizontal/paper too high to view against ruler/parallax in viewing start position/paper held by hand which moves/metre rule not vertical. C Difficult to start stop-watch and release filter paper at the same time. D Problem with fall of filter paper with a reason, e.g. paper does not fall vertically/erratic path/hits boss or stand/misses bench/papers separate while falling. E Difficulty with judging when to stop the stop-watch <u>with a reason</u>, e.g. difficult to align head at bench level/papers arrive separately. F Times are small so large error/uncertainty (in t) or high <u>percentage</u> uncertainty in t. <i>1 mark for each point up to a maximum of 4.</i>	4

Question	Answer	Marks
2(e)(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 Improved method to hold/release filter paper, e.g. horizontal bar level with top of rule or use a set square with detail, e.g. use set square between bench and ruler or use plumb-line. C Video/record/film with timer/frame-by-frame. D Use more filter papers/heavier or thicker paper/glue together or switch off air-conditioning/close windows/use a wind shield. E Use a pressure sensor below/position sensor above or below. F Use a greater distance to fall through or use larger diameters/use fewer papers/use lighter papers/use thinner papers <i>(Credit once only if heavier papers suggested for D and lighter papers suggested for F.)</i> <i>1 mark for each point up to a maximum of 4.</i>	4



Cambridge International AS & A Level

PHYSICS

9702/34

Paper 3 Advanced Practical Skills 2

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MARK SCHEME

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Question	Answer	Marks
1(a)(i)	Value of p in range 35.0–45.0 cm.	1
1(a)(ii)	Value of q in range 50.0–70.0 cm	1
1(b)	Six sets of readings of p and q (different values) with correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks etc.	5
	Range: $p_{\min} \leq 25.0 \text{ cm}$ and $p_{\max} \geq 65.0 \text{ cm}$.	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. $1/q \text{ (cm}^{-1}\text{)}$. p/q must have no unit.	1
	Consistency: All values of q and p must be given to the nearest mm.	1
	Significant figures: All values of $1/q$ should have the same number of s.f. as, or one more than, the number of s.f. in the corresponding raw q value(s).	1
	Calculation: Values of $1/q$ 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 should be no more than three large squares 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 (at least 5) must be plotted on the grid. Trend of points must be correct. It must be possible to draw a straight line that is within $\pm 0.001 \text{ cm}^{-1}$ ($\pm 0.1 \text{ m}^{-1}$) on the $1/q$ axis (normally y-axis) of all plotted points.	1
1(c)(ii)	Line of best fit: Judge by the balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Line 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, e.g. $\Delta y / \Delta x$. 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 $p/q = 0$, accurate to half a small square.	1

Question	Answer	Marks
1(d)	Value of <i>a</i> equal to candidate's gradient and value of <i>b</i> equal to candidate's intercept. Values are not written as fractions.	1
	Units for <i>a</i> and <i>b</i> correct (e.g. cm ⁻¹).	1

Question	Answer	Marks
2(a)(i)	Raw value(s) of y to nearest 0.1 cm and final value in range 44.0–48.0 cm.	1
2(a)(ii)	Raw value(s) of θ to nearest degree and final value in range 40–60°.	1
2(a)(iii)	Percentage uncertainty based on an absolute uncertainty in the range 2–5°. 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)(iv)	Correct calculation of D .	1
2(a)(v)	Justification based on significant figures in y and θ .	1
2(b)(i)	Final value of S with unit and in range 1.00–1.50 s.	1
	Repeats: at least two values of nS , where $n \geq 5$.	1
2(b)(ii)	All raw times to nearest 0.1 s or all to nearest 0.01 s.	1
2(c)	Second values for θ , S and B .	1
	Quality: B decreases as θ decreases.	1
2(d)(i)	Two values of k calculated correctly. The final k values must not be written as fractions.	1
2(d)(ii)	Valid comment relating to the calculated values of k , testing against a criterion stated by the candidate.	1

Question	Answer	Marks
2(e)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Difficult to set or keep rod horizontal or string slips on pin. C Difficult to measure θ with reason e.g. rod moves if touched/parallax error/difficult to hold protractor steady in hand. D Difficulty with mode of oscillation e.g. rod oscillates in more than one plane/different modes of oscillation/rod twists as it oscillates from side to side. E Difficulty with <u>B</u> oscillation with reason e.g. rod hits stand/difficult to release both ends at the same time/hands get in the way at release. F Difficult to judge/determine/tell/know start of/end of/complete oscillation. <i>1 mark for each point up to a maximum of 4.</i>	4
2(e)(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 Notch in pin/use rough pin. C Clamp protractor/take a photograph and measure θ on photo/measure lengths and use trigonometry. D Method of restricting other modes of oscillation e.g. two sheets placed either side of rod. E Improved method of release for B oscillation, e.g. pull towards you/use card gate to release both ends at the same time or use longer pin. F Video/film/record with timer in view/view frame-by-frame or use (fiducial) marker at <u>midpoint</u> of oscillation. <i>1 mark for each point up to a maximum of 4.</i>	4



Cambridge International AS & A Level

PHYSICS

9702/35

Paper 3 Advanced Practical Skills 1

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MARK SCHEME

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Question	Answer	Marks
1(a)	Value of H with unit <u>and</u> in the range 20.0–40.0 cm.	1
1(b)	Final value of T in the range 2.0–10.0 s.	1
	At least two measurements of nT where $n \geq 5$.	1
1(c)	Six (or more) sets of readings of w (different values) and time with the correct trend and without help from the Supervisor scores 4 marks, five sets scores 3 marks, etc.	4
	Range: $w_{\min} \leq 6.0$ cm and $w_{\max} \geq 18.0$ 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. T/s and $1/w/\text{cm}^{-1}$ or $1/w$ (1/cm).	1
	Consistency: <u>All</u> values of w must be given to the nearest 0.1 cm.	1
	Significant figures: All values of $1/w$ must be given to the same number of s.f. as (or one more than) the number of s.f. of raw w .	1
	Calculation: Values of $1/w$ are correct.	1

Question	Answer	Marks
1(d)(i)	Axes: Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Axes must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares 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 (at least 5) must be plotted on the grid. Trend of points on graph must be correct. It must be possible to draw a straight line that is within $\pm 0.01 \text{ cm}^{-1}$ (or $\pm 1 \text{ m}^{-1}$) on the $1/w$ axis of all plotted points.	1
1(d)(ii)	Line of best fit: Judge by the balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Line 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, e.g. $\Delta y / \Delta x$. Gradient sign on answer line matches graph drawn.	1
1(e)(i)	B = candidate's gradient value. Value must not be written as a fraction.	1
	Unit for B correct (e.g. cm s or m s).	1
1(e)(ii)	Correct calculation of g consistent with the unit.	1

Question	Answer	Marks
2(a)(i)	L_0 in the range 3.0–8.0 cm.	1
2(a)(ii)	Percentage uncertainty based on an absolute uncertainty ΔL_0 in the range 2–5 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)	Value of $L_1 > L_0$.	1
2(b)(ii)	Correct calculation of $(L_1 - L_0)$.	1
2(b)(iii)	Correct calculation of k .	1
2(b)(iv)	Justification of the number of significant figures linked to the number of significant figures in F and $(L_1 - L_0)$.	1
2(c)(i)	Raw value(s) of d and L recorded to the nearest millimetre.	1
2(c)(ii)	Second values of d and L .	1
	Second value of $(L_1 - L_0)$ is larger than the first value of $(L_1 - L_0)$.	1
2(d)(i)	Two values of C calculated correctly. The final values must not be written as fractions.	1
2(d)(ii)	Valid comment consistent with the calculated values of C , testing against a criterion stated by the candidate.	1
2(e)	Correct calculation of W .	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 d with reason, e.g. rule falls/rule slips off/end point near mass hanger difficult to identify. C Values of $(L - L_0)$ or $(L_1 - L_0)$ are small giving large uncertainty (error) or large <u>percentage</u> uncertainty (error) in $(L - L_0)$ or $(L_1 - L_0)$. D Problem with mass of putty, e.g. mass of putty not included/putty changes force on spring. E Difficulty to judge whether spring is vertical/to make spring vertical. F Difficult to measure L_0, L, L_1 or length of spring with reason, e.g. holding rule to measure length nudges spring/coils slanted/rule not vertical/parallax/hands unsteady. G k determined using only <u>one</u> result. <i>1 mark for each point up to a maximum of 4.</i>	4

Question	Answer	Marks
2(f)(ii)	A Take more readings <u>and</u> plot a graph or take more readings <u>and</u> compare C values (not “repeat readings” on its own). B Method to improve measurement of d, e.g. string loop under mass hanger to hold rule. C Use of <u>named</u> device for more precise length measurements, e.g. calipers/travelling microscope. D Improved method to account for mass of putty, e.g. use a balance to measure mass of putty/use glue/use tape (instead of putty). E Method to provide a vertical reference, e.g. use a plumb-line behind spring/set square on bench large enough to be viewed behind spring/method to ensure metre rule is vertical with set square on bench. F Improved method to measure L_0, L, L_1 or length of spring, e.g. pointers on rule/clamped ruler/mark points on spring coils for reference. G Method to improve determination of k, e.g. take many readings and plot graph/use a range of masses/many readings and calculate average. <i>1 mark for each point up to a maximum of 4.</i>	4



Cambridge International AS & A Level

PHYSICS

9702/36

Paper 3 Advanced Practical Skills 2

October/November 2021

MARK SCHEME

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Question	Answer	Marks
1(a)(i)	Value of L with unit and in the range 20.0–25.0 cm.	1
1(a)(ii)	Value of T in range 0.80–1.20 s.	1
	Repeats: at least two measurements of at least $5T$.	1
1(b)	Six sets of readings of L and T with correct trend and without help from the Supervisor scores 4 marks, five sets scores 3 marks, etc.	4
	Range: $L_{\min} \leq 12.0 \text{ cm}$ and $L_{\max} \geq 40.0 \text{ cm}$.	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. L^2 / cm^2 .	1
	Consistency: All values of raw L must be given to the nearest mm.	1
	Significant figures: Values of L^2 should be to the same number of s.f. as (or one more than) the number of s.f. in the corresponding value of L .	1
	Calculation: Values of L^2 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 should be no more than three large squares 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 (at least 5) must be plotted on the grid. Trend of points on graph must be correct. It must be possible to draw a straight line that is within $\pm 0.02 \text{ m}^2$ on the L^2 axis (x-axis) of <u>all</u> plotted points.	1
1(c)(ii)	Line of best fit: Judge by the balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Line 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, e.g. $\Delta y / \Delta x$. 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 $L^2 = 0$, accurate to half a small square.	1

Question	Answer	Marks
1(d)	a equal to candidate's gradient and b equal to candidate's intercept. Values must not be written as fractions.	1
	Units for a (e.g. s^2cm^{-2}) and b (e.g. s^2) are correct.	1

Question	Answer	Marks
2(a)(i)	Evidence of measuring a multiple of t and then dividing.	1
2(a)(ii)	Values of d_1 and d_2 to nearest 0.1 cm.	1
2(a)(iii)	Correct calculation of V_R .	1
2(a)(iv)	Justification based on significant figures in t , d_1 and d_2 .	1
2(b)(i)	Value of x_1 to nearest 1 cm ³ and in range 45–55 cm ³ .	1
2(b)(ii)	Value of x_2 less than x_1 .	1
	Correct calculation of V_A .	1
2(b)(iii)	Percentage uncertainty based on an absolute uncertainty in the range 2–4 cm ³ . 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(c)	Second values for x_1 and x_2 .	1
	Second $V_A > \text{first } V_A$.	1
2(d)(i)	Two values of k calculated correctly. The final values must not be written as fractions.	1
2(d)(ii)	Valid comment consistent with the calculated values of k , testing against a criterion specified by the candidate.	1

Question	Answer	Marks
2(e)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Large percentage uncertainty in $t/d_1/d_2/V_R$. C Difficult to remove all air from cup at start/air leaks out of cup when operating syringe. D Difficult to judge when cup starts to rise or difficult to operate plunger smoothly or difficult to stop plunger when cup starts to rise. E Cup sticks to wall of container. F <u>Volume (or mass)</u> of cup/paper clip/string not taken into account. G <u>x (or V_A)</u> values affected by water getting into tube. <i>1 mark for each point up to a maximum of 4.</i>	4

Question	Answer	Marks
2(e)(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 Use vernier calipers/digital calipers/micrometer/travelling microscope. C Description of workable method of removing air. D Video/film/record with <u>syringe</u> in view or mark cup starting position on container. E Use wider container. F Method of finding volume of cup/string/paper clip or method of measuring mass of cup/string/paper clip e.g. top pan balance. G Method of removing water from tube or use new tube. <i>1 mark for each point up to a maximum of 4.</i>	4