
PHYSICS

9702/31

Paper 3 Advanced Practical Skills 1

May/June 2018

MARK SCHEME

Maximum Mark: 40

Published

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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:

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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:

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Question	Answer	Marks
1(a)	Value of raw d to nearest mm with unit and in the range 29.0–31.0 cm.	1
1(b)	Value of T in the range 0.8–2.0 s with unit and evidence of at least two sets of nT where $n \geq 5$.	1
1(c)	Second set of values of s and T .	1
1(d)	Five sets of readings of s and time (different values) with the correct trend and without help from the Supervisor scores 4 marks, four sets scores 3 marks etc.	4
	Range: at least one value of $s \leq 70.0$ cm and at least one value of $s \geq 85.0$ 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. s/cm , T/s , T^2/s^2 or $T^2 (\text{s}^2)$.	1
	Consistency: All raw time values must be given to 0.1 s or all given to 0.01 s.	1
	Significant figures: All 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 raw value(s) of time. If raw times are given to 0.01 s, allow T^2 to be recorded to 1 s.f. less than the raw times.	1
	Calculation: Values of T^2 are correct.	1

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Question	Answer	Marks
1(e)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	1
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leq$ half a small square (no “blobs”). Points must be plotted to an accuracy of half a small square.	1
	Quality: All points in the table must be plotted on the grid for this mark to be awarded. It must be possible to draw a straight line that is within ± 2.5 cm (to scale) on the s axis (normally x axis) of all plotted points.	1
1(e)(ii)	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 4 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least four points left after the anomalous point is disregarded. Line must not be kinked or thicker than half a small square.	1
1(e)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions. Sign of gradient must match graph.	1
	y-intercept: Correct read-off from a point on the line substituted correctly into $y = mx + c$ or an equivalent expression. Read-off must be accurate to half a small square in both x and y directions. or Intercept read directly from the graph, with read-off at $s = 0$, accurate to half a small square in y direction.	1

Question	Answer	Marks
1(f)	Value of P = candidate's gradient and value of Q = candidate's intercept. The values must not be fractions.	1
	Unit for P correct (e.g. s^2m^{-1} or s^2cm^{-1} or s^2mm^{-1}). and Unit for Q is s^2 .	1

Question	Answer	Marks
2(a)	Value of x with unit and in the range 1.0–5.0 mm.	1
2(b)	All value(s) of raw y to nearest mm with unit.	1
	Evidence of repeat values of y .	1
2(c)	Absolute uncertainty in y in the range 2–4 mm. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to find percentage uncertainty.	1
2(d)	Second value of x .	1
	Second value of y .	1
	Quality: second value of y < first value of y .	1
2(e)(i)	Two values of k calculated correctly.	1
2(e)(ii)	Valid comment consistent with the calculated values of k , testing against a criterion stated by the candidate.	1
2(f)(i)	Value of y .	1
2(f)(ii)	Correct calculation of x .	1
2(f)(iii)	Justification for s.f. in x linked to s.f. in y .	1

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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 alignment at A with a reason e.g. string twists/magnet will not settle/magnet continually moves/draughts or air conditioning disturb magnet. C Difficulty with finding position C or position after 30 oscillations or finding y with a reason e.g. magnet only stays at position C for a short time/difficult to estimate where magnet will stop/difficult to judge the end of an oscillation/parallax. D Difficulty linked to x with a reason e.g. metre rule (too large or not precise enough/large <u>percentage</u> uncertainty in x/value of x is small/ adjustment difficult or clumsy with clamp and cork/angled lower surface of magnet. E Difficulty with the oscillation e.g. magnet rotates while swinging/wrong mode of oscillation/magnetic stand attracts the magnet affecting its motion. <i>1 mark for each point up to a maximum of 4.</i>	4
2(g)(ii)	A Take many readings <u>and</u> plot a graph or take more readings <u>and</u> compare k values (not “repeat readings” on its own). B Improved method of alignment with A e.g. valid improvement to suspension e.g. nylon thread/wire/double point of suspension/switch off AC/windshield. C Improved method of locating C e.g. use a scale/use of a pointer with detail of how pointer is used e.g. attached to magnet/use to refine position of C. D1 Improved method to adjust x e.g. scissor jack/rearrange suspension to use screw thread on clamp. D2 Improved method to measure x e.g. travelling microscope/vernier or digital calipers/use of thin spacers e.g. sheets of paper/shim. E Use a wooden or plastic stand i.e. a named non-magnetic material. <i>1 mark for each point up to a maximum of 4.</i>	4

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Paper 3 Advanced Practical Skills 2

May/June 2018

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GENERIC MARKING PRINCIPLE 3:

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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:

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.

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Question	Answer	Marks
1(a)(i)	Value of h to nearest mm, with unit.	1
1(a)(ii)	Value of t in the range 1.0–5.0 s, with unit.	1
	At least two readings of t .	1
1(b)	Six sets of readings of h and t showing the correct trend and without help from the Supervisor scores 4 marks, five sets scores 3 marks etc.	4
	Range: $t_{\max} \geq 2.0 \text{ s}$ and $t_{\min} \leq 1.5 \text{ s}$.	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. $(1/t^2)/\text{s}^{-2}$.	1
	Consistency: All raw values of t must be given to 0.01 s or all must be given to 0.1 s.	1
	Significant figures: Significant figures for every value of $1/t^2$ same as, or one greater than, the number of s.f. of t as recorded in table.	1
	Calculation: Values of $1/t^2$ calculated correctly to the number of s.f. given by the candidate.	1

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Question	Answer	Marks
1(c)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	1
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leq$ half a small square (no “blobs”). Plots must be accurate to within 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. Scatter of points must be no more than $\pm 0.05\text{s}^{-2}$ from a straight line in the $1/t^2$ direction.	1
1(c)(ii)	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 5). There must be an even distribution of points either side of the line along the full length. Allow one anomalous only if clearly indicated (i.e. circled or labelled) by the candidate. Lines must not be kinked or thicker than half a small square.	1
1(c)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions. Sign of gradient must match graph.	1
	y-intercept: Correct read-off from a point on the line substituted into $y = mx + c$ or an equivalent expression. Read-off must be accurate to half a small square in both x and y directions. or Intercept read directly from the graph, with read-off at $x = 0$ accurate to half a small square in y direction.	1
1(d)	Value of a equal to candidate's gradient and value of b equal to candidate's intercept.	1
	Unit for a correct (e.g. $\text{mm}^{-1}\text{s}^{-2}$ or $\text{cm}^{-1}\text{s}^{-2}$) and unit for b is s^{-2} .	1

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Question	Answer	Marks
2(a)	Value for L to nearest mm with unit and in range 50.0–75.0 cm.	1
2(b)	Value for x with unit.	1
	Raw value(s) of x to nearest mm and value on answer line in range 100–200 mm.	1
2(c)	Absolute uncertainty in x value of 0.2–0.5 cm and correct method of calculation to obtain percentage uncertainty. If repeated readings have been taken, then the absolute uncertainty can be half the range (but not zero) if the working is clearly shown.	1
2(d)	Correct calculation of λ to the number of significant figures used by the candidate.	1
2(e)	Justification linking s.f. in λ to s.f. in L .	1
2(f)	Correct calculation of f .	1
2(g)	Second values of L and x .	1
	Quality: x increases as μ increases.	1
	Second values of λ and f .	1
2(h)(i)	Two values of k calculated correctly.	1
2(h)(ii)	Valid comment consistent with the calculated values of k , testing against a numerical criterion specified by the candidate.	1

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Question	Answer	Marks
2(i)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Difficult to see string <u>pattern</u>. C String pattern dies away quickly. D Difficult to produce <u>exact pattern</u> required. E Difficulty with wooden block e.g. doesn't grip blade/hard to hold down block and oscillate blade/view pattern at same time. F Hacksaw/mass not at a node in the string pattern. <i>1 mark for each point up to a maximum of 4.</i>	4
2(i)(ii)	A Take many readings <u>and</u> plot a graph or take more values of k <u>and</u> compare (not “repeat readings” on its own). B Put contrasting/black/white background behind string. C Use photo/video <u>to assess pattern</u> or description of workable method of producing continuous oscillations. D Add a scale/marks to hacksaw blade. E Clamp/put weight on the movable wooden block. F Workable solution to allow a node e.g. move excitation point away from node/use heavier mass. <i>1 mark for each point up to a maximum of 4.</i>	4

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Question	Answer	Marks
1(a)	Values of V_1 and V_2 with units and to the nearest 0.01 V.	1
	$ V_2 > V_1 $.	1
1(b)	Six sets of readings of x , V_1 and V_2 (different values) showing the correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks etc.	5
	Range: $x_{\min} \leq 10.0 \text{ cm}$ and $x_{\max} \geq 70.0 \text{ cm}$.	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. $(V_1/x)/\text{Vm}^{-1}$.	1
	Consistency: All values of x must be given to the nearest mm.	1
	Significant figures: All values of V_1/x must be given to 2 or 3 s.f.	1
	Calculation: Values of V_1/x are correct.	1
1(c)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	1
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leq$ half a small square (no “blobs”). Points must be plotted to an accuracy of half a small square.	1
	Quality: All points in the table must be plotted on the grid for this mark to be awarded. It must be possible to draw a straight line that is within 0.040 on the $(V_2 - V_1)$ axis of all plotted points.	1

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Question	Answer	Marks
1(c)(ii)	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 5). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated by the candidate. Line must not be kinked or thicker than half a small square.	1
1(c)(iii)	Gradient: The hypotenuse of the triangle used should be greater than half the length of the drawn line. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions. Sign of gradient must match graph.	1
	y-intercept: Correct read-off from a point on the line substituted into $y = mx + c$. Read-off must be accurate to half a small square in both x and y directions. or Intercept read directly from the graph with read-off at $x = 0$, accurate to half a small square.	1
1(d)	Value of P = candidate's gradient and value of Q = candidate's intercept. The values must not be fractions.	1
	Unit for P correct (e.g. m or cm or mm) and unit of Q correct (e.g. V) unless zero.	1

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Question	Answer	Marks
2(a)	Value of L to the nearest mm with unit and in range 50.0–60.0 cm.	1
2(b)(i)	Value of A to the nearest degree with unit and in the range 11–17°.	1
2(b)(ii)	Percentage uncertainty in A based on absolute uncertainty of 2°–5°. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	1
2(c)(i)	Value of T in the range 1.20–1.60 s with unit.	1
	Evidence of at least two sets of nT where $n \geq 5$.	1
2(c)(ii)	Correct calculation of d .	1
2(c)(iii)	Justification for s.f. in d linked to s.f. in A (or measured angle).	1
2(d)	Second value of A .	1
	Second value of T .	1
	Quality: second value of $T >$ first value of T .	1
2(e)(i)	Two values of k calculated correctly.	1
2(e)(ii)	Valid comment consistent with calculated values of k , testing against a criterion specified by the candidate.	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 Difficult to measure L with reason e.g. locating centre of bob/parallax/bob or cork gets in the way of the ruler. C Difficult to measure A or 45° or angle with a reason e.g. no indication of vertical/hard to hold and measure from protractor/hard to hold protractor steady/string too thick/parallax error. D Problem with bob moving between setting and releasing. E Difficulty setting rod at $L/2$ with reason e.g. setting rod and angle at the same time/rod moves when tightening the clamp/rod moves when pendulum hits. F Difficulty in judging start/end of oscillation. <i>1 mark for each point up to a maximum of 4.</i>	4
2(f)(ii)	A Take many readings (for different values of A) <u>and</u> plot a graph or take more values of k <u>and</u> compare (not “repeat readings” on its own). B Improved method of measuring L e.g. measure diameter and add on (or take away) radius from length of string from cork to top (bottom) of bob, or e.g. clear use of pointer(s). C Improved method of measuring angle e.g. use a plumb line/clamp protractor/use thinner string, or e.g. shadow projection ideas/photograph and measure angle. D Improved mechanism of releasing the bob e.g. clamp bob/use a card gate/add a stop. E Mark string. F Method of improving timing e.g. put a marker anywhere except at the ends/video with timer (or replay frame by frame). <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 V_s in range 2.00–4.00 V, with unit.	1
1(b)	Value of V less than V_s .	1
	Evidence of repeat readings of V .	1
1(c)	Six sets of readings of n and V with the correct trend and without help from the Supervisor scores 4 marks, five sets scores 3 marks, etc.	4
	Range: $n_{\min} = 1$ or 0 and $n_{\max} \geq 7$.	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention, e.g. $(1/V)/V^{-1}$ or $1/V (V^{-1})$.	1
	Consistency: All raw values of V must be given to 0.01 V, without trailing zeros.	1
	Significant figures: Significant figures for every value of $1/V$ the same as, or one greater than, the s.f. of V as recorded in the table.	1
	Calculation: Values of $1/V$ calculated correctly.	1
1(d)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	1
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leq$ half a small square (no “blobs”). 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. Scatter of points must be no more than $\pm 0.025V^{-1}$ from a straight line in the $1/V$ direction.	1

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Question	Answer	Marks
1(d)(ii)	Line of best fit: Judge by balance of all 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. Allow one anomalous point only if clearly indicated by the candidate. There must be at least 5 points left after the anomalous point is disregarded. Line must not be kinked or thicker than half a small square.	1
1(d)(iii)	Gradient: The hypotenuse of the triangle used should be greater than half the length of the drawn line. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions. Sign of gradient must match graph.	1
	y-intercept: Correct read-off from a point on the line substituted into $y = mx + c$ or an equivalent expression. Read-off must be accurate to half a small square in both x and y directions. or Intercept read directly from the graph, with read-off at $n = 0$, accurate to half a small square in the y direction.	1
1(e)	Value of a equal to candidate's gradient and value of b equal to candidate's intercept.	1
	Unit for a is V^{-1} and unit for b is V^{-1} .	1

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Question	Answer	Marks
2(a)	Correct calculation of M .	1
2(b)(i)	Value for T in range 0.50–1.00 s, with unit.	1
	Evidence of repeat readings of time, with at least two sets of nT where $n \geq 5$.	1
2(b)(ii)	Absolute uncertainty in time measurement of 0.20–0.50 s and correct method of calculation to obtain percentage uncertainty. If repeated readings have been taken, then the absolute uncertainty can be half the range (but not zero) if the working is clearly shown.	1
2(c)(i)	Second value of M .	1
2(c)(ii)	Second value of T .	1
	Quality: T greater for greater M .	1
2(d)(i)	Two values of k calculated correctly.	1
2(d)(ii)	Valid comment relating to the calculated values of k , testing against a criterion specified by the candidate.	1
2(e)(i)	Value(s) for D to nearest mm and value for D (on answer line) in range 0.050–0.200 m.	1
2(e)(ii)	Correct calculation of A .	1
2(e)(iii)	Correct calculation of ρ using second value of k .	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 Reason for M not being accurate, e.g. mass of bottle ignored/uncertainty in the volume of water linked to precision of beaker. C Difficulty with oscillation with reason, e.g. masses move/bottle hits side of bucket/does not oscillate vertically/other modes of oscillation. D Difficult to measure D with reason, e.g. bottle flexes when measuring D/non-uniform D/bottle not circular/D varies with depth. E Difficult to judge when an oscillation starts/ends/is completed. <i>1 mark for each point up to a maximum of 4.</i>	4
2(f)(ii)	A Take more readings <u>and</u> plot a graph or take more values of k <u>and</u> compare (not “repeat readings” on its own). B Use electronic balance/top-pan balance or use measuring cylinder. C Method of fixing mass hanger in position in bottle, e.g. Blu-Tack, glue, tape or use suitable alternative to slotted masses, e.g. sand/lead shot/single mass or use wider bucket/larger diameter. D Use vernier/digital calipers or details of alternative method to find D, e.g. use two set squares/two wooden blocks or measure D in different directions/positions and find average. E Use video <u>and</u> timer/video <u>and</u> view frame by frame or position/motion sensor above bucket. <i>1 mark for each point up to a maximum of 4.</i>	4

PHYSICS

9702/35

Paper 3 Advanced Practical Skills 1

May/June 2018

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.

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This document consists of **7** printed pages.



Cambridge Assessment
International Education

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.

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Question	Answer	Marks
1(a)(i)	Value of z in the range 29.0–31.0 cm to the nearest mm with unit.	1
1(a)(ii)	Value of y with unit and $y \leq 35.0$ cm.	1
1(b)	Six sets of readings of x and y (different values) showing the correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks etc.	5
	Range: values of x must include at least one negative value.	1
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of the quantity and unit must conform to accepted scientific convention e.g. x/m .	1
	Consistency: All raw values of x and y must be given to the nearest mm.	1
1(c)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	1
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted point must be $\leq$ half a small square (no “blobs”). All points must be plotted to an accuracy of half a small square.	1
	Quality: All points in the table must be plotted on the grid for this mark to be awarded. It must be possible to draw a straight line that is within 1.0 cm (to scale) on the y -axis of all plotted points.	1
1(c)(ii)	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated by the candidate. Line must not be kinked or thicker than half a small square.	1

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Question	Answer	Marks
1(c)(iii)	Gradient: The hypotenuse of the triangle used should be greater than half the length of the drawn line. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions. Sign of gradient must match graph.	1
	y-intercept: Correct read-off from a point on the line and substituted into $y = mx + c$. Read-off must be accurate to half a small square in both x and y directions. or Intercept read directly from the graph with read-off at $x = 0$, accurate to half a small square.	1
1(d)	Value of A = candidate's gradient and value of B = candidate's intercept. The values must not be fractions.	1
	No unit for A and unit for B correct (m, cm, mm).	1
1(e)	Correct calculation of p to the number of s.f. given by the candidate.	1
1(f)	Line W drawn with the same gradient but lower value of y-intercept.	1

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Question	Answer	Marks
2(a)(i)	Value of T less than 1.0s with unit and evidence of at least two sets of nT where $n \geq 5$.	1
2(a)(ii)	Correct calculation of f to the number of s.f. given by the candidate.	1
2(a)(iii)	Justification for s.f. in f linked to s.f. in time or period.	1
2(b)(i)	Value of n .	1
2(b)(ii)	Value of I .	1
2(b)(iii)	Percentage uncertainty in I based on absolute uncertainty $\geq 0.2 \mu\text{A}$. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	1
2(c)(i)	Second value of T .	1
	Second value of $T >$ first value of T .	1
2(c)(ii)	Values of n and I .	1
	Quality: second $I <$ first I .	1
2(d)(i)	Two values of k calculated correctly.	1
2(d)(ii)	Valid comment consistent with calculated values of k , testing a criterion specified by the candidate.	1

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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 Reason for difficulty with oscillation e.g. magnet struck top of tube/magnet not passing through all turns/some turns are not near magnet/magnet oscillates outside of coil. C Difficulty in judging end/start of (complete) oscillation. D Difficulty with the current readings with reason e.g. because of positive and negative values/meter does not refresh quickly enough/current small/resistance of connecting leads high/maximum current lasts for short time. E Difficulty with the practical setup e.g. tube fell over/magnet fell off/spring moving along rod. F n is not a whole number. <i>1 mark for each point up to a maximum of 4.</i>	4
2(e)(ii)	A Take many readings (for different values of n or f) <u>and</u> plot a graph or take more values of k <u>and</u> compare (not “repeat readings” on its own). B Method of improving difficulty with oscillation e.g. use wider tube/use shorter tube/bunch up coils/longer magnet. C Method of improving timing e.g. put a marker with position (except at the ends)/video with timer (or replay frame by frame)/position or motion sensor placed below. D Method to reduce difficulties with current e.g. use (centre-zero) analogue meter/use c.r.o./galvanometer/use more turns of wire/smaller masses/stiffer spring/stronger magnet/sand contacts/video ammeter and replay to find maximum current. E Named method of attaching to table/holder e.g. clamp tube/tape magnet to weight/tape spring to rod/tape tube to table. F Calculate n from the length of the wire and the diameter of the tube. <i>1 mark for each point up to a maximum of 4.</i>	4