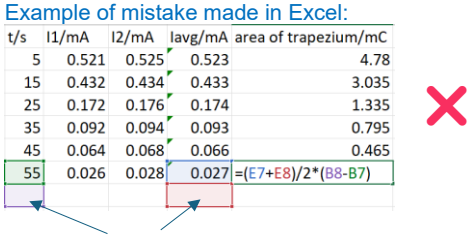
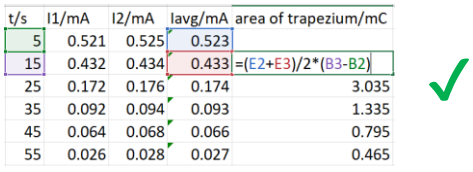
2026 JC2 Prelims P4

Qns	Marking Instructions	Mark
1(a)	V_0 recorded to the nearest 0.01 V.	1
1(b)(i)	value of t = 12 s to 17 s evidence of repeated readings of t	1
1(b)(ii)	accept Δt from 0.2 to 0.6 s percentage uncertainty of $t \approx 2.5\%$ percentage uncertainty expressed to 1 s.f. or 2 s.f.	1
1(c)(i)	6 sets of data without assistance and table headings correct, with units shown (table heading should include t, I_1, I_2, I_{mean}, ln I_{mean}) repeated readings of I for each t	1
	All raw data recorded and expressed to correct precision (I to nearest 0.01 mA or 0.001 mA)	1
	ln I_{mean} calculated correctly and d.p. corresponding to s.f. of I_{mean}	1
	Comments: Many students expressed the precision of ln I_{mean} incorrectly. Many students recorded the value of current incorrectly, such as recording it as 6.02 mA instead of 0.602 mA. A small number of students did not repeat readings for I.	
1(c)(ii)	working showing how B and A can be determined from gradient and y-intercept respectively	1
	sketch of suitable graph with axes labelled AND trendline equation shown	1
	A and B determined correctly, and units shown (unit of A = A or mA, unit of B = s)	1
	Comments: Many students labelled the unit for A incorrectly. It is important to note that in an equation $I = Ae^{-\frac{t}{B}}$, the unit for A follows the unit for I. A small number of students fitted an exponential curve instead of linearising it. The equation has to be linearised because the question referred to a trendline. By convention, 'line' refers to a straight line. Plotting the straight line also allows us to see and assess the fit more clearly, as we can visually check for linearity.	
1(d)(i)	The absolute uncertainty in t remains the same because it is caused by human reaction time. As the rate of change of I decreases, the absolute uncertainty in I also decreases.	1

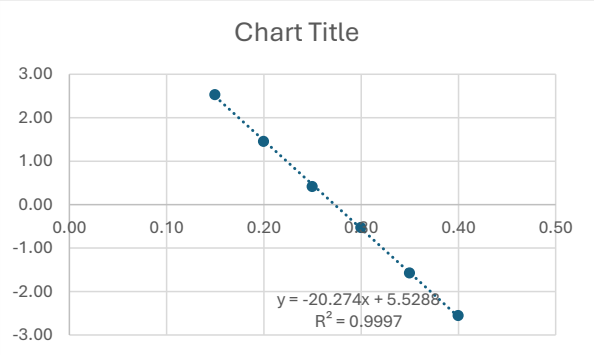
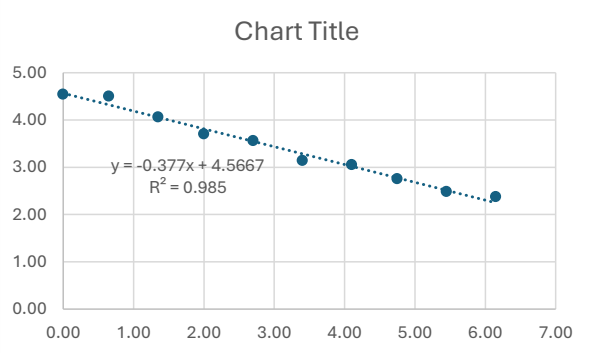
1(d)(ii)	The total amount of charge transferred can be determined by taking the area under the *I*-*t* graph.	1
	Comments: This question was generally done well. Students who did not score the mark commonly failed to state clearly which graph should be plotted, specifically identifying the quantities to be plotted on the y-axis and x-axis.	
1(d)(iii)	amount of charge transferred ≈ 0.0150 C	1
	Comments: • A number of students gave the final answer with incorrect units. Students should take care to note that the readings in the table are typically recorded in mA and, hence, the estimated charge should be expressed in mC. • A number of students obtained estimates that differed significantly from the expected value. Inspection of the working suggested that this was due to incorrect use of Excel. In particular, some students used a formula to calculate the area of each trapezium and then dragged the formula down for the subsequent rows, but inadvertently included the final row, which should have been excluded. Note that if there are 6 data points, there should only be 5 trapeziums. Example of mistake made in Excel:  These are not valid data. Excel assumes that its value is 0 and continues calculation without providing an error message. There should not be a 6th trapezium. Recommended: Start from the second row, so you will not forget about it at the last row. 	

t/s	I1/mA	I2/mA	Iavg/mA	area of trapezium/mC
5	0.521	0.525	0.523	4.78
15	0.432	0.434	0.433	3.035
25	0.172	0.176	0.174	1.335
35	0.092	0.094	0.093	0.795
45	0.064	0.068	0.066	0.465
55	0.026	0.028	0.027	=(E7+E8)/2*(B8-B7)

t/s	I1/mA	I2/mA	Iavg/mA	area of trapezium/mC
5	0.521	0.525	0.523	
15	0.432	0.434	0.433	=(E2+E3)/2*(B3-B2)
25	0.172	0.176	0.174	3.035
35	0.092	0.094	0.093	1.335
45	0.064	0.068	0.066	0.795
55	0.026	0.028	0.027	0.465

Total: 12 marks

Qns	Marking Instructions	Mark
2(a)	t = 0.770 mm Accept value of t in range of 0.730 – 0.800 mm	1
	Comments: While repeated thicknesses were not marked for this time, it is good practice to actually do so to ensure that there are no anomalies. Some candidates took measurements at the wrong end and their readings were skewed by the thickness of the tape used for labelling.	
(b)(i)	T_1 = 0.6910 s • *total timing of oscillations NT to be more than 20 s* • *Number of oscillations N should be clearly stated* • *Accept value of period T_1 in range of 0.60 to 0.80 s* • *Take repeated readings of total timings NT.* • *NT to the nearest 0.01 s with correct units.* • *T to follow s.f. of NT.*	1
	Comments: Most were able to get credit for this but there are still some candidates who presented their answers in 2 s.f, not realising that the raw data was in 4 s.f.	
(ii)	$f = \frac{1}{T}$ = 1.447 Hz f calculated corrected and presented with correct s.f. and units.	1
(iii)	$f = \frac{1}{T} \Rightarrow \frac{\Delta f}{f} = \frac{\Delta T}{T} = \frac{\Delta t}{t}$ Percentage uncertainty in f calculated corrected using appropriate uncertainty for T Δt between 0.2 to 0.5 s	1
	Comments: Candidates should take note to present their workings clear. There were some who calculated the percentage uncertainty using the frequency or period directly, it is important that they show clearly how the corresponding absolute uncertainty was obtained	
(iv)	T_2 less than T_1. *NT* to the nearest 0.01 s with correct units.	1
(c)(i)	25.4 cm Sum up amplitudes of crests and troughs from t = 0 to t = 2 s Accept value within (25.2 – 25.5 cm), units included	1
	Comments: Quite a number of candidates misread the question and seemed to have calculated the total distance travelled for the entire dataset.	

Qns	Marking Instructions	Mark
(ii)	Maximum speed = 20.3 cm s^{-1}  Accept value with 10% difference (17.9 – 22.8 cm s^{-1}), units included	1
	Comments: Most students were able to get this, small number did not include the proper units.	
(iii)	Explanation corresponding to use of steepest gradient for first oscillation.	1
	Comments: Most candidates were able to give an satisfactory explanation.	
(iv)	 sketch of negative-sloping graph with axes labelled AND trendline equation shown	1
	Gradient of graph is approximately -0.36 if at least 6 pts is selected (accept – 0.45 to -0.35)	1
	Comments: This part proved challenging to some candidates. They were not able to get an equation for the trendline. Some also misread the question and simply drew the variation with time of the displacement of the particle.	

Qns	Marking Instructions	Mark
c)	measurement of displacement and corresponding time using an appropriate method for fast oscillations, with a suitable means of measuring/calibrating displacement and appropriate positioning of the measuring device *(e.g. video analysis with ruler/scale in the plane of motion; motion sensor fixed relative to the laboratory and positioned such that the blade moves towards/away from the sensor, connected to a data logger to obtain displacement–time data))*	1
	method to determine amplitude from displacement–time data by identifying the maximum displacements from equilibrium position for each oscillation (e.g. identify successive peak values for each oscillation/ turning points)	1
	plot of ln(amplitude) against time to test for exponential relationship. If a straight line/ constant gradient (negative) is obtained, relationship is valid.	1
	reference to valid improvement **method to improve identification of maxima** (e.g. use a **higher frame-rate recording** so that the turning point can be located more precisely / interpolate between adjacent frames near the maximum) **control of conditions to ensure exponential damping** *(small amplitude / constant damping conditions)* **method to reduce uncertainty in amplitude measurement** *(parallax-free / perpendicular recording / fixed scale)* **secure clamping of blade to prevent injury from oscillating blade / secure with blu-tack**	1
	Comments: This planning was challenging for the candidates. For measuring the displacement and corresponding time, some candidates simply mentioned to use camera, not realising that while the camera can be used to show the motion of the fast-moving hacksaw blade, there will still need to be a means to show the actual displacement of the hacksaw blade. Better responses typically have the ruler clearly drawn with the displacement labelled in the diagram. For determining of the amplitude, some candidates were also too vague in their descriptions. Poor responses simply stated that for amplitude and time to be recorded during the oscillations, not making clear how these can be identified. It is important for candidates to linearise the expression so that they can obtain the correct variables for plotting a linear graph. Quite a number mistakenly use the power-law For	

Qns	Marking Instructions	Mark
	precautions, candidates should avoid mention steps that should already be taken or apparatus that are already provided should as repeated readings or use of safety goggles.relationship $x = kt^n; \ln x = n \ln t + \ln k$ which is not valid as the relationship was stated to be exponential. The actual relationship should be $x = Ae^{-bt}; \ln x = -bt + \ln A$ For precautions, candidates should avoid mention steps that should already be taken or apparatus that are already provided should as repeated readings or use of safety goggles.	

Total: 14 marks

<table>
<tr><th>Qns</th><th>Marking Instructions</th><th>Mark</th></tr>
<tr><td>3(b)(i)</td><td>θ = 19°

Accept value of θ in range of 1° ≤ θ ≤ 40°
Take repeated readings of θ.
θ to the nearest 1° with correct units.</td><td>1</td></tr>
<tr><td></td><td>Comments:

A number of students did not account for the uncertainty in the measurement of θ by taking repeated readings. Some students did not provide the units for the answer.</td><td></td></tr>
<tr><td>(b)(ii)</td><td>$\frac{\Delta\theta}{\theta} = \frac{2}{18} \times 100\% = 11\%$ (Accept 1 or 2 s.f.)

Expression is to be shown clearly

Accept absolute uncertainty within the range 2° ≤ θ ≤ 5°
(1 s.f.)</td><td>1</td></tr>
<tr><td></td><td>Comments:
A number of students did not account for the uncertainty in the measurement of θ by using absolute uncertainty of θ that is greater than the absolute uncertainty of 1° that is provided by the measuring instrument (protractor). A handful of students did not provide the correct number of s.f. for absolute uncertainty (1 s.f.).</td><td></td></tr>
<tr><td>(c)</td><td>6 readings without assistance

Correct trend: θ increases as m increases.

Accept value of θ in range of 1° ≤ θ ≤ 40°
Take repeated readings of θ.
θ to the nearest 1° with correct units.</td><td>1</td></tr>
<tr><td></td><td>table of results AND column headings with units

<table><tr><td>m/g</td><td>θ_1 / °</td><td>θ_2 / °</td><td><θ> / °</td><td>sin(<θ> / °)</td></tr><tr><td></td><td></td><td></td><td></td><td></td></tr></table></td><td>1</td></tr>
<tr><td></td><td>calculated values with correct significant figures / decimal places</td><td>1</td></tr>
<tr><td></td><td>Comments:</td><td></td></tr>
</table>

	A number of students did not include the calculated values ($\sin\theta$) in the table and did not include the brackets in the title for $\sin\theta$. There is also a significant number of students who did not provide repeated readings of θ. Some students gave the wrong number of s.f. for $\sin\theta$ and wrong number of d.p. for θ.	
(d)	sketch of suitable graph with axes labelled and show trendline equation	1
	Correct linearization statement: "Plot a graph of sinθ against m. If it is a straight line graph, Gradient = A and y-intercept = B"	1
	Correct units of A (g^{-1}) and B (no units)	1
	accuracy of *A* and *B* Gradient = A and y-intercept = B	1
	Comments: This question is generally well answered. Some students gave the wrong number of s.f. or units for A and/or B. Some students did not provide the linearization statement or only provide a partial one without mentioning the gradient and y-intercept.	
(e)	**<u>No anomalous data</u>** Since all the points lie on or close to the best fit line, there is no anomalous result. ***OR*** There is no anomalous point as all plotted points follow the trend of the best-fit line **<u>Anomalous data is present</u>** There is one anomalous point as it does not follow the trend of the best-fit line. ***OR*** There is one anomalous point as it lies relatively far from the best-fit line.	1
	Comments: This question is generally well-answered. Some students did not seem to understand what the question requires and	

Commented [HWC(1]: Add the answer for anomaly case

Commented [HWC(2R1]: Done

	provided explanations of the difficulties encountered in the experiment.	
(f)(i)	$M_{experiment}$ calculated correctly with correct units (g) and correct significant figures (follow number of s.f. of *A*)	1
	Comments: This question is generally well-answered. Some students did not provide the correct number of s.f. for $M_{experiment}$ based on the s.f. of A.	
(f)(ii)	Accept value of M_{actual} in the range 149.15–164.85 g and with unit to the nearest 0.01 g Percentage difference of *M* calculated correctly with correct units (%) and correct significant figures (1 or 2 s.f.).	1
	Comments: Most students were able to answer this question correctly. Some students did not include the slotted mass attached to the wooden block during measurement of its total mass. Some students did not give the correct number of s.f. for the percentage difference of *M*.	
(g)(i)	Any one of the following answers: Difficult to determine accurately the angle at which the block starts to slide because one needs to change the positions of the board and pulley simultaneously. Friction is not the same when the wooden block is placed at different parts of the board, thus affecting angle θ. Angle θ is small in this experiment, giving rise to large percentage uncertainty in θ	1
	Comments: There are a number of students wrongly stating that it is very difficult to measure θ using the protractor. Some students mentioned that there is significant friction at the pulley and wooden plank. Some students stated that it is difficult to measure θ without further details.	
(g)(ii)	Instead of changing angle for a fixed load, one fixes the angle (with the string aligned parallel to the board) and adds small masses to the load until the block starts to move. Make a mark on the board to ensure that the block is always placed on the same spot. Use larger value for the slotted mass so that angle θ is larger.	1
	Comments:	

	Some students suggested adding lubricant on pulleys and wooden plank or replace the wooden plank by smooth plastic or metal plank.	
(h)	two values of k calculated correctly (Take repeated readings of θ) Correct trend: θ decreases as M increases.	1
	values given to 2 or 3 significant figures	1
	Comments: This question is generally well-answered. A number of students did not take repeated readings of θ. Some students did not collect the data with the correct trend. Some students mistakenly use m instead of M to do the calculation of k.	
(i)	correct calculation of percentage difference between the two values of k. valid conclusion based on calculated values of k. [Note: candidate must test using the percentage uncertainty in **3(b)(ii)**.]	1 1
	Comments: A number of students did not compare the percentage difference between the two values of k with the percentage uncertainty in 3(b)(ii) as required by the question. They compared with either 10% or the percentage difference calculated in 3(f)(ii).	
(j)	appropriate diagram showing **labelled apparatus** and **suitable modifications to the setup** for determining the coefficient of static friction of the materials of the given blocks. • Use of Newton metre to measure tension • Horizontally placed wooden plank (inclination angle=0) • Collect 6 data sets for different weight of block of the same material by adding slotted mass on top of the block one at a time. • Plot a graph of tension against weight of block to determine the gradient of the graph which is the coefficient of static friction of the material of the block.	1 1 1
	Control of variables **For determination of the coefficient of friction** • Independent variable: mass of block • Dependent variables: frictional force f_s	1

Commented [HWC(3]: Add two sets of control variables for the two experiments involved.

Commented [HWC(4R3]: Done

	• Constants: coefficient of static friction of wooden plank **<u>For determination of *B*</u>** • Independent variable: mass *m* • Dependent variables: *θ* • Constants: coefficient of static friction of wooden plank, mass of block	
	describe how data will be analysed and how conclusion will be made • For each material of block, plot a graph of sin*θ* against m and determine value of B. • Compare the value of B for each material of block and conclude the effect of coefficient of static friction on the value of B by plotting a graph of the value of B against the coefficient of static friction of the material of the block (expected result: B should increase as coefficient of static friction increases).	1 1
	Comments: This question is generally not well-answered. A number of merely repeated the experiment in the main question but not specifically for this planning question. Some students did not answer this question or hardly answered it (e.g. only stated the constant variables). A number of students did not seem to realise that there is a need to determine the coefficient of friction and the value of B before a relationship between them can be determined. Diagrams are generally not well drawn (straight line are not drawn straightly and a thin line is used for objects with thickness such as wooden plank and retort stand. Objects are floating and surface of table is not drawn).	

Total: 24 marks