Question	Answer	Marks
1(a)	Value for *R* with unit.	**1**
	Value for *a* with unit in range 10.0–75.0 cm.	**1**
1(b)	Six (or more) sets of readings of *R* (different values) and *a* and *b* with correct trend (as *R* increases, *a* increases and *b* decreases) and without help from the Supervisor scores 5 marks, five sets scores 4 marks, etc.	**5**
	Range: *R* values include 220 Ω **and** 4700 Ω.	**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. $1 / R$ ($k\Omega^{-1}$) and b / a (no unit)	**1**
	Consistency: Values of *a* and *b* must all be given to the nearest 0.1 cm.	**1**
	Significant figures: All values of b / a must be given to the same number of s.f. as (or one more than) the lowest number of s.f. in the corresponding *a* and *b* values.	**1**
	Calculation: Values of $1 / R$ are calculated correctly.	**1**
1(c)(i)	Axes: Axes must be labelled with the correct 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. Scales must not be awkward (e.g. 3:10 or fractions).	**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: Trend of points must be positive. All points in the table must be plotted (at least 5). It must be possible to draw a straight line that is within ± 0.2 on the b / a axis of all plotted points.	**1**

Question	Answer	Marks
1(c)(ii)	Line of best fit: 'Best fit' is judged by the 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. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If 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. There must be at least 5 points left after the anomalous point is disregarded.	**1**
1(c)(iii)	Gradient: The hypotenuse of the triangle used should 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. The method of calculation must be correct, not $\Delta x / \Delta y$. The gradient sign on the answer line must be consistent with the graph drawn.	**1**
	y-intercept: Intercept read directly from the graph, with read-off at $1 / R = 0$, accurate to half a small square in y direction. **or** Correct read-off from a point on the line and substituted correctly into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions.	**1**
1(d)	Value of M = candidate's gradient **and** value of N = candidate's y-intercept. The values must not be written as fractions or given to only one significant figure.	**1**
	Unit for M correct (e.g. Ω) **and** no unit for N.	**1**

Question	Answer	Marks
2(a)	Values for *A*, *B* and *C*.	**1**
	B in range 16.0–24.0 cm.	**1**
	Correct calculation of *x*.	**1**
2(b)(i)	Value(s) of *h*, with unit, to nearest mm.	**1**
	Evidence of repeat readings of *h*.	**1**
2(b)(ii)	Percentage uncertainty in *h* based on an absolute uncertainty in the range 0.2–0.8 cm. Correct method of calculation to obtain percentage uncertainty, e.g. (absolute uncertainty × 100 / final value from **(b)(i)**). If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is shown clearly.	**1**
2(c)	Second set of values for *A* and *B*.	**1**
	Second value for *h*.	**1**
	Second value of *h* less than first value of *h*.	**1**
2(d)(i)	Two values of *k* calculated correctly. The final *k* values must not be written as fractions or given to only one significant figure.	**1**
2(d)(ii)	Justification for significant figures in *k* linked to significant figures in *x*, *h* and *s*.	**1**
2(e)	Calculation of percentage difference between candidate's two *k* values. Comparison of percentage difference with 20% leading to a consistent conclusion.	**1**

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 Difficulty when measuring *B* with reason e.g. difficult to judge centre of rod **or** difficult to align hole with ruler. C Difficulty when measuring *A* or *C* with reason e.g. parallax error, difficult to hold/maintain ruler vertical. D Difficulty with water jet with a description e.g. too thick, multiple streams, jet spreads out. E Difficulty with judging/marking water level because of needing to look at the rod and water at the same time **or** water level is (quickly) changing. F Difficult to see/mark/judge water level with reason e.g. water is colourless/ribbed bottle. G Difficulty with paper strip e.g. ink on strip can be washed away. *1 mark for each point up to a maximum of 4.*	**4**

Question	Answer	Marks
2(f)(ii)	A Take more readings (for different values of *h*) and plot a graph **or** take more readings and compare *k* values (**not** "repeat readings" on its own). B Use string or measuring tape **or** use a thinner rod **or** use rule(r) with scale starting at end **or** measure horizontal distance and vertical distance and calculate a value for *B*. C Improved method to ensure vertical e.g. use clamped ruler/plumb line/spirit level. D Decrease diameter of hole **or** use a hole with smoother edge. E Improved method to determine water level e.g. record/film/video with scale/ruler in view **or** put cap/cork on bottle top or cover hole at moment jet hits rod. F Use coloured water/smooth bottle. G Use permanent marker/waterproof strip. *1 mark for each point up to a maximum of 4.*	**4**