Paper 4 – Practical

Qns	Answer	Marks
1bi	• Correct precision of 0.1 cm and corresponding unit for L_1 • Repeated readings for L_1	1
	• Correct precision of 0.1 cm and corresponding unit for x_1	1
1bii	• Show $\Delta L_0 < \Delta L_1$ • $\Delta x_1 > 4$ mm ($\Delta L_0 < \Delta L_1$) • Correct calculation of percentage uncertainty • 2 s.f. for final answer	1 no marks if not shown 1
1biii	• Correct precision of 0.1 cm and corresponding unit for x_2 • $x_2 > x_1$	1
1ci	• β correctly calculated without units accept 2 or 3 s.f.	1
1cii	Either • Plot a graph of x_2 against x_1 where the gradient is $e^{2\beta\pi}$ and the y-intercept is zero. • $\beta = \frac{1}{2\pi}\ln(\text{gradient})$	1 1
	Or • Plot a graph of $\ln x_2$ against $\ln x_1$ where the gradient is 1 and the y-intercept is $2\beta\pi$ • $\beta = \frac{1}{2\pi}(\text{vertical intercept})$	
1ciii	• If the pipe is frictionless, $x_1 = x_2$ (as the spring will retract back to an extension of x_1 after being stretched further).	1
	• Hence, $\ln(x_2/x_1) = \ln(1) = 0$ and this implies $\beta = 0$.	1
	Total	10

Qns	Answer	Marks
2ai	• Correct precision of 0.1 cm and corresponding unit for *L* and *r* • Repeated readings for *L* and *r* • Repeated readings for *t* in 2 d.p. • t > 10 s , 45.0 cm ≤ L ≤ 55.0 cm • Correct calculation, number of d.p. / s.f. and unit for <*t*>, *T*	1
2aii	• 1 cm ≤ Δr ≤ 3 cm • Correct calculation of percentage uncertainty to 2 s.f. • Percentage uncertainty ≥10%	1
2b	• 4 sets of readings <u>without assistance</u> • Correct trend: as *L* decreases, *T* decreases	1
	• Correct column headings with correct units. Must include column for no. of oscillations & <*t*> • Repeated readings for *t* • Table must not be broken up into 2 separate tables	1
	• Consistent and correct d.p. for raw data in each column • Correct s.f./d.p. for processed data • Correct calculation, s.f. for <*t*>, *T* • t > 10 s , 45.0 cm ≤ L ≤ 55.0 cm	1
2c	• Statement of graph to be plotted must be provided. • All observations must be plotted to an accuracy to half a small square. • Scale chosen is such that the plotted points occupy at least half the graph grid in both directions. Awkward scales (e.g. 1:3) are not allowed. • Axes are labelled no more than 4 cm apart, but no less than 2 cm apart • Best-fit line drawn	1
	• Coordinates used to find gradient are read to the accuracy of half small square. • The coordinates used must be more than half the length of the line away. • Correct calculation of gradient to 3 s.f.	1
	• *A* determined correctly with correct unit to 3 s.f.	1
2d	• *g* determined correctly in m s^{-2} to 3 s.f.	1
2e	• Percentage difference calculated correctly and given to 2 s.f.	1
	• Compare percentage difference in *g* and percentage uncertainty in *r* • Draw correct conclusion depends on candidate's experimental results.	1
2f	• Expected line clearly labelled as *M* • Larger A → steeper gradient • Larger B → lower *y*-intercept (larger negative value) * If new line's gradient and *y*-intercept not clearly discernable, may award marks if student annotate correctly	1
	Total	12

Qns	Answer	Marks
3ai	• 5 sets of readings without assistance • Correct trend: as I increases, V increases	1
	• 2 d.p. for I in mA • 2 d.p. for V in V	1
3aii	• All observations must be plotted to an accuracy to half a small square. • Scale chosen is such that the plotted points occupy at least half the graph grid in y-direction. Awkward scales (e.g. 1:3) are not allowed. • Axes are labelled no more than 4 cm apart, but no less than 2 cm apart	1
	• Even number of data points on each side of best-fit curve. If anomalous data present, it must be circled and labelled.	1
3aiii	• As current increases, LED resistance decreases	1
3bi	• Repeated readings for V_{min} in 2 d.p. in volts • 1.5 V $\leq V_{min} \leq$ 1.75 V	1
3bii	• Correct explanation of use of 22 Ω resistor: to limit current passing through the LED	1

Qns	Answer	Marks
3ci	• 5 sets of readings for 5 different LED colours without assistance • Correct trend: as *frequency* increases, V_{min} increases	1
	• Repeated readings for V_{min} in 2 d.p. in volts	1
3ciii	Possible source of uncertainty: 1. Difficulty in judging when LED "just turn on" based on visual inspection, thus affecting the measurement of V_{min} 2. Difficulty in getting a precise value of V_{min} as a slight shift of the jockey on the resistance wire produces a large change in the voltmeter reading.	1 (B/BFL)
3cii	**Linearising equation and statement.** • Correct linearization with statement clearly presented	1
	Gradient • The hypotenuse of the gradient triangle must be at least half the length of the drawn line. Both read-offs must be accurate to half a small square. • Gradient triangle must occupy at least half the graph grid in both *x*- and *y*- directions. • Correct calculation of gradient	1
	Determine constant Correct determination of *h* with units	1
	Axes • Scale chosen is such that the plotted points occupy at least half the graph grid in x and *y*-direction. Awkward scales (e.g. 1:3) are not allowed. • Axes are labelled no more than 4 cm apart, but no less than 2 cm apart	1 (S)
	Plotting of points • All observations must be plotted to an accuracy to half a small square.	1 (P)
	Line of best-fit • Best fit line drawn with equal distribution of data points on either side There must be an even distribution of points either side of the line along the full length. Line must not be kinked. • Anomalous point must be circled and labelled.	1 (B/BFL)

Qns	Answer	Marks
3d	In general, the plan should be written such that the marker can carry out the experiment successfully by following your planning. The procedure should be in sequential logical order. • <u>Diagram</u> showing workable setup: - circuit plus position of light sensor and light meter	1 (d)
	• Method to vary and measure <u>independent variable</u>: - measurement of current I, V using ammeter & voltmeter - computation of input power P	1 (I)
	• Method to vary and measure <u>dependent variable</u>: - measurement of light intensity L with light sensor connected to light meter or using light intensity meter or lux meter.	1 (D)
	• Method to keep <u>control variable</u> constant: - distance and direction of light sensor to LED kept constant - use same colour LED	1 (C)
	• <u>Analysis</u>: - details on expected graph to be plotted, e.g P against L^2 - relation valid if straight-line graph passing through origin obtained and mentioned of gradient	1 (A)
	• <u>Precaution (any one)</u>: - conduct experiment in dark room - look at LED through a hollow tube to cut out ambient light	1 (P)
	Total	22

Q4

Diagram **P**	Workable arrangement including • with **speaker** connected to **signal generator** at one end of tube, • **sound sensor / microphone** at other end connected to **datalogger / CRO** • apparatus held in place, and not hanging in mid air supernaturally.	**D1**
Procedure **P**	**Independent Variable(s)** Measure length of tube ***L*** with **metre rule** Measure **<u>inner</u> diameter *d*** with **<u>internal jaw</u>** of the **vernier calliper.**	 **B1** **B2**
	Dependent Variable Method to measure *f*: • **increase *f*** on signal generator **from zero** to get first harmonics when **sound intensity reaches maximum the first time**. • determine **period T from CRO / data logger**, and use formula ***f* = 1/*T***	 **C1** **C2**
	Run #1: **Method to maintain *L* + Method to vary *d*** Vary *d* **<u>by</u>** <u>using tubes of the same length</u> but <u>different inner diameters</u>. **Measure *f* for different *d*.**	**R1**
	Run #2: **Method to maintain *d* + Method to vary *L*.** Vary *L* **<u>by</u>** <u>using tubes of same inner diameter</u> but <u>different lengths</u> **Measure *f* for different *L***	**R2**
Analysis **A**	Run #1 Plot of log (*1/f*) against log *d* gives a straight-line graph of gradient *n* **if relationship is valid.** ***n* = gradient**	**A1**
	Run #2 Plot of log (*1/f*) against log *L* gives a straight-line graph of gradient *m* **if relationship is valid.** ***m* = gradient**	**A2**
Control of variables AND Extra details **CE**	Accepted answers: • Linearization: $\log\left(\frac{1}{f}\right) = \log k + m \log L + n \log d$ • <u>Measure *L* and *d* in in different orientations by rotating tube about its axis</u>. <u>Compute average measurements</u> for more accurate results. • Conduct experiment in a <u>quiet room</u> to <u>avoid interference by background noise.</u> • As temperature and humidity of air affects the velocity of sound and thus the wavelength and frequency, conduct experiment in	**E1**

	a fixed temperature, air-conditioned room. Temperature of room is maintained by a thermostat. • Confirmation of *f* by finding 2*f* (2nd harmonics), 3*f* (3rd harmonics).	
Safety **S**	Accepted answers: • Wear **ear plugs** to **protect ears against loud sound**. • Determine a suitable detectable and safe sound intensity to use by performing pre-experimental trials of increasing intensity.	**S1**

[Total: 11 marks]