

Cambridge International AS & A Level

PHYSICS**9702/31**

Paper 3 Advanced Practical Skills 1

October/November 2024

MARK SCHEME

Maximum Mark: 40

Published

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GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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- the specific skills defined in the mark scheme or in the generic level descriptors for the question
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GENERIC MARKING PRINCIPLE 2:

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

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Marks must be awarded **positively**:

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- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
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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.

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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).

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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.
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- 5 'List rule' guidance
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PUBLISHED

Question	Answer	Marks
1(a)	Value(s) of raw θ_0 to the nearest degree and final θ_0 value in the range $75^\circ \leq \theta_0 \leq 85^\circ$.	1
1(b)	Value of m in range $3.0 \text{ g} \leq m \leq 6.0 \text{ g}$ with unit and to at least 0.1 g.	1
1(c)	Correct calculation of e with correct unit.	1
1(d)	Six (or more) sets of readings of M (different values) and θ with correct trend (as M increases, θ decreases) and without help from supervisor scores 4 marks, five sets scores 3 marks etc.	4
	Range: $M_{\max} - M_{\min} \geq 30 \text{ g}$.	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. L / cm , M / g , e / cm , $\theta / ^\circ$, $\sin \theta$.	1
	Consistency: All values of raw L must be given to the nearest mm.	1
	Significant figures: Values of $\sin \theta$ must be given to the same number of s.f. (or one more than) the number of s.f. in the corresponding raw θ values.	1
	Calculation: Values of $\sin \theta$ are correct.	1

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Question	Answer	Marks
1(e)(i)	Axes: Axes must be labelled with the required 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, no awkward scales (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 must be plotted (at least 5) on the grid for this mark to be awarded. It must be possible to draw a straight line that is within ± 0.25 cm (to scale) on the e axis (normally y-axis) of <u>all</u> plotted points.	1
1(e)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 points on the grid) 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 small 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 five points left after the anomalous point is disregarded.	1

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Question	Answer	Marks
1(e)(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. Method of calculation must be correct (not $\Delta x / \Delta y$). Gradient sign on answer line consistent with graph drawn.	1
	y-intercept: Intercept read directly from the graph, with read-off at $\sin \theta = 0$, 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(f)	P = candidate's gradient value and Q = candidate's intercept value. Values must not be written as fractions, roots or given to only one significant figure.	1
	Correct and consistent units for P (e.g. cm or m or mm) and Q (e.g. cm or m or mm).	1

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Question	Answer	Marks
2(a)	Value of w on answer line in the range 6.0–8.0 cm with unit and value of x on answer line in the range 1–4 mm with unit.	1
2(b)(i)	Value(s) of raw d to the nearest mm.	1
	Final value of d in the range 92.0–99.0 cm.	1
2(b)(ii)	Percentage uncertainty based on an absolute uncertainty in d in range 2–10 mm. Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty/value from 2(b)(i)) $\times$ 100. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	1
2(c)	Value of T in the range 1.0–2.0 s.	1
	Repeats: At least two measurements of time.	1
2(d)	Second value of d .	1
	Second value of T .	1
	Second value of $T <$ first value of T .	1
2(e)(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(e)(ii)	Justification for significant figures in k linked to significant figures in T or time <u>and</u> d .	1
2(f)	Calculation of percentage difference between candidate's two k values. Comparison of percentage difference with 10%, 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 Difficulty with measuring x with a reason e.g. x is a small value and minimum rule marking 1 mm / rule is not precise enough / rule unwieldly / large percentage uncertainty. C Difficult to measure d with a reason e.g. rule hand held / rule may not be horizontal / parallax. D Difficult to determine T with a reason e.g. number of oscillations is small / identifying start or end point of oscillation. E Difficulty with spring e.g. rolls at an angle / falls off strip / loops restrict movement / spring slides as well as rolling. F Difficulty with board e.g. board twists / does not touch stand because of boss / roughness restricts rolling / stands move during the experiment / board hard to bend. <i>1 mark for each point up to a maximum of 4.</i>	4
2(g)(ii)	A Take more readings (for different values of d) <u>and</u> plot a graph / take more readings <u>and</u> compare k values (not “repeat readings” on its own). B Improved method to measure x e.g. (vernier/digital) calipers or micrometer screw gauge. C Improved method to measure d e.g. clamp rule (with pointers). D Improved method to measure T e.g. fiducial marker at centre of oscillation or video / film / record with timer in view. E Improved method of release e.g. use of a stop / card gate. F Use G-clamps to fix the stands / add weights to stands. <i>1 mark for each point up to a maximum of 4.</i>	4

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1(a)	Final value of L in the range 44.0–46.0 cm and final value of V in range 0–2.0 V.	1
1(b)	Six sets of readings of L (different values) and V with the correct trend (as L increases, V increases) and without help from supervisor scores 3 marks, five sets scores 2 marks, etc.	3
	Range: Uses $L \leq 25.0$ cm and $L \geq 85.0$ cm.	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. $\frac{1}{L} / \text{cm}^{-1}$	1
	Consistency: <u>All</u> raw values of L must be given to 0.1 cm.	1
	Significant figures: All values of $\frac{1}{V}$ must be given to the same number of s.f. as (or one more than) the number of s.f. in raw V values.	1
	Calculation: Values of $\frac{1}{V}$ are correct.	1

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Question	Answer	Marks
1(c)(i)	Axes: Axes must be labelled with the required 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, no awkward scales (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) on the grid for this mark to be awarded. It must be possible to draw a straight line that is within $\pm 0.5 \text{ V}^{-1}$ ($\pm 0.0005 \text{ mV}^{-1}$) on the $\frac{1}{V}$ axis (normally y-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 five 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 five points left after the anomalous point is disregarded.	1

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	y-intercept: Intercept read directly from the graph, with read-off at $\frac{1}{L} = 0$, 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
1(d)	J = candidate's gradient value and W = candidate's y-intercept value. The values must not be written as fractions, roots or given only to one significant figure.	1
	Correct unit for J: $V^{-1}m$ or $V^{-1}cm$ and correct unit for W: V^{-1}.	1
1(e)(i)	Value of d in the range 0.200–0.300 mm with unit and <u>all</u> raw values given to either 0.01 mm or <u>all</u> to 0.001 mm.	1
	Repeat values of d.	1
1(e)(ii)	ρ correctly calculated from J and W: $\rho = \frac{\pi d^2 RW}{4J}$ Final answer with correct power of ten for ρ.	1

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Question	Answer	Marks
2(a)	Mass m of A (and string) measured and to the nearest 0.1 g or better.	1
2(b)(i)	Value of b in the range 2.0–4.0 cm, recorded to the nearest millimetre and value of d in the range 9.0–11.0 cm, recorded to the nearest millimetre.	1
	Value of $\sqrt{(d-b)}$ calculated with correct unit i.e. $\text{cm}^{1/2}$.	1
2(b)(ii)	Number of significant figures in $\sqrt{(d-b)}$ must link to number of significant figures in $(d-b)$.	1
2(b)(iii)	Final value of H : $b < H < d$.	1
	Evidence of repeats.	1
2(b)(iv)	Percentage uncertainty based on absolute uncertainty in H in range 0.3–1.0 cm. Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty / value from 2(b)(iii)) $\times 100$. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	1
2(b)(v)	$\sqrt{(H-b)}$ calculated correctly.	1
2(c)	Second values of H and M .	1
	Second value of $H >$ first value of H .	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 15% 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 b with a reason e.g. difficult to locate the centre of the ball / holding ball A whilst measuring at the same time. C Difficult to measure H with reason e.g. difficult to judge <u>when</u> at maximum height / at maximum height for a <u>short</u> period of time / final horizontal position not known. D Difficulty with <u>collision</u> / <u>impact</u> e.g. ball B and ball A are not at the same height / ball A does not hit ball B head-on / glances off at an angle. E Difficulty with <u>mass(es)</u> with reason e.g. mass of adhesive putty not taken into account / mass added is not uniformly distributed / mass not added at the centre of gravity. <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 M) <u>and</u> plot a graph or take more readings <u>and</u> compare k values (not “repeat readings” on its own). B Use a clamped rule (to measure b) or measure to the bottom <u>and</u> top of ball or measure diameter of ball <u>and</u> measure to top or bottom of ball or clamp or place stop for ball <u>A</u> (related to measuring b). C Video / record / film with rule in view or place grid behind or trial and error with pointer / stop. D Set up the two strings with two separate clamps (so balls are at the same height at the point of impact). E Specified method to determine / account for the mass of the adhesive putty e.g. measure mass of adhesive putty and add to mass or measure <u>total</u> mass or repeat with heavier ball (A) instead of using extra 10 g mass. <i>1 mark for each point up to a maximum of 4.</i>	4

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1(a)(i)	Values of h_t and h_b with unit and in range 19.0–24.0 cm.	1
1(a)(ii)	Value of T in range 1.20–2.60 s.	1
	Evidence of repeat measurements of T .	1
1(b)	Six sets of readings of h_t , h_b and T with correct trend (as h_t increases, T decreases) and without help from supervisor scores 4 marks, five sets scores 3 marks etc.	4
	Range: $\max h_t - \min h_t \geq 5.0$ 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. $1/T/s^{-1}$.	1
	Consistency: All values of h_t and h_b must be given to the nearest mm.	1
	Significant figures: Values of $1/T$ given to same number of s.f. as (or one more than) number of s.f. in T .	1
	Calculation: Values of $1/T$ calculated correctly.	1

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Question	Answer	Marks
1(c)(i)	Axes: Axes must be labelled with the required 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, no awkward scales (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: All points in the table must be plotted (at least 5) for this mark to be awarded. It must be possible to draw a straight line that is within $\pm 0.05 \text{ s}^{-1}$ (to scale) on the $1/T$ axis (normally the y-axis) of <u>all</u> plotted points. General trend of points must be positive.	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 five 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. Method of calculation must be correct, not $(\Delta x / \Delta y)$. Gradient sign on answer line consistent with 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 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)	p equal to candidate's gradient and q equal to candidate's intercept. Values must not be written as fractions, roots or given to only one significant figure.	1
	Units for p and q correct and consistent with readings, e.g. $s^{-1}cm^{-1}$ for p and s^{-1} for q.	1

PUBLISHED

Question	Answer	Marks
2(a)(i)	All raw value(s) for r to nearest mm.	1
	Final value of r in range 45.0–49.5 cm.	1
2(a)(ii)	Final value of x less than 15.0 cm.	1
	Evidence of repeat readings of x .	1
2(a)(iii)	Percentage uncertainty based on absolute uncertainty in x in range 0.3–1.0 cm. Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty / value from (a)(ii)) $\times 100$. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	1
2(a)(iv)	Correct calculation of h .	1
2(b)	Second value of x .	1
	Second value of h .	1
	Second $x < \text{first } x$.	1
2(c)(i)	Two values of k calculated correctly. The final k values must not be written as fractions or given to one significant figure.	1
2(c)(ii)	Justification for significant figures in k linked to significant figures in $(M + m)$ and h .	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

PUBLISHED

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 r with reason e.g. holding ruler in air / rod moves when hit by ruler / estimating magnet’s centre. C Difficulty with the starting position with reason e.g. parallax / knowing which part of the magnet to use as a reference. D Difficulty with x with reason e.g., parallax / judging when at maximum displacement / at maximum displacement for short time / knowing which part of nut to use as a reference point. E Difficulty with picking up the nut. <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 Clamp ruler / measure magnet’s length and distance to top (or bottom) of magnet / measure to top of magnet and to bottom of magnet and average the length. C Use set square on ruler/a stop to set the starting position. D Record/film/video with ruler in view / use grid behind / trial and error with pointer / use position sensor to side of swing. E Lower the magnet / use a strong(er) magnet / reduce the starting displacement / use a low(er) mass nut / different workable method of increasing adhesion. <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 2024

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 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **9** printed pages.

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 descriptions 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.

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 s is greater than a and $(a + s) \leq 70.0$ cm.	1
1(b)	Six (or more) sets of readings of a (different values) and s with the correct trend (as a increases, s decreases) and without help from supervisor scores 5 marks, five sets scores 4 marks, etc.	5
	Range: $s_{\min} \leq 10.0$ 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. $1/a$ / cm^{-1} and no unit for s/a .	1
	Consistency: <u>All</u> raw values of a and s must be given to the nearest mm.	1
	Significant figures: All values of s/a must be given to the same number of s.f. as (or one more than) the least number of s.f. in raw a and s values.	1
	Calculation: Values of s/a are correct.	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, no awkward scales (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) on the grid for this mark to be awarded. It must be possible to draw a straight line that is within $\pm 0.2 \text{ m}^{-1}$ (0.002 cm^{-1}) on the $1/a$ axis (normally x -axis) of <u>all</u> plotted points.	1

PUBLISHED

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 five 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 small 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 five 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. Method of calculation must be correct (not $\Delta x / \Delta y$). Gradient sign on answer line consistent with graph drawn.	1
	y-intercept: Intercept read directly from the graph, with read-off at $1/a = 0$, accurate to half a small square in y direction. or Correct read-off from a point on the line substituted 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)(i)	Value of P = candidate's gradient value and value of Q = candidate's y-intercept value. The values must not be written as fractions, roots or given to one significant figure.	1
	Correct unit for P: m or cm or mm and no unit for Q.	1
1(d)(ii)	Correct calculation of R with correct unit, e.g. g.	1

PUBLISHED

Question	Answer	Marks
2(a)(i)	Final L value in the range 89.0–91.0 cm with unit and L to nearest mm.	1
	Final d value in the range 8.00–12.00 mm with unit and <u>all</u> raw values to the nearest 0.01 mm or <u>all</u> to the nearest 0.001 mm.	1
2(a)(ii)	Justification for significant figures in V linked to significant figures in L and d .	1
2(b)(i)	S_0 in the range 0.030–0.150 m.	1
2(b)(ii)	Percentage uncertainty based on an absolute uncertainty in S_0 in range 0.2 cm (0.002 m) to 0.6 cm (0.006 m). Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty / value from 2(b)(i)) $\times 100$. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	1
2(b)(iii)	Correct calculation of k .	1
2(c)	Final T in range $0.30 \text{ s} \leq T \leq 0.70 \text{ s}$.	1
	At least two measurements of nT where $n \geq 5$.	1
2(d)	Second value of M and second value of T .	1
	Second value of $T >$ first value of T .	1
2(e)	Two values of r calculated correctly. The final r values must not be written as fractions or given to only to one significant figure	1
2(f)	Calculation of percentage difference between candidate's two ρ 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 S_0 or S_1 with a reason e.g. <u>ruler</u> disturbs lower rod while measuring / parallax error / <u>ruler</u> moves during measurement as hand-held. C S_0 and/or S_1 vary along the length of the rods with reason e.g. springs are of different lengths / rods bend / rod(s) not uniform. D Difficult to measure time or T with reason e.g. difficult to judge / identify / tell / know the start or end of an oscillation. E Difficulty with oscillation(s) with reason e.g. springs move on rod / other modes of oscillation are present / mass hanger swings (or moves) on rod / mass (hanger) hits the stand. <i>1 mark for each point up to a maximum of 4.</i>	4

PUBLISHED

Question	Answer	Marks
2(g)(ii)	A Take more readings <u>and</u> plot a graph or take more readings <u>and</u> compare ρ values (not “repeat readings” on its own). B Clamp ruler / pointers on rule or use calipers or measure between middles of rods / measure diameter of rod and take account in measurement. C Use springs of identical length (and spring constant) or adjust positions of springs so that the extensions of each spring are the same or move mass hanger to make rods parallel. D Fiducial mark <u>at the centre</u> of the oscillation or video / record / film with timer in view or view frame by frame or motion / position sensor located under the lower rod / mass hanger E Carve / use grooves in rod or method of attachment <u>to rod</u> e.g. tape / glue / use adhesive putty for the springs or string <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 2024

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.

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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.

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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 x in range 12.0–16.0 cm, with unit.	1
	Raw values to nearest degree and final value of θ in range 10°–30°.	1
1(b)	Six (or more) sets of readings of x (different values) and θ with correct trend (x increases, θ decreases) and without help from supervisor scores 5 marks, five sets scores 4 marks etc.	5
	Range: $x_{\min} \leq 5.0 \text{ cm}$ and $x_{\max} \geq 20.0 \text{ cm}$.	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. x / cm . $1 / \tan \theta$ must have no unit.	1
	Consistency: <u>All</u> values of <u>raw</u> x must be given to the nearest mm.	1
	Significant figures: All values of $1 / \tan \theta$ given to same (or one more) number of s.f. as raw θ .	1
	Calculation: Values of $1 / \tan \theta$ calculated correctly.	1
1(c)(i)	Axes: Axes must be labelled with the required 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, no awkward scales (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: All points in the table must be plotted (at least 5) for this mark to be awarded. Trend of points must be positive. It must be possible to draw a straight line that is within ± 0.20 on the $1 / \tan \theta$ axis (normally y -axis) of <u>all</u> plotted points.	1

PUBLISHED

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 five 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 five 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. Method of calculation must be correct (not $\Delta x / \Delta y$). Gradient sign on answer line consistent with 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 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)	a equal to candidate's gradient value and b equal to candidate's intercept value. Values must not be written as fractions, roots or given to only one significant figure.	1
	Units for a and b correct and consistent with readings (e.g. cm^{-1} for a and no unit for b).	1

PUBLISHED

Question	Answer	Marks
2(a)	Raw D to nearest mm and final value for D in range 17.0–19.0 cm.	1
2(b)(i)	Raw p to nearest mm.	1
2(b)(ii)	Percentage uncertainty based on an absolute uncertainty in p in range 2–5 mm. Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty / value from 2(b)(i)) $\times 100$. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	1
2(c)(i)	Period determined correctly and final value for T with unit in range 0.60–1.10 s.	1
	Evidence of repeated readings for T (at least two values of at least $5T$).	1
2(c)(ii)	Correct calculation of ϕ .	1
2(d)	Second value for p .	1
	Second value for T .	1
	Second value of $T < \text{first value of } T$.	1
2(e)(i)	Two values of k calculated correctly. The final k values must not be written as fractions, roots or given to only one significant figure.	1
2(e)(ii)	Justification based on the significant figures in D , p and raw times.	1
2(f)	Valid calculation of percentage difference between candidate's two k 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 p with a reason e.g. parallax error / difficult to determine (judge) centre of bob / ruler not parallel to string. C Problem with matching bob movement to circle with reason e.g. difficult to judge whether path of bob matches circle drawn. D Difficult to keep (rotation) speed constant. E Problem with measurement of time with reason e.g. difficult whilst maintaining motion of bob / difficult to judge when one rotation is complete <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 bob diameter <u>and</u> knot to edge of bob / workable method of avoiding parallax. C Put paper lower down e.g. on floor and view from above / rotate inside a cylinder instead of above line (to judge path). D Valid method to maintain constant rotation e.g. use motor (instead of hand). E Video/film/record with timer in view or replay frame by frame or pointer or mark on circle e.g. radius line. <i>1 mark for each point up to a maximum of 4.</i>	4