Question	Answer	Marks
1	**Additional detail including safety considerations**	**6**
	D1 use safety goggles/safety screen <u>to prevent injury to eyes from (moving) spring/load</u> **or** use cushion/sand box <u>in case load falls</u>	
	D2 keep constant <u>all</u> of: • w • N • ρ (or use same material for wire)	
	D3 measure mass <u>of load/m</u> with a balance **or** use newton meter to measure weight of load	
	D4 use ruler/calipers to measure the width of the <u>spring/w</u>	
	D5 use the equation ρ = mass of metal / volume to calculate ρ	
	D6 method to measure w, e.g. w measured to the outside and subtract d **or** method to measure ρ, e.g. mass (balance) and volume (measuring cylinder)	
	D7 repeat measurement of x (for the same A) and average	
	D8 repeat measurements of either d or w made in different places/directions and average	
	D9 use of $A = \pi d^2 / 4$ to determine A of <u>wire</u>	
	D10 use of set square to check that clamped ruler is vertical to bench **or** use of set square/pin as a fiducial mark to read positions (on the ruler)	

Question	Answer	Marks
2(a)	gradient = $\dfrac{1}{f}$ y-intercept = $\dfrac{t}{2f} - 1$	1
2(b)	$\dfrac{h_i}{h_o}$ 0.71 or 0.708 0.79 or 0.792 0.92 or 0.917 1.1 or 1.08 1.3 or 1.29 1.5 or 1.50	1
	Absolute uncertainties in $\dfrac{h_i}{h_o}$ from ± 0.07 to ± 0.1 (or ± 0.10 or ± 0.11).	1
2(c)(i)	Six points plotted correctly. Must be accurate to nearest half a small square. Diameter of points must be less than half a small square.	1
	Error bars in $\dfrac{h_i}{h_o}$ plotted correctly. All error bars must be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.	1

Question	Answer	Marks
2(c)(ii)	Line of best fit drawn. Points must be balanced. Do not accept line from top to bottom point. Line must pass between (55, 0.75) and (56, 0.75) **and** between (77, 1.40) and (78, 1.40).	**1**
	Worst acceptable line drawn (steepest or shallowest possible line that passes through all the error bars). All error bars must be plotted.	**1**
2(c)(iii)	Gradient determined with clear substitution of data points into $\Delta y / \Delta x$. Distance between data points must be at least half the length of the drawn line.	**1**
	Gradient of worst acceptable line determined. uncertainty = (gradient of line of best fit – gradient of worst acceptable line) **or** uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)	**1**
2(c)(iv)	y-intercept determined from substitution into $y = mx + c$.	**1**
	y-intercept determined using gradient from worst acceptable line. uncertainty = y-intercept of line of best fit – y-intercept of worst acceptable line **or** uncertainty = ½ (steepest worst line y-intercept – shallowest worst line y-intercept) No ECF from false origin method.	**1**

Question	Answer	Marks
2(d)(i)	f determined using gradient with correct substitution shown. $$f = \frac{1}{\text{gradient}} = \frac{1}{\textbf{(c)(iii)}}$$	**1**
	f determined using gradient **and** given to two or three significant figures **and** correct SI unit shown with correct power of ten e.g. 33 cm or 0.33 m or 33.1 cm or 0.331 m	**1**
	Absolute uncertainty in f determined. absolute uncertainty in $f = \dfrac{\Delta \text{gradient}}{\text{gradient}} \times f$	**1**
2(d)(ii)	t determined using y-intercept **and** given to two or three significant figures. Correct substitution of numbers required. $t = 2f \times (y\text{-intercept} + 1)$ **or** $t = \dfrac{2 \times (y\text{-intercept} + 1)}{\text{gradient}}$	**1**