



Cambridge International AS & A Level

PHYSICS

9702/31

Paper 3 Advanced Practical Skills 1

May/June 2023

MARK SCHEME

Maximum Mark: 40

Published

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GENERIC MARKING PRINCIPLE 1:

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- 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.

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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).

GENERIC MARKING PRINCIPLE 6:

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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.
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	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • 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 <i>n</i> responses may be ignored even if they include incorrect science.

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

Question	Answer	Marks
1(a)	Value of S_1 with unit and $10.0 \text{ cm} \geq S_1 \geq 2.0 \text{ cm}$.	1
1(b)(i)	Values of L_1 and L_2 to the nearest mm with unit.	1
1(b)(ii)	e_1 and e_2 correctly calculated and $e_2 > e_1$.	1
1(c)	Five sets of readings of x (different values), L_1 and L_2 with correct trend (as x increases L_1 decreases and L_2 increases) and without help from Supervisor scores 5 marks, four sets scores 4 marks, etc.	5
	Range: $50.0 \text{ cm} \leq x_{\min} \leq 55.0 \text{ cm}$ and $x_{\max} \geq 95.0 \text{ cm}$.	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit conforms to accepted scientific convention e.g. x/cm , L_1/cm , no unit for e_2/e_1 .	1
	Calculation: Correct calculation of e_2/e_1 .	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 x and y directions. Scale markings are no more than 2 cm apart (one large square). Sensible scales must be used. Scale 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 less than 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. It must be possible to draw a straight line that is within ± 0.1 (to scale) on the e_2/e_1 axis of all plotted points.	1

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 4 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 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 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 is accurate to half a small square in both x and y directions.	1
1(e)	Value of P = candidate’s gradient and value of Q = – candidate’s intercept value. Values must not be written as fractions or given to one significant figure.	1
	Units for P consistent with readings: m^{-1} or cm^{-1} or mm^{-1} and no unit given for Q.	1
1(f)	W line shown with larger gradient (and larger negative value of y-intercept).	1

Question	Answer	Marks
2(a)	Value of a to the nearest mm and (final) a in the range 23.0–25.0 cm with unit.	1
2(b)	Value of final t in the range 10.50–12.50 s with unit.	1
	Evidence of repeat readings for t .	1
2(c)(i)	Value of l in the range 27.0–39.0 cm with unit and correct calculation of $(l - a)$.	1
2(c)(ii)	Absolute uncertainty in $(l - a)$ in range 3–8 mm. Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty / value from (c)(i)) $\times 100$. 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(d)	Second values of a and t .	1
	Second value of l .	1
	Second value of $(l - a) >$ first value of $(l - a)$.	1
2(e)(i)	Two values of C calculated correctly. The final C values must not be written as fractions or given to one significant figure.	1
2(e)(ii)	Justification for significant figures in C linked to significant figures in a and $(l - a)$.	1
2(f)	Calculation of percentage difference between candidate's two C values. Comparison of percentage difference with 5% leading to a consistent conclusion.	1
2(g)	Correct calculation of g in the range 9.0–12.0 m s ⁻² with consistent unit.	1

Question	Answer	Marks
2(h)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Difficult to ensure $t_{\text{wooden strip}} = t_{\text{pendulum}}$. C Difficult to measure a with a reason e.g. finding centre of hole/<u>strip moves</u> on pivot. D Difficult to measure l with a reason e.g. parallax/bob moves when touched by rule/rule moves/rule not vertical/deciding position of centre of bob. E Difficult to measure t or time for 10 oscillations with a reason e.g. judging/determining the start of or end of or one complete oscillation/strip wobbling/strip oscillating in different planes. F Times for holes G and H are close/small difference. G Difficult to balance wooden strip. <i>1 mark for each point up to a maximum of 4.</i>	4
2(h)(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 ensure t values are the same e.g. use two stands allowing wood and pendulum to oscillate at the same time. C Improved method to measure a e.g. draw a scale on the strip/mark position of the pivot on strip/grooves on lower side/roughen strip lower surface. D Improved method for measuring l e.g. rule with pointers/clamp ruler/measure diameter of bob <u>and</u> add or subtract or find radius. E Improved method for measuring t e.g. video or record or film <u>and</u> timer or replay frame-by-frame/use a (fiducial) marker at the <u>centre</u> of the oscillation. F Holes further apart. <i>1 mark for each point up to a maximum of 4.</i>	4



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Paper 3 Advanced Practical Skills 2

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Question	Answer	Marks
1(a)	Final value of x with unit in range 29.0–31.0 cm.	1
	Value of θ to nearest degree and in the range 60–80°.	1
1(b)	Six sets of readings of x (different values) and θ with correct trend (as x increases θ increases) and without help from the Supervisor scores 4 marks, five sets scores 3 marks, etc.	4
	Range: $x_{\min} \leq 10.0$ cm and $x_{\max} \geq 55.0$ 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. $\theta / ^\circ$, x / cm . $\cos \theta$ must not have a unit.	1
	Consistency: All values of x must be given to the nearest millimetre.	1
	Significant figures: Values of $\cos \theta$ given to 2 or 3 significant figures.	1
	Calculation: Values of $\cos \theta$ calculated correctly.	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 x and y directions. Scale markings are no more than 2 cm apart (one large square). Sensible scales must be used. Scale 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 less than 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 on the grid. It must be possible to draw a straight line that is within ± 4.0 cm (to scale) on the x-axis of all plotted points.	1
1(c)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 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 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 is accurate to half a small square in both x and y directions.	1

Question	Answer	Marks
1(d)	Value of a = candidate's gradient and value of b = candidate's intercept. Values must not be written as fractions 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
1(e)	Correct calculation of S with unit (e.g. N m^{-1} or N cm^{-1}).	1

Question	Answer	Marks
2(a)(i)	Value for D_1 to nearest mm and in range $4.0 \text{ cm} \leq D_1 \leq 6.0 \text{ cm}$.	1
	Correct calculation of C .	1
2(a)(ii)	Justification for significant figures in C linked to significant figures in M_1 <u>and</u> D_1 .	1
2(a)(iii)	All values of T to nearest 0.01 s or all to the nearest 0.1 s, with unit.	1
	Evidence of repeat readings of T .	1
2(b)(i)	Value for D_2 that is greater than D_1 .	1
2(b)(ii)	Absolute uncertainty in D_2 in the range 0.2–0.5 cm. Correct method of calculation to find percentage uncertainty in D_2 , e.g. (absolute uncertainty / value from 2(b)(i)) $\times 100$. If repeated readings have been taken, then the absolute uncertainty can be half the range (but not zero) provided the working is clearly shown.	1
2(b)(iii)	Correct calculation of new value of C .	1
2(b)(iv)	Value for T .	1
	New value of T greater than first T .	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

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 measure T or time with a reason e.g. difficult to judge when mass hanger reaches the floor/difficult to judge start of descent of mass hanger. C Time or T is short so uncertainty in T is large or percentage uncertainty in T is large. D Difficult to measure D_1 or D_2 or diameter with a reason e.g. plastic tube gets in way of ruler/parallax error. E Difficulty with D_2 with a reason e.g. inconsistent thickness of clay layer, thickness of clay layer varies. F Difficult to exactly judge 16 turns of the flywheel/difficult to exactly judge number of turns of the flywheel. G Mass hanger does not fall smoothly/consistently/hanger stops and starts. <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 Use video/record/film (descent of mass hanger in view) and timer in view/view frame-by-frame. C Method to increase T or time e.g. use longer drop/decrease mass of mass hanger/increase number of turns. D Use (vernier) calipers. E Hold a roller on the modelling clay while flywheel is turned/use a preformed ring of clay/use a mould/flatten clay between boards. F Use height change (preset height) instead of turns or use fiducial mark and line up with slot on mass/mark on mass. G Improved method to allow hanger to fall smoothly e.g. support bamboo rod at both ends/use tube with circular cross-section. <i>1 mark for each point up to a maximum of 4.</i>	4



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1(a)	Value of L in the range 40.0–50.0 cm with consistent unit.	1
1(b)	Value of T in the range 1.0–1.5 s with unit.	1
	Evidence of repeats of nT where $n \geq 5$.	1
1(c)	Six sets of readings of L (different values) and time with correct trend (time increases as L increases) and without help from the Supervisor scores 4 marks, five sets scores 3 marks, etc.	4
	Range: $L_{\min} \leq 30.0$ cm and $L_{\max} \geq 55.0$ cm.	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit conforms to scientific convention e.g. T^3/s^3 and L^2/m^2 .	1
	Consistency: All raw values of L given to the nearest millimetre.	1
	Significant figures: All values of L^2 must be given to the same number of s.f. as (or one more than) the number of significant figures in raw L .	1
	Calculation: Correct calculation of L^2 .	1

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Question	Answer	Marks
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 x and y directions. Scale markings are no more than 2 cm apart (one large square). Sensible scales must be used. Scale 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 less than 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. It must be possible to draw a straight line that is within $\pm 0.02 \text{ m}^2$ (200 cm^2) on the L^2 axis of all plotted points.	1
1(d)(ii)	Line of best fit: 'Best fit' is judged by 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 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 5 points left after the anomalous point is disregarded.	1

PUBLISHED

Question	Answer	Marks
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 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 $L^2 = 0$, 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 is accurate to half a small square in both x and y directions.	1
1(e)	Value of E = candidate's gradient and value of F = candidate's intercept. The values must not be written as fractions or given to only one significant figure.	1
	Units for E consistent with readings: $s^3 m^{-2}$ or $s^3 cm^{-2}$ and units for F : s^3 .	1

PUBLISHED

Question	Answer	Marks
2(a)(i)	Values of h and x to the nearest mm.	1
2(a)(ii)	Correct calculation of A in the range 150–170 cm ² .	1
2(a)(iii)	Justification for significant figures in A linked to significant figures in x <u>and</u> h .	1
2(b)(i)	Values of c and d to the nearest mm.	1
	Values of c and d in the range 6.0–8.0 cm.	1
2(b)(ii)	Percentage uncertainty in c based on absolute uncertainty in the range 2–8 mm. Correct method of calculation to obtain percentage uncertainty e.g. (absolute uncertainty / value from (b)(i)) $\times$ 100. If several readings have been taken, then the absolute uncertainty can be half the range (but not zero) provided the working is shown clearly.	1
2(c)(i)	Raw value(s) of x to the nearest mm in the range 8.5–9.5 cm.	1
2(c)(ii)	Second value of c .	1
	Second value of d .	1
	Second values of c and d less than first values of c and d respectively.	1
2(d)	Two values of k calculated correctly. The final k values must not be written as a fraction 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 5% 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 draw lines with reason e.g. ruler moving/card moving/nail in the way/no support behind card/card flexible/parallax error/card suspended. C Difficult to judge vertical/get line vertical/get ruler vertical. D Lines did not meet at a point/not unique intersection/triangle of error. E Problem with card e.g. difficult to cut parallel edge/card bends or deforms or tears when nail punches. F Card doesn't hang or swing freely or friction <u>between card and nail</u>. <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 x) <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 or mark card and then remove and draw line with card on the bench. C Use plumb-line or spirit level. D Use more holes/lines (to locate the point more accurately) or use thinner nail/needle/pin/smaller holes. E Use a hole punch or use support beneath when punching nail or use a guillotine/template/paper trimmer/rotary cutter /paper cutter or score with a (sharp) knife along (metal) ruler. <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

May/June 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 May/June 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U 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	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • 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 <i>n</i> 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)	Value of M with unit and in range 10–100 g.	1
	Value of T with unit and in range 0.950–2.00 s.	1
	Repeats: At least two measurements of at least $5T$.	1
1(b)	Six sets of readings of M (different values, may include 0 g) and T (or time) with correct trend (as M increases T increases) <u>and</u> without help from the Supervisor scores 4 marks, five sets scores 3 marks etc.	4
	Range: $M_{\min} \leq 10 \text{ g}$ and $M_{\max} \geq 70 \text{ g}$.	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit conforms to accepted scientific convention e.g. M^2/g^2 .	1
	Consistency: <u>All</u> values of raw time must be given to the nearest 0.01 s or <u>all</u> to the nearest 0.1 s.	1
	Significant figures: Values of T^2 must be given to the same number of s.f. as (or one more than) the number of s.f. in the corresponding T .	1
	Calculation: Values of T^2 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 x and y directions. Scale markings are no more than 2 cm apart (one large square). Sensible scales must be used. Scale 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 less than 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. It must be possible to draw a straight line that is within $\pm 500 \text{ g}^2$ (to scale) on the M^2 axis of all plotted points.	1
1(c)(ii)	Line of best fit: 'Best fit' is judged by 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 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 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 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 $M^2 = 0$, 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 is 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 intercept. Values must not be written as fractions or given to only one significant figure.	1
	Correct units for a and b (e.g. s^2g^{-2} for a and s^2 for b).	1

PUBLISHED

Question	Answer	Marks
2(a)	Value for L with unit, to nearest mm and in range 11.7–12.7 cm.	1
	Value for T_0 with unit and to nearest degree.	1
2(b)(i)	Value for x_1 with unit and to nearest mm.	1
2(b)(ii)	Value for T greater than T_0 .	1
	Value of x_2 different from x_1 .	1
2(b)(iii)	Correct calculation of $(x_1 - x_2)$.	1
2(b)(iv)	Percentage uncertainty in $(x_1 - x_2)$ based on absolute uncertainty in the range 0.2–0.5 cm. Correct method of calculation to obtain percentage uncertainty e.g. (absolute uncertainty / value from (b)(iii)) $\times 100$. If several readings have been taken, then the absolute uncertainty can be half the range (but not zero) provided the working is shown clearly.	1
2(c)	Second values of L , x_1 , T and x_2 .	1
	Second L less than first L .	1
2(d)(i)	Two values of k calculated correctly. The final k values must not be written as fractions.	1
2(d)(ii)	Justification for significant figures in k linked to significant figures in $(x_1 - x_2)$, L and $(T - T_0)$.	1
2(e)	Calculation of percentage difference between candidate's two k values. Comparison of percentage difference with 20% leading to a consistent conclusion.	1

Question	Answer	Marks
2(f)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Difficult to measure x or <u>height</u> with a reason e.g. rod moves/rule not vertical/ruler moves. C $(x_1 - x_2)$ is small so large uncertainty or large % uncertainty in $(x_1 - x_2)$. D Difficult to measure T or <u>water temperature</u> with a reason e.g. T varies with position in measuring cylinder/thermometer touches sides of cylinder/cannot measure x and T at the same time/T decreases rapidly. E T_0 or <u>room temperature</u> may change during the experiment. F Difficulty with pipe e.g. difficult to measure L because pipe is curved/pipe does not expand as expected/L is not the distance between the holes. G Difficulty with string e.g. string changes length when wet. <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 x) <u>and</u> plot a graph or take more readings <u>and</u> compare k values (not “repeat readings” on its own). B Clamp rule/use a plumb line. C Increase length of rod/pipe. D Use a stirrer for the water/clamp thermometer/<u>thermostatically controlled</u> water bath. E Measure T_0 just before water is added. F Use tape measure/string and ruler or make L the distance between the holes. G Use named waterproof material e.g. nylon string/plastic/metal wire. <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

May/June 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
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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.
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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	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • 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 <i>n</i> responses may be ignored even if they include incorrect science.

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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 of raw I_1 to the nearest 0.1 mA with unit and in range 0–1.0 A.	1
1(b)	Value of I_2 and $I_2 < I_1$.	1
1(c)	Six sets of readings of w (different values), I_1 and I_2 with correct trend (as w increases I_1 and I_2 decrease) and without help from the Supervisor scores 5 marks, four sets scores 4 marks etc.	5
	Range: $w_{\min} \leq 60.0 \text{ cm}$ and $w_{\max} \geq 90.0 \text{ cm}$.	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit conforms to accepted scientific convention e.g. $I_1 I_2 / \text{mA}^2$ and $1 / w / \text{cm}^{-1}$.	1
	Consistency: All values of w must be given to the nearest millimetre.	1
	Calculation: Correct calculation of $I_1 I_2$.	1
	Significant figures: Values of $I_1 I_2$ must be given to the same number of s.f. as (or one more than) the least number of significant figures in I_1 or I_2 .	1

PUBLISHED

Question	Answer	Marks
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 x and y directions. Scale markings are no more than 2 cm apart (one large square). Sensible scales must be used. Scale 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 less than 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. It must be possible to draw a straight line that is within $\pm 0.05 \text{ m}^{-1}$ (to scale) on the $1/w$ axis of all plotted points.	1
1(d)(ii)	Line of best fit: 'Best fit' is judged by 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 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 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 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 $1/w = 0$, 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 is accurate to half a small square in both x and y directions.	1

PUBLISHED

Question	Answer	Marks
1(e)	Value of P = candidate's gradient and value of Q = candidate's intercept. Values must not be written as fractions or given to only one significant figure.	1
	Units for P consistent with readings: $\text{mA}^2 \text{ cm}$, $\text{mA}^2 \text{ m}$, $\text{A}^2 \text{ cm}$ or $\text{A}^2 \text{ m}$ and units for Q : mA^2 or A^2 .	1

Question	Answer	Marks
2(a)(i)	Value of (raw) D to the nearest mm and (final) value in the range 6.5–7.5 cm with unit.	1
2(a)(ii)	Percentage uncertainty in D based on absolute uncertainty in the range 2–5 mm. Correct method of calculation to find percentage uncertainty (e.g. absolute uncertainty / value from (a)(i)) $\times 100$. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) provided the working is clearly shown.	1
2(b)	Value of T_1 in the range 1.2–1.6 s with unit.	1
	Repeats: at least two measurements of nT where $n \geq 5$.	1
2(c)(i)	Value of T_2 and $T_2 < T_1$.	1
2(c)(ii)	Correct calculation of $(T_1 - T_2)$.	1
2(d)	Second values of L and D .	1
	Second values of T_1 and T_2 .	1
	Second value of $(T_1 - T_2) > \text{first value of } (T_1 - T_2)$.	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 $(T_1 - T_2)$, D and L .	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

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 D with reason e.g. parallax/shape of jar. C Difficult to set or measure L with reason e.g. locating centre of bob/parallax/bob moves when touched by rule/rule moves/rule not vertical/string slipping through cork. D Large percentage uncertainty in $(T_1 - T_2)$ or large uncertainty in $(T_1 - T_2)$ because T_1 and T_2 are similar or change in $(T_1 - T_2)$ is small. E Difficult to measure nT with reason e.g. judge start/end of oscillation/complete oscillation. F Difficulty with practical setup e.g. clamping cylinder in right position/ensuring adhesive putty is at the top. <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 x) <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 D e.g. use (vernier) calipers/place blocks either side of cylinder. C Improved method to measure L e.g. rule with pointers/clamp rule/measure diameter of bob and add/subtract/find radius. D Use larger values of D/larger difference in D. E Method to improve timing e.g. video/record/film <u>with</u> timer/frame-by-frame/use fiducial marker at the centre of oscillation. F Method to improve setup e.g. use a plumb-line. <i>1 mark for each point up to a maximum of 4.</i>	4