
PHYSICS

9702/31

Paper 3 Advanced Practical Skills 1

May/June 2019

MARK SCHEME

Maximum Mark: 40

Published

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GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

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)	Value of <u>raw</u> v to nearest mm, with final value in the range 3.0–7.0 cm with a unit.	1
1(b)	Value of $x < y$.	1
1(c)	Six sets of readings of x and y (different values) with the correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks etc.	5
	Range: Values include one (average) x value above 50.0 cm and one (average) x value below 50.0 cm.	1
	Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate. The presentation of the quantity and unit must conform to accepted scientific convention e.g. x / cm .	1
	Consistency: All raw values of x and y must be given to the nearest mm only.	1
1(d)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 15 small squares for 10 units 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. Trend of points on graph must be correct. It must be possible to draw a straight line that is within ± 2.0 cm (to scale) on the y -axis (y / cm axis) of all plotted points.	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 (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	1
1(d)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. 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(e)	Value of P = candidate's gradient and value of Q = candidate's intercept. The values must not be fractions.	1
	No unit for P and unit for Q correct e.g. mm or cm or m.	1
1(f)	Correct calculation of R .	1
	Value of R on the answer line given to 3 significant figures.	1

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Question	Answer	Marks
2(a)(i)	Value(s) of <u>raw</u> d and <u>raw</u> t to nearest mm with units.	1
2(a)(ii)	Percentage uncertainty in d based on an absolute uncertainty in the range 2–5 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 obtain percentage uncertainty.	1
2(b)(i)	Correct calculation of V .	1
2(b)(ii)	Justification for s.f. in V linked to s.f. in d and t .	1
2(c)	Value of n .	1
	Evidence of repeated n .	1
2(d)	Second values of d and t .	1
	Second value of n .	1
	Quality: Second value of n less than first value of n .	1
2(e)(i)	Two values of k calculated correctly. The final k values must not be fractions.	1
2(e)(ii)	Valid comment consistent with calculated values of k , testing against a criterion stated by the candidate.	1
2(f)	Correct unit and calculation of M using second k , and in the range 1.0–10.0 g.	1

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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 Lid tilts/sinks more quickly with a reason e.g. cannot stack in one place/tendency to drop coins heavily/force added by hand. C Lid has a curved edge leading to inaccurate $d/t/V$. D Parallax error in t. E Large percentage uncertainty in t as t is small. F Mass of lid needs to be known/masses of two lids are different. G Coins have different mass or Coins or lid heavier when readings repeated because they are wet. <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 Improved method of loading coins e.g. tweezers/tongs/forceps/guide for coins mounted centrally. C Improved method of finding V e.g. displacement method/filling with liquid using syringe or pipette. DE Improved method of measuring t e.g. (vernier/digital) calipers/travelling microscope/two blocks/use many stacked lids of the same type. F Method to measure mass e.g. balance/scales. G Method to ensure coins or lid are dry e.g. allow water to evaporate/use hair dryer/use fresh coins or lid each time. <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 2019

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- the standard of response required by a candidate as exemplified by the standardisation scripts.

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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
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- 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.

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GENERIC MARKING PRINCIPLE 5:

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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)	Value of x in range 45.0–55.0 cm.	1
1(b)	Value of $y < x$.	1
1(c)	Six sets of readings of x and y with the correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks etc.	5
	Range: $x_{\min} \leq 20.0$ cm and $x_{\max} \geq 80.0$ cm.	1
	Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. $1/x/\text{cm}^{-1}$.	1
	Consistency: All values of x and y must be given to the nearest mm.	1
	Significant figures: The number of significant figures for every value of $1/y$ should be the same as, or one greater than, the number of s.f. of y as recorded in the table.	1
	Calculation: Values of $1/y$ calculated correctly.	1

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Question	Answer	Marks
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). Plots must be accurate to within half a small square in both x and y directions.	1
	Quality: All observations in the table (at least 5) must be plotted on the grid. Trend of points on graph must be correct. It must be possible to draw a straight line that is within $\pm 0.005 \text{ cm}^{-1}$ ($\pm 0.5 \text{ m}^{-1}$) in the $1/x$ direction of all plotted points.	1
1(d)(ii)	Line of best fit: Judge by balance of all points on the grid (at least 5) 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 (i.e. circled or labelled) by the candidate. Lines must not be kinked or thicker than half a square.	1
1(d)(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 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

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Question	Answer	Marks
1(e)	a equal to candidate's gradient and b equal to candidate's intercept. The values must not be fractions.	1
	No unit for a and unit for b is correct (e.g. m^{-1}).	1

Question	Answer	Marks
2(a)	Value for θ recorded to nearest degree and $\theta < 90^\circ$.	1
2(b)	Value for F recorded to nearest 0.1 N with unit.	1
	Evidence of repeat readings of F .	1
2(c)	Percentage uncertainty in F based on an absolute uncertainty of 0.2–0.5 N. 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(d)(i)	Second value for θ .	1
2(d)(ii)	Second value for F .	1
	Quality: Second $F < \text{first } F$.	1
2(e)	Value of W in range 1.0–5.0 N with unit.	1
2(f)(i)	Two values of μ calculated correctly.	1
2(f)(ii)	Valid comment consistent with the calculated values of μ , testing against a criterion specified by the candidate.	1
2(g)	Correct calculation of F .	1
	F given to 2 or 3 significant figures.	1

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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 clamp board <u>so that it is stable</u>. C Difficult to pull (block) at steady speed. D Difficulty with F/force/newton-meter reading with reason (e.g. fluctuates / friction varies in different places). E F is small so percentage uncertainty in F is large. <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 μ values (not “repeat readings” on its own). B Improved clamping method e.g. use two clamps/fix base to bench with adhesive putty. C Detail of constant speed pulling arrangement (e.g. use motor/pulley with mass adjusted to give terminal velocity). D Video/film/record linked to <u>measurement of force</u>. E Use force sensor with data logger/use more precise newton-meter/add masses on top of block. <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 x in the range 18.0–22.0 cm with unit.	1
1(b)	Value of T in the range 2.50–4.50 s with unit.	1
	Evidence of at least two readings of nT where $n \geq 2$.	1
1(c)	Five sets of readings of x and T (different values) showing the correct trend and without help from the Supervisor scores 4 marks, four sets scores 3 marks etc.	4
	Range: $x_{\min} \leq 5.0$ cm.	1
	Column headings: Each column heading must contain a quantity, a unit and a separating mark 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 must be given to the nearest mm only.	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 correctly 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 observations in the table (at least 4) must be plotted on the grid. Trend of points on graph must be correct. It must be possible to draw a straight line that is within ± 2.0 cm (to scale) of all the plotted points on the x -axis.	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 (at least 4 points). There must be an even distribution of points either side of the line along the full length. If there are 5 or more points, allow one anomalous point only if clearly indicated by the candidate. Lines must not be kinked or thicker than half a small square.	1
1(d)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. 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(e)	Value of P = candidate's gradient and value of Q = candidate's intercept. The values must not be fractions.	1
	Units for P (s m^{-1} , s cm^{-1} or s mm^{-1}) and Q (s) correct.	1
1(f)	Correct calculation of $x [= (T - Q) / P]$ from values of T , P and Q and consistent sign.	1
	Final answer for x given to three significant figures.	1

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Question	Answer	Marks
2(a)(i)	Raw values of θ to the nearest degree and $\theta < 90^\circ$.	1
2(a)(ii)	Correct calculation of $(\sin 2\theta)(\cos 2\theta)$.	1
2(a)(iii)	Justification for s.f. in $(\sin 2\theta)(\cos 2\theta)$ linked to s.f. in θ or angle.	1
2(b)	Value of d to the nearest mm with unit.	1
	Value of d in the range $35.0 \text{ cm} < d < 45.0 \text{ cm}$.	1
2(c)(i)	Value of h with unit in the range $10.0 \text{ cm} < h < 100.0 \text{ cm}$.	1
2(c)(ii)	Percentage uncertainty in h based on absolute uncertainty of 0.5–5.0 cm. 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(d)	Second values of θ and d .	1
	Second value of h .	1
	Quality: Second value of h greater than first value of h .	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 stated by the candidate.	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 set θ (or angle) with a reason e.g. board moves/is tilted or moves when clamp tightened. C Difficult to locate A or B because difficult to judge the horizontal. D Difficult to measure d with reason e.g. parallax error, moving card, ruler held by hand, card not perpendicular to bench, card not vertical. E Difficult to release/align the ball either directly above the dot or without applying a force or in exactly the same place when repeated. F Difficult to find/measure h with a reason e.g. parallax error, ruler held by hand, ball held by hand, ruler not vertical, uneven bounce of ball. G Difficult to judge whether the ball hits the line or A or B. <i>1 mark for each point up to a maximum of 4.</i>	4

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Question	Answer	Marks
2(f)(ii)	A Take more readings <u>and</u> plot a graph or take more readings <u>and</u> compare k values (not “repeat readings” on its own). B Improved method to make ramp more stable or θ easy to adjust e.g. use two stands, use pile of books (that can be moved), lab jack. C Improved method of locating A or B e.g. detailed use of spirit level/set squares/ruler(s). D Improved method of measuring d e.g. clamp a ruler horizontally or to measure d, trigonometry with detail, clamp top of card, use stiffer or thicker card. E Improved method of aligning or releasing ball e.g. launch guide, plumb line, short tube (with card), clamp guide vertically, method of fixing release point, hang ball by string and cut/burn. F Improved method to find h e.g. clamp ruler vertically or to measure h (allow use of set square on bench and ruler (with detail)). G Improved method of judging where the ball hits the card e.g. paint ball, coloured screen, sticky screen or video/film (and replay) linked to ball hitting card. <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 α to nearest degree and in range $46\text{--}52^\circ$.	1
1(b)	Value of $\beta > \alpha/2$.	1
1(c)	Six sets of readings of β and x (different values) showing the correct trend (β increases as x decreases) and without help from the Supervisor scores 5 marks, five sets scores 4 marks etc.	5
	Range: $x_{\min} = 0.0\text{ cm}$ and $x_{\max} \geq 6.5\text{ cm}$.	1
	Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate. The heading for $\tan(\beta - \alpha/2)$ must have no unit. The presentation of the quantity and unit must conform to accepted scientific convention e.g. $\beta/^\circ$.	1
	Consistency: All raw values of x must be given to the nearest mm.	1
	Significant figures: All values of $\tan(\beta - \alpha/2)$ should be to 2 or 3 significant figures.	1
	Calculation: Values of $\tan(\beta - \alpha/2)$ calculated correctly.	1

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Question	Answer	Marks
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.	1
	Quality: All observations in the table (at least 5) must be plotted on the grid. Scatter of plots must be no more than ± 0.5 cm (to scale) from a straight line in the x direction.	1
1(d)(ii)	Line of best fit: Judge by balance of all points on the grid (at least 5) 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. Lines must not be kinked or thicker than half a square.	1
1(d)(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 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

Question	Answer	Marks
1(e)	Value of P = candidate's gradient and value of Q = candidate's intercept.	1
	Unit for P correct (e.g. cm^{-1}) and consistent with results and no unit for Q .	1

Question	Answer	Marks
2(a)	Value of c to the nearest mm, with unit.	1
	Value of c in the range 20.0–40.0cm.	1
2(b)	Value of $d < c$.	1
2(c)	Percentage uncertainty in d based on an absolute uncertainty of 2–10 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 obtain percentage uncertainty.	1
2(d)	Second value of c .	1
	Second value of d .	1
	Quality: Second $c < \text{first } c$ and second $d < \text{first } d$.	1
2(e)(i)	Two values of k calculated correctly.	1
2(e)(ii)	Justification based on s.f. in c <u>and</u> $(c - d)$.	1
2(e)(iii)	Valid comment relating to the calculated values of k , testing against a criterion specified by the candidate.	1
2(f)	Correct calculation of ρ_{rock} .	1
	ρ_{rock} in range 2100–3200 kg m^{-3} , with unit.	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 balance strip/prism moves/strip slips/strip slides/strip moves on prism. C Difficult to measure c or d with reason e.g. difficult to locate centre of (the) mass/parallax error. D Wet string changes mass/weight. E Volume of string not taken into account/string displaces water/upthrust on string or Mass of string not taken into account. F Difficult to set/measure the position of the rock because of thick string. <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 Improved method of balancing strip e.g. groove under strip/flatten top of prism/method of fixing prism or wooden block. C Improved method of measuring c or d e.g. scale markings on strip/suspend mass under strip. D Method of reducing water absorbed by string e.g. use waterproof string/nylon/wire/other named (suitable) material. E Method of reducing volume/mass of string e.g. thin(ner) string. F Use thin(ner) string (<i>allow ‘thin(ner) string’ only once in total</i>). <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 2019

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 2019 series for most Cambridge IGCSE™, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

This document consists of **7** 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 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 c in the range 55.0–65.0 cm with unit.	1
1(a)(ii)	Value of I in the range 75.0–175.0 mA with unit.	1
1(b)	Six sets of readings of c and I (different values) showing the correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks etc.	5
	Range: Includes a reading of $c \geq 95.0$ cm and no values of $c < d$.	1
	Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate. There should be no units for the n or $(n + 2) / (n + 1)$ columns. The presentation of the quantity and unit must conform to accepted scientific convention e.g. c / m .	1
	Consistency: All values of c must be given to the nearest mm only.	1
	Calculation: Values of $(n + 2) / (n + 1)$ 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 correctly 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 observations in the table (at least 4) must be plotted on the grid. Trend of points on graph must be correct. It must be possible to draw a straight line that is within ± 0.05 (to scale) of all the plotted points on the $(n + 2) / (n + 1)$ axis.	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 points). There must be an even distribution of points either side of the line along the full length. If there are 6 or more points, allow one anomalous point only if clearly indicated 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 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 S = candidate's gradient and value of T = candidate's intercept. The values must not be fractions.	1
	Unit for S and T correct (mA or A).	1
1(e)	Correct line W with smaller gradient and below the original line (with a smaller intercept if false origin).	1

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Question	Answer	Marks
2(a)	Raw values of x and L_1 to the nearest mm.	1
	Mean values of x and L_1 in the range 23.0–27.0 cm.	1
2(b)(i)	Values of L_2 in the range 40.0–50.0 cm.	1
2(b)(ii)	Percentage uncertainty in L_2 based on absolute uncertainty of 2–10 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 obtain percentage uncertainty.	1
2(b)(iii)	Correct calculation of L_1 / L_2 .	1
2(b)(iv)	Justification for s.f. in L_1 / L_2 linked to s.f. in L_1 and L_2 .	1
2(c)	Second values of x and L_1 .	1
	Second value of L_2 .	1
	Quality: Second value of $L_2 <$ first value of L_2 .	1
2(d)(i)	Two values of k calculated correctly.	1
2(d)(ii)	Valid comment consistent with calculated values of k , testing against a criterion stated by the candidate.	1
2(e)	Correct calculation of l with a consistent unit.	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 get the lengths the same with reason e.g. judging the strip horizontal, checking the strings vertical, adjusting the setup. C Difficult to determine lengths with a reason e.g. cannot place rule alongside strings, difficult to hold the ruler still, holding ruler with hands, parallax error, difficult to locate centre of bob. D Difficulty with oscillations of rule e.g. have small amplitude, unwanted modes, strings move along during oscillation, stands move, oscillations die away quickly. or Difficult to ensure that x straddles centre of the strip equally. E Difficult to see when both oscillations match their periods. F Releasing bob and rule simultaneously is difficult/uneven force may be applied. <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 readings <u>and</u> compare k values (not “repeat readings” on its own). B Detailed use of spirit level/plumb line/set squares. C Mark strings or use a clamped rule/pointer on rule with detail. D Clamp stand to bench/method of attaching string to strip. or Attach/mark scale onto strip or mark centre of strip. E Use longer dimensions (to increase period)/use a video to identify when in phase/use a timer and check individually. F Use a card for a gate for both to release together. <i>1 mark for each point up to a maximum of 4.</i>	4