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PHYSICS **9702/31**

Paper 3 Advanced Practical Skills 1 **October/November 2016**

MARK SCHEME

Maximum Mark: 40

Published

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1 **(b)** Value for T in the range 0.60 s to 0.80 s with unit. [1]

Evidence of repeat timings (at least two recordings of nT where $n \geqslant 5$). [1]

(c) Correct calculation of k. [1]

Value of k must be given to the same number of s.f. as (or one more than) the s.f. in the values of the raw times. [1]

(e) Six sets of readings of $(h - h_1)$ and T (with correct trend and without help from Supervisor) scores 5 marks, five sets scores 4 marks etc. [5]

Range: [1]
$\Delta(h - h_1) \geqslant 30.0$ cm.

Column headings: [1]
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. T / s or T (s).

Consistency: [1]
All values of $(h - h_1)$ must be given to the nearest mm.

(f) **(i)** Axes: [1]
Sensible scales must be used. Awkward scales (e.g. 3:10, fractions or non-linear) 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 should be no more than three large squares apart.

Plotting of points: [1]
All observations must be plotted on the grid.
Diameter of plotted points must be $\leqslant$ half a small square (no "blobs").
Points must be plotted to an accuracy of half a small square.

Quality: [1]
All points in the table must be plotted on the grid for this mark to be awarded.
All points must be within 0.01 s on the y-axis of 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. There must be at least five points left after the anomalous point is disregarded.
Line 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.
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.

y-intercept: [1]
Either:
Check 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:
Check read-off of the intercept directly from the graph (accurate to half a small square.

(g) Value of *P* = candidate's gradient and value of *Q* = candidate's intercept. [1]
Do not allow fractions.

Units for *P* (e.g. $s\,m^{-1}$ or $s\,cm^{-1}$ or $s\,mm^{-1}$) and *Q* (s) correct. [1]

2 (a) (i) Value for *D* with unit in the range 0.14 mm to 0.16 mm. [1]

(ii) Percentage uncertainty in *D* based on an absolute uncertainty of 0.01 mm.
Correct method of calculation to obtain percentage uncertainty. [1]

(c) (iii) Value of *I* in range $10\,mA \leqslant I \leqslant 200\,mA$ with unit (collected without help from Supervisor). [1]

(iv) Value of *V* in range $0.4\,V \leqslant V \leqslant 1.0\,V$ with unit (collected without help from Supervisor). [1]

(d) (i) Value of $d > D$ and $d < 1$ mm. [1]

(ii) Correct calculation of *G*. [1]

(iii) Justification for s.f. in *G* linked to s.f. in *D* <u>and</u> *d*. [1]

(f) (i) Second value of *V*. [1]

Quality: second value of *V* less than first value of *V*. [1]

(ii) Second value of *d*. [1]

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(g) **(i)** Two values of *k* calculated correctly, and to at least 2 significant figures. [1]

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

(h)	**(i)** Limitations [4]	**(ii)** Improvements [4]	Do not credit
A	Two readings not enough to draw a conclusion	Take many readings (for different diameters) and plot a graph/ take more readings and compare *k* values	Two readings not enough for accurate results Repeat readings Few readings Take more readings and calculate average *k*
B	Difficult to measure diameter(s) with reason e.g. awkward placing micrometer round wire/ only one direction to measure diameter	Provide separate lengths of wire	
C	Meter readings changed in a particular direction over time/ repeat readings of I or V were often different/ contact resistance varies	Use power supply/ allow reading to reach steady value/ method of cleaning crocodile clips or wires	
D	Wire is very thin introducing a large percentage error in the diameter	Use thicker wire/ use digital micrometer	
E	Rheostat movement not precise enough – overshot I reading	Method to ensure exact current easier to produce e.g. use of screw thread adjustment	

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1 (a) (v) Value of I in range 20 mA $\leqslant I \leqslant$ 200 mA with unit. [1]

(c) Six sets of readings of R and y (with correct trend and without help from Supervisor) scores 5 marks, five sets scores 4 marks etc. [5]

Range: [1]
Values of R must include 33 Ω.

Column headings: [1]
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. $1/y/\text{m}^{-1}$ or $1/y$ (m^{-1}).

Consistency: [1]
All values of raw y must be given to the nearest mm.

Significant figures: [1]
Every value of $1/R$ must be given to 2 or 3 significant figures.

Calculation: [1]
$1/y$ calculated correctly to the number of s.f. given by the candidate.

(d) (i) Axes: [1]
Sensible scales must be used. Awkward scales (e.g. 3:10, fractions or non-linear) 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 should be no more than three large squares apart.

Plotting of points: [1]
All observations must be plotted on the grid.
Diameter of plotted points must be $\leqslant$ half a small square (no "blobs").
Plotted points must be accurate to half a small square.

Quality: [1]
All points in the table must be plotted on the grid for this mark to be awarded.
All points must be within 0.001 cm^{-1} (0.1 m^{-1}) (to scale) on the y-axis of 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. There must be at least five points left after the anomalous point is disregarded.
Line 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.
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.

y-intercept: [1]
Either:
Check 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:
Check read-off of the intercept directly from the graph (accurate to half a small square.

(e) Value of $P = -$candidate's gradient and value of $Q =$ candidate's intercept.
Do not allow fractions. [1]

Units for *P* (e.g. $\Omega\,m^{-1}$) and *Q* (e.g. m^{-1}) correct. [1]

(f) (ii) Value of *X* in the range 5.0 Ω to 20.0 Ω from correct calculation. [1]

2 (b) (iii) All raw readings stated to at least 0.1 s. Value for *T* with unit in the range 0.50 s to 0.90 s. [1]

Evidence of repeats (at least two recordings of *nT* where $n \geqslant 5$). [1]

(c) (i) Correct calculation of l. [1]

(ii) Justification of s.f. in l linked to s.f. in time readings (e.g. time, raw time, *nT*). [1]

(d) (ii) Value of *d* ($l \pm 0.050$ m). [1]

(iii) Absolute uncertainty in *d* in range 2 mm–8 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]

(e) (ii) Value for *t* in the range 2.0 s–8.0 s. [1]

(f) Second value of *T*. [1]

Second value of *t*. [1]

Quality: Second value of *t* > first value of *t*. [1]

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(g) **(i)** Two values of *k* calculated correctly, and to at least 2 significant figures. [1]

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

(h)	**(i)** Limitations [4]	**(ii)** Improvements [4]	Do not credit
A	Two readings not enough to draw a conclusion	Take many readings (for different masses) and plot a graph/ take more readings and compare *k* values	Two readings not enough for accurate results Repeat readings Few readings Take more readings and calculate average *k*
B	Difficult to set *d* with reason e.g. knot takes some string/knot or weight slips	Improved method to set *d* e.g. trial and error/glue knots to stop slipping	
C	Difficult to measure *d* with reason e.g. parallax error/cannot get ruler close/hands move holding ruler in place/difficult to judge centre of mass(es)/rule not vertical	Clamped metre rule/ measure to top and bottom of masses and find the average/ detailed method to check rule vertical/ detailed method to reduce parallax error	Eyes level Eyes perpendicular Reference to set square without detail
D	Difficult to measure (n)T with reason e.g. difficult to judge complete oscillation	Use fiducial marker at centre of oscillation/ use a motion sensor placed under masses	Reaction time error Force on release
E	Difficult to see when coil separation is constant **or** Separation of coils constant for a short time	Video with timer/ video and view frame by frame/ screen behind spring	Video timer
F	Movement of spring along rod	Method to fix spring to rod e.g. Blu-Tack or groove in rod	Air conditioning/draughts Unwanted modes of oscillation

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PHYSICS **9702/34**

Paper 3 Advanced Practical Skills 2 **October/November 2016**

MARK SCHEME

Maximum Mark: 40

Published

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1 (b) (ii) Value for x in range 24.0 cm to 26.0 cm, with unit. [1]

(iv) Value for T in range 0.30 s to 1.00 s. [1]

Evidence of repeat readings (at least two recordings of nT where $n \geqslant 5$). [1]

(c) Six sets of values for x and T (with correct trend and without help from Supervisor) scores 4 marks, five sets scores 3 marks etc. [4]

Range: [1]
$x_{min} \leqslant 20.0$ cm and $x_{max} \geqslant 30.0$ cm.

Column headings: [1]
Each column heading must contain a quantity and an appropriate unit. The presentation of the quantity and unit must conform to accepted scientific convention e.g. $1/T^2$ (s^{-2}) or $1/T^2$ / $1/s^2$.

Consistency: [1]
All values of x must be given to the nearest mm.

Significant figures: [1]
Every value of $1/T^2$ must be given to the same number of s.f. as (or one greater than) the number of s.f. in the corresponding times.

Calculation: [1]
Values of $1/T^2$ calculated correctly to the number of s.f. given by the candidate.

(d) (i) Axes: [1]
Sensible scales must be used. Awkward scales (e.g. 3:10, fractions or non-linear) 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 of points: [1]
All observations in the table must be plotted on the grid.
Diameter of plotted points must be $\leqslant$ half a small square (no "blobs").
Points must be plotted to an accuracy of half a small square.

Quality: [1]
All points in the table must be plotted (at least 5) for this mark to be awarded.
All points must be within ± 1.0 cm (to scale) of a straight line in the x direction.

(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 plot 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.
Line 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.
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.

y-intercept: [1]
Either:
Check 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:
Check read-off of the intercept directly from the graph (accurate to half a small square.

(e) Value of p = candidate's gradient and value of q = candidate's intercept.
Do not allow fractions. [1]

Units for p (e.g. $cm^{-1} s^{-2}$) and q (e.g. s^{-2}) correct. [1]

2 **(b)** L in range 19.0 cm to 21.0 cm, with unit. [1]

(c) (iv) Values for x_1 and x_2 to nearest mm and $x_2 > x_1$. [1]

Evidence of repeat readings of x_1 and x_2. [1]

(v) Correct calculation of X. [1]

(d) Absolute uncertainty in X in range 2 mm to 10 mm.
If repeated readings have been taken, then absolute uncertainty can be half the range (but not zero) if working is clearly shown.
Correct method of calculation to obtain percentage uncertainty. [1]

(e) Second value for L. [1]

Second values for x_1 and x_2. [1]

Quality: X smaller for larger L. [1]

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

(ii) Justification of s.f. in k based on the s.f. in L, x_1 and x_2. [1]

(iii) Valid comment consistent with the calculated values of k, testing against a <u>stated</u> numerical criterion. [1]

(g) Value for X = 50 cm. [1]

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(h)	(i) Limitations [4]	(ii) Improvements [4]	Do not credit
A	Two readings not enough to draw a conclusion	Take more readings and plot graph/ obtain more *k* values and compare	Two readings not enough for accurate results Repeat readings Few readings Take more readings and calculate average *k*
B	Metre rule is not parallel to bench/horizontal	Use a second rule and measure at both ends/ use a (spirit) level	
C	Difficult to move stands with reason e.g. friction/ bench is rough/ stands tend to stick	Guide for stands (fixed to bench)/ mount stands on rollers/ put wheels on stands/ method to reduce friction e.g. sand bench with sandpaper	Use a smooth(er) bench Use lubricant
D	Difficulty with rule e.g. rule skewed/ moves sideways	Use V-shaped rods/ groove in rods/ guide for ruler with some details	Falls off
E	Difficult to measure *x* with reason e.g parallax error/ difficult to tell point where rod touches ruler	Scale on vertical edge of rule/ draw a line on the rod/ use a thinner rod/ replace rods with sharp edges e.g. prisms	Large contact area

Do not allow ‘use a computer to improve the experiment’.

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1 (a) (i) Value of V_F in the range 260.0 cm^3 to 400.0 cm^3. [1]

(c) (v) All values of raw y to the nearest mm and less than 20 cm. [1]

(d) (ii) Six sets of readings of V and y (with correct trend and without help from Supervisor) scores 5 marks, five sets scores 4 marks etc. [5]

Range: [1]
Maximum value of $V \geqslant 200\,cm^3$.

Column headings: [1]
Each column heading must contain a quantity and an appropriate unit.
The presentation of the quantity and unit must conform to accepted scientific convention, e.g. y / m or y (cm), V / cm^3 , $2V_F$ / 3 / cm^3.

Consistency: [1]
All values of raw V must be given to the nearest cm^3.

(e) (i) Axes: [1]
Sensible scales must be used. Awkward scales (e.g. 3:10, fractions or non-linear) 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 should be no more than three large squares apart.

Plotting of points: [1]
All observations in the table must be plotted on the grid.
Diameter of plotted points must be $\leqslant$ half a small square (no "blobs").
Points must be plotted to an accuracy of half a small square.

Quality: [1]
All points in the table must be plotted on the grid (at least 5) for this mark to be awarded.
All points must be within ± 0.25 cm (to scale) in the y direction 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.
There must be at least four points left after disregarding the anomalous point.
Line 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.
The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Sign of gradient on answer line must match graph 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 and substituted into $y = mx + c$.
Read-off must be accurate to half a small square in both *x* and *y* directions.
Or:
Check read-off of the intercept directly from the graph (accurate to half a small square.

(f) Value of *P* = candidate's gradient and value of *Q* = candidate's intercept.
Do not allow fractions. [1]

Units for *P* (e.g. mm^{-2}, cm^{-2}, m^{-2} but **not** e.g. cm / cm^3) and *Q* (e.g. m) correct. [1]

(g) (i) *V* calculated correctly to the number of significant figures given by the candidate.
Sign of answer must be consistent with *P* and *Q* values in **(f)**. [1]

(ii) Valid comment with a comparison of volumes e.g. *V* is greater than V_F. [1]

2 (a) (ii) Value of *L* with unit in range 0.790 m to 0.810 m. [1]

(iii) Absolute uncertainty in *L* either 1 mm or 2 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]

(b) (ii) All values of raw d_1 with unit to the nearest mm. [1]

(c) (ii) $d_2 > d_1$ showing scale on rule is used correctly. [1]

(iii) Correct calculation of $|d_2 - d_1|$. [1]

(iv) Correct calculation of *M* with consistent unit. Do not allow answers to 1 s.f. [1]

(d) Justification for s.f. in *M* linked to s.f. in *m* <u>and</u> *L*. [1]

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(e) Second value of d_1. [1]

Second value of d_2. [1]

Quality: Second value of $|d_2 - d_1|$ < first value of $|d_2 - d_1|$. [1]

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

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

(g)	**(i)** Limitations [4]	**(ii)** Improvements [4]	Do not credit
A	Two readings not enough to draw a conclusion	Take more readings <u>and</u> plot a graph/ obtain more k values <u>and</u> compare	Two readings not enough for accurate results Repeat readings Few readings Take more readings and calculate average k
B	Difference between d_2 and d_1 is small/ $(d_2 - d_1)$ is small/ large % uncertainty in $(d_2 - d_1)$	Improved method to measure $(d_2 - d_1)$ values e.g. travelling microscope/larger masses/clamp vernier calipers above strip	Laser Ultrasonic position sensor Longer strip Change strip Deflection of strip
C	Difficult to distribute mass evenly/ gaps between masses vary/ masses do not lie in a straight line/ masses have slots	Improved method of distribution e.g. use marker or scale on wooden strip/ use smaller masses to produce the same m/ continuous strip of named material e.g. modelling clay	Masses inaccurate Stick masses to strip Masses falling Replace strip with metre rule Masses with no slots
D	Difficult to measure <u>d</u> values with reason e.g. rule not vertical/ difficult to hold second rule still as a pointer/ parallax error/ rule not held stationary	Improved method to measure d e.g. clamp metre rule/ place a set square on the floor next to ruler (to ensure rule is vertical)/ use of pointer (to metre rule)	Strip oscillates when masses are put on it Use a set square Effects of wind Reference to L
E	Strip becomes permanently bent or deformed	Method to overcome deformation e.g. check d without masses before and between readings/ lay weights on strip to flatten	Elastic properties of wood vary Use a new strip

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1 (b) (i) Value for x in range 45.0 cm to 55.0 cm. [1]

(iii) Value for I in range 500 μA to 1500 μA (or 0.50 mA to 1.50 mA), with unit. [1]

(c) Six sets of values for x and I (with correct trend and without help from Supervisor) scores 5 marks, five sets scores 4 marks etc. [5]

Range: [1]
x values must include 20 cm or less and 80 cm or more.

Column headings: [1]
Each column heading must contain a quantity and an appropriate unit.
The presentation of the quantity and unit must conform to accepted scientific convention e.g. I / μA.

Consistency: [1]
All values of raw x must be given to the nearest mm.

(d) (i) Axes: [1]
Sensible scales must be used. Awkward scales (e.g. 3:10, fractions or non-linear) 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 of points: [1]
All observations in the table must be plotted on the grid.
Diameter of plotted points must be ⩽ half a small square (no "blobs").
Plotting of points must be accurate to half a small square.

Quality: [1]
All points in the table (at least 5) must be plotted on the grid.
All points must be within ±20 μA (±0.02 mA) of a straight line in the y (I) direction.

(ii) Line of best fit: [1]
Judge by balance of all points on the grid about the candidate's line (at least five points). There must be an even distribution of points either side of the line along the full length.
One anomalous plot is allowed if clearly indicated (i.e. circled or labelled). There must be at least five points left after disregarding the anomalous point.
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.
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.

y-intercept: [1]
Either:
Check 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:
Check read-off of the intercept directly from the graph (accurate to half a small square.

(e) Value of *S* = candidate's gradient and value of *T* = candidate's intercept.
Do not allow fractions. [1]

Consistent units for *S* (e.g. $\mu A\,cm^{-1}$) and *T* (e.g. μA). [1]

(f) Calculation: *r* calculated correctly to the s.f. given by the candidate. [1]

Significant figures: *r* given to 2 or 3 s.f. [1]

2 (b) (ii) x_1 in range 10.0 cm to 40.0 cm. [1]

(c) Value of $x_2 < x_1$. [1]

(d) (i) Second value of x_1. [1]

(ii) Value of x_2 given to nearest mm and all other raw values of *x* in **(b)**, **(c)** and **(d)** are to the nearest mm. [1]

(e) (i) Two values of *k* calculated correctly. [1]

(ii) Justification of the s.f. in *k* based on the s.f. in x_1 and the s.f in x_2. [1]

(iii) Valid comment consistent with the calculated values of *k*, testing against a <u>stated</u> numerical criterion. [1]

(f) (i) Raw values of *D* to nearest 0.001 cm and in range 1.400 cm to 2.200 cm. [1]

Evidence of repeated readings for *D.* [1]

(ii) Absolute uncertainty in *D* of 0.001 cm or 0.002 cm.
If repeated readings have been taken, then absolute uncertainty could be half the range (but not zero) if working is clearly shown.
Correct method of calculation to obtain percentage uncertainty. [1]

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(iii) *V* calculated correctly. [1]

(iv) Quality: *M* in range 3 g to 13 g. [1]

(g)	**(i)** Limitations [4]	**(ii)** Improvements [4]	Do not credit
A	Two readings are not enough to draw a valid conclusion	Take more readings and plot graph/ take more readings and compare *k* values	Two readings not enough for accurate results Repeat readings Few readings Take more readings and calculate average *k*
B	Empty beaker moves on bench	Fix beaker with Blu-Tack/tape/ glue	
C	Difficult to balance rule: rule slips on pivot/ wind disturbs balance	Make groove in rule (under 50cm mark)/ other practical method e.g. hinge/nail through rule	Blu-tack Tape Switch off fans String slips on rule
D	Spheres/string/tape still wet after immersion so <u>mass changes</u> **or** string/tape adds to mass of sphere	Use waterproof string/ use wire	Dry the spheres Waterproof tape
E	Difficult to measure *x* with reason, e.g. string too thick (so it covers graduations on rule)	Use thin(ner) string	Parallax problems
F	Marble not round	Improved method of finding *V* (e.g. liquid displacement)	Repeat readings and average

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