

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2014 series

9702 PHYSICS

9702/31

Paper 3 (Advanced Practical Skills 1),
maximum raw mark 40

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- 1 (b) Value of T in the range 1.1 s – 1.5 s with unit. [1]
Evidence of repeated timings. [1]
- (d) Six sets of readings of B and C and time scores 5 marks, five sets scores 4 marks etc. [5]
Incorrect trend –1. Help from Supervisor –1.
- Range: [1]
 $B = 1 - 7$ (or 8) and $B + C = 8$.
- Column headings: [1]
Each column heading must contain a quantity and a unit where appropriate.
The unit must conform to accepted scientific convention e.g. $T^2/B/s^2$, and C/B must not have a unit.
- Consistency: [1]
All values of t must be given to either the nearest 0.1 s or 0.01 s.
- Significant figures: [1]
All values of T^2/B must be given to the same s.f. as (or one more than) the s.f. in raw t .
- Calculation: [1]
Values of T^2/B are calculated correctly.
- (e) (i) Axes: [1]
Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
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 must be no more than three large squares apart.
- Plotting: [1]
All observations in the table must be plotted on the graph grid, except $B = 0$.
Diameter of plots must be $\leq$ half a small square (no “blobs”).
Plotted points must be accurate to within half a small square.
- Quality: [1]
All points in the table must be plotted (at least 5) for this mark to be awarded.
Judge by scatter of all points about a straight line.
All points must be less than $\pm 0.05 s^2$ in the T^2/B direction from a straight line.
- (ii) Line of best fit: [1]
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 plot only if clearly indicated by the candidate (i.e. circled or labelled).
Lines must not be kinked or thicker than half a small square.

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- (iii) Gradient: [1]
 Sign of gradient must match graph (expect a positive gradient).
 The hypotenuse of the triangle must 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.

- y -intercept: [1]
 Either:
 Correct read-offs from a point on the line and substituted into $y = mx + c$.
 Read-offs must be accurate to half a small square in both x and y directions.
 Or:
 Correct read-off of the intercept directly from the graph.

- (f) Value of F = candidate's gradient. Value of G = candidate's intercept. [1]
 Do not allow a value presented as a fraction.

- Unit for F (s^2) and G (s^2) correct. [1]

[Total: 20]

- 2 (a) (i) Value of D with unit in range $6.0 \leq D \leq 10.0$ mm. [1]

- (ii) Value of d with unit to the nearest 0.01 or 0.001 mm in the range 0.14 to 0.16 mm. [1]

- (iii) Correct calculation of $(D + d/2)$. [1]

- (b) (ii) Value of $(n + t)$: [1]
 Whole number [1]
 Representation of part of a turn as a decimal or as a fraction [1]

- (iii) Absolute uncertainty of twenty-fifth of turn $\leq$ uncertainty in $(n + t) \leq$ quarter of a turn.
 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 get percentage uncertainty. [1]

- (c) Second value of d . Evidence of repeated readings here or in (a)(ii) [1]
 Second value of $(n + t)$. [1]
 Second value of $(n + t) <$ first value of $(n + t)$. [1]

- (d) (i) Correct calculation of two values of k . [1]

- (ii) Justification of s.f. in k linked to raw data in D , d and $(n + t)$. [1]

- (iii) Valid conclusion based on the calculated values of k , testing against a stated criterion. [1]

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(e)	(i) Limitations (4 max.)	(ii) Improvements (4 max.)	Do not credit
A	Two readings not enough to draw a conclusion.	Take many readings (for different diameters) <u>and</u> plot a graph / compare k values.	repeat readings / few readings
B	Difficult to judge fractions of a turn	Improved method to measure the fraction of a turn e.g. have appropriate markings on rod. e.g. measure spare length and work out as a fraction of the circumference of the rod. e.g. $50 / \text{circumference}$.	
C	Wire slips from start position / springs away from rod.	Method to prevent wire moving e.g. tape / Blu-tack / attach weight / clamp wire on rod.	Wire unstable
D	Length not exactly 50 cm with reason e.g. kinks	Method to <u>straighten</u> wire e.g. apply load or improved method to cut e.g. use tape and knife or use thinner wire for second wire	
E	Thicker wire occupies a longer part of the rod so there are fewer turns / angle of turn of wire affects $(n + t)$ / difficult to make turns touch along the rod	Improved method of placing turns close together e.g. use motor to turn rod.	
F	The values of $(n + t)$ are close together.	Use a thinner rod.	

[Total: 20]

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- 1 (c) Value of T in range 1.0 s – 2.0 s with unit. [1]
Evidence of repeated timings. [1]
- (d) Six sets of readings of L and time (different values) scores 5 marks, five sets scores 4 marks etc. [5]
Help from Supervisor –1.
- Range: [1]
 $L_{\max} - L_{\min} \geq 30.0 \text{ cm}.$
- Column headings: [1]
Each column heading must contain a quantity and a unit.
The unit must conform to accepted scientific convention e.g. $T^2L/\text{s}^2\text{m}$, L^2/m^2 .
Accept separating mark as a solidus, brackets or 'in' but not commas.
- Consistency: [1]
All values of raw L must be given to the nearest mm.
- Significant figures: [1]
All values of L^2 must be given to the same s.f. as (or one more than) the s.f. in L .
- Calculation: [1]
Values of T^2L calculated correctly.
- (e) (i) Axes: [1]
Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
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 must be no more than three large squares apart.
- Plotting: [1]
All observations in the table must be plotted on the graph grid.
Diameter of plotted points must be $\leq$ half a small square (no "blobs").
Plotted points must be accurate to within half a small square.
- Quality: [1]
All points in the table must be plotted on the grid for this mark to be awarded.
Judge by scatter of all points about a straight line.
All points must be within $\pm 0.025 \text{ m}^2$ (250 cm^2) in the L^2 direction from a straight line.
- (ii) Line of best fit: [1]
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 candidate (i.e. circled or labelled).
Lines must not be kinked or thicker than half a small square.

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- (iii) Gradient: [1]
 Sign of gradient must match the graph.
 The hypotenuse of the triangle must 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.

- y -intercept: [1]
 Either:
 Correct read-offs from a point on the line and substituted into $y = mx + c$.
 Read-offs must be accurate to half a small square in both x and y directions.
 Or:
 Correct read-off of the intercept directly from the graph.

- (f) Value of A = candidate's gradient. Value of B = candidate's intercept. [1]
 Allow correct rounding unless to 1 s.f.

- Unit for A ($\text{s}^2 \text{m}^{-1}$ or $\text{s}^2 \text{cm}^{-1}$ or $\text{s}^2 \text{mm}^{-1}$) and B ($\text{s}^2 \text{m}$ or $\text{s}^2 \text{cm}$ or $\text{s}^2 \text{mm}$). [1]

[Total: 20]

- 2 (a) (ii) Value of h_2 with unit, in the range $20.0 \text{ cm} \leq h_2 \leq 35.0 \text{ cm}$. [1]
 Evidence of repeat readings. [1]

- (b) (ii) Value of $\theta = 10^\circ$, 11° or 12° with unit. [1]

- (iii) Correct calculation of $\cos^2(2\theta)$. [1]

- (iv) Correct justification of s.f. in $\cos^2(2\theta)$ linked to s.f. in value of θ . [1]

- (c) (iii) Value of h with consistent unit. [1]

- (iv) Absolute uncertainty in h in range $5 \text{ mm} - 20 \text{ mm}$.
 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 get percentage uncertainty. [1]

- (d) (i) Second value of θ . [1]

- (ii) Second value of h . [1]
 Second value of $h < \text{first value of } h$. [1]

- (e) (i) Correct calculation of two values of k . [1]

- (ii) Valid comment consistent with the calculated values of k , testing against a stated criterion. [1]

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(f)	(i) Limitations (4 max.)	(ii) Improvements (4 max.)	Do not credit
A	Two readings not enough to draw a <u>conclusion</u>	Take many readings (for different angles) <u>and</u> plot a graph. Take more readings and compare values of k	repeat readings / few readings / “too few readings” / “two readings” / “not enough readings”
B	Large uncertainty in θ	Make θ larger / use trigonometry with detail	Parallax error in angle measurement Use larger protractor More accurate protractor “Angle too small” Zero line not on edge
C	Difficult to release the ball without applying a force / difficult to drop at 40 cm with reason e.g. hands shaking.	Clamp ball prior to release / use a card gate or stop gate / use marker at 40 cm / valid method of release	Electromagnet Robotic arm
D	Difficult to measure / judge position of h <u>with timing reason</u> e.g. ball stops at maximum height for a short time	Use a video <u>with a scale</u> / trial and improvement with marker	Use camera Ignore high speed/slow motion camera
E	Difficult to measure / judge position of h <u>with positioning reason</u> e.g. because of parallax error / ruler not vertical / no lower horizontal reference line.	Use a set square on bench / plumb-line / (graduated) grid behind / clamp a ruler horizontally / use a second rule with detail of position.	Judging centre of ball / marking line on ball / vertical lines / lines
F	Rebound height is variable / ball veers off course / ball moves sideways.	Detailed method to ensure ball does not veer off course.	Ball falls off the board.

[Total: 20]

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- 1 (b) (ii) Value for p in range 4.0 to 5.0 cm. [1]
- (c) (iii) Value for q greater than p . [1]
- (d) Six sets of values for p and q scores 5 marks, five sets scores 4 marks etc. [5]
 Incorrect trend –1. Help from Supervisor –1.
- Range: [1]
 p values must include 3.0 cm or less and 5.0 cm or more.
- Column headings: [1]
 Each column heading must contain a quantity and a unit where appropriate.
 Units should be shown using accepted scientific convention e.g. $1/p/\text{cm}^{-1}$ or $1/p$ (1/cm), and q/p must have no unit.
- Consistency: [1]
 All values of p and q must be given to the nearest mm.
- Significant figures: [1]
 Every value of $1/p$ must be given to the same s.f. as (or one more than) the s.f. in the corresponding p .
- Calculation: [1]
 $1/p$ calculated correctly.
- (e) (i) Axes: [1]
 Sensible scales must be used, no awkward scales (e.g. 3:10).
 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 must be no more than three large squares apart.
- Plotting: [1]
 All observations in the table must be plotted on the grid.
 Diameter of plotted points must be $\leq$ half a small square (no “blobs”).
 Plotted points must be accurate to within half a small square.
- (ii) Line of best fit: [1]
 Judge by the 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 plot only if clearly indicated by the candidate (i.e. circled or labelled).
 Line must not be kinked or thicker than half a small square.

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- (iii) Gradient: [1]
 The hypotenuse must 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.

y -intercept: [1]
 Either:
 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:
 Correct read-off of the intercept directly from the graph.

- (f) $a = \text{gradient} / (1 - \text{intercept})$ and $b = \text{intercept}$. [1]

Correct and consistent units for a (e.g. cm) and no unit for b . [1]

Quality: Value for b in range 1.40 to 1.55. [1]

[Total: 20]

- 2 (a) (i) Raw value(s) for d to nearest 0.01 cm or 0.001 cm and in range 0.5 to 1.5 cm. [1]

- (ii) Value for x in range 2.2 to 2.8 cm. [1]

- (iii) Raw value(s) of l to nearest mm or better. [1]

- (b) Estimate of percentage uncertainty based on an absolute uncertainty of 2 to 5 mm and method of calculation correct. [1]
 If repeated readings have been taken, then uncertainty can be half the range (but not zero) if the working is clearly shown.

- (c) Correct calculation of A with consistent unit. [1]

- (d) (v) Value for n . [1]
 Evidence of repeat measurements of n . [1]

- (e) Second values of x and l . [1]

Quality: n increases as l increases. [1]

- (f) (i) Correct calculation of two values of k . [1]

- (ii) Justification based on the s.f. in x , d and l . Ignore any reference to n or A . [1]

- (iii) Valid comment consistent with the calculated values of k , testing against a stated criterion e.g. "The calculated percentage difference between k values is less than the percentage uncertainty in (b), so the relationship is valid". [1]

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(g)	Limitations (4 max.)	Improvements (4 max.)	Do not credit
A	Two readings are not enough to draw a valid <u>conclusion</u>	Take many <i>A</i> values and plot a graph/take more readings and compare <i>k</i> values/repeat readings and plot graph	Repeat/too few readings
B	Difficult to measure because hard to judge where parallel section of pencil starts/to judge where to measure from	Use a flat-ended rod	
C	Pencil not vertical	Use guides	
D	Difficult to keep drop height constant/drop height <u>not</u> constant	Use a stop <u>with detail</u> /use a fixed ruler behind strip/use pointer <u>with detail</u> e.g. pointer mounted in a stand	Difficult to release strip without a force/use fiducial marker
E	Difficult to judge when mark reaches surface because rice surface uneven	Use ring of card resting on rice around pencil/measure change in height of pencil	Rice spills out of container during experiment
F	Difficult to judge if strip is horizontal/strip may not be horizontal/strip is not horizontal	Measure (or compare) height at each end/use spirit level	
G	Conical section of pencil not taken into account		

[Total: 20]

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- 1 (a) (ii) Value of $(m - P)$ with consistent unit. [1]
- (b) (ii) $10.0\text{ s} \leq t \leq 60.0\text{ s}$, with unit. If out of range allow Supervisor's value $\pm 5.0\text{ s}$. [1]
- (c) Six sets of readings of m and t scores 5 marks, five sets scores 4 marks etc. [5]
 Incorrect trend -1 . Help from Supervisor -1 .
- Range: [1]
 $m_{\text{max}} \geq 360\text{ g}$.
- Column headings: [1]
 Each column heading must contain a quantity and a unit.
 The unit must conform to accepted scientific convention e.g. $1/t^2/\text{s}^{-2}$ or $1/t^2\text{ (s}^{-2}\text{)}$.
- Consistency: [1]
All values of t must be given to the nearest 0.1 s or all to the nearest 0.01 s .
- Significant figures: [1]
 Every value of $1/t^2$ must be given to the same s.f. as (or one more than) the s.f. in raw t .
- Calculation: [1]
 Values of $1/t^2$ calculated correctly to the number of significant figures given by the candidate.
- (d) (i) Axes: [1]
 Sensible scales must be used, no awkward scales (e.g. 3:10).
 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 must be no more than three large squares apart.
- Plotting: [1]
 All observations in the table must be plotted on the graph grid.
 Work to an accuracy of half a small square in both the x and y directions.
 Diameter of plotted points must be $\leq$ half a small square (no "blobs").
- Quality: [1]
 All points in the table must be plotted (at least 5) for this mark to be awarded.
 Judge by the scatter of all points about a straight line.
 All points must be $\pm 0.01\text{ kg}$ ($\pm 10\text{ g}$) from a straight line in the $(m - P)$ direction.
- (ii) Line of best fit: [1]
 Judge 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.
 Allow one anomalous point only if clearly indicated by the candidate.
 Lines must not be kinked or thicker than half a small square.

Page 3	Mark Scheme	Syllabus	Paper
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- (iii) Gradient: [1]
 The hypotenuse of the triangle should be greater than half the length of the line drawn.
 Both read-offs must be accurate to half a small square in both the x and y directions.

y -intercept: [1]
 Either:
 Check 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:
 Correct read-off of the intercept directly from the graph.

- (e) U = value of candidate's gradient and V = value of candidate's intercept. [1]
 Do not allow a value presented as a fraction.

Unit for U ($\text{s}^{-2} \text{kg}^{-1}$ or $\text{s}^{-2} \text{g}^{-1}$) and $V(\text{s}^{-2})$. [1]

[Total: 20]

- 2 (a) Raw value(s) for x to nearest 0.01 mm or 0.001 mm, with unit. [1]
 $0.10 \text{ mm} \leq x \leq 0.30 \text{ mm}$.
 If outside this range, allow Supervisor's value $\pm 0.10 \text{ mm}$.

- (b) (i) Value of A in the range $7.0 \text{ cm}^2 - 15.0 \text{ cm}^2$. There must be a circle drawn on the grid. [1]

- (ii) Estimate of percentage uncertainty based on absolute uncertainty in A in range $0.25 \text{ cm}^2 - 2.0 \text{ cm}^2$ and method of calculation correct. [1]
 If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.

- (iii) Correct calculation of V . [1]
 Correct and consistent unit. [1]

- (iv) Correct justification of s.f. in V linked to significant figures in x and A . [1]

- (c) (iii) Value of T in the range $1.0 \text{ s} - 10.0 \text{ s}$ with unit. [1]

- (d) Second value of A . [1]
 Evidence of measurement of repeat values of T . [1]
 Quality: Second value of $T < \text{first value of } T$. [1]

- (e) (i) Correct calculation of two values of k . [1]

- (ii) Valid comment consistent with the calculated values of k , testing against a stated criterion. [1]

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(f)	(i) Limitations (4 max.)	(ii) Improvements (4 max.)	Do not credit
A	Two readings are not enough to draw a conclusion	Take many readings (for different diameters) <u>and</u> plot a graph / take more readings <u>and</u> compare k values	'Not enough (repeat) readings' / 'too few readings' / 'two readings' on its own
B	Difficult to measure A , with reason e.g. jagged circle / cup moves when drawing circle	Improved method for measuring A (e.g. put base of cup in ink and use as stamp on grid) or: improved method for cutting circle e.g. circle cutter / hot wire / laser cutter	Use different cup e.g. harder / stronger cup
C	Effect of cup loaded on one side e.g. movement lopsided / does not fall vertically / cup hits sides on the way down	Method to balance cup e.g. use two equal masses on either side	Put mass on bottom of cup Use a wider bucket
D	Large (percentage) uncertainty in t (because times are short)	Use video / film / record / (camera + playback) with timer / view frame-by-frame. Method to increase length of time e.g. taller container, smaller mass, smaller hole (for C)	High speed or slow-motion cameras unless linked to playback
E	Difficult to judge when cup hits bottom	Use transparent / clear bucket	
F	Thickness of base different from rim / plastic deformed when measuring thickness		

Do not credit:

Use a computer / data loggers / sensors

Use an assistant

Force on release

Cup heavier due to water droplets

[Total: 20]

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9702 PHYSICS

9702/36

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maximum raw mark 40

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- 1 (a) (ii) Value of voltmeter reading with unit in range $0.30\text{ V} \leq V \leq 0.70\text{ V}$. [1]
- (b) (ii) Value of l with unit in range $20\text{ cm} \leq l \leq 80\text{ cm}$. [1]
- (c) Six sets of readings of R and l scores 5 marks, five sets (or use of $R = 0$) scores 4 marks etc. [5]
 Incorrect trend –1. Major help from Supervisor –2. Minor help from Supervisor –1.
- Range: [1]
 Values of R must include $0.22\text{ k}\Omega$ or $0.33\text{ k}\Omega$, and $4.7\text{ k}\Omega$ or $3.3\text{ k}\Omega$.
- Column headings: [1]
 Each column heading must contain a quantity and a unit. The presentation of quantity and unit must conform to accepted scientific convention e.g. $1/R/\text{k}\Omega^{-1}$ or $1/R(\text{k}\Omega)^{-1}$, $1/l(\text{m}^{-1})$ or $1/l(1/\text{m})$ but **not** $1/R/\text{k}^{-1}\Omega^{-1}$, $1/R(\text{k}\Omega)$ or $1/l(\text{m})$.
- Consistency: [1]
 All values of raw l must be given to the nearest mm only.
- Significant figures: [1]
 Every value of $1/l$ must be given to the same s.f. as (or one greater than) the s.f. in raw l .
- Calculation: [1]
 Values of $1/R$ calculated correctly to the number of significant figures given by the candidate.
- (d) (i) Axes: [1]
 Sensible scales must be used, no awkward scales (e.g. 3:10).
 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.
- Plotting: [1]
 All observations in the table must be plotted.
 Diameter of points must be $\leq$ half a small square (no “blobs”).
 Plotted points must be accurate to within half a small square.
- Quality: [1]
 All points in the table must be plotted (at least 5) for this mark to be awarded.
 Scatter of points must be less than $\pm 0.001\text{ cm}^{-1}$ of $1/l$ from a straight line.
- (ii) Line of best fit: [1]
 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.
 Lines must not be kinked or thicker than half a small square.

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- (iii) Gradient: [1]
 The hypotenuse of the triangle must be greater than half the length of the drawn line.
 Both read-offs must be accurate to half a small square in both the x and y directions.

y -intercept: [1]
 Either:
 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:
 Correct read-off of the intercept directly from the graph.

- (e) a = the value of the gradient and b = the value of the y -intercept. [1]

Unit for a and unit for b consistent with values given. [1]
 e.g. $\text{k}\Omega \text{ m}^{-1}$ for a and m^{-1} for b .

[Total: 20]

- 2 (a) (ii) Value of L in range $150 \text{ mm} \leq L \leq 250 \text{ mm}$ and to nearest mm only. [1]

- (b) (ii) Value of $d = 0.5L \pm 20 \text{ mm}$. [1]

- (iv) Correct justification of significant figures in c linked to significant figures in L and d . [1]

- (c) Correct calculation of q . [1]

- (d) (ii) Value of raw t to 0.1 s or better, with unit, in range $6 \text{ s} \leq t \leq 20 \text{ s}$. [1]
 Evidence of repeat measurements of t . [1]

- (iii) Absolute uncertainty in t in range 0.2 s to 0.5 s. [1]
 If repeated readings have been taken, uncertainty can be half the range (but not zero) if the working is shown.
 Method of calculation to obtain percentage uncertainty must be correct.

- (e) (ii) Second value of d . [1]
 Second value of t . [1]
 Quality: Correct trend for t with respect to d (t decreases as d increases). [1]

- (f) (i) Two values of k calculated correctly. [1]

- (ii) Valid comment consistent with calculated values of k , testing against a stated criterion e.g. "The calculated percentage difference between k values is less than the percentage uncertainty found in (d)(iii), so the relationship is valid". [1]

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(g)	(i) Limitations (4 max.)	(ii) Improvements (4 max.)	Do not credit
A	Two readings not enough to draw a conclusion	Take more readings (for different d) <u>and</u> plot a graph / take more readings <u>and</u> compare k values	Not enough readings / repeat readings / few readings / too few readings / 'two readings' (on its own)
B	Difficult to measure L or d with reason e.g. parallax / transparent liquid / hanging above bench / bottle not vertical / bottle not uniform	Improved method to measure L or d e.g. detailed use of set square on bench / colour water / add scale to bottle / place bottle on bench and use rule	Marks on bottle / finding centre of nail / meniscus problem
C	Difficult to judge the end of oscillation	Improved method of timing e.g. video <u>with timer</u> / video and view frame by frame / put marker at the <u>centre</u> of oscillation / motion sensor with correct position i.e. placed so the bottle moves towards and away from it.	Release height / amplitude varies / human reaction time / video and play back / high speed camera / slow motion camera / use of motion sensor / use of light gates /
D	d varies as bottle swings	Use sand (or named material that can be poured)	
E	Difference in t values is small	Use larger change in depths	Use longer bottle / t is small
F	Stand (or nail) moves while bottle oscillates	Method to stabilise clamp (or nail) e.g. G-clamp / add weight to stand / clamp nail between wooden blocks	Glue stand to bench

Do not credit:

damping / release force / friction / hitting stand / fans / problems with counting / use computer / just "use data logger" on its own.

[Total: 20]