This document consists of **9** printed pages.

Question	Answer	Marks
1(a)(i)	Value of M_L, with unit, equal to 200 g.	**1**
1(a)(ii)	Value of T with unit and in range 0.90–1.60 s.	**1**
	Repeats: at least two measurements of at least $5T$.	**1**
1(b)	Six sets of readings of M_L and T with correct trend and without help from the Supervisor scores 4 marks, five sets scores 3 marks, etc.	**4**
	Range: min $M_L \leqslant 100$ g **and** max $M_L \geqslant 500$ g.	**1**
	Column headings: Each column heading must contain a quantity and a unit where appropriate The presentation of quantity and unit must conform to accepted scientific convention e.g. $\sqrt{M_L}$ / g$^{\frac{1}{2}}$.	**1**
	Consistency: All values of raw time must be given to the nearest 0.01 s or all to the nearest 0.1 s.	**1**
	Significant figures: Values of $\sqrt{M_L}$ given to 3 significant figures.	**1**
	Calculation: Values of $\sqrt{M_L}$ calculated correctly.	**1**

Question	Answer	Marks
1(c)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both the *x* and *y* directions. Axes must be labelled with the quantity that is being plotted. Scale markings must be no more than 2 cm (one large square) apart.	1
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square. Points must be plotted to an accuracy of half a small square in both *x* and *y* directions.	1
	Quality: All points in the table must be plotted (at least 5) for this mark to be awarded. General trend of points must be positive. Scatter of plotted points must be no more than ± 1 g$^{\frac{1}{2}}$ from a straight line in the x ($\sqrt{M_L}$) direction. If $\sqrt{M_L}$ has unit kg$^{\frac{1}{2}}$ then tolerance is ± 0.03 kg$^{\frac{1}{2}}$.	1
1(c)(ii)	Line of best fit: 'Best fit' is judged by the 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. Candidates do not need to identify an anomalous point. However if there is a point off trend, it may be identified as anomalous by circling or labelling it. There must be at least 5 points left after one anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	1

Question	Answer	Marks
1(c)(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 matches graph drawn.	1
	y-intercept: Correct read-off from a point on the line and substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions. **or** Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square.	1
1(d)	Value of a = candidate's gradient **and** b = candidate's intercept. Values must not be written as fractions.	1
	Units for a and b correct and consistent with value (e.g. s g$^{-\frac{1}{2}}$ for a and s for b).	1

Question	Answer	Marks
2(a)	Value of R to nearest mm, with unit, in range 3.5–6.0 cm.	**1**
2(b)(i)	Correct calculation of E <u>with no unit</u>.	**1**
2(b)(ii)	Raw value(s) for d_1 to nearest mm.	**1**
	Evidence of repeated readings of d_1.	**1**
2(b)(iii)	Absolute uncertainty in range 2–8 mm. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if working is clearly shown. Correct method of calculation to find percentage uncertainty.	**1**
2(b)(iv)	Value for d_2 greater than d_1.	**1**
2(c)	Second values of A and B.	**1**
	Second values of d_1 and d_2.	**1**
	Second d_1 < first d_1 **and** second d_2 < first d_2.	**1**
2(d)	Two values of k calculated correctly.	**1**
2(e)	Calculation of percentage difference between candidate's two k values. Comparison of percentage difference with 5% leading to a consistent conclusion.	**1**
2(f)	Correct calculation of f.	**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").	4
	B Difficulty in <u>measuring distance between central lines</u> (or A) with reason, e.g. large % uncertainty in A/A is small so uncertainty is large.	
	C Difficult to achieve/judge alignment of lines.	
	D Hard to keep block still in correct position.	
	E Difficult to <u>measure</u> d_1 (or d_2) with reason, e.g. difficult to hold rule still/rule too long/parallax error.	
	F Difficulty in <u>measuring</u> d_2 with reason, e.g. judging lowest point of block.	
	1 mark for each point up to a maximum of 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).	4
	B Measure <u>line spacing</u> using calipers.	
	C Use thinner ruled lines.	
	D Detail of support method for block, e.g. stand and clamp, support on two adjustable stands **or** perform the experiment sideways so the paper is against the wall and the block lies on the bench.	
	E Improved instrument to measure d_1 (or d_2), e.g. shorter ruler/clamped ruler/set square <u>instead of ruler</u>/thinner ruler.	
	F Measure to (flat) top of block and subtract radius (for d_2).	
	1 mark for each point up to a maximum of 4.	