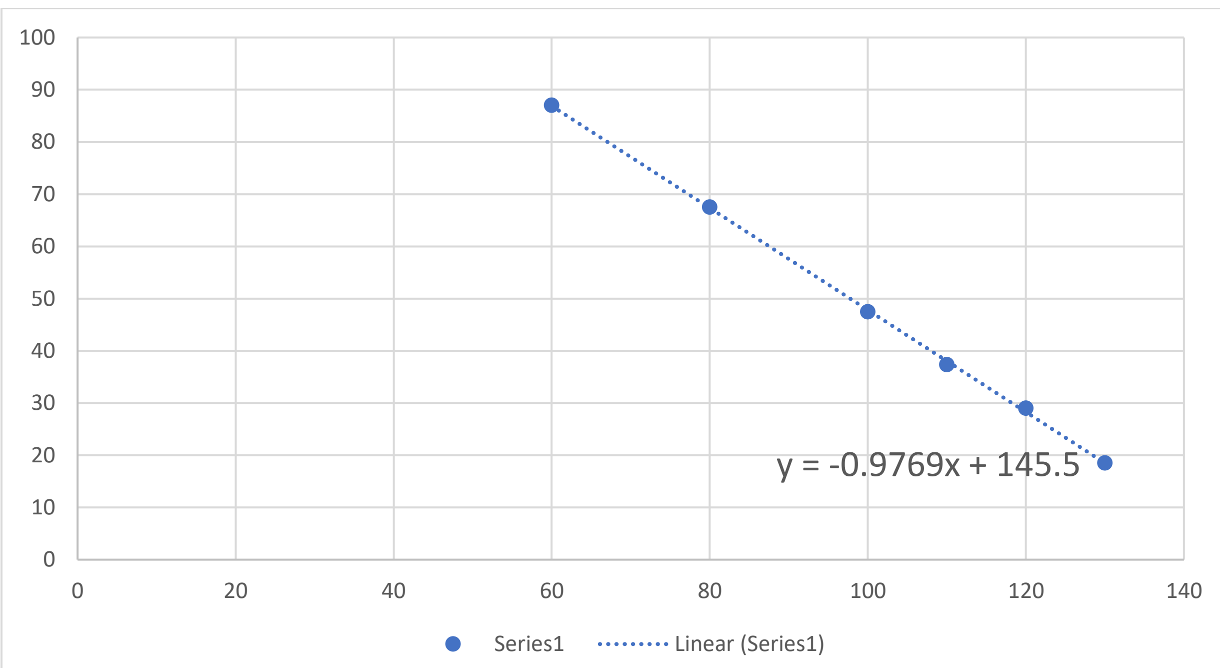
Mark Scheme

Question	Answer	Marks
1(a)(i)	current recorded to correct 1 d.p. in mA (setting of digital ammeter)	1
(ii)	$\frac{1}{I}$ recorded in the same s.f. as recorded in the corresponding I.	1
(iii)	percentage uncertainty calculated correctly using appropriate method and given to 1 or 2 s.f. E.g. *I* = 70.4 mA, $\frac{1}{I} = 14.2$ A^{-1} Using $\frac{\Delta(\frac{1}{I})}{1/I} = \frac{\Delta I}{I}$, so percentage uncertainty = $\frac{\pm 2}{70.4} \times 100\% = \pm 2.8\%\ or \pm \mathbf{3}\%$ <u>Alternative</u> or max $\frac{1}{I} = \frac{1}{68.4} = 14.6$ A^{-1} taking difference with $\frac{1}{I} = 14.2$ A^{-1} So absolute uncertainty can be estimated as ± 0.4 A^{-1}, so percentage uncertainty = $\frac{\pm 0.4}{\mathbf{14.2}} \times 100\% = \pm 2.8\%\ or \pm \mathbf{3}\%$	M1 A1
(b)	gradient = $\frac{R}{E}$ intercept = $\frac{r}{E}$	1
(c)(i)	correctly plotting of points with acceptable best fit line drawn	1
(ii)	correct method to calculate gradient	1
	correct method to calculate intercept	1
(iii)	$\frac{R}{r}$ obtained by $\frac{gradient}{intercept}$	1
(iv)	line parallel to original line <u>and</u> shifted upwards (or to the left)	1

Question	Answer	Marks
2(a)	• L = 98.5 ± 0.1 cm	1
(b)	• y_2 lesser than y_1 • y, y_2 and y_1 are all recorded to the nearest 0.1 cm • Repeated measurements	1
(c)	Tabulation • Collected 5 sets of data for m, y_1 and y_2. • Correct trend (0 marks for 4 sets and fewer)	1
	Column Heading • Each column heading must contain a **quantity and a unit**: y/cm, m/g • No split table	1
	Raw data (i.e x and I): Precision of recording • All values of y_1 and y_2. to nearest mm & • All values of m to nearest g	1
	Calculated quantity: Accuracy of calculation All values of y calculated correctly with the correct d.p	1
(d)	Graph: Scale, Size & Axes • Sensible scales, no awkward scales (eg 3 units into 10 small squares) • Plotted pts occupy at least **½ the graph grid in both x & y directions** • Axes labelled with the quantity & unit {ECF for wrong units in (c)} Successive scale markings: no more than 20 small squares apart.	1
	Plotting of Points • ALL observations in table must be plotted • accurate to within half a small square. • **Thickness of plots** (ie the crosses, 'x') ≤ half a small square	1
	Best fit line & Anomaly • **Minimum number of 4** non-anomalous points. • Line drawn with **approx. equal number** of points on either side of line (anomalous points not considered). • Line not be kinked/disjointed or thicker than half a small square • Anomalous plot **clearly indicated** (eg by a circle or labelled.) • Allow 1 anomalous plot only.	1

	• {Rule of thumb: A plot is considered anomalous if it is > 4 mm from line of best fit.}	
	<u>Determination of Gradient</u> ☐ Recorded the **4 coordinates** for gradient calculation **correctly** ☐ Hypotenuse of triangle **> half length** of line drawn ☐ **No obscurity** of the 2 points used for gradient calculation. {Hence triangle must not be drawn too near a data plot.}	1
	<u>Determination of y-intercept</u> Vertical intercept calculated using a <u>point on the line</u> {not from the table} & value of gradient. {Allow reading off the y- intercept if x-axis starts from zero & there is no 'bunching of plots'}	1

m/g	y1/cm	y2/cm	y/cm
60	90.0	84.0	87.0
80	70.0	65.0	67.5
100	51.0	44.0	47.5
110	40.2	34.5	37.4
120	34.0	24.0	29.0
130	24.0	13.0	18.5



Question	Answer	Marks
3(a)(ii)	value of *d* to nearest 0.01 mm and final value in range 1.50 – 1.70 mm show repeated readings	1
3(a)(iii)	value of θ to nearest degree and final value in range 55°–65°	1
3(a)(iv)	$\Delta\theta$ range from $\pm3°$ to $\pm5°$ percentage uncertainty given to 1 or 2 s.f.	1
3(a)(v)	correct calculation of $\sin^2(\theta/2)$ using values from (a)(iii) substitution of values in your working is needed correct significant figures no units	1
3(b)(i)	Value of *e* to nearest 0.1 cm and final value in range 0.8 – 1.6 cm. Δe range from $\pm$ 0.2 cm to $\pm$ 0.5 cm percentage uncertainty given to 1 or 2 s.f. clear working and substitutions correct significant figures correct units	2
3(b)(iii)	value of *t* in range 15.00 – 20.00 s show repeated readings <u>All</u> *t* values to nearest 0.01 s	1
3(c)	value of θ to nearest degree and final value in range 25°–35° correct calculation of $\sin^2(\theta/2)$ value of *t* in range 7.00 – 9.00 s show repeated readings for values of *t* <u>All</u> *t* values to nearest 0.01 s correct significant figures correct units	2
3(d)(i)	Two values of *k* calculated correctly. correct significant figures correct units	2
3(d)(ii)	Testing against percentage uncertainty in (a)(iv) and (b)(i) with appropriate conclusion. Do not accept arbituary criterion such as 10% or 20%	1

3(d)(iii)	spring constant of spring / length of wire / mass of wire / angle θ between the straight part of the wire	1
3(e)	• Setup according to Fig. 3.2 and conduct oscillations according to Fig. 3.3. Appropriate procedures with mention of variation of masses and collect corresponding values of t. Conduct at least 6 sets of data for masses and t. • Identify masses attached to end of wire as independent variable, time as dependent variable. Angle of bend, length of wire, spring constant, etc as controlled variable. • Identify stopwatch to record timing and protractor to measure angle. (optional: mass balance to measure calibrated masses). • Plot a graph of time against mass to determine constant gradient of the graph and zero y-intercept. • Light masses may result in unstable oscillating behaviour of the wire / Heavy masses may fall off the wire during oscillating (or not able to conduct experiment since the spring is deformed due to heavy masses)	5
3(f)(i)	values of *t* (no mass) is less values of *t* (with mass) Use a table to present the results. Repeats: At least two values of $t \geq 10$ s All *t* values to nearest 0.01 s correct significant figures correct units	3
3(f)(ii)	When masses are attached to the end of the wire, the centre of gravity shifted lower/away from the pivot point. Since period is proportional to the distance between the pivot and the centre of gravity for a simple oscillating object about the vertical plane, the period increases when masses are added.	1

Qn	Answer	Marks
4	**Diagram**	
	labelled diagram with • retort stand to hold capillary tube; • *h* labelled; container resting on bench. (Include rule if mentioned in procedure)	1
	Defining the problem	
	Part 1 *r* is the independent variable and *h* is the dependent variable or vary *r* measure *h*. and density of liquid to be kept constant.	1
	Part 2 ρ is the independent variable and *h* is the dependent variable or vary *r* measure *h*. and *r* to be kept constant.	1
	Methods to data collection	
	Measure inner diameter *d* using travelling vernier microscope or allow estimate diameter *d* by measuring external *d* using micrometer screw gauge or vernier caliper and ***r = d/2***	1
	Measure volume of water using measuring cylinder Measure mass of water using electronic balance. Calculate density using mass / volume (accept measure density using hydrometer)	1
	Measure *h* using tail of vernier caliper or metre rule clamped vertically.	1
	Method of varying density of liquid. E.g. changing different types of liquid or add solute into solvent. Need to give examples of solute used.	1
	Method of analysis	
	Part 1 Plot $\lg h\ \ vs\ \lg r$; p= gradient	1
	Part 2 Plot Plot $\lg h\ \ vs\ \lg \rho$; q = gradient	1

	Additional detail including safety considerations	max 3
	• Method of ensure capillary tube and instruments used to measure *h* is vertical. E.g. **use of plumbline** or **use set square**	1
	• Ways to check if cross-section of capillary tube is constant. E.g. pass a fixed volume of coloured liquid through tube. Check if length of coloured liquid is constant.	1
	• check that the temperature is constant throughout experiment to <u>prevent expansion or contraction of capillary tube.</u>	1
	• Method to exclude mass of container. E.g. use 'tare' function or subtract mass of empty container.	1
	• take preliminary readings for radius <u>and/or</u> density to obtain range that gives significant variation in *h*. Other good answers • colour the liquid to aid measurement of *h*.	1 1
	Safety: • way to handle broken glass capillary tube. E.g. wear gloves to handle broken glass. *(thick cloth glove should be used, not thin latex glove.)* • way to prevent breaking glass capillary tube. E.g. using foam to cushion clamp. • way to prevent spillage. Eg. put a cloth or container under the beaker. • cloth to wipe off spilled oil/water	max 1
	<u>No marking value (NMV)</u> unrealistic for this experiment - methods pertaining wearing of boots. - methods pertaining electric shock. - methods pertaining splashes of liquid. common expectation in procedure that should be done anyway. - wearing of goggles. - take average of several readings - clean and dry containers and tubes	