VICTORIA JUNIOR COLLEGE
2024 JC2 PRELIMINARY EXAMINATION
Higher 2

Name : Answers CT group : ________________

PHYSICS **9749/04**

Paper 4 Practical

29 August 2024

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

Write your name and Civics Group in the spaces at the top of this page.
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.
DO **NOT** WRITE ON ANY BARCODES.

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 marks if you do not show your working or if you do not use appropriate units.

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	
1	
2	
3	
4	
Total	

1 In this experiment, you will determine the resistivity of a metal.

(a) Set up the circuit as shown in Fig. 1.1, using the resistor of resistance R = 68 Ω.

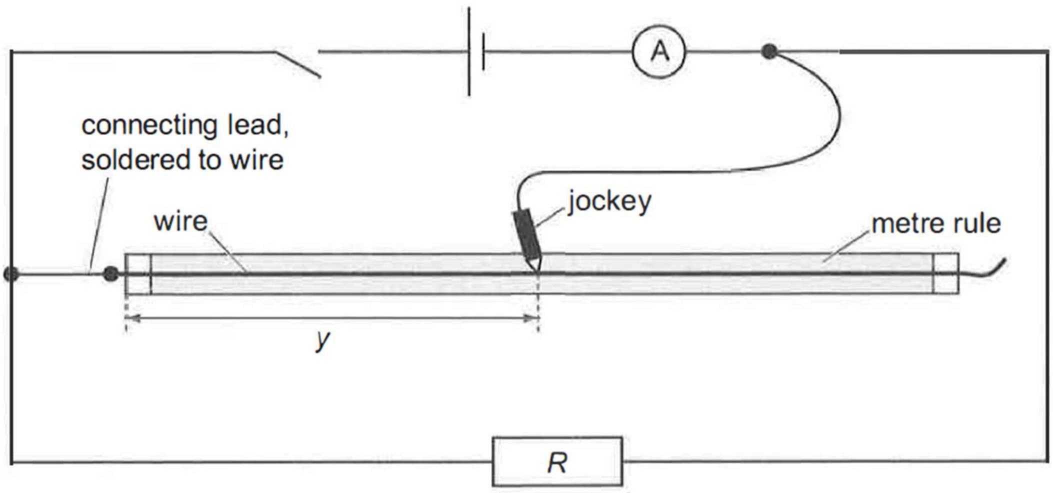


Fig. 1.1

Place the jockey on the wire about half-way along the metre rule. The distance between the end of the wire and the jockey is *y*, as shown in Fig. 1.1.

Close the switch.

Adjust the position of the jockey until the ammeter reading I is as close as possible to 121 mA.

Record *R*, I and *y*.

R = ……68 Ω………………

I = ……121.0 mA…………..

y = ……60.0 cm……………..

[1]

Open the switch.

(b) Vary *R* and adjust *y* each time so that *I* is always as close as possible to 121 mA. Present your results clearly.

R/Ω	y/cm	R/y / Ω cm^{-1}
56	61.1	0.92
68	60.0	1.1
82	56.3	1.5
100	54.6	1.83
120	53.3	2.25
150	52.2	2.87

When R is 2 sf, y is 3sf
Then R/y is only 2 sf.

When R is 3 sf, y is 3sf,
then R/y is 3 sf.

[3]

(c) It is suggested that *R* and *y* are related by the expression:

$$\frac{R}{y} = \frac{QIR}{F} - Q$$

where I is your value from **(a)** and *Q* and *F* are constants.

Plot a suitable graph to determine values of *Q* and *F.*

Plot R/y vs R, gradient = QI/F, and y-intercept = -Q

$$grad = \frac{(2.70-1.00)}{(140.0-60.0)} = \frac{1.70}{80.0} = 0.0213 \text{ cm}^{-1}$$

Subst (140.0, 2.70) into y = mx + c

2.70 = 0.0213(140.0) + c

Hence y-int, c = - 0.282 Ω cm^{-1}

Hence Q = 0.282 Ω cm^{-1}

$$\frac{QI}{F} = 0.0213$$

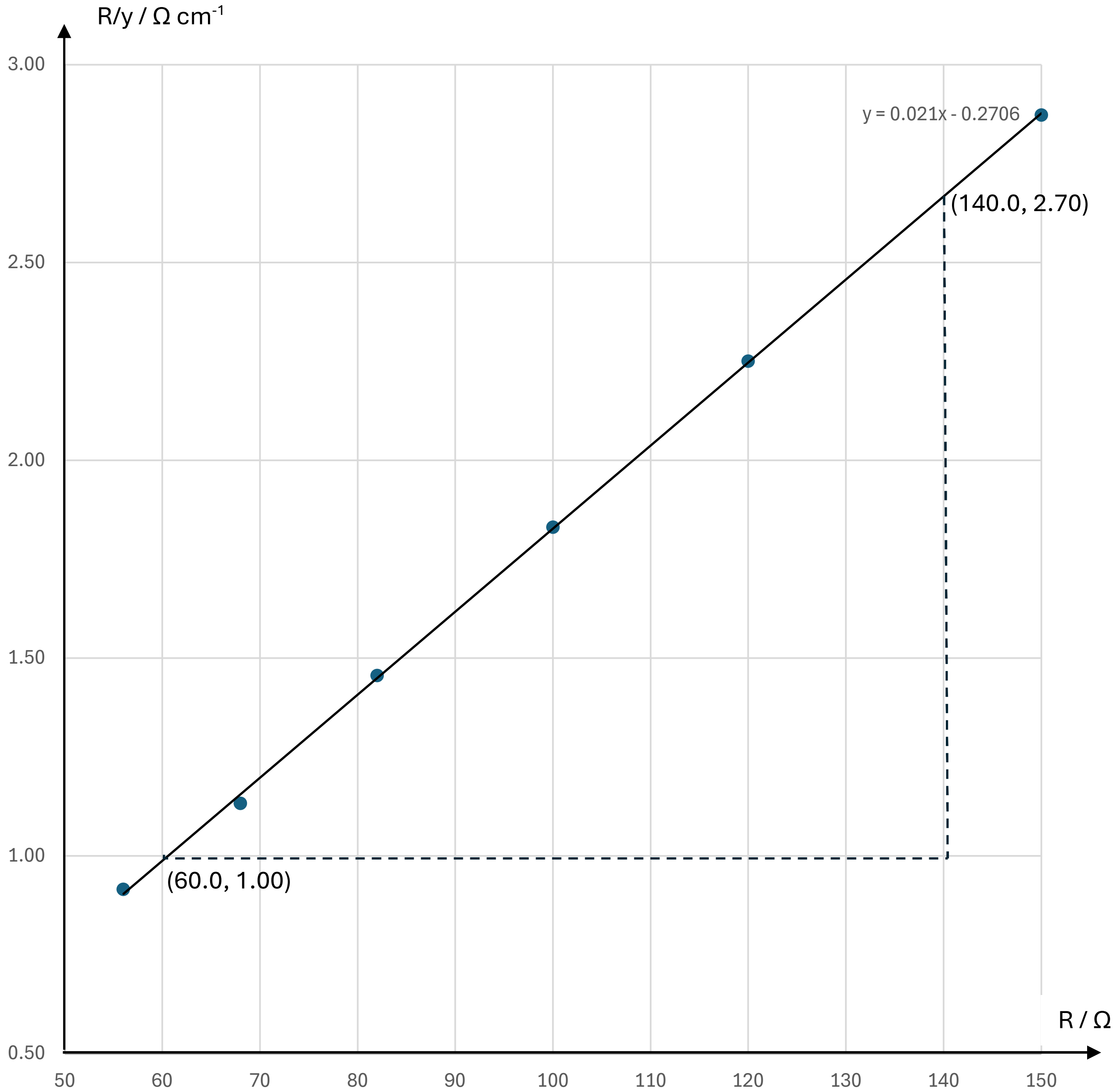
$$\frac{0.282 \times 0.1210}{F} = 0.0213$$

$$F = \frac{0.282 \times 0.1210}{0.0213} = 1.60 \text{ V (or A } \Omega)$$

Q = ……0.282 Ω cm^{-1}………..

F = ……1.60 V………………..

[8]


R/y / Ω cm-1
3.00
2.50
2.00
1.50
1.00
0.50
50
60
70
80
90
100
110
120
130
140
150
R / Ω
y = 0.021x - 0.2706
(140.0, 2.70)
(60.0, 1.00)

(d) Theory suggests that:

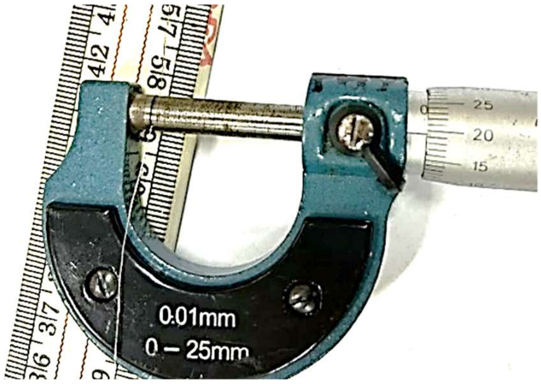
$$Q = \frac{4\rho}{\pi d^2}$$

where *d* is the diameter of the wire and ρ is the resistivity of the metal.

Determine a value for ρ.

d = 0.19 mm (using a micrometer)

From (c), Q = 0.282 Ω cm^{-1} = 28.2 Ω m^{-1}



$$Q = \frac{4\rho}{\pi d^2}$$

$$\rho = \frac{Q\pi d^2}{4}$$

$$= \frac{28.2\pi \times (0.19 \times 10^{-3})^2}{4}$$

$$= 8.0 \times 10^{-7}\ \Omega\ \text{m}$$

ρ = ...8.0 x 10^{-7}........ Ω m [2]

[Total: 14]

2 In this experiment, you will investigate an oscillating system.

Clamp the short wooden rod to a height of about 0.40 m. Using Blu-Tack, suspend two pendulum bobs A and B on the wooden rod so the they are 15 cm apart (using the notch on the short wooden rod as guide) as shown in Fig. 2.1.

Adjust the length *L* of both pendulums so that they are both equal to 30 cm.

Using the marker pen provided, make a mark at the midpoint of the pendulum A.

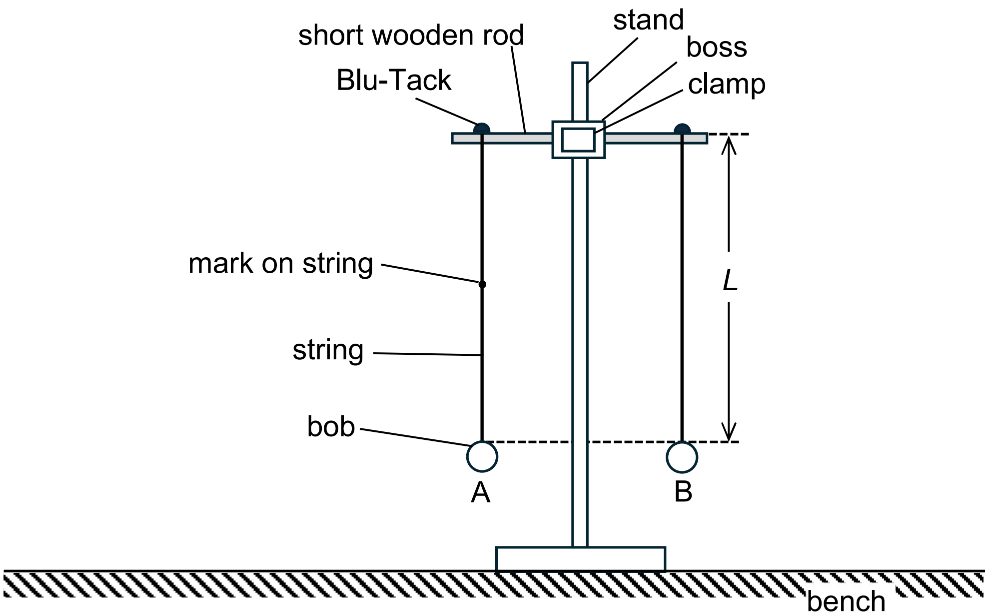


Fig. 2.1

(a) Clamp the long wooden rod on another stand and set up as shown in Fig. 2.2.

The long wooden should pass between the stand and the strings.

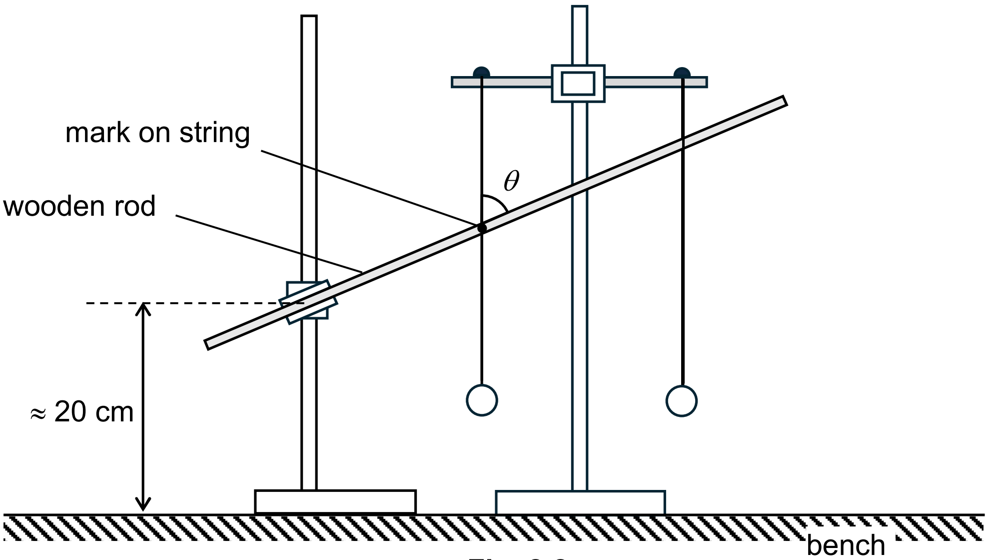


Fig. 2.2

(i) The angle between the long wooden rod and the string supporting A is θ.

Adjust the position of the long wooden rod so that θ is approximately 60° and the rod is **behind** the mark on the string supporting A. The rod should be just touching both strings, with the string hanging vertically.

Measure and record θ.

θ = ……60…………….° [1]

(ii) Pull A and B a short distance away from the long wood rod. Keep the same separation between A and B.

Release A and B at the same time.

B first oscillates in phase with A, then out of phase, and then back in phase again. This takes n oscillations of B.

Determine n.

1st trial : n = 8
2nd trial : n = 8

n = ……8……………… [2]

(b) It is suggested that:

$$n = k\tan\theta$$

where k is a constant.

Calculate k.

$$k = \frac{n}{\tan\theta}$$
$$= \frac{8}{\tan 60^\circ} = 4.6$$

n is a integer. So k follows the sf of tanθ, which 60° is 2 sf.

k = ...4.6..................... [2]

(c) Determine n and k for two more values of θ.

Tabulate your results.

θ/°	n	k
60	8	4.6
75	9	3.7
82	12	1.7

Trend is that larger θ, n is larger.

[2]

(d) Explain why you would not select a value of $\theta = 90^\circ$ in **(c)**.

When $\theta = 90^\circ$ the two pendulums have the same length and thus will always oscillate in phase and thus n will be very large. Also tan(90°) gives an infinite number and thus k will be undefined.

.... [1]

[Total: 8]

3 A cantilever beam is a beam that is supported at one end only.

In this experiment, you will investigate how the following properties affect the behaviour of a cantilever beam:

- the length of the beam
- the load on the beam
- the cross-section of the beam
- the stiffness of material from which the beam is made.

(a) Set up the half-metre rule on the benchtop as shown in Fig. 3.1.

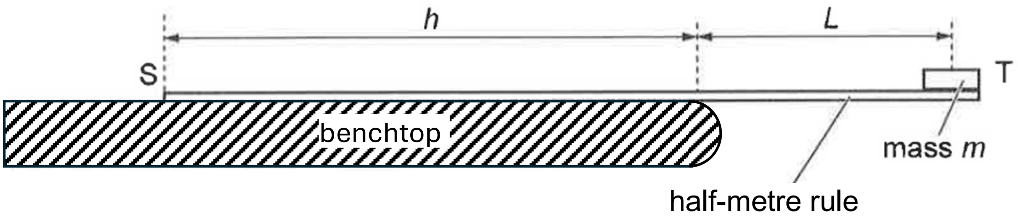


Fig. 3.1

The ends of the rule are S and T.

Use Blu-Tack to firmly attach a mass m, where m = 50 g, at T.

The distance between S and the edge of the surface is h.

The distance between the centre of mass m and the edge of the surface is L.

(i) Adjust the position of the rule so that S just lifts off the surface.

Measure and record h and L.

h = ……37.2 cm……………..

L = ……11.4 cm……………..

[1]

(ii) Calculate $\frac{h}{L}$.

$$\frac{h}{L} = \frac{37.2}{11.4} = 3.26$$

h/L should have 3 sf since h and L are both 3 sf.

$\frac{h}{L}$ = …3.26……………………

[1]

(iii) Estimate the percentage uncertainty in your value of $\frac{h}{L}$.

$$\frac{\Delta(\frac{h}{L})}{\frac{h}{L}} = \left(\frac{\Delta h}{h} + \frac{\Delta L}{L}\right) \times 100$$

$$= (\frac{0.3}{37.2} + \frac{0.3}{11.4}) \times 100$$

$$= 3.4\%$$

(Δh, ΔL should be about 0.2 to 0.5 cm)
% uncertainty should be only 2 sf.

percentage uncertainty in $\frac{h}{L}$ = ……3.4%…………. [2]

(b) Vary *m* and repeat **(a)(i)** and **(a)(ii)**.

m/g	h/cm	L/cm	h/L
50	37.2	11.4	3.26
100	40.7	7.9	5.2
150	43.1	5.5	7.8
200	44.9	3.9	12
250	45.3	3.6	13

When h and L have 3 sf, the h/L is 3 sf.

When L is 2 sf, then h/L is only 2 sf.

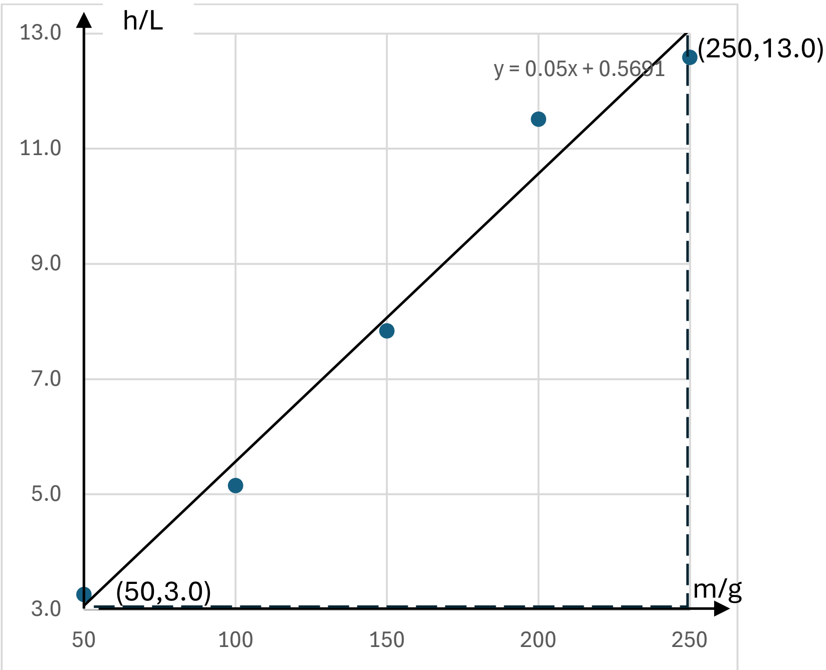
[2]

(c) It is suggested that *h*, *L* and *m* are related by the expression:

$$\frac{h}{L} = \frac{2m}{X} + 1$$

where *X* is the mass of the half-metre rule.

(i) Plot your results on the grid and draw the line of best fit.



[1]

(ii) Use your graph to determine a value for *X*.

$$\frac{2}{X} = grad = \frac{(13.0 - 3.0)}{(250 - 50)} = \frac{10.0}{200} = 0.0500\ \text{g}^{-1}$$

$$X = \frac{2}{grad} = \frac{2}{0.0500} = 40.0\ \text{g}$$

X = ...40.0........... g [1]

(d) Use a balance to determine the mass *X* of your half-metre rule.

X = ...52.84................ g

Show whether your value in (a)(iii) explains the difference between your two values of *X*.

$$\frac{X_2 - X_1}{X_2} \times 100 = \frac{54.84 - 40.0}{54.84} \times 100 = 27\%$$

The error in a(iii) is only 3.4%. Hence the error in a(iii) cannot explain the difference in the values of X.

....

[1]

(e) You will now use a metal hacksaw blade as a cantilever beam.

When one end of the blade is fixed and the other end is loaded, the loaded end will move downwards, as shown in Fig. 3.2.

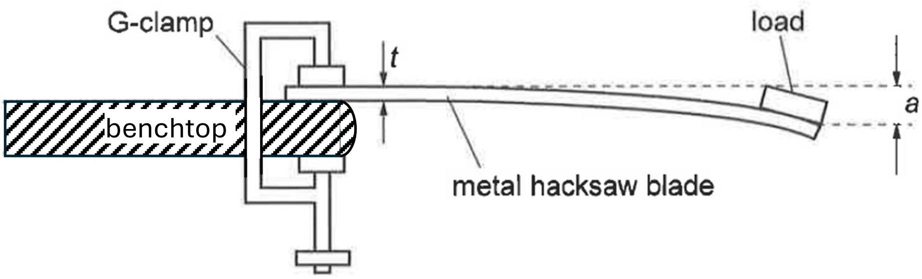


Fig. 3.2

The distance moved down is *a*, given by:

$$a = \frac{4MgL^3}{Yut^3}$$

where:

- *M* is the mass of the load
- *L* is the distance between the centre of the load and the edge of the surface
- *U* is the width of the blade
- *t* is the thickness of the blade
- *Y* is the stiffness of the of the metal
- g = 9.81 N kg^{-1}

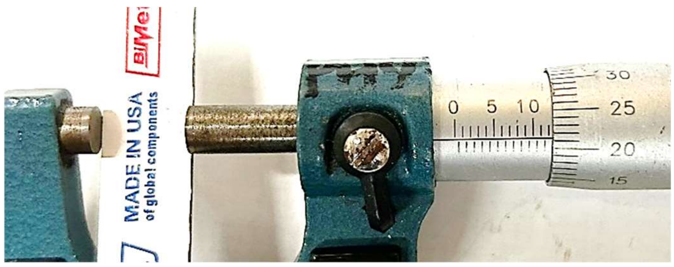
(i) Wearing safety goggles, set up the apparatus as shown in Fig. 3.2.

Use Blu-Tack to firmly attach a 50 g mass to the metal hacksaw blade.

Take measurements to determine a value for *Y*.

Show the measurements of L, a, u, t and M clearly.

L = 26.7 cm = 0.267 m
a = 6.9 cm = 0.069 m
t = 0.94 mm = 0.94 x 10^{-3} m
u = 12.22 mm = 12.22 x 10^{-3} m
M = 50 g = 50 x 10^{-3} kg

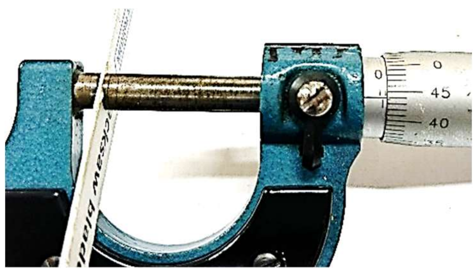


$$Y = \frac{4MgL^3}{aut^3}$$

$$= \frac{4(50\times10^{-3})(9.81)(0.267)^3}{0.069(12.22\times10^{-3})(0.94\times10^{-3})^3}$$

$$= 5.3\times10^{10} \text{ Pa}$$

$$= 53 \text{ GPa}$$



Y = …………53……………..…. GPa [4]

(ii) Suggest one significant source of uncertainty in this measurement.

It is difficult to measure the deflection a of the blade as the blade tends to be vibrating. Also the ruler is not mounted by a retort stand and tends to be moving.

.... [1]

(iii) The value of Y for wood is 12 GPa.

Explain why it is **not** possible to perform this experiment using a wooden beam with the same dimensions as the metal hacksaw blade.

Using a wooden beam of same dimensions as the hacksaw blade, then the deflection a $\propto$ 1/Y. Since the value of Y for wood is 12/53 = 0.23 that of metal means that the wood will deflect 1/0.23 = 4.4 times more that steel. This might cause the wooden beam to break.

.... [1]

(f) A diving board at a swimming pool has length *L*. A person of mass *M* jumps up and down on the end of the diving board.

The frequency of oscillation of the end of the diving board is *f*, given by:

$$f^2 = \frac{Z}{ML^3}$$

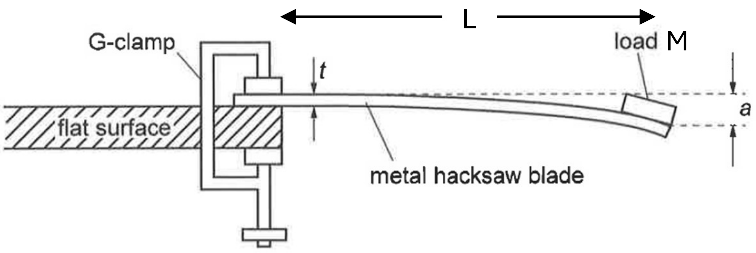
where *Z* is a constant.

The metal hacksaw blade can be used as a model diving board.

Plan an investigation to find Z for the blade.

Your answer should include a diagram, your experimental procedure and a precaution to improve the safety of the experiment.

Wearing safety goggles, use your apparatus to determine two values of *Z* for different values of *M* and *L*. Tabulate your results.



1. Set up as shown in Fig 3.2 with mass M = 50 g.
2. Measure using ruler distance L between centre of load and edge of surface.
3. Displace the load downwards and release. Using stopwatch, record the time t_1 for N oscillations. Repeat for time t_2 and find the average time <t>. The period T = <t>/N and frequency f = 1/T.
4. Repeat Step 3 by varying the mass M in steps of 50 g, keeping L constant.
5. Plot a graph of f^2 against 1/M. If a straight line is obtained, then the gradient = Z/L^3.
6. Hence Z = gradient x L^3 can be determined.

Safety Precaution: With large masses, the hacksaw blade may be bended a lot and may break. For large masses, displace the blade by small distance or small amplitude of oscillations.

N = 30 oscillations

M/kg	L/m	t_1/s	t_2/s	<t>/s	T/s	f/Hz	Z /kg m^3 s^{-2}
0.050	0.250	15.3	15.3	15.3	0.510	1.96	3.0×10^{-3}
0.100	0.210	15.8	15.8	15.8	0.527	1.90	3.34×10^{-3}

[7]

[Total: 22]

4 Two of the sources of naturally-occurring background radiation are from buildings and from soil.

The amount of background radiation detected depends on the distance *b* from a building and the distance *s* from the soil.

The background count rate *C* is given by the equation:

$$C = K\ b^p s^q$$

where *K*, *p* and *q* are constants.

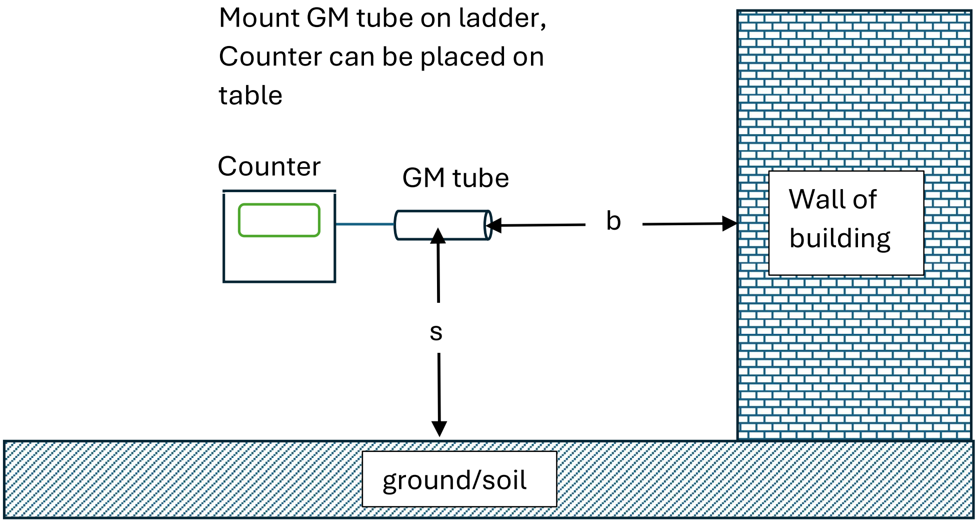
Design an experiment to determine the values of *p* and *q*.

Assume that the investigation takes place outdoors close to a building and that you have a Geiger-Muller (GM) tube which counts individual particles.

Draw a diagram to show the arrangement of your apparatus. You should pay particular attention to:

(a) the equipment you would use
(b) the procedure to be followed
(c) the control of variables
(d) any precautions that should be taken to improve the accuracy of the experiment.

Diagram



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....

....

Procedure

1. Setup as shown. The GM-tube is connected to a counter.
2. Measure distance b from window of GM-tube to the wall of building and distance s from centre of GM-tube to the ground using tape measure.

Experiment 1: Vary b, measure C and keep s constant.

3. Starting with a distance b, say 0.50 m from the wall.
4. Starting the stopwatch and at the same time start the counter. After a time t, stop the counter. Record the counter number N. The count rate Cr = N/t. To get the actual count rate C = Cr – Co, where Co is the background count rate far from ground and building.
5. Repeat Step 4 by increasing the distance b in steps of 0.50 m for at least 6 more sets of readings and measuring the corresponding C. Distance s must be kept constant.

Experiment 2: Vary s, measure C and keep b constant.

5. Turn the GM-tube such that the window of the GM-tube is facing the ground. The distance s is now the distance from the window of the tube to the gound.
6. Starting with a distance s, say 0.50 m from the ground
7. Starting the stopwatch and at the same time start the counter. After a time t, stop the counter. Record the counter number N. The count rate Cr = N/t. To get the actual count rate C = Cr – Co, where Co is the background count rate far from ground and building.
8. Repeat Step 7 by increasing the distance s in steps of 0.50 m for at least 6 more sets of readings and measuring the corresponding C. Distance b must be kept constant.

Control of Variable:

The experiment 1 and 2 should be done around the same time of the day because ionising radiation may come from the sun.

Analysis:

$$C = K\ b^p s^q$$

$$\lg C = \lg K + p \lg b + q \lg s$$

For Expt 1, plot a graph of lg C vs lg b. If a straight line graph is obtained, then the gradient = p.

For Expt 2, plot a graph of lg C vs lg s. If a straight line graph is obtained, then the grad = q.

Accuracy/Precautions:

1. To measure the background count rate Co far from ground and buildings, can mount the GM-tube and counter on a drone and fly it high above ground and far from buildings. The counter can be connected to a datalogger so that readings can be recorded remotely.

2. When measuring radiation from building, the window of GM-tube must be facing the building. Similarly when measuring radiation from the ground, the window of the GM tube must be facing the ground.

3. The count rate is likely to be very low. To improve accuracy, it is important to perform the experiment over a long time t so that the number of counts N is large.