



Cambridge International AS & A Level

PHYSICS

9702/31

Paper 3 Advanced Practical Skills 1

October/November 2023

MARK SCHEME

Maximum Mark: 40

Published

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This document consists of **8** printed pages.

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GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

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Science-Specific Marking Principles

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Question	Answer	Marks
1(a)	Value of final L in the range 38.0–42.0 cm with unit.	1
	Values of I_1 and I_2 each less than 1 A and each with unit.	1
	$I_1 > I_2$.	1
1(b)	Six (or more) sets of readings of L (different values), I_1 and I_2 with correct trend (as L increases, I_1 increases and I_2 decreases) and without help from the Supervisor scores 4 marks, five sets scores, 3 marks etc.	4
	Range: $L_{\min} \leq 10.0$ cm and $L_{\max} \geq 70.0$ 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. L / cm, I_1 / mA. I_2 / ($I_1 - I_2$) must have no unit.	1
	Consistency: <u>All</u> values of L must be given to the nearest 0.1 cm.	1
	Significant figures: All values of I_2 / ($I_1 - I_2$) must be given to the same number of s.f. (or one more than) the least number of s.f. in I_1 , I_2 and ($I_1 - I_2$) values.	1
	Calculation: Values of I_2 / ($I_1 - I_2$) are correct.	1

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Question	Answer	Marks
1(c)(i)	Axes: Axes must be labelled with the correct quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used. Scales must not be awkward (e.g. 3:10 or fractions).	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: Trend of points on graph must be negative. All points in the table must be plotted (at least 5). It must be possible to draw a straight line that is within ± 5 cm (± 0.05 m) to scale on the <i>L</i> axis of <u>all</u> 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 points) about the candidate’s line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If they identify one point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit. There must be at least 5 points left after the anomalous point is disregarded.	1
1(c)(iii)	Gradient: The hypotenuse of the triangle used should 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. The method of calculation must be correct, not $\Delta x / \Delta y$. The gradient sign on the answer line must be consistent with the graph drawn.	1
	y-intercept: Intercept read directly from the graph where <i>L</i> = 0 and accurate to half a small square in y direction. or Correct read-off from a point on the line substituted correctly into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions.	1

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Question	Answer	Marks
1(d)	Value of P = candidate's gradient and value of Q = candidate's y -intercept. Values must not be written as fractions or given to only one significant figure.	1
1(d)	Unit for P correct e.g. cm^{-1} or m^{-1} or mm^{-1} and no unit for Q .	1

Question	Answer	Marks
2(a)(i)	Value(s) of θ to the nearest degree.	1
	Final value of θ in the range $10\text{--}15^\circ$.	1
2(a)(ii)	Correct calculation of $\cos \theta$.	1
2(b)(i)	Value(s) of V to the nearest cm^3 .	1
	Evidence of repeat values of V .	1
2(b)(ii)	Percentage uncertainty based on an absolute uncertainty in V in range $2\text{--}5 \text{ cm}^3$. Correct method of calculation to find percentage uncertainty e.g. absolute uncertainty $\times 100$ / final V value from (b)(i) . If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is shown clearly.	1
2(c)	Second value of θ .	1
	Second value of V .	1
	Second value of V is greater than first value of V .	1
2(d)(i)	Two values of k calculated correctly. The final k values must not be written as fractions or given to only one significant figure.	1
2(d)(ii)	Justification for significant figures in k linked to significant figures in V and θ (not $\cos \theta$).	1
2(e)	Calculation of percentage difference between candidate's two k values. Comparison of percentage difference with 15% leading to a consistent conclusion.	1

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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 filling container with a reason e.g. overflows as filling or restricted access or small container not level or if put a little too much water in it overflows. C Difficulty measuring accurate value of V with a reason e.g. some water stays in large container or water sticks to outside of small container or water splashes out. D Difficulty with setup e.g. holding trolley <u>and</u> positioning masses at the same time. E Difficulty with alignment with reason e.g. container moves as being filled or container may be replaced in a different position after measuring V or masses hit container. F Difficult to ensure the trolley is held at same position each time. <i>1 mark for each point up to a maximum of 4.</i>	4
2(f)(ii)	A Take more readings (for different values of θ) <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 of filling e.g. pipette/syringe/burette. C Improved method to measure V e.g. measure volume needed to top up smaller container. D Improved method for holding trolley e.g. clamp trolley/stop for trolley. E Detailed method to improve alignment e.g. marked sheet taped on floor. F Improved method of to ensure the same position of release e.g. use of gate/mark ramp/use marker. <i>1 mark for each point up to a maximum of 4.</i>	4



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Question	Answer	Marks
1(a)	Value of L in range 52.5–53.5 cm.	1
1(b)	Value of T in the range 1.00–2.00 s.	1
	At least two measurements of nT where $n \geq 5$.	1
1(c)	Six (or more) sets of readings of S (different values) and T with the correct trend (as S increases T decreases) and without help from the Supervisor scores 4 marks, five sets scores 3 marks, etc.	4
	Range: Includes $S \leq 10.0$ cm and $S \geq 40.0$ 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. $\sqrt{(L - S)} / \text{cm}^{1/2}$.	1
	Consistency: All values of S must be given to the nearest 0.1 cm.	1
	Calculation: Values of $\sqrt{(L - S)}$ are correct.	1
1(d)(i)	Axes: Axes must be labelled with the correct quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used. Scales must not be awkward (e.g. 3:10 or fractions).	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: Trend of points must be positive. All points in the table must be plotted on the grid (at least 5). It must be possible to draw a straight line that is within $\pm 0.2 \text{ cm}^{1/2}$ ($\pm 0.02 \text{ m}^{1/2}$) on the $\sqrt{(L - S)}$ axis of all plotted points.	1

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Question	Answer	Marks
1(d)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If they identify one point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit. There must be at least 5 points left after the anomalous point is disregarded.	1
1(d)(iii)	Gradient: The hypotenuse of the triangle used should 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. The method of calculation must be correct, not $\Delta x / \Delta y$. The gradient sign on the answer line must be consistent with the graph drawn.	1
	y-intercept: Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square in y direction. or Correct read-off from a point on the line and substituted correctly into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions.	1
1(e)(i)	Value of A = candidate's gradient and value of B = candidate's y-intercept. The values must not be written as fractions or surds or given to only one significant figure.	1
	Unit for A: $\text{s m}^{-1/2}$ or $\text{s cm}^{-1/2}$ and unit for B: s.	1
1(e)(ii)	g calculated correctly using $g = \pi^2 / A^2$ and with correct unit.	1

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Question	Answer	Marks
2(a)(i)	x , y and z measured to the nearest millimetre and x in the range 0.495–0.505 m.	1
	Correct calculation of volume.	1
2(a)(ii)	Justification for significant figures in V linked to significant figures in x , y and z .	1
2(b)(i)	d in the range 0.145–0.155 m.	1
2(b)(ii)	F measured to the nearest 0.01 N and final F in range 0.10–1.00 N.	1
	At least two measurements of F .	1
2(b)(iii)	Percentage uncertainty in F based on an absolute uncertainty in the range 0.02–0.06 N. Correct method of calculation to obtain percentage uncertainty, e.g. (absolute uncertainty $\times$ 100 / final value from (b)(ii)). If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is shown clearly.	1
2(b)(iv)	Second value of d and second value of F .	1
	Second value of F larger than first value of F .	1
2(c)	Two values of k calculated correctly. The final k values must not be written as fractions or given to only one significant figure.	1
2(d)	Calculation of percentage difference between candidate's two k values. Comparison of percentage difference with 15% leading to a consistent conclusion.	1
2(e)	Correct calculation of ρ with correct unit e.g. kg m^{-3} .	1

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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 y is small so uncertainty is large or large <u>percentage</u> uncertainty in measuring y. C Difficult to measure d with a reason e.g. difficult to judge the centre of the mass, parallax error, difficult to hold/maintain ruler parallel to strip. D Difficult to get a value of F <u>with reason</u> e.g. reading changes suddenly or difficult to determine when strip leaves the rod. E Difficult to keep/ensure/maintain the newton meter vertical. F Newton meter not at the end of the strip. G Mass of adhesive putty not taken into account. <i>1 mark for each point up to a maximum of 4.</i>	4
2(f)(ii)	A Take more readings (for different values of d) <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 measure y e.g. use micrometer or (vernier/digital) calipers. C Improved method to measure d e.g. measure to the edge of the mass <u>and</u> add on the radius of the mass or clamp ruler. D Improved method to get value F e.g. video/record/film <u>with newton meter</u> (and strip) <u>in view</u> or force sensor <u>and</u> data logger. E Improved method to ensure vertical e.g. use a clamped metre rule <u>and</u> a set square to ensure vertical or use a plumb line as reference. F Add a hook/tape at end or tape string to strip or glue string to strip. G Subtract weight of putty from F or add mass of putty onto the mass or tape mass (instead of putty). <i>1 mark for each point up to a maximum of 4.</i>	4



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1(a)	Value for R with unit.	1
	Value for a with unit in range 10.0–75.0 cm.	1
1(b)	Six (or more) sets of readings of R (different values) and a and b with correct trend (as R increases, a increases and b decreases) and without help from the Supervisor scores 5 marks, five sets scores 4 marks, etc.	5
	Range: R values include 220Ω and 4700Ω .	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. $1/R$ ($\text{k}\Omega^{-1}$) and b/a (no unit)	1
	Consistency: Values of a <u>and</u> b must all be given to the nearest 0.1 cm.	1
	Significant figures: All values of b/a must be given to the same number of s.f. as (or one more than) the lowest number of s.f. in the corresponding a and b values.	1
	Calculation: Values of $1/R$ are calculated correctly.	1
1(c)(i)	Axes: Axes must be labelled with the correct quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used. Scales must not be awkward (e.g. 3:10 or fractions).	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: Trend of points must be positive. All points in the table must be plotted (at least 5). It must be possible to draw a straight line that is within ± 0.2 on the b/a axis of all plotted points.	1

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1(c)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If they identify one point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit. There must be at least 5 points left after the anomalous point is disregarded.	1
1(c)(iii)	Gradient: The hypotenuse of the triangle used should 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. The method of calculation must be correct, not $\Delta x / \Delta y$. The gradient sign on the answer line must be consistent with the graph drawn.	1
	y-intercept: Intercept read directly from the graph, with read-off at $1 / R = 0$, accurate to half a small square in y direction. or Correct read-off from a point on the line and substituted correctly into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions.	1
1(d)	Value of M = candidate's gradient and value of N = candidate's y-intercept. The values must not be written as fractions or given to only one significant figure.	1
	Unit for M correct (e.g. Ω) and no unit for N.	1

PUBLISHED

Question	Answer	Marks
2(a)	Values for A , B and C .	1
	B in range 16.0–24.0 cm.	1
	Correct calculation of x .	1
2(b)(i)	Value(s) of h , with unit, to nearest mm.	1
	Evidence of repeat readings of h .	1
2(b)(ii)	Percentage uncertainty in h based on an absolute uncertainty in the range 0.2–0.8 cm. Correct method of calculation to obtain percentage uncertainty, e.g. (absolute uncertainty $\times$ 100 / final value from (b)(i)). If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is shown clearly.	1
2(c)	Second set of values for A and B .	1
	Second value for h .	1
	Second value of h less than first value of h .	1
2(d)(i)	Two values of k calculated correctly. The final k values must not be written as fractions or given to only one significant figure.	1
2(d)(ii)	Justification for significant figures in k linked to significant figures in x , h and s .	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

PUBLISHED

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 when measuring <i>B</i> with reason e.g. difficult to judge centre of rod or difficult to align hole with ruler. C Difficulty when measuring <i>A</i> or <i>C</i> with reason e.g. parallax error, difficult to hold/maintain ruler vertical. D Difficulty with water jet with a description e.g. too thick, multiple streams, jet spreads out. E Difficulty with judging/markings water level because of needing to look at the rod and water at the same time or water level is (quickly) changing. F Difficult to see/mark/judge water level with reason e.g. water is colourless/ribbed bottle. G Difficulty with paper strip e.g. ink on strip can be washed away. <i>1 mark for each point up to a maximum of 4.</i>	4

PUBLISHED

Question	Answer	Marks
2(f)(ii)	A Take more readings (for different values of h) <u>and</u> plot a graph or take more readings <u>and</u> compare k values (not “repeat readings” on its own). B Use string or measuring tape or use a thinner rod or use rule(r) with scale starting at end or measure horizontal distance and vertical distance and calculate a value for B. C Improved method to ensure vertical e.g. use clamped ruler/plumb line/spirit level. D Decrease diameter of hole or use a hole with smoother edge. E Improved method to determine water level e.g. record/film/video <u>with scale/ruler in view</u> or put cap/cork on bottle top or cover hole at moment jet hits rod. F Use coloured water/smooth bottle. G Use permanent marker/waterproof strip. <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

October/November 2023

MARK SCHEME

Maximum Mark: 40

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

PUBLISHED**GENERIC MARKING PRINCIPLE 5:**

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

- 1 Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
- 2 The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
- 3 Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
- 4 The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
- 5 'List rule' guidance
 For questions that require ***n*** responses (e.g. State **two** reasons ...):
 - The response should be read as continuous prose, even when numbered answer spaces are provided.
 - Any response marked *ignore* in the mark scheme should not count towards ***n***.
 - Incorrect responses should not be awarded credit but will still count towards ***n***.
 - Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response.
 - Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

PUBLISHED

Question	Answer	Marks
1(a)	Final value of E in the range 2.50–6.00 V.	1
1(b)	Six (or more) sets of readings of R_1 and R_2 (different values of $(R_1 + R_2)$) and I with the correct trend (as $(R_1 + R_2)$ increases, I decreases) and without help from the Supervisor scores 3 marks, five sets scores 2 marks, etc.	3
	Range: Uses $(R_1 + R_2) = 45 \, \Omega$ and $(R_1 + R_2) = 138 \, \Omega$.	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. $(R_1 + R_2) / \Omega$, $\frac{1}{I} \, (\text{A}^{-1})$. Do not allow $1 / I \, (\text{A})$.	1
	Consistency: <u>All</u> raw values of I must be given to 0.1 mA or <u>all</u> given to 0.01 mA.	1
	Significant figures: All values of $\frac{1}{I}$ must be given to the same number of s.f. as (or one more than) the number of s.f. in raw I values.	1
	Calculation: Values of $\frac{1}{I}$ are correct.	1

PUBLISHED

Question	Answer	Marks
1(c)(i)	Axes: Axes must be labelled with the correct quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used. Scales must not be awkward (e.g. 3:10 or fractions).	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: Trend of points must be positive. All points in the table must be plotted on the grid (at least 5). It must be possible to draw a straight line that is within $\pm 4 \Omega$ on the $(R_1 + R_2)$ axis of <u>all</u> 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 points) about the candidate’s line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If they identify one point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit. There must be at least 5 points left after the anomalous point is disregarded.	1

PUBLISHED

Question	Answer	Marks
1(c)(iii)	Gradient: The hypotenuse of the triangle used should 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. The method of calculation must be correct, not $\Delta x / \Delta y$. The gradient sign on the answer line must be consistent with the graph drawn.	1
	y-intercept: Intercept read directly from the graph, with read-off at $(R_1 + R_2) = 0$, accurate to half a small square in y direction. or Correct read-off from a point on the line is substituted correctly into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions.	1
1(d)	Value of F = candidate's gradient and value of G = candidate's y-intercept. The values must not be written as fractions or given to only one significant figure.	1
	Correct unit for F e.g. $\text{mA}^{-1} \Omega^{-1}$ and correct unit for G e.g. mA^{-1} .	1
1(e)(i)	<u>All</u> raw values given to either 0.01 mm or <u>all</u> to 0.001 mm and final value of d in the range 0.100–0.300 mm with unit.	1
	Measurements of d repeated.	1
1(e)(ii)	Correct calculation of ρ using $\rho = \pi d^2 EG / 4L$.	1

PUBLISHED

Question	Answer	Marks
2(a)	Evidence of mass of 5 or more paper clips measured to the nearest 0.1 g or better and mass of one paper clip determined.	1
2(b)(i)	Raw h recorded to the nearest millimetre and final value of h in range 10.0–60.0 cm.	1
2(b)(ii)	N recorded.	1
2(b)(iii)	Value of t in the range 0.50–10.00 s with unit.	1
	Evidence of repeats.	1
2(b)(iv)	Percentage uncertainty based on an absolute uncertainty in t in the range 0.2–0.5 s. Correct method of calculation to find percentage uncertainty e.g. absolute uncertainty $\times 100$ / value from (b)(iii) . If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if working is shown clearly.	1
2(b)(v)	Value of a calculated correctly.	1
2(b)(vi)	Justification for significant figures in a linked to significant figures in h and t .	1
2(c)	Second values of N and t .	1
	Second value of t is smaller than the first value of t .	1
2(d)	Two values of k calculated correctly. The final k values must not be written as fractions or given to only one significant figure.	1
2(e)	Calculation of percentage difference between candidate's two k values. Comparison of percentage difference with 25% leading to a consistent conclusion.	1

PUBLISHED

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 h with a reason e.g. because mass hanger is not horizontal or rule not vertical or rule disturbs mass hanger/pulley. C t is small so uncertainty is large or large <u>percentage</u> uncertainty in t. D Difficult to measure t with a reason e.g. difficult to start stop-watch and release mass at the same time. E Difficulty with pulley and/or string e.g. hanger starts and stops or pulley too narrow so masses collide or masses too wide so collide. F Difficulty with adhesive putty e.g. mass of putty not taken into account or adhesive putty adds mass to slotted mass. G Difficulty with paper clips e.g. paper clips fall off mass hanger or difficult to balance clips on hanger or paper clips are discrete (large increments) so mass hanger suddenly releases and falls. <i>1 mark for each point up to a maximum of 4.</i>	4

PUBLISHED

Question	Answer	Marks
2(f)(ii)	A Take more readings (for different values of N) <u>and</u> plot a graph or take more readings <u>and</u> compare k values (not “repeat readings” on its own). B Workable method to measure h accurately e.g. clamp metre rule (and use a fiducial marker). C Use a longer string or larger h. D Workable method to measure t e.g. record/film/video with timer in view/frame by frame or electromagnet for start, gate for end <u>with timer</u> or motion sensor above or below. E Workable improvement e.g. use a pulley with larger diameter or masses of smaller diameter. F Valid method to account for the mass of the adhesive putty e.g. measure mass and add on or tie mass using string or use tape. G Workable method for improvement e.g. hook/container added to hanger or use smaller/lighter paper clips. <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 2023

MARK SCHEME

Maximum Mark: 40

Published

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- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

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- marks are not deducted for omissions
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GENERIC MARKING PRINCIPLE 5:

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Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

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For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

PUBLISHED

Question	Answer	Marks
1(a)	Value for R in range 0.68–4.7 k Ω with unit.	1
	Value for V in range 2.30–3.50 V with unit.	1
1(b)	Six sets of readings of R and V with correct trend (as V increases as R increases) and without help from the Supervisor scores 5 marks, five sets scores 4 marks, etc.	5
	Range: $R_{\min} = 0.68 \text{ k}\Omega$ and $R_{\max} = 4.7 \text{ k}\Omega$.	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. $1/R (\text{k}\Omega^{-1})$.	1
	Consistency: Values of V must all be given to the nearest 0.01 V.	1
	Significant figures: Values of $1/R$ should be given to the same number of s.f. as, or one more than, the number of s.f. in the corresponding value of R .	1
	Calculation: Values of $1/R$ calculated correctly.	1

PUBLISHED

Question	Answer	Marks
1(c)(i)	Axes: Axes must be labelled with the correct quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used. Scales must not be awkward (e.g. 3:10 or fractions).	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: Trend of points must be negative. All points in the table (at least 5) must be plotted. It must be possible to draw a straight line that is within $\pm 0.01\text{ V}$ on the V 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 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If they identify one point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit. There must be at least 5 points left after the anomalous point is disregarded.	1
1(c)(iii)	Gradient: The hypotenuse of the triangle used should 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. The method of calculation must be correct, not $\Delta x / \Delta y$. The gradient sign on the answer line must be consistent with the graph drawn.	1
	y-intercept: Intercept read directly from the graph, with read-off at $1/R = 0$, accurate to half a small square in y direction. or Correct read-off from a point on the line and substituted correctly into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions.	1

PUBLISHED

Question	Answer	Marks
1(d)	Value of a = candidate's gradient and value of b = candidate's y -intercept. The values must not be written as fractions or given to only one significant figure.	1
	Units for a (e.g. $\text{k}\Omega\text{V}$) and b (e.g. V) are correct.	1

Question	Answer	Marks
2(a)	Value for l_0 in range 30.0–50.0 cm.	1
2(b)	Value(s) for d to nearest mm.	1
	Final d in range 1.0–3.0 cm.	1
2(c)(i)	Value for h .	1
2(c)(ii)	Percentage uncertainty in h based on an absolute uncertainty in the range 0.3–0.5 cm. Correct method of calculation to obtain percentage uncertainty, e.g. (absolute uncertainty $\times$ 100 / final value from (c)(i)). If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is shown clearly.	1
2(c)(iii)	Value for l_{max} to nearest mm and greater than l_0 .	1
2(d)	Second values of d_0 and d .	1
	Second values of l_0 , h and l_{max} .	1
	Second value of h less than first value of h .	1
2(e)(i)	Two values of C calculated correctly. The final C values must not be written as fractions or given to only one significant figure.	1
2(e)(ii)	Justification for significant figures in C based on the significant figures in $(l_{\text{max}} - l_0)$, h and $(d_0 - d)$.	1
2(f)	Calculation of percentage difference between candidate's two C values. Comparison of percentage difference with 15% leading to a consistent conclusion.	1

PUBLISHED

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 Difficult to measure l_0 with a reason e.g. hard to get the string straight / hard not to stretch the string. C Difficult to measure d with a reason e.g. parallax or 100 g mass falls off or rule moves string. D Hard to judge if the mass just touches the pad or difficult to align mass with clip before release. E Parallax error when measuring h. F Difficult to measure $l_{\max}$ with a reason e.g. rule unsteady or string may not be vertical. <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 C values (not “repeat readings” on its own). B Improved method to find l_0 e.g. method to fix one end (e.g. tape to the bench). C Use smaller 100 g mass or mirror scale behind 50 g mass. D Improved method for judging contact e.g. video and replay frame by frame or use pressure pad or use sand tray or place microphone near paper and display trace on CRO. E Clamp rule and use pointer (for h or d). F Measure to bottom of mass (or to paper pad) and subtract diameter of mass (for $l_{\max}$). <i>1 mark for each point up to a maximum of 4.</i>	4