

1(a)	Final value of n_0 with no unit and in the range $10 \leq n_0 \leq 30$.
	Evidence of repeats.
1(b)(i)	$n < n_0$.
1(b)(ii)	Correct calculation of N .
1(c)	Five sets of readings of M (different values) and n with correct trend (M increases, n decreases) and without help from Supervisor scores 4 marks, four sets scores 3 marks, etc.
	Range of M : Must include $M_{min} = 10 \text{ g}$ and $M_{max} \geq 60 \text{ g}$.
	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. M / g .
	Significant figures: All values of N^3 given to 3 significant figures.
	Calculation: Correct calculation of N^3 .
1(d)(i)	Axes: Axes must be labelled with the required quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).
	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. Points must be plotted to an accuracy of half a small square in both x and y directions.
	Quality: All N^3 values are positive and trend of points must be positive. All points in the table (at least 4 points) must be plotted on the grid for this mark to be awarded. It must be possible to draw a straight line that is within $\pm 5 \text{ g}$ on the M -axis of all plotted points.
1(d)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 4 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If 5 or more points are plotted and they identify one point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit.
1(d)(iii)	Gradient: The hypotenuse of the triangle used 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. Method of calculation must be correct, not $\Delta x / \Delta y$. Gradient sign on answer line must be consistent with graph drawn.
	y-intercept: Intercept read directly from the graph, with read-off at $M = 0$, accurate to half a small square in y direction. or Correct read-off from a point on the line is substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions.
1(e)	Value of P = candidate's gradient value and value of Q = candidate's intercept value. Values must not be written as fractions or given to only one significant figure.
	Units for P : g^{-1} or kg^{-1} consistent with their readings and no units for Q .

2(a)(i)	Value of B in range 7.50–9.50 cm with unit and to nearest mm.
2(a)(ii)	Percentage uncertainty based on absolute uncertainty in range 2–5 mm. Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty / value from (a)(i)) $\times$ 100. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.
2(b)(i)	Value for d in range 2.00–6.00 mm with unit and to nearest 0.1 mm.
2(b)(ii)	Value for L in range 20.0–40.0 cm with unit.
	Value of T in range 2.00–9.00 (s).
	Repeat readings for T : at least two values of nT where $n \geq 2$.
2(c)	Second values of d and L .
	Second value of T .
	Second d smaller than first d .
2(d)(i)	Two values of k calculated correctly. Values not written as fractions or given to only one significant figure.
2(d)(ii)	Justification for significant figures in k linked to significant figures in B , L , d and T .
2(e)	Correct calculation of percentage difference between candidate's two k values. Comparison of percentage difference with 20%, leading to a consistent conclusion.
2(f)(i)	A Two (sets of) readings are not enough to draw a (valid) conclusion (not "not enough for accurate results", "few readings"). B Difficult to measure B with a reason e.g. difficult to judge the position of the centres of the masses / masses not parallel to each other on wire / B changes when clip and masses are suspended. C Difficult to measure L with a reason e.g. parallax error / rubber cord moves <u>when touched by rule</u> / clip moves <u>when touched by rule</u>. D Difficult to measure d with a reason e.g. jaws of calipers compress width of rubber cord. E Difficult to measure T with a reason e.g. because oscillations die away (very) quickly / amplitude of oscillations decreases quickly / oscillations are heavily damped / difficult to judge start and/or end of oscillations. F Difficulty with oscillation (of cord/clip/masses) e.g. oscillations in more than one mode / vertical or side-to-side oscillations / oscillation affected if rubber cord is not attached at centre of lower clip / wire moves in the clip during oscillation. <i>1 mark for each point up to a maximum of 4.</i>

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 of measuring B e.g. measure from left (or right) hand side of one mass to left (or right) hand side of the other mass / measure B when clip is suspended. C Method to improve measurement of L e.g. clamp rule (to measure L) / use pointers attached to rule or attached to edges of clips. D Method to improve measurement of d e.g. use a micrometer (to measure d) / use travelling microscope (to measure d). E Method to improve measurement of T e.g. twist masses through larger angle before releasing / use marker placed at midpoint/equilibrium point/rest point of oscillation / record/film/video oscillation <u>with</u> timer in view. F Workable method to improve release of clip/masses e.g. mark centre of clip for attaching to the rubber cord / marker to indicate initial height / marker to indicate initial position of centre of clip vertically under cord. <i>1 mark for each point up to a maximum of 4.</i>
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