NJC Preliminary Examination 2024

H2 Physics Paper 4

Question	Marking points	Marks
1(a)	Value of R_A and R_B recorded to nearest 0.1 Ω m^{-1}.	1
1(b)(i)	Values recorded to nearest 0.1 cm with correct unit (cm).	1
	x > *y*.	1
1(c)	Six sets of readings of *x* and *y* including the data from **(a)** without assistance. Correct trend of increasing *x* and *y*	1
	Range: Smallest 20 cm ≤ *x* ≤ 30 cm and largest *x* ≥ 80 cm.	1
	Each column heading (*x*, y, $\frac{1}{x}$ and $\frac{1}{y}$) contains a quantity and a unit.	1
	All calculated values $\frac{1}{x}$ and $\frac{1}{y}$ must be given to the same number of significant figures as the raw values.	1
1(d)	Axes: ● Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). ● Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. ● Axes must be labelled with the quantity which is being plotted. ● Scale markings should be no more than two large squares apart.	1
	Plotting of points: ● All observations in the table must be plotted on the grid. ● Diameter of plotted points must be ⩽ half a small square. ● Points must be plotted to an accuracy of half a small square in both the x and y directions.	1
	Line of best fit: ● Judge by balance of all points on the grid about the candidate's line (at least 6 points). There must be an even distribution of points either side of the line along the full length. ● Allow one anomalous point only if clearly indicated. There must be at least five points left after the anomalous point is disregarded. ● Lines must not be kinked or thicker than half a small square.	1
	Gradient: ● The hypotenuse of the triangle used must be greater than half the length of the drawn line. ● Method of calculation must be correct, i.e. Δy / Δx. ● Gradient sign on answer line matches graph drawn. ● Both read-offs must be accurate to half a small square in both the *x* and *y* directions.	1
	y-intercept: Check correct read-off from a point on the line and substituted into $y = mx + c$. Read-off must be accurate to half a small square in both x and y directions. **or** Intercept read directly from the graph at $x = 0$, accurate to half a small square.	1
	Value of *a* = gradient with no unit.	1
	Value of b = *y*-intercept with correct unit (cm^{-1} or m^{-1}).	1
1(e)	Correct calculation of Internal resistance *r* and *r* must be positive	1

Question	Marking points	Marks
2(b)(ii)	Value of θ recorded to the nearest degree with correct unit.	1
	$L \geq L_0$, expressed to 1 decimal place	1
2(c)	Value of *e* calculated from $L - L_0$.	1
	Correct calculation of *k*.	1
2(d)	*m* is varied to obtain angle θ, adjust the apparatus to keep the length of spring or extension of the spring fixed (and PQ horizontal) or *m* is varied to obtain extension of spring *e*, adjust the apparatus to keep θ fixed.	1
	Plot a graph of cos θ against *m* or Plot a graph of *e* against *m*	1
	State how *k* is calculated e.g. $k = g / (\cos\theta \times \text{gradient})$ or $k = g / (e \times \text{gradient})$	1

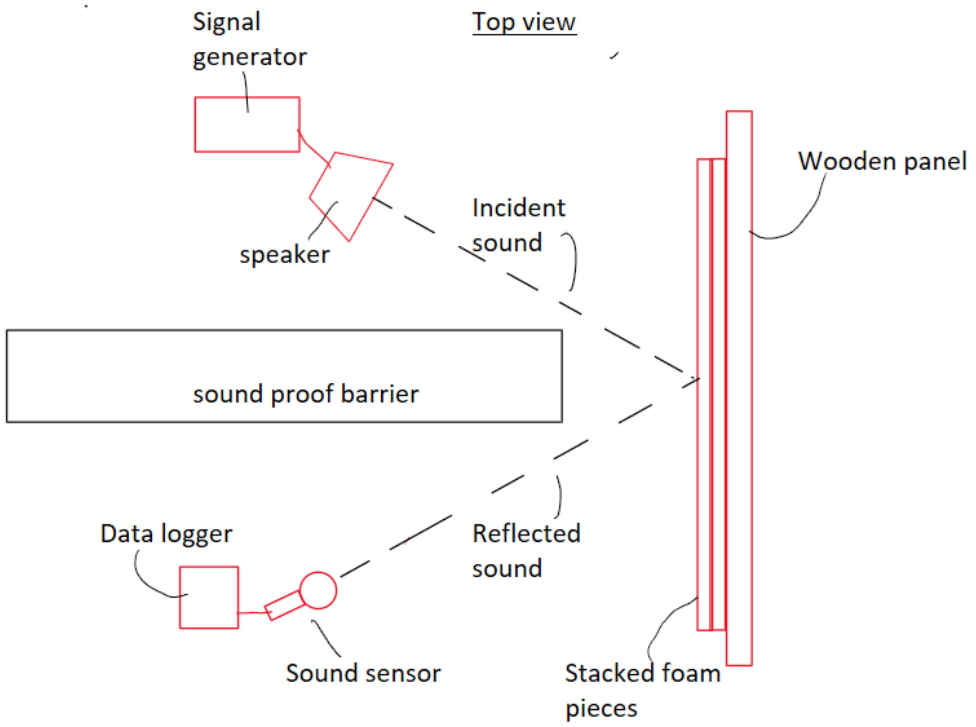
Question	Marking points	Marks
3(a)(ii)	0.30 mm ≤ *d* ≤ 0.32 mm.	1
	Evidence of repeat readings of diameter expressed to 0.01 mm.	1
3(a)(iii)	• Absolute uncertainty in *d* in range 0.01 mm (if repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown). • Correct method of calculation to obtain percentage uncertainty expressed to 1 s.f. or 2 s.f.	1
3(a)(iv)	*A* calculated correctly.	1
3(b)(iv)	Evidence of repeat readings of timings (repeat twice for timings ≥ 15 s, repeat thrice for 5 s ≤ timings ≤ 15 s).	1
	T expressed to the number of significant figures as the timings.	1
3(b)(v)	• Absolute uncertainty in timing in range 0.2 s – 0.5 s (if repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown). • Correct method of calculation to obtain percentage uncertainty expressed to 1 s.f. or 2 s.f.	1
3(c)(i)	0.14 mm ≤ *d* ≤ 0.16 mm.	1
	A calculated correctly.	1
3(c)(ii)	Second value of *T* > first value of *T*.	1
3(d)(i)	Two values of *k* calculated correctly, expressed to the least significant figures of values used, *k* correct unit (e.g. $\text{cm}^{1.5}$ s).	1

Question	Marking points	Marks
3(d)(ii)	Valid comment consistent with the percentage difference of the values of *k* and testing against the any one of the two percentage uncertainties in **(a)(iii)** and **(b)(v)**.	1
	Testing percentage difference of the values of *k* against percentage uncertainty = 2 × **(a)(iii)** + **(b)(iii)**.	1
3(e)(ii)	Varying of *m* with at least one reading of *T* greater and one reading smaller than T_S	1
	Reasonable method to approx. *m* eg. Sketch *T* against *m* as accurately as possible.	1
	m is approximated by showing *T* = T_S on the sketched graph.	1
	Note: When period T for different m is similar, candidate must have collected the data of swinging oscillation rather than torsional oscillation. This part will be awarded zero.	
3(f)	Measure diameter of mass with vernier callipers and state radius = diameter / 2. *Note: Micrometer screw gauge is not accepted because if r > jaw, instrument cannot be used.*	1
	Set up the apparatus and follow the procedure in **(a)** and **(b)** using mass of at least 6 different radii. Follow the procedure in **(a)(iii)** and **(b)** to determine the period *T* of the (torsional) oscillations.	1
	Keep *L* and *m* constant when repeating for different radii.	1
	Plot a graph of *T* against *r* or *r* against *T* and state proportionality shown when a straight line through origin obtained.	1
	Very small radii has very short period (and difficult to count the number of oscillations). To keep the mass constant, large radii means that the mass must be very thin or very large radii has very long period (and difficult to ascertain the completion of one oscillation).	1

Question 4 marking points		Marks
D1	**Diagram** ● Labelled diagram, drawn with ruler, with either a table or indicated as top view. ● Equipment must not be “floating”. ● Diagram must include speaker, foam, wooden panel ● Diagram include the apparatus mentioned in the procedure e.g. speaker connected to signal generator, sensor/ microphone/ receiver, CRO, data logger etc.	1
M1	**Methods + Instruments to measure dependent variable** Measure intensity I (or amplitude) of reflected signal using sound meter or microphone connected to CRO or data logger / sound sensor or sound intensity sensor connected to data logger. The following are not accepted: “power sensor”/ “intensity sensor”	1
M2 M3 M4 M5	**Methods + instruments to measure independent.** **Procedure 1** Vary frequency f with signal generator, t fixed f read directly from signal generator (must mention) or calculate using $f = 1/T$ and measure T from c.r.o. or sound sensor connected to data logger. Note: sound meter/sound intensity meter only measures intensity in dB (unless connected to data logger). Do not accept measurement of frequency using sound meter. **Procedure 2** Vary thickness by stacking the foam pieces, fix f Measure the thickness of foam with a rule/ micrometer/ vernier calipers.	4
C1	**Control of variables** ● Speaker at fixed angle and cannot be normal to the panel ● Fixed distance between speaker to foam and foam to microphone ● Fixed speaker output (loudness, intensity, etc)	1
A1 A2	**Method of analysis** Procedure 1: Plot a graph of lg I vs lg f with gradient is y. Procedure 2: Plot a graph of lg I vs lg t with gradient is x.	2
P1	**Procedure to reduce interference** Valid methods to reduce interference (shown either in procedure or indicated in the diagram) e.g. shielding between speaker and sensor (NOT sound-proof room) or position of sensor ‘behind’ speaker at sufficiently wide angle such that no interference from speaker.	1
	Additional detail and/or safety precaution (max 2 marks)	
AD1	Preliminary reading to ensure intensity can be read by sensor (without distortion) and varied by procedure	
AD2	Details on how to arrange angle of microphone to maximise the intensity measured	
AD3	Repeat and average the measurement of thickness of foam	
AD4	Measure background intensity and subtract from data	
AD5	Precaution linked to loud sounds, e.g. use ear plugs/muffs/defenders.	
Designs that are penalised		

1. Experiment that does not yield meaningful data e.g. using stationary wave approach (speaker and microphone along the same line to screen), microphone in front of speaker, microphone directly behind speaker.	**max 3 marks**
2. If the dependent variable cannot be measured reasonably e.g. no sensor, completely wrong sensor, no marks should be awarded for M1, A1 and A2	**max 9 marks**
3. If speaker is used without reasonable means to control frequency (e.g. without signal generator), no marks should be awarded for M2, M3 and A2	**max 9 marks**

Suggested solution for Q4



Procedure:

lg I = lg A + x lg t + y lg f

Expt 1: lg I against lg t, gradient = x
Expt 2: lg I against lg f, gradient = y

<u>Setup instructions</u>

Set up the experiment as shown in the diagram above.

Conduct preliminary experiments to adjust the angle of the speaker and sound sensor to obtain the loudest intensity of the reflected sound. Throughout both experiments described, ensure the following:

- keep the angle determined from preliminary data the same,
- speaker, foam pieces, wooden panel and sound sensor are kept at the same positions so that the distance between the speaker and foam pieces, sound sensor and foam pieces are constant,
- volume of the speak or the amplitude/intensity setting of the signal generator is kept constant.

Incident sound from speaker may reach sound sensor, to minimise such interference:

- position sound sensor slightly behind the speaker so that incident sound reaching sensor minimised,

- place sound proof barrier between the speaker and the sound sensor.

To improve accuracy, measure the average background sound intensity. The intensity *I* of the sound used in the analysis for the two experiments are obtained by subtracting the background value from the measured intensities.

Experiment 1

1. Measure the thickness t_1 of each of the provided identical pieces of foam using vernier calipers at different places and take average. To vary thickness, stack the foam pieces and use $t = Nt_1$ to determine thickness of the stacked foam pieces. (Alternative, measure after stacking at different places and take average)
2. Using the signal generator connected to the speaker, use a frequency that can be detected by the sound sensor. Keep this frequency of sound constant for this experiment. Frequency *f* is read directly from signal generator.
3. Measure and record the intensity *I* of the reflected signal using the sound sensor connected to the data logger.
4. Vary the thickness of the foam pieces and measure the intensity of the reflected signal for another 9 sets of readings. Tabulate the data.
5. Plot a graph of lg *I* against lg *t*, the gradient of the graph is *x*.

Experiment 2

1. Use just one piece of foam for this experiment. Measure the thickness of the foam.
2. Adjust the signal generator to vary frequency. Obtain the frequency *f* of the sound wave directly from the signal generator and record this value.
3. Measure the intensity *I* using the sound sensor connected to data logger.
4. Repeat for a total of 10 different values of frequencies, obtaining intensity of reflected wave for each frequency. Tabulate the data.
5. Plot a graph of lg *I* vs lg *f*, the gradient of the graph is *y*.

Safety precaution
To protect your hearing, ear muffs should be worn when the speaker is switched on.