Paper 4 – Practical

Qns	Answer	Marks
1aiii	• Maximum reading for *w* is 6.5 cm • Correct precision of 0.1 cm and corresponding unit • Repeated readings	1
1bii	• No. of oscillations stated clearly • Measured time precise to 0.01 s with correct unit Duration > 10s • Repeated readings	1
	• Period calculated to least s.f. with correct units	1
1ci	Largest value is 6.3 cm (Accept 6.0-6.5 cm) Corresponds to the width of the bull dog clip provided OR Largest value is 8 cm (Accept 7-14 cm) Oscillation dies down too quickly when *w* is larger.	1
1cii	• All headings accurately labelled with correct units. • Repeated readings for *t* • At least 6 sets of data collected	1
	• *w* / cm recorded to 0.1 cm • *t* / s recorded 0.01 s • *t* > 10s • N, n recorded	1
	• *t* average calculated and given to 0.01 s (same d.p. as *t)* • *T* calculated and given to least s.f. • 1/*w* calculated and given to least s.f.	1
	If table is split (e.g. 1/w or *T* in a separate table, minus 1 mark from 1cii	MINUS 1
1di	• Axes labelled with correct quantity and corresponding units • Labelled at every 2 cm or 4 cm interval • Plotted points cover at least half of the grid given	1
	• All points from table are plotted correctly (should not have more crosses than data sets from the table) • Best fit <u>straight line</u> drawn with anomalous points clearly labelled as “anomalous”, where applicable (not allowed to consider points as anomalous if data set is less than 6 sets)	1

Qns	Answer	Marks
1dii	• One point clearly identified – this point cannot be an anomalous point. • Expected *T* read to half the precision of a grid • Measured *T* can be read to the precision of the grid OR can be read from the table directly. • Difference in *T* calculated with correct units	1
1diii	***If candidate drew a straight line:*** If the relationship is valid, the plot of T against 1/w should give a line through the origin. OR The relationship is not valid because the best fit (straight) line does not pass through the origin. **OR, i*f candidate drew a curve:*** If the equation is valid, the plot of T against 1/w should give a straight line through the origin.	1
	The y-intercept of the graph is 0.6, and the difference of the y-intercept to zero is larger than the maximum difference between the best fit line and the data points as calculated in (d)(i), which is 0.3. Hence, the graph is a straight line which does not pass through the origin, and therefore, the results do not support the relationship. **OR, *if candidate drew a straight line:*** From the plot in (d)(i), the best fit line fit a curve, not a straight line. The difference in (d)(ii) shows a maximum percentage difference of ____ for the value of *T* based on a best fit straight line, which is larger than 10%. Hence, my results do not support the relationship. **OR, *if candidate drew a curved line:*** The difference in (d)(ii) shows a maximum percentage difference of ____ for the value of *T*, which is smaller than 10% (min 10%, max 20%). Hence, my results support a curved line and do not support the given relationship.	1
1ei	• All headings accurately labelled with correct units. • Repeated readings for *t* • 4 sets of data collected	1
	• *c* / mm recorded to 0.01 mm, around 0.10 mm, 0.20 mm, 0.23 mm and 0.30 mm (cannot exceed 0.50 mm) • *t* / s recorded 0.01 s • *t* > 10 s • N, n recorded	1
	• *t* average calculated to 0.01 s • *T* calculated and given to least s.f.	1
	If data is not presented in a single table, minus 1 mark from 1ei	MINUS 1
1eii	• Axes labelled with correct quantity and units	1

Qns	Answer	Marks
	• Labelled at every 2 cm or 4 cm interval • Plotted points cover at least half of the grid given	
	• All points in table are plotted correctly • Cannot have anomaly (too little data points) • Best fit line drawn (can accept straight line too) • Trend is correct: negative gradient	1
1eiii	As c increases, T decreases at a decreasing/increasing/constant rate. (*Conclusion should be based on candidate's results.)* Do not accept "inverse" or "opposite" relationship.	1
1f	Measure independent and dependent variables using appropriate measuring instruments. • Measure the length l of the rod with a metre rule / measuring tape • Measure the time taken for oscillations using a stopwatch • Repeat steps to collect a set of readings by varying l	1
	Statement of what graph to plot; Expected observation if the relationship is valid. • Plot a graph of T against l^2 • If T is directly proportional l^2, a straight line graph through the origin will be obtained.	1
	Any one of the control of variables correctly identified. • The axis of rotation should pass through the geometric centre of the rod, by aligning the centre of the rod to the centre of the strip of paper • Use the same (thickness/width/length of) paper strip for the oscillating system. • Use the same diameter/mass/volume/density for the rod Do not accept "same material of the rod", since the material (wood) has already been given.	1
2ai	• E recorded to correct precision of 1 mV or 0.001 V • Repeated readings for E • Value should be 1.3 V – 1.9 V	1
2aiii	• L recorded to correct precision of 0.001 m or 0.1 cm • Value should be 40 cm – 48 cm • Repeated readings for L	1
2bii 2biv	• I recorded to correct precision of 0.0001 A or 0.1 mA • x recorded to correct precision of 0.001 m or 0.1 cm • Repeated readings x and I	1
2c	• All headings accurately labelled with correct units. • Repeated readings for I	1
	• x / cm recorded to 0.1 cm • I / mA recorded 0.1 mA	1

Qns	Answer	Marks
	• As x increases, I increases. • At least 6 sets of data collected • Range of x is at least 20 cm	1
	• $\langle I \rangle$ calculated and given to 1 d.p. (same as I) • $\frac{1}{\langle I \rangle}$ calculated and given to least s.f. (3 s.f.)	1
2d	Linearising equation and statement. • Plotting $\frac{1}{I}$ against x should give a straight-line graph with gradient $-P$ and y-intercept Q.	1
	Axes: • Sensible scales must be used, no awkward scales (only allow 1, 2, 5). • Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. • Scales must be labelled with the quantity and units which are being plotted. • Scale markings should be no more than 4 cm apart. • Must label origin if a plot falls within the first 2 cm.	1
	Plotting of points: • All observations must be plotted on the grid. • Plots must be accurate to within half a small square in both x and y directions.	1
	Line of best-fit • Judged by balance of all points on the grid about the line. There must be an even distribution of points either side of the line along the full length. • One anomalous point is allowed only if clearly indicated (i.e. circled and labelled) by the candidate. • Lines must not be kinked or thicker than half a small square.	1
	P (gradient) is correctly calculated with correct units (cm^{-1} A^{-1}) and correct significant figures. *Gradient*: the hypotenuse of the Δ must be greater than half the length of the drawn line. Check for $\Delta y/\Delta x$ (i.e. do not allow $\Delta x/\Delta y$). Gradient triangle must be clearly drawn. All coordinates read-off from graph must be accurate to half a small square.	1
	Q (y-intercept) is correctly calculated with correct units (A^{-1}) and correct significant figures. *y-intercept*: Either correct read-off from a point (accurate to half a small square) on the line substituted into $y = mx + c$, or intercept is read directly from the graph, with read-off accurate to half a small square.	1
2e	• R calculated correctly and given to correct units and correct s.f.	1

Qns	Answer	Marks
3a	• *d* recorded to correct precision of 0.01 cm, with correct units • Repeated readings *d*	1
3bi	• *h* recorded to correct precision of 0.001 m or 0.1 cm, with correct units • Repeated readings *h*	1
3bii	• θ recorded to correct precision of 1°, with correct units • $50° < \theta < 80°$ • Repeated readings θ	1
3biii	• $\Delta\theta$ between 2° to 5° • Percentage uncertainty calculated and given to 2 s.f. *Alternative method:* • $\Delta\theta = \frac{1}{2}(\theta_{max} - \theta_{min})$ *to 1 s.f.* • *Formula and substitution must be shown* • *Absolute uncertainty must be at least* 1^o *(precision of instrument)*	1
3biv	• *V* calculated correctly using earlier values • $30\ \text{cm}^3 < V < 60\ \text{cm}^3$ • Correct units	1
3c	• Repeated readings of *h* with correct precision and units • *h* is less than (b)(i)	1
	• θ recorded to correct precision of 1° and correct units • Repeated readings for θ • θ is less than (b)(ii)	1
3d	• Calculation of k to correct s.f. and units	1
	• Correct calculation of percentage difference in k (accept ECF from wrong calculation of k) and comparison with percentage uncertainty in θ • Correct conclusion based on results.	1

Question 4		
Diagram	Diagram labelled, showing coil connected to a (variable) power supply AND plane of the cross section of the ring must be parallel to the plane of the cross section of the coil	1
Procedure	**Independent Variables** Measure the inner diameter of the ring using the inner jaws of the vernier caliper and measure the outer diameter of the ring using the outer jaws of the vernier caliper. $d = \frac{d_{in}+d_{out}}{2}$	1
	Measure the magnetic flux density *B* at the ends of the coil using a Hall probe sensor connected to a datalogger. Accept calculation using $B = \frac{1}{2}\mu_0 nI$, with measurement of current *I* and determination of *n* clearly explained	1
	Dependent Variable measure the height *h* using a metre rule.	1
	Repeat Run #1: use same ring to keep diameter *d* constant vary *B* by adjusting the variable power supply / variable e.m.f. source such that the current through the coil changes.	1
	Run #2: Keep *B* constant by keeping the current through the coil constant, (as seen from the ammeter). Vary *d* by using rings with different diameters.	1
Analysis	Run #1 Plot a graph of $\ln h$ against $\ln B$ The relationship is valid if graph is a straight line. *n* = *gradient*	1
	Run #2 Plot a graph of $\ln h$ against $\ln d$ The relationship is valid if graph is a straight line. *m* = *gradient*	1
Control of variables and Extra details	• Use rings of the same material *(optional: to ensure same resistivity)* DO NOT ACCEPT using the same coil Any good/further detail. Examples of creditworthy points might be: • linearization $\ln h = \ln k + m\ln d + n\ln B$ • use a plumbline to ensure that the axes of the ring and the coil are in the vertical direction OR adjust the position of the ring such that the distance of the edge of the ring to the metal rod on the retort stand along the circumference of the ring are equal so that the ring and the coil are coaxial. • Adjust orientation of hall probe until a maximum value is obtained OR place the hall probe along the centre axis of the coil. • Method to determine *h* more accurately (e.g. using a video camera and play back frame by frame to identify point where the ring is at the highest point)	2

	• Do a preliminary trial to determine the maximum current that can be used to prevent the ring from flying out beyond the top of the metal rod on the retort stand.	
Safety	Safety screen/stopper (not sand tray) to prevent being hit by the flying aluminium ring. OR Reasoned method to prevent the coil overheating - switch off when not in use. Or reasoned method to prevent injury from hot coil - do not touch hot coil, use insulating/thermal/heat-proof gloves. COIL/WIRE must be mentioned.	1