2021 JC2 Prelim Paper 4 Question 1 MS

Q1	Answer	Mark	Code
(b)	***Measurement of I*, V and θ** Values of I, V and θ measured to the correct unit within appropriate range.	1	**M1**
(c)	***Set up apparatus from a circuit diagram and follow of written instructions*** • Award 2 marks if the student has successfully collected 6 or more sets of data (*I, V* and *θ*), without assistance/intervention. • Award 1 mark if student has successfully collected 5 sets of data (*I, V* and *θ*), without assistance/intervention. • Award zero mark if student has successfully collected 4 or fewer sets of data (*I, V* and *θ*), without assistance/intervention. • Deduct 1 mark if student requires some assistance/intervention but has been able to do most of the work independently. Indicate the nature of any assistance. • Deduct 2 marks if student has been unable to collect data without substantial assistance/intervention. Minimum mark for **M2** = 0.	2	**M2**
(c)	***Layout: Column headings (raw data & calculated quantities: I*, V, θ, T, R, ln R, 1/T*)** Each column heading must contain an appropriate quantity and a unit. Ignore units in the body of the table. There must be some distinguishing mark between the quantity and the unit i.e. solidus is expected.	1	**P1**
(c)	***Table of results: raw data (appropriate degree of precision)*** All values of I, *V*, *θ* to the correct precision.	1	**P2**
(c)	***Table of results: calculated quantities (appropriate no. of significant figures)*** For each calculated value of *T, R*, ln *R* and 1/*T*, the number of s.f. should be the same (or one more) as the number of s.f. in the raw data.	1	**P3**
(c)	***Table of results: calculated quantities*** Correctly calculated values of calculated quantities. Allow one slip computation.	1	**A1**
(d)	***Linearising Equation*** Linearising equation and deriving expressions that equate gradient to *E/k* and y-intercept to ln *A*.	1	**A2**
(d)	***Graph: Layout, choice of scale and labeling of axes*** Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. 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.	1	**P4**
(d)	**Graph: plotting of points** All observations must be plotted. Check any 3 points and put ticks if correct. Work to an accuracy of half a small square.	1	**P5**
(d)	**Graph: trend line and ability to draw best fit line**		

Q1	Answer	Mark	Code
	Straight line of best fit – judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line.	1	**P6**
(d)	***Interpretation of graph – gradient*** Gradient – the hypotenuse of the Δ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square.	1	**A3**
(d)	***Interpretation of graph – intercept*** y-intercept must be read off to the nearest half small square or determined from y = mx + c using a point on the line.	1	**A4**
(d)	***Interpretation of graph – values of E and A*** Values of E and A calculated correctly with units.	1	**A5**
(e)	*Identification of anomaly* *Anomalous data/results, if any, must be identified. Appropriate justification must be given. Otherwise, comment of absence of anomalous data.*	*1*	*M3*

JC2 Prelim Question 2 MS

Q2	*Answer*	Mark	Code
(b)(ii)	***Measurement of d*** Value of *d* to the nearest mm with correct unit and correct range	1	**M1**
(b)(iii)	***Evidence of repeated readings*** Repeated timings for a value of *d,* with *t*>10 s	1	**M2**
(b)(iii)	***Calculated quantity T*** Correct calculation of *T* to 3 s.f.	1	**A1**
(c)(i)	***Calculated quantity k*** Correct substitution of *d, T, l* and *g* to calculate *k*	1	**A2**
(c)(i)	***Calculated quantity k*** Correct calculation of *k* value with appropriate s.f.	1	**A3**
(c)(ii)	***Determine k by plotting a graph*** Repeat the experiment with different *d* by changing the position of the wooden rod to obtain 6 sets of *d* and *T* Correct graph plotted	1	**A4**
(c)(ii)	***Determine k by plotting a graph*** Correct method to find *k* graphically.	1	**A5**

JC2 Prelim Question 3 MS

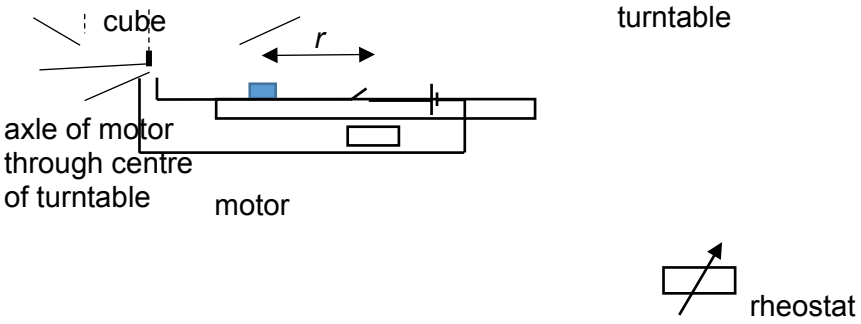
Q3	Answer	Mark	Code
(a)(i)	***Measurement of x and h*** Value of *x* and *h* measured to the nearest 1 mm with unit.	1	M1
(a)(ii)	***Estimating uncertainties*** Sensible value of Δx (e.g. 0.2 cm to 0.5cm). Percentage uncertainty in *x* calculated correctly to 2 s.f.	1	A1

Q3	Answer	Mark	Code
(b)(i)	***Measurement of θ and y*** Value of θ measured to the nearest 1°. Value of y measured to the nearest 1 mm with unit. Evidence of repeated readings of θ and *y.*	1 1	M2 M3
(b)(ii)	***Calculation of tan θ*** Value calculated correctly with appropriate s.f.	1	A2
(c)(ii)	***Measurement of x, h, θ and y*** Record of readings *x, h*, θ and *y.* θ in **(c)(ii)** > θ in **(b)(i)**.	1 1	M4 M5
(d)(i)	***Calculation of k values*** Correct calculation of *k* values with appropriate s.f. and units.	1	A3
(d)(ii)	***Validation of relationship*** Draw conclusion based on stated criterion e.g. not obeyed because % difference in *k* more than % uncertainty in *x*.	1	A4
(e)(i)	***Sources of error*** 1. Difficult to maintain the position of the tilted cone while measuring angle and height after the ball is dropped, affecting values of θ and *y*. 2. Difficult to measure *y* accurately with positioning reason (e.g. ruler is not vertical), affecting values of *y.* 3. Difficult to measure *x* as the cone changes shape easily, affecting values of *x*.	any 2 1 1	A5
(e)(ii)	***Improvement*** 1. Clamp the protractor and ruler with retort stands, and measure angle and height after the ball is dropped. OR Hold the cone using the clamp of the retort stand. Rotate the clamp to drop the ball and tighten the boss after the ball is dropped. Measure angle and height after the ball is dropped 2. Hang a plumbline using a retort stand to check that ruler is vertical.	1	A6
(f)(i)	***Graph : plotting of points and best-fit line*** Points correctly plotted. Straight line of best fit – judge by scatter of points about the candidate's line. There must be a fair scatter of points on either side of the line.	1	P1
(f)(ii)	***Graph : gradient*** Gradient – the hypotenuse of the Δ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. ***Graph : y-intercept*** y-intercept must be determined from y = mx + c using a point on the line.	1 1	A7 A8

Q3	**Answer**	**Mark**	**Code**
(f)(iii)	***Drawing conclusion*** Correct conclusion based on whether the y-intercept obtained in **(f)(ii)** is zero.	1	A9
(g)	***Planning*** Diameter of the cone, *x*, is kept constant Height of the cone, *h* is varied and corresponding readings for *θ* taken (where *θ* is the angle of cone tilted until the ball falls out). Table with correct headings (e.g *h* / cm, *θ* / °) Plot a graph of *h* against *θ* and draw the best fit curve Accept other suitable graphs e.g. $\theta = kh^x$ Read off the value of *h* which gives $\theta = 60°$	1 1 1 1 1	PL1 PL2 PL3 PL4 PL5

Prelim P4 Q4 Suggested Solutions and Mark Scheme

Diagram



Experiment (i) *f* vs *r*

Dependent variable	Independent variables	Control variables
What? Frequency of rotation, *f*	Distance from centre of turntable to centre of mass, *r*	• mass of cube, m
How? Stopwatch Take timing *t* for *N* turns. Period, $T = t/N$ $f = N/t$ Vary by adjusting rheostat	Half metre rule moving the cube to a different position	• electronic balance • use the same cube

Experiment (ii) *f* vs *m*

Dependent variable	Independent variables	Control variables
What? Frequency of rotation, *f*	mass of cube, *m*	• Distance from centre of turntable to centre of mass, *r*
How? Stopwatch Take timing *t* for *N* turns. Period, $T = t/N$ $f = 1/T$ Vary by adjusting rheostat	electronic balance using cubes of different sizes / mass	• Mark on turntable fixed position

Procedure

1. **How f varies with r, keeping m constant**
2. Set up the apparatus as shown. Ensured the motor is securely clamped using a retort stand.
3. Measure and record *r* using a half metre rule.
4. Measure and record *m* using an electronic balance.
5. Close the switch to spin the turntable. Adjust the variable resistor in the circuit to increase the frequency of rotation until the cube moves relative to the turntable.
6. Measure and record time t for N number of complete rotations of the turntable using a stopwatch.
7. Calculate period T, using T = t/N.
8. Calculate f = 1/T.
9. Repeat the experiment with different *r* by moving the cube to a different position to obtain 6 sets of readings of ***r* and *f***.

10. **How f varies with m, keeping r constant**
11. Repeat the experiment by using cubes of different sizes / mass to obtain 6 sets of readings of ***m* and *f***.

Analysis

Given that $f = K r^p m^q$ where *K, p and q* are constants,

Experiment (i)

$\lg f = p \lg r + \lg (K m^q)$
Plot a graph of lg *f* against lg *r*.
If the graph is a straight line, p is the gradient and $\lg (K m^q)$ is the y-intercept.
Calculate the gradient to find *p*.

Experiment (ii)

$\lg f = q \lg m + \lg (K r^p)$
Plot a graph of lg *f* against lg *m*.
If the graph is a straight line, *q* is the gradient and $\lg (K r^p)$ is the y-intercept.
Calculate the gradient to find *q*.

Using the values of *p* from experiment (i) and constant *r*, substitute into
y-intercept, $c = \lg (K r^p)$
$K = 10^c / r^p$

Control of Variables

1. For experiment (i), ensure m is the constant by using the same cube.
2. For experiment (ii), ensure r is the constant by marking the position of the cube on the turntable.

Accuracy and Safety

1. Take preliminary readings to find suitable values of *r* and *m* to obtain measurable values of *t.*
2. Wait for turntable to rotate steadily before increasing frequency **OR** gradual or incremental or slowly increase in frequency.
3. Use a spirit level to check that turntable is horizontal.
4. Put a mark on the cube to ensure distance *r* is measured to centre of the cube.
5. Measure two or more diameters, take average and halved its value to determine centre the turntable.
6. Take two readings of *t* for each *r* and *m* and find average *f* to reduce random error.
7. Use safety screen as a protection against the cube in case it spins off the turntable.

[Total: 12]

Q4	**Code**
Design/Diagram	
Labelled diagram showing power supply connected to motor (two leads) under turntable with axle through the centre of turntable, and a variable resistor in series.	D1
Procedure	
Measure and record the distance *r* using ruler and mass *m* using an electronic balance.	P1
Increase the frequency until the cube moves (relative to turntable).	P2
Workable method to determine the period of rotation e.g. stopwatch, lightgate attached to timer/datalogger or stroboscope.	P3
How to vary *m* and *r* to get 6 sets of data of *m* and *r*	P4
Control of variables	
Method to keep *r* and *m* constant.	C1
Analysis	
Plot a graph of lg *f* against lg *r* and equate *p* to gradient	G1
Plot a graph of lg *f* against lg *m* and equate *q* to gradient.	G2
$K = 10^c / r^p$ or $10^{c - p \lg r}$ or $10^c / m^q$ or $10^{c - q \lg m}$	G3
Accuracy and Safety (max 3 = 2A + 1S)	
Take preliminary readings to find suitable values of *r* and *m* to obtain measurable values of *f*.	A1
Wait for turntable to rotate steadily before increasing frequency **OR** gradual or incremental or slowly increase in frequency.	A2
Use a spirit level to check that turntable is horizontal.	A3
Method to ensure *r* is measured to the centre of the cube.	A4
Method to determine the centre of the turntable.	A5
Repeat experiment for each *r* and *m* and find average *f* .	A6
Use slow motion video / playback frame-by-frame to determine period more accuracy.	A8
Mark position of cube on turntable to better determine if cube has moved.	A9
Use safety screen as a protection against the cube as it spins off the turntable.	S1