Name: ______________________________ (    )                                        PDG: ______/ 16

# ANDERSON JUNIOR COLLEGE

## 2017 JC2 Preliminary Examination

## PHYSICS Higher 2                                                        9749/04

**Paper 4 Practical**                                                        **Friday 25 August 2017**

**2 hours 30 minutes**

Candidates answer on the Question Paper.
Additional Materials: As listed on the Confidential Instructions

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**READ THESE INSTRUCTIONS FIRST**

Write your name, class index number and PDG in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose mark if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| **Shift** |
| --- |
| |
| **Laboratory** |
| |

| **For Examiner's Use** | |
| --- | --- |
| **Paper 4 (55 marks)** | |
| **1** | |
| **2** | |
| **3** | |
| **4** | |
| **Total (55 marks)** | |

This document consists of **16** printed pages and **0** blank page.

For Examiner's Use

**1** In this experiment, you will investigate how the period of torsional oscillations of a bar magnet suspended above a fixed bar magnet changes with the separation between the two magnets.

**(a)** **(i)** Fix one of the magnets to the bench top using Blu-tack.

**(ii)** Suspend a second magnet using a stirrup and thread so that it lies in a horizontal plane about 50 cm below the point of suspension. The distance *d* between the bottom of the suspended magnet and the top of the fixed magnet should initially be about 5 cm. The base of the stand should be as far as possible from the fixed bar magnet. The arrangement is shown in Fig. 1.1.

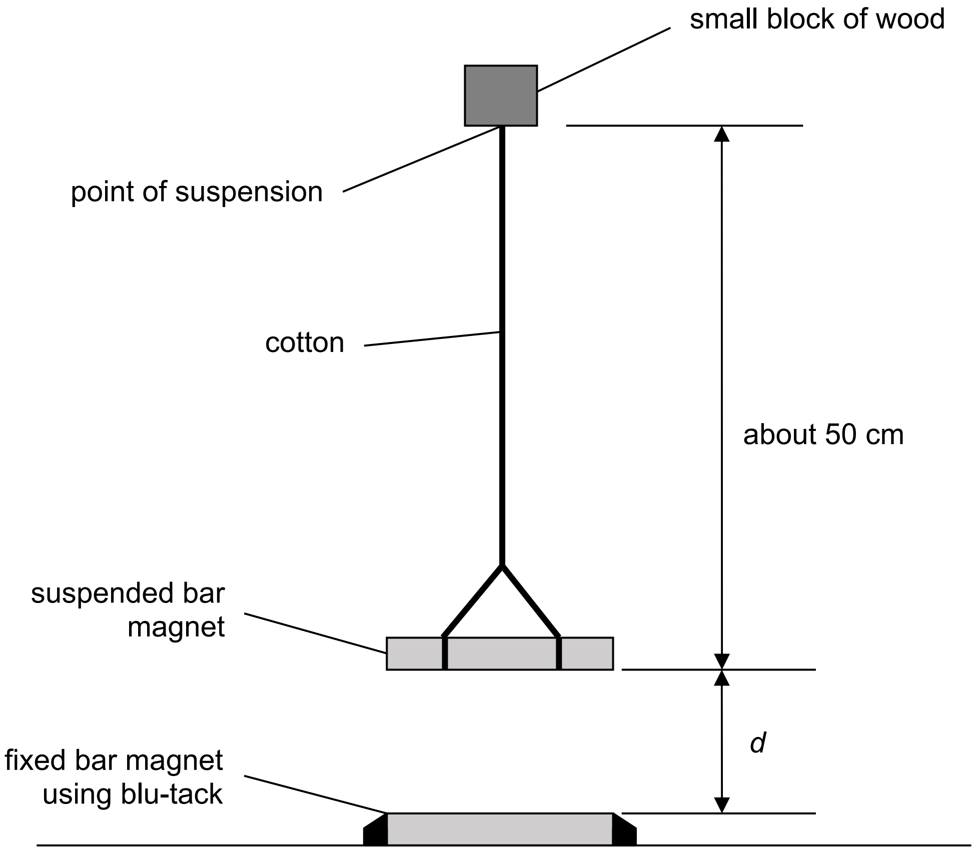


**Fig. 1.1**

**(b)** **(i)** Measure and record distance *d*.

*d* = …………………………… [1]

M1

**(ii)** Estimate the percentage uncertainty in *d*, showing your working.

percentage uncertainty =…………………………… [1]

A1

*For Examiner's Use*

**(iii)** Gently rotate the suspended magnet and release it so that it performs small torsional oscillations in a horizontal plane, as shown in Fig. 1.2.

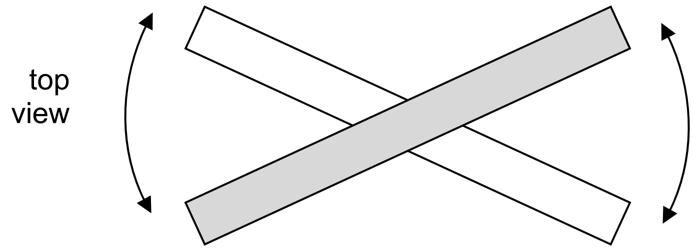


**Fig.1.2**

Make and record measurements to determine the period $T$ of these oscillations.

$T$ = …...………………………. [2]

| | |
|---|---|
| M2 | |
| A2 | |

**(c)** It is suggested that period $T$ is proportional to separation $d$.

Change $d$ to a value between 3 cm to 10 cm and take another set of measurements to investigate this suggestion.
State and explain whether or not you agree with this suggestion.

Present your measurements and calculated results clearly.

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…………………………………….………………………………………………………… [5]

| | |
|---|---|
| M3 | |
| A3 | |
| A4 | |
| A5 | |
| A6 | |



**[Turn Over**

*For Examiner's Use*

**(d)** Explain why, in practice, it may be difficult to measure the period $T$ directly for a separation $d$ = 1 cm.

…………………………………………………………………………………………………………

………………………………………………………………………………………………………… [1]

| A7 | |
|---|---|

**(e)** A student suggests that the period of torsional oscillations $T$ depends on the mass distribution of the oscillating body about its axis of rotation.

Suggest changes that could be made to the setup in Fig. 1.1 to study the student's claim when two lumps of plasticine of equal mass are provided.

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………………………………………………………………………………………………………… [3]

| PL1 | |
|---|---|
| PL2 | |
| PL3 | |

**[Total: 13 marks]**

**2** This investigation considers how the force required to maintain equilibrium of a horizontal rule depends on the position of a mass suspended from the rule.

**(a)** **(i)** Suspend a metre rule horizontally using two loops of string and a newton-meter, as shown in Fig. 2.1. The strings must be vertical.

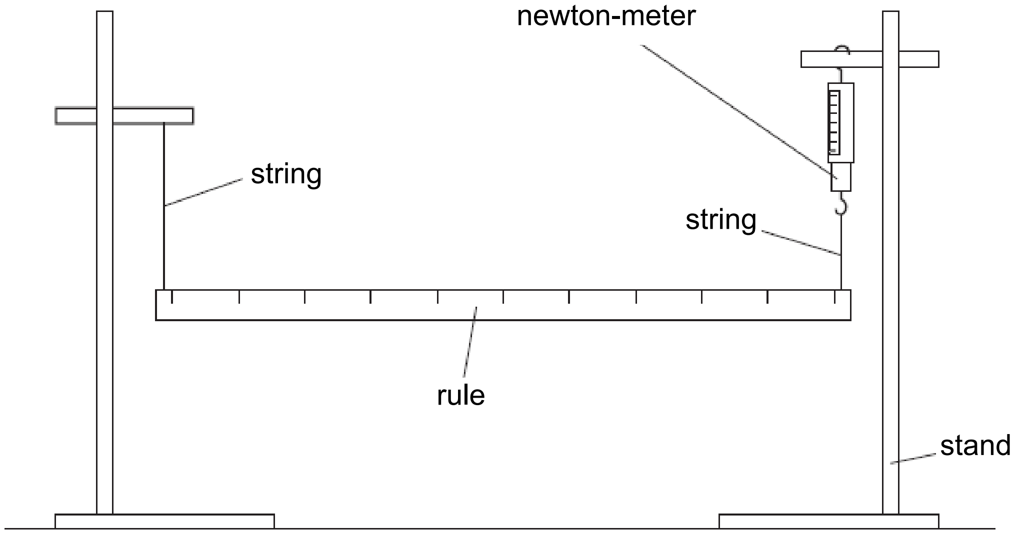



**Fig. 2.1**

**(ii)** Suspend the 50 g mass at a distance *d* from the newton-meter using a loop of string. You will need to adjust the position of the clamps to ensure that the rule remains horizontal. The arrangement should now be as shown in Fig. 2.2.

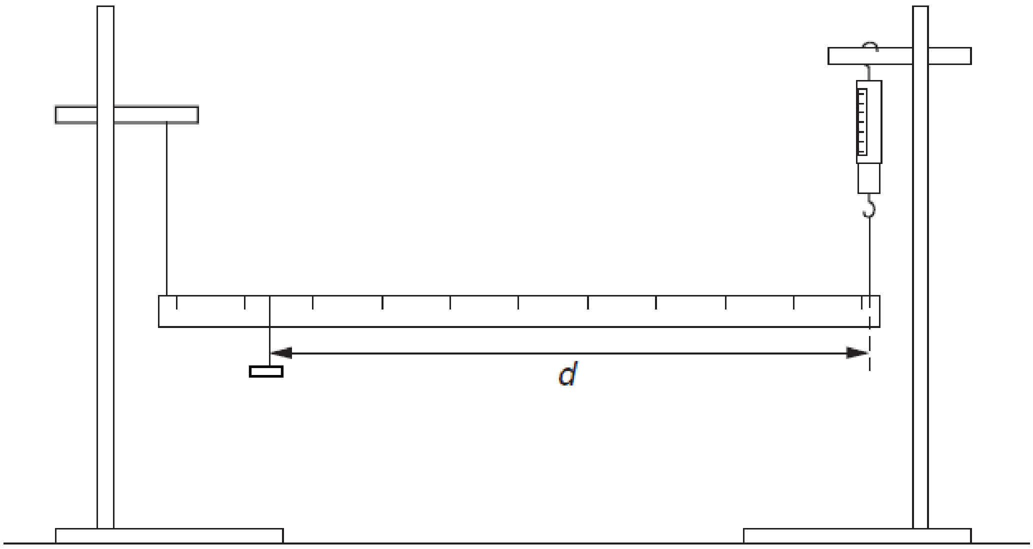



**Fig. 2.2**

**(b)** **(i)** Measure and record the value of *d* and the reading *F* from the newton-meter.

*d* =…………………

*F* =…………………[1]

M1

For Examiner's Use

**(ii)** Slide the suspended mass to a new position on the rule and repeat **(b)(i)**. Record at least five more readings of *d* and *F*. You should ensure when you are taking readings that the rule is horizontal and that the newton-meter does not go off scale.

| | |
|---|---|
| M2 | |
| M3 | |
| M4 | |

[3]

**(iii)** Explain how you ensured that the rule was horizontal when the measurements were taken.

…..……………………………………………………………………………………………..…

…..……………………………………………………………………………………….…..…

……………………………………………………………………………………...…….[1]

| | |
|---|---|
| A1 | |

**(c)** Plot your values from **(b)(ii)** on Fig. 2.3.

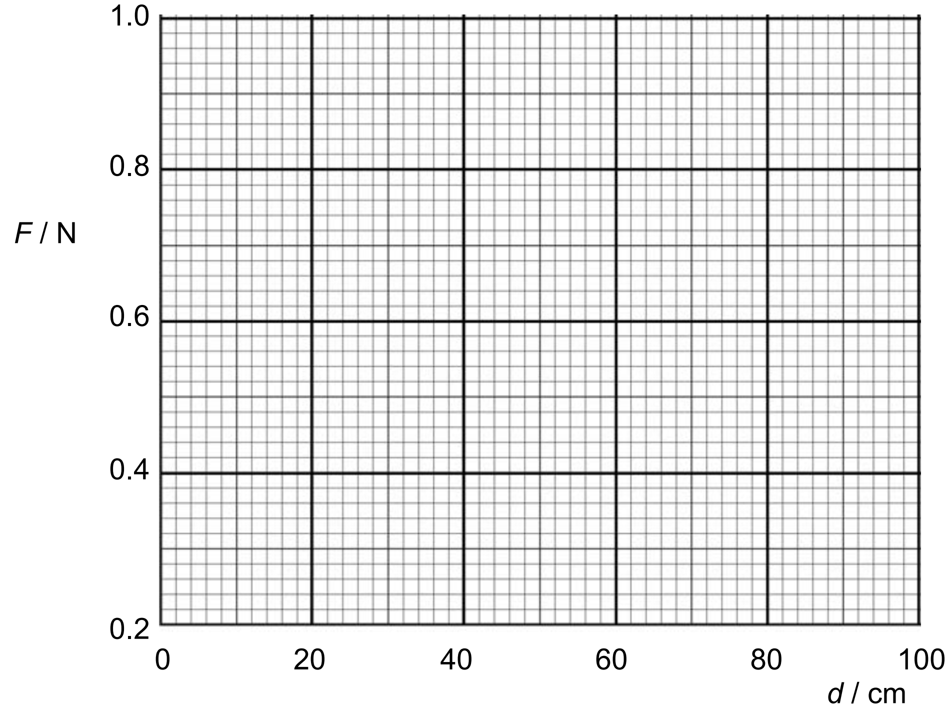



**Fig. 2.3**

| | |
|---|---|
| P1 | |
| P2 | |

[2]

**(d)** The equation that relates $F$ and $d$ is

$$F = \frac{-Wd}{L} + \frac{mg}{2} + W$$

where $W$ is the weight of the suspended mass, $m$ is the mass of the rule, $L$ = 0.980 m, and $g$ = 9.81 m s$^{-2}$.

Use your graph of Fig. 2.3 to determine value for $m$. Include appropriate unit.

For Examiner's Use

| | |
|---|---|
| A2 | |
| A3 | |
| A4 | |

$m$ =……..………..….[3]

**[Total: 10 marks]**

For Examiner's Use

**3** In this experiment, you will determine the resistivity of a metal in the form of a wire.

**(a)** **(i)** Measure and record the diameter *d* of the wire attached to the metre rule.

*d* = .................................. [1]

M1

**(ii)** Calculate the cross-sectional area *A* of the wire.

*A* = ..................................$m^2$ [1]

A1

**(b)** **(i)** Use the wire attached to the metre rule, one of the voltmeters and one of the two identical resistors of resistance *R* to set up the partial circuit shown in Fig. 3.1.
The value of *R* is 10 Ω.

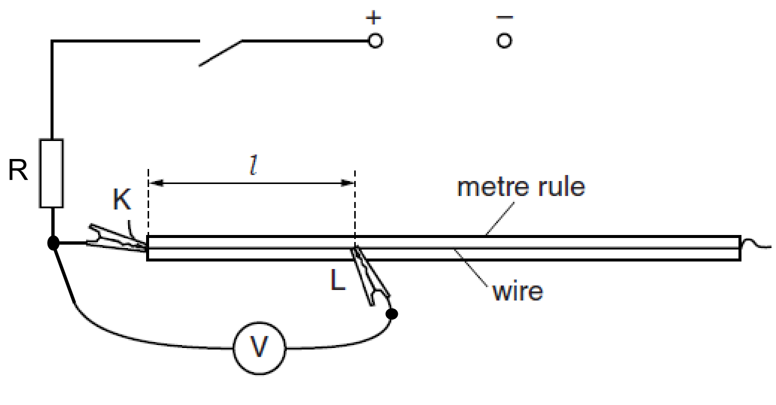



**Fig. 3.1**

There are two crocodile clips, one labelled K and the other labelled L.
Place K and L so that the distance *l* between them is approximately 30 cm.

**(ii)** Measure and record the distance *l* between K and L.

*l* = ......................................

For Examiner's Use

**(iii)** Use the other resistor and the other voltmeter to complete the circuit shown in Fig. 3.2.

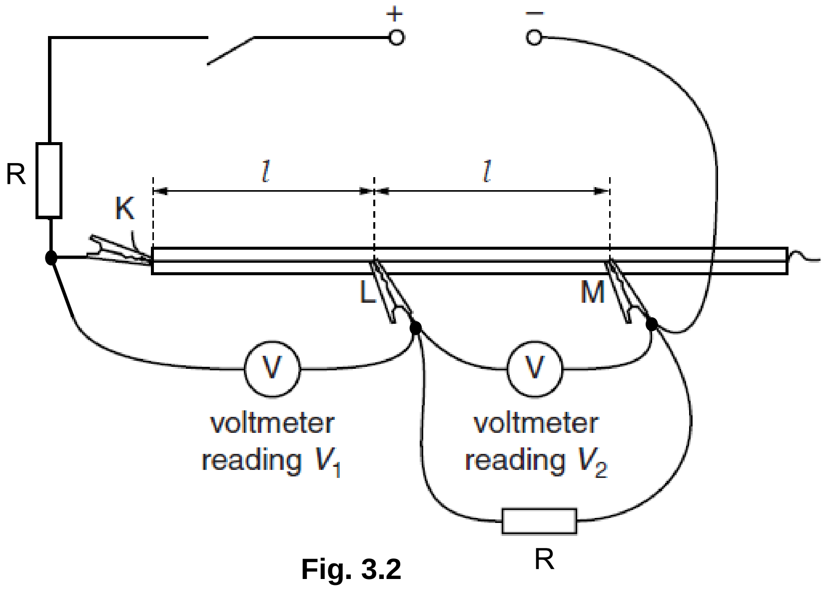



**Fig. 3.2**

**(iv)** Place the crocodile clip M at a distance $l$ from L.
The value of $l$ should be the same as in **(b)(ii)**.

**(c)** **(i)** Switch on the power supply.

**(ii)** Record the voltmeter readings $V_1$ and $V_2$ as shown in Fig. 3.2.

$V_1$ = ……………..…… V

$V_2$ = ……………..…… V

**(iii)** Switch off the power supply.



**[Turn Over**

*For Examiner's Use*

**(d)** Change $l$ and repeat **(b)(ii)**, **(b)(iv)** and **(c)** for further sets of readings of $l$, $V_1$ and $V_2$. For each set of readings, distances KL and LM should **both** be $l$.

[7]

| | |
|---|---|
| M2 | |
| M3 | |
| P1 | |
| P2 | |
| P3 | |
| A2 | |

**(e)** Theory suggests that $V_1$, $V_2$ and $l$ are related by the expression

$$\frac{V_1}{V_2} = P\,l + Q$$

where $P$ and $Q$ are constants.

Plot a suitable graph to determine the values of $P$ and $Q$.

| | |
|---|---|
| A3 | |
| A4 | |
| A5 | |

$P$ = ……..…………..…………

$Q$ = ………………..………… [3]

*For Examiner's Use*

| | |
|---|---|
| P4 | |
| P5 | |
| P6 | |
| A7 | |

[3]

For Examiner's Use

**(f)** Comment on any anomalous data or results you may have obtained.
Explain your answer.

.....................................................................................................................

.....................................................................................................................

.....................................................................................................................[1]

M4

**(g)** The quantity $P$ is given by the expression

$$P = \frac{\rho}{AR}$$

where $\rho$ is the resistivity of the material of the wire.

**(i)** Use values from **(a)(ii)**, **b(i)** and **(e)** to find a value for $\rho$.

$\rho$ = ..................................... [1]

A6

**(ii)** In the expression $\frac{V_1}{V_2} = P\,l + Q$, $Q$ is independent of $R$.

The experiment is repeated with a smaller value of R.

On the graph grid on page 11, sketch a second graph to represent the new results. Label it Z. [1]

**(h)** **(i)** State one significant source of error.

.....................................................................................................................

.....................................................................................................................

.....................................................................................................................[1]

A8

**(ii)** Suggest one improvement that could be made to the experiment to address the source of error identified in **(h)(i)**. You may suggest the use of other apparatus or a different procedure.

.....................................................................................................................

.....................................................................................................................

.....................................................................................................................[1]

A9

**[Total: 20 marks]**

**Please turn over for question 4.**

**4** A student is interested in 'bungee jumping', where a person attached to an elastic cord falls from a height and travels downwards through a distance before moving upwards. Different cords are used for different people. A schematic diagram is shown in Fig. 4.1.

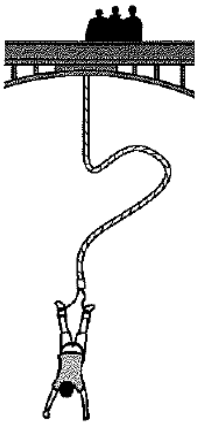


**Fig 4.1**

The student models 'bungee jumping' in the laboratory by using elastic cords of unstretched length 50.0 cm with different spring constants. An object is attached to each cord.
The student investigates the relationship between the maximum distance *h* fallen by the object and the spring constant *k* of the elastic cord.

It is suggested that the relationship between *h* and *k* is

$$\frac{1}{2}k(h - L)^2 = mgh$$

where *L* is the unstretched length of the cord, *m* is the mass of the object and *g* is the acceleration of free fall.

Design a laboratory experiment to test the relationship between *h* and *k*.
Explain how your results could be used to plot a graph with $\frac{(h-L)^2}{h}$ on the y-axis and to determine the value of *g*. You should draw a labelled diagram to show the arrangement of your apparatus.

In your account you should pay particular attention to

**(a)** the procedure to be followed,
**(b)** the measurements to be taken,
**(c)** the control of variables,
**(d)** the analysis of the data,
**(e)** any precautions that would be taken to improve the accuracy and safety of the experiment.

**Diagram**

[12]

**JC2 Prelim Question 1 MS**

| Q1 | Answer | Mark | Code |
|---|---|---|---|
| **(b)(i)**<br>**MMO** | ***Measurement of d***<br>Value of *d* with unit and to nearest 1 mm. | 1 | **M1** |
| **(b)(ii)**<br>**ACE** | ***Estimating uncertainties***<br>Percentage uncertainty in *d* calculated correctly to 2 s.f using sensible value of $\Delta d$ (e.g. 2 mm ≤ $\Delta d$ ≤ 4 mm). | 1 | **A1** |
| **(b)(iii)**<br>**MMO**<br>**ACE** | ***Calculation of T***<br>Evidence of repeated readings for raw time and NT > 10 s<br>Correct calculation of *T* to 3 s.f. with unit. | <br>1<br>1 | <br>**M2**<br>**A2** |
| **(c)**<br>**PDO**<br>**ACE** | 3.0 cm ≤ 2$^{nd}$ *d* ≤ 10.0 cm<br>2$^{nd}$ T calculated correctly<br>Higher/lower 2$^{nd}$ *d* , higher/lower 2$^{nd}$ *T*<br>Two values of *k* calculated correctly with correct units<br>Valid conclusion relating to the calculated values of *k*, testing against a stated criterion. | 1<br>1<br>1<br>1<br>1 | **M3**<br>**A3**<br>**A4**<br>**A5**<br>**A6** |
| **(d)**<br>**ACE** | Oscillations are too quick to timed accurately.<br>OR<br>Magnets may stick together in this small separation. | 1 | **A7** |
| **(e)**<br>**APLE** | <u>Placed each lump at equal distance from the axis of rotation</u> of (top) bar magnet and measure the period<br><u>Vary the distance between the 2 masses</u><br><u>*d* between the magnets kept the same</u> | 1<br><br>1<br>1 | **PL1**<br><br>**PL2**<br>**PL3** |

**JC2 Prelim Question 2 MS**

| Q2 | Answer | Mark | Code |
|---|---|---|---|
| **(b)(i)**<br>**MMO** | ***Measurement of F***<br>Values of *F* to 0.01 N and *d* to 0.1 cm. | 1 | **M1** |
| **(b)(ii)**<br>**MMO** | ***Set up apparatus from a diagram and follow of written instructions***<br>6 sets of readings with correct trend.<br>Reasonable intervals between values of *d* (> 5cm) and range of *d* ≥ 80 cm.<br>All values of *F* to 0.01 N and *d* to 0.1 cm. | <br>1<br>1<br>1 | <br>**M2**<br>**M3**<br>**M4** |
| **(b)(iii)**<br>**ACE** | ***Evaluation on keeping rule horizontal***<br>Use metre rule to measure distance from the bench at two different points on the rule to ensure the rule is horizontal. | 1 | **A1** |
| **(c)**<br>**PDO** | ***Graph***<br>Points correctly plotted.<br>Line of best fit | <br>1<br>1 | <br>**P1**<br>**P2** |
| **(d)**<br>**ACE** | ***Value of m calculated correctly from y-intercept***<br>Y-intercept must read off to the nearest half small square or determine from y = mx + c using a point on the line.<br>Correct calculation and unit of *m*.<br>Values of *m* between 80 to 120 g. | <br>1<br><br>1<br>1 | <br>**A2**<br><br>**A3**<br>**A4** |

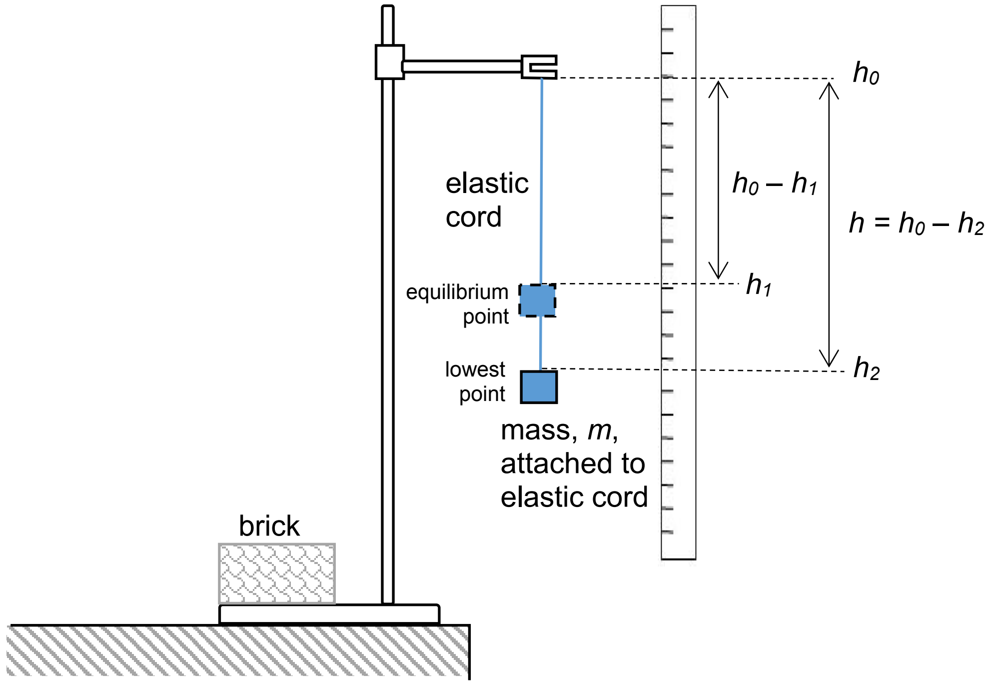
JC2 Prelim Question 3 MS

| Q3 | Answer | Mark | Code |
|---|---|---|---|
| **(a)(i)**<br>**MMO** | ***Measurement of d***<br>Record zero error and take repeated readings for *d*.<br>Value of *d* in the range 0.15 mm ≤ *d* ≤ 0.25 mm, with unit to nearest 0.01 mm. | 1 | **M1** |
| **(a)(ii)**<br>**ACE** | ***Calculation of A***<br>Calculation of *A* in $m^2$ with same significant figure as *d.* | 1 | **A1** |
| **(d)**<br>**MMO** | ***Set up apparatus from a circuit diagram and follow of written instructions***<br>• Award 2 marks if the student has successfully collected 6 or more sets of data ($l$, $V_1$, $V_2$), with $V_1$>$V_2$, without assistance/intervention.<br>• Award 1 mark if student has successfully collected 5 sets of data ($l$, $V_1$, $V_2$) , with $V_1$>$V_2$, without assistance/intervention.<br>• Award zero mark if student has successfully collected 4 or fewer sets of data ($l$, $V_1$, $V_2$) without assistance/intervention.<br>• 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.<br>• Deduct 2 marks if student has been unable to collect data without substantial assistance/intervention.<br><br>Minimum mark for **M2** = 0. | 2 | **M2** |
| **(d)**<br>**MMO** | ***Range of l***<br>Range of $l$ ≥ 30 cm. | 1 | **M3** |
| **(d)**<br>**PDO** | ***Layout: Column headings (raw data & calculated quantities: l, $V_1$, $V_2$, $V_1/V_2$)***<br>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** |
| **(d)**<br>**PDO** | ***Table of results: raw data (appropriate degree of precision)***<br>ALL values of $l$ to nearest mm and $V_1$ & $V_2$ to nearest 0.001 V. | 1 | **P2** |
| **(d)**<br>**PDO** | ***Table of results: calculated quantities (appropriate no. of significant figures)***<br>Calculated values of $V_1/V_2$ should consistently be to the same no. of s.f. as the raw data.<br>ALL values of $V_1/V_2$ are given to 3 s.f. for this mark to be awarded. | 1 | **P3** |
| **(d)**<br>**ACE** | ***Table of results: calculated quantities***<br>Correctly calculated values of $V_1/V_2$. Allow one slip in computation. | 1 | **A2** |
| **(e)**<br>**ACE** | ***Linearising Equation***<br>Linearising equation and deriving expressions that equate e.g. gradient to *P* and y-intercept to *Q*. | 1 | **A3** |
| **(e)**<br>**PDO** | ***Graph: Layout, choice of scale and labeling of axes***<br>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.<br>Axes must be labelled with the quantity which is being plotted. | 1 | **P4** |

| Q3 | Answer | Mark | Code |
|---|---|---|---|
| **(e)**<br>**PDO** | **Graph: plotting of points**<br>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** |
| **(e)**<br>**PDO** | **Graph: trend line and ability to draw best fit line**<br>Straight line of best fit – judge by scatter of points about the student's line. There must be a fair scatter of points on either side of the line. | 1 | **P6** |
| **(e)**<br>**ACE** | ***Interpretation of graph – gradient***<br>Gradient – the hypotenuse of the triangle must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. Check for $\Delta y/\Delta x$ (do not allow $\Delta x/\Delta y$).<br>Value of $P$ = candidate's gradient with correct unit $m^{-1}$. | 1 | **A4** |
| **(e)**<br>**ACE** | ***Interpretation of graph – intercept***<br>y-intercept – must be read off to nearest half a small square or determined from $y = mx + c$ using a point on the line.<br>Value of $Q$ = candidate's y-intercept and Q has no unit. | 1 | **A5** |
| **(f)**<br>**MMO** | ***Identification of anomaly***<br>Anomalous data/results, if any, must be identified. Appropriate justification must be given. Otherwise, comment of absence of anomalous data.<br>Possible answer for anomalous point<br>The point (x, y) is an anomalous point because it is far away from the best fit line. This could be due to the difficulty in clipping crocodile clips tightly to the wire attached to metre rule. | 1 | **M4** |
| **(g)(i)**<br>**ACE** | ***Drawing conclusions***<br>Value of $\rho$ calculated correctly with unit $\Omega$ m.<br>Range of $\rho$ in the range of $1.0 – 20.0 \times 10^{-7}$ $\Omega$ m. | 1 | **A6** |
| **(g)(ii)**<br>**ACE** | ***Interpretation of graph – underlying principles***<br>Steeper gradient with the same intercept and line is labelled Z. | 1 | **A7** |
| **(h)(i)**<br>**ACE** | ***Sources of errors***<br>Relevant point might be:<br>1. It is difficult to measure $l$ because the crocodile clip has a broad width. This will affect the accuracy of $l$. | 1 | **A8** |
| **(h)(ii)**<br>**ACE** | ***Improvement***<br>Relevant point might be (correspond to sources of errors):<br>1. Replace the crocodile clip with a sliding jockey or a narrower clip to reduce the error in $l$ measured. | 1 | **A9** |

**Suggested Solution to Q4**

**Diagram**




**Define problem**

To test the relationship between $h$ and $k$, and determine value of $g$.

**Procedure**

1. Setup the experiment as shown in the diagram above.
2. Measure and record mass, $m$, of the given object using an electronic balance.
3. Hang the elastic cord from clamp of the retort stand. Measure and record the initial height $h_0$ of mass $m$ at its starting position using a metre rule.
4. Lower the attached mass m and allow it to come to rest.
5. Measure record the height $h_1$ of mass $m$ at its equilibrium position using a meter rule, determine the spring constant $k$ using $\dfrac{mg}{(h_0 - h_1) - L}$, where $L$ is 50.0 cm.
6. Bring the mass $m$ back to its initial height $h_0$ and drop it from rest.
7. Measure and record the lowest height reached by the mass, $h_2$ using a metre rule.
8. Determine the height fallen by the mass $m$, h using $h = h_2 - h_0$
9. Repeat the experiment using different elastic cords to obtain 6 sets of values for $h$ and $k$.

**Control of variables**

**1.** Mass of object used is kept constant by using the same mass throughout the experiment.

**Analysis**

$$\frac{(h-L)^2}{h} = \frac{2mg}{k}$$

Plot a graph of $\dfrac{(h-L)^2}{h}$ against $\dfrac{1}{k}$ where the gradient is $2mg$ and y-intercept is zero.

Relationship is valid if the graph is a straight line passing through the origin.

Value of $g$ can be determined from $\dfrac{gradient}{2m}$.

**Safety and Accuracy**

1. Take preliminary readings to locate approximate lowest height $h_2$ / to prevent object hitting surface
2. Ensure that the position of the metre rule is not shifted during the experiment by clamping it to a retort stand.
3. Use set square to ensure that metre rule is vertical
4. Use a set square as a marker, repeat the experiment a few times to better locate the lowest position of the mass $h_2$ */ OR*
   Use of video camera with slow motion or frame by frame playback to determine lowest position of mass $m$ / OR
   Place a motion sensor directly beneath the mass m to record its displacement from the sensor. Lowest position of the mass could be read off from the datalogger.
5. Ensure that cord obeys Hooke's law and has not exceeded proportional limit by checking the $L$ remains unchanged after the experiment.
6. Use sand tray to catch falling object to prevent mass / cord from hitting a person.
7. Use goggles / safety screen to prevent mass / cord from hitting a person
8. Use a heavy mass to stabilize the retort stand to prevent setup from toppling.