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Question	Answer	Marks
1(c)(i)	<p>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).</p>	1
	<p>Plotting of points:            All observations in the table must be plotted on the grid.            Diameter of plotted points must be <math>\leq</math> half a small square.            Points must be plotted to an accuracy of half a small square in both x and y directions.</p>	1
	<p>Quality:            Trend of points must be positive.            All points in the table must be plotted on the grid (at least 5).            It must be possible to draw a straight line that is within <math>\pm 4 \Omega</math> on the <math>(R_1 + R_2)</math> axis of <u>all</u> plotted points.</p>	1
1(c)(ii)	<p>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.</p> <p>Some candidates may choose to identify an anomalous point. If they identify <b>one</b> 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.</p>	1

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Question	Answer	Marks
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 $(R_1 + R_2) = 0$ , accurate to half a small square in y direction. <b>or</b> Correct read-off from a point on the line is 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 $F$ = candidate's gradient <b>and</b> value of $G$ = candidate's y-intercept. The values must not be written as fractions or given to only one significant figure.	1
	Correct unit for $F$ e.g. $\text{mA}^{-1} \Omega^{-1}$ <b>and</b> correct unit for $G$ e.g. $\text{mA}^{-1}$ .	1
1(e)(i)	<u>All</u> raw values given to either 0.01 mm or <u>all</u> to 0.001 mm <b>and</b> final value of $d$ in the range 0.100–0.300 mm with unit.	1
	Measurements of $d$ repeated.	1
1(e)(ii)	Correct calculation of $\rho$ using $\rho = \pi d^2 EG / 4L$ .	1



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Question	Answer	Marks
2(a)	Evidence of mass of 5 or more paper clips measured to the nearest 0.1 g or better <b>and</b> mass of one paper clip determined.	1
2(b)(i)	Raw $h$ recorded to the nearest millimetre <b>and</b> final value of $h$ in range 10.0–60.0 cm.	1
2(b)(ii)	$N$ recorded.	1
2(b)(iii)	Value of $t$ in the range 0.50–10.00 s with unit.	1
	Evidence of repeats.	1
2(b)(iv)	Percentage uncertainty based on an absolute uncertainty in $t$ in the range 0.2–0.5 s. Correct method of calculation to find percentage uncertainty e.g. absolute uncertainty $\times 100 /$ value from <b>(b)(iii)</b> . If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if working is shown clearly.	1
2(b)(v)	Value of $a$ calculated correctly.	1
2(b)(vi)	Justification for significant figures in $a$ linked to significant figures in $h$ and $t$ .	1
2(c)	Second values of $N$ and $t$ .	1
	Second value of $t$ is smaller than the first value of $t$ .	1
2(d)	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(e)	Calculation of percentage difference between candidate's two $k$ values. Comparison of percentage difference with 25% leading to a consistent conclusion.	1





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Question	Answer	Marks
2(f)(i)	<p>A Two readings are not enough to draw a (valid) conclusion (<b>not</b> “not enough for accurate results”, “few readings”).</p> <p>B Difficult to measure <math>h</math> with a reason e.g. because mass hanger is not horizontal <b>or</b> rule not vertical <b>or</b> rule disturbs mass hanger/pulley.</p> <p>C <math>t</math> is small so uncertainty is large <b>or</b> large <u>percentage</u> uncertainty in <math>t</math>.</p> <p>D Difficult to measure <math>t</math> with a reason e.g. difficult to start stop-watch and release mass at the same time.</p> <p>E Difficulty with pulley and/or string e.g. hanger starts and stops <b>or</b> pulley too narrow so masses collide <b>or</b> masses too wide so collide.</p> <p>F Difficulty with adhesive putty e.g. mass of putty not taken into account <b>or</b> adhesive putty adds mass to slotted mass.</p> <p>G Difficulty with paper clips e.g. paper clips fall off mass hanger <b>or</b> difficult to balance clips on hanger <b>or</b> paper clips are discrete (large increments) so mass hanger suddenly releases and falls.</p> <p><i>1 mark for each point up to a maximum of 4.</i></p>	<b>4</b>



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Question	Answer	Marks
2(f)(ii)	<p>A Take more readings (for different values of <math>N</math>) <u>and</u> plot a graph <b>or</b> take more readings <u>and</u> compare <math>k</math> values (<b>not</b> “repeat readings” on its own).</p> <p>B Workable method to measure <math>h</math> accurately e.g. clamp metre rule (and use a fiducial marker).</p> <p>C Use a longer string <b>or</b> larger <math>h</math>.</p> <p>D Workable method to measure <math>t</math> e.g. record/film/video with timer in view/frame by frame <b>or</b> electromagnet for start, gate for end <u>with timer</u> <b>or</b> motion sensor above or below.</p> <p>E Workable improvement e.g. use a pulley with larger diameter <b>or</b> masses of smaller diameter.</p> <p>F Valid method to account for the mass of the adhesive putty e.g. measure mass and add on <b>or</b> tie mass using string <b>or</b> use tape.</p> <p>G Workable method for improvement e.g. hook/container added to hanger <b>or</b> use <u>smaller/lighter</u> paper clips.</p> <p><i>1 mark for each point up to a maximum of 4.</i></p>	<b>4</b>

