EUNOIA JUNIOR COLLEGE
JC1 PROMOTIONAL EXAMINATIONS 2021
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	2	1	-			REGISTRATION NUMBER	

PHYSICS

9749/04

Paper 4 Practical

September 2021

1 hour 30 minutes

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

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number 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.

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.

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	
1	/ **12**
2	/ **21**
Total	/ **33**

This document consists of **11** printed pages and **1** blank page.

1 In this experiment, you will investigate the motion of a marble along an incline.

(a) Draw a 45° line in the lower left corner of the graph paper.

(b) Secure the graph paper to the wooden board using adhesive putty. Incline the wooden board at an angle θ of about 10°. Use additional adhesive putty to secure the position of the wooden board on the benchtop. Keep the wooden board at the same angle of incline throughout the experiment, as shown in Fig. 1.1.

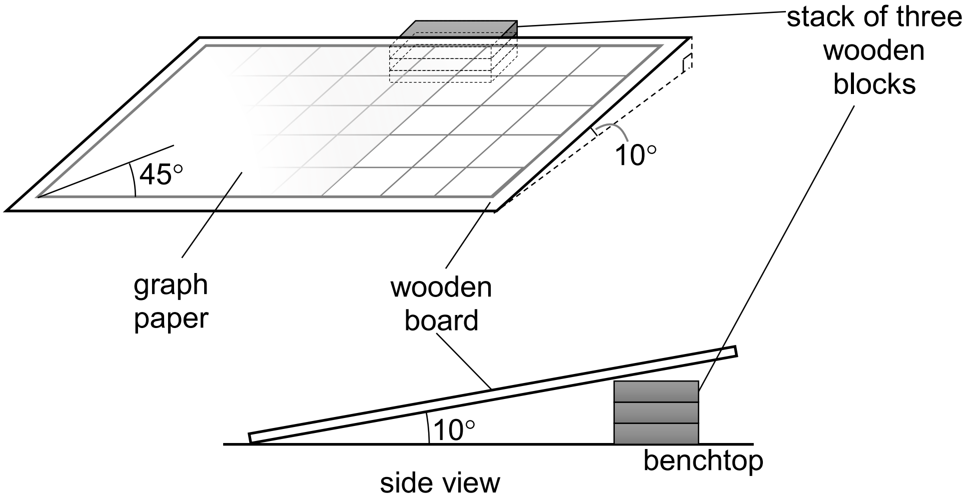
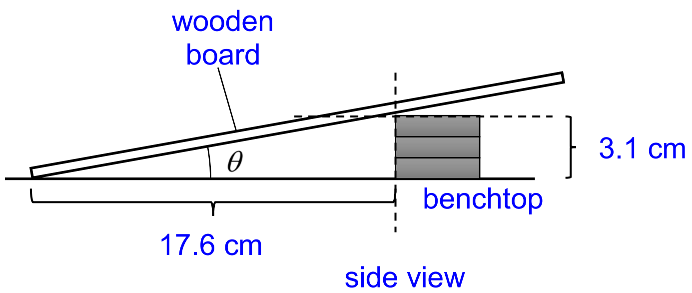


Fig. 1.1

Without using a protractor, determine the angle θ in your set up.

Present your method clearly. You may wish to include a diagram.



$$\tan\theta = \frac{3.1}{17.6}$$

$$\theta = \tan^{-1}\left(\frac{3.1}{17.6}\right)$$

$$= 10°$$

- Clear method; measurements of lengths leading to correct use of trigonometry functions
- Value of θ within range $9° \leq \theta \leq 11°$ with appropriate unit
- Accept 2 – 3 s.f.

θ = ..10°.................................... [2]

(c) Fold the cardboard to form a track that has a V-shape cross-section. Mark the cardboard track at distances *d* of 30 mm and 120 mm from one end as shown in Fig. 1.2.

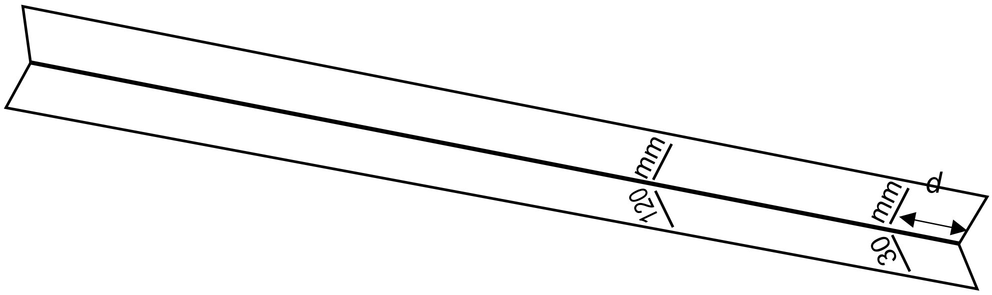


Fig. 1.2

(d) Support the unmarked end of the track at about 7 cm above the benchtop using the retort stand, boss and clamp.

Position the marked end of the track on the graph paper such that the axis of the track is aligned to the 45° line, as shown in Fig. 1.3.

Where appropriate, use adhesive putty to secure surfaces that slip.

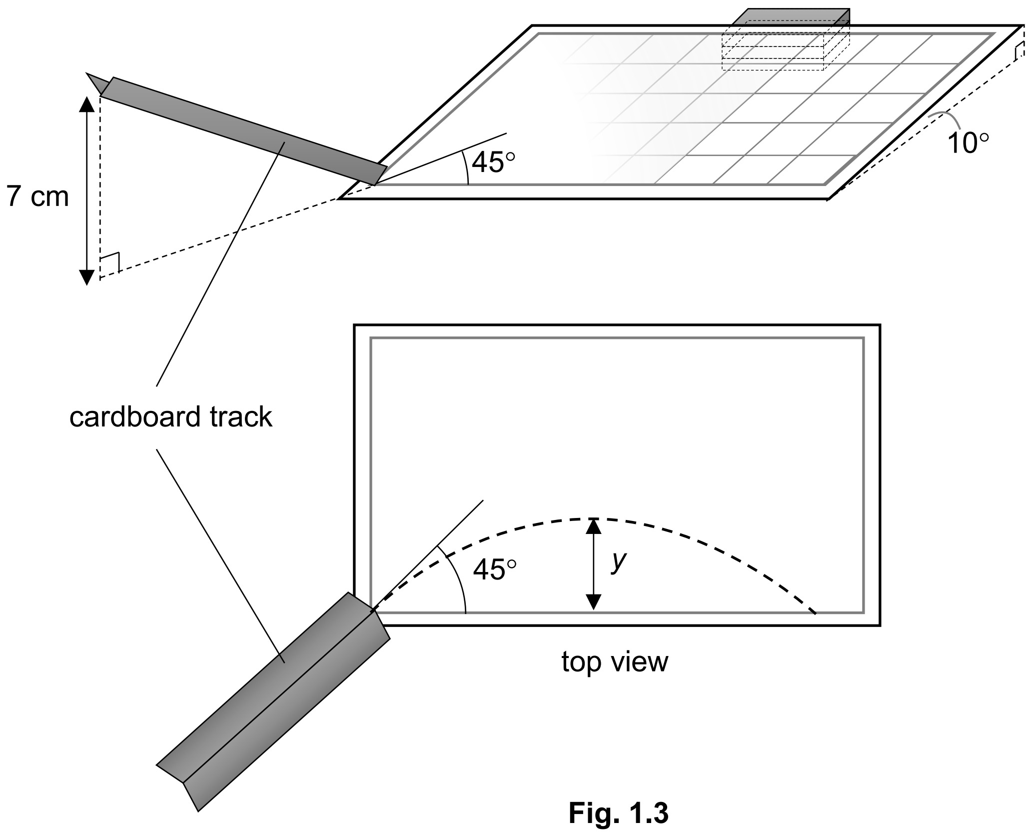


Fig. 1.3

(e) A marble released from rest on the track should roll smoothly onto the inclined wooden board.

(i) Release a marble from rest at the d = 120 mm mark.

Measure and record the maximum distance up along the incline y that the marble travels.

y_1 / cm	y_2 / cm	y_2 / cm	$\langle y \rangle$ / cm
2.1	2.2	2.0	2.1

- Value of y to the correct precision (0.1 cm or 1 mm) and recorded with an appropriate unit.
- Averaging of at least 2 measurements

y = 2.1 cm .... [1]

(ii) Estimate the percentage uncertainty of y.

$$\frac{\Delta y}{\langle y \rangle} \times 100\% = \frac{0.7}{2.1} \times 100\% = 33\%$$

- Absolute uncertainty must be in the range of 5 mm to 20 mm.
- Correct calculation.
- Final answer to 2 s.f.

percentage uncertainty of y = 33% .... [1]

(iii) Repeat **(e)(i)** using d = 30 mm.

y_1 / cm	y_2 / cm	y_2 / cm	$\langle y \rangle$ / cm
1.1	1.1	1.1	1.1

- Value of y to the correct precision (0.1 cm or 1 mm) and recorded with an appropriate unit.
- Averaging of at least 2 measurements

second value of y = 1.1 cm .... [1]

(f) It is suggested that the relationship between y and d is

$$y = kd$$

where k is a constant.

(i) Using your data, calculate two values of k.

$$k_1 = \left.\frac{\langle y \rangle}{d}\right|_1 = \frac{2.1}{12} = 0.175$$

$$k_2 = \left.\frac{\langle y \rangle}{d}\right|_2 = \frac{1.1}{3.0} = 0.360$$

- Correct calculation to check proportionality constant k
- k given to 2 or 3 s.f.
- k should be dimensionless as it is a ratio of length/length – the units for numerator and denominated should be converted to the same

first value of k = 0.175 ....

second value of k = 0.360 ....

[1]

(ii) Explain whether your results support the suggested relationship.

percentage difference in k

$$= \frac{0.360 - 0.175}{0.175} \times 100\%$$

$$= 110\%$$

- Percentage difference in the two k values calculated correctly and given to 2 s.f.
- Divide by smaller value of k
- Correct conclusion given with reasoning

percentage difference in k of 110% exceeds the percentage uncertainty of y at 33%

results do not support suggested relationship

[2]

(g) **(i)** Suggest one significant source of error in this experiment.

Relevant points can include:

- Two sets of readings insufficient to draw valid conclusion.
- Marble was moving too fast so was difficult to determine the maximum height it reached, affected measurement of y.

Wrong to say marble does not stay at max position for a long time or a short time. The marble does not *stay* at rest for any duration of time, there is still velocity (and KE) "horizontally" and the velocity component along the slope is 0 only **instantaneously** (and not for a duration no matter how short).

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

Relevant points can include:

(i) Take more variations of d and plot a graph.

(ii) Position a video camera in front of the experimental set up and record the motion of the marble while it is in motion. Analyse the video and by playing back using slow motion / analyse frame by frame to determine the maximum height y the marble could travel up the board.

(iii) Do trials and place an object (eg eraser) as a marker on the graph paper to help identify the maximum height y more accurately.

Failure to provide **and** describe correctly a source of error in (g)(i) will see no marks given for this item.

(h) State and explain the changes, if any, to the value of k if the incline of the wooden board is made steeper.

The gradient of the graph would be less steep

By conservation of energy, initial amount of GPE of marble remains constant; marble will moves to a smaller maximum distance y when the incline is increased since GPE is dependent on the vertical height reached which remains constant here.

OR

When incline increases, deceleration (= $g \sin\theta$) is larger, speed of marble along slope slows down faster, lower y is reached for each d.

Few candidates described the physics behind effect on k correctly. Can approach the explanation via energy or force:

In terms of energy changes,

> initial amount of GPE of the marble is constant

> so KE of marble just as it leaves cardboard track is constant,

> so vertical height to which marble reaches is constant.

> so height up the slope, y is less if the incline is made steeper.

In terms of forces acting on the marble, some common mistakes include describing the component along the slope as the vertical component of the gravitational force. Generally, candidates have difficulty in making descriptions in a clear and concise manner. Most wrong answers are overly lengthy and vague.

Question 2 begins on the next page.

2 In this experiment, you will investigate the oscillations of a mass suspended on a V-shaped string.

(a) (i) Attach the longer length of string to the metre rule by tying it at two points at about 25 cm apart.

Attach the shorter length of string to the oscillating mass from the middle of the longer string as shown in Fig. 2.1.

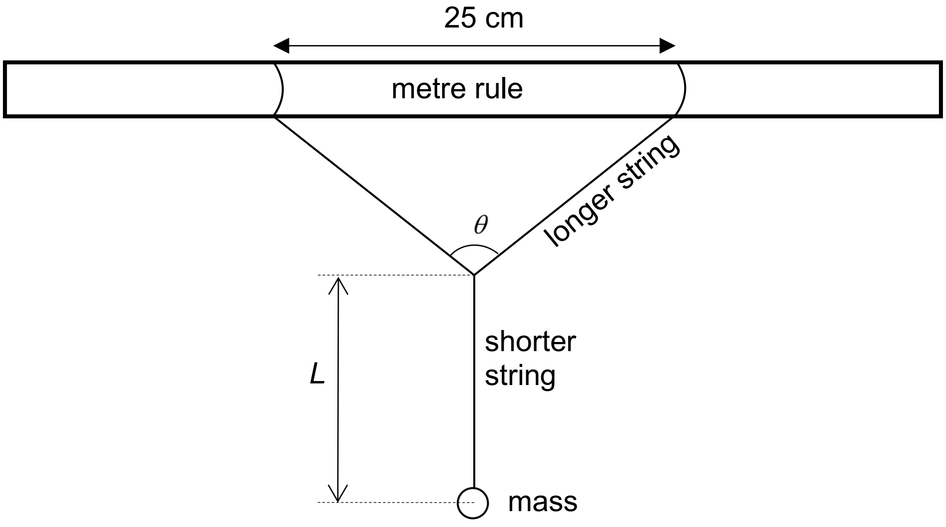


Fig. 2.1

(ii) Measure and record the distance *L*.

L_1 / cm	L_2 / cm	$\langle L \rangle$ / cm
9.5	9.5	9.5

- Value of *L* to the correct precision (0.1 cm or 1 mm) and recorded with an appropriate unit.
- Averaging of at least 2 measurements

L = 9.5 cm .... [1]

(iii) Measure and record the angle θ.

θ_1 / °	θ_2 / °	$\langle \theta \rangle$ / °
70	70	70

- Value of θ to the correct precision (0 d.p.) and recorded with an appropriate unit.
- Averaging of at least 2 measurements

θ = 70° .... [1]

(iv) Estimate the percentage uncertainty in your value of θ.

percentage uncertainty

$$= \frac{3}{70} \times 100\%$$

$$= 4.5\%$$

- Absolute uncertainty must be in the range of 3° to 6°.
- Correct calculation.
- Final answer to 2 s.f.

percentage uncertainty of θ = 4.5% .... [1]

(b) **(i)** Displace the mass through a short distance in the direction that is normal to the vertical plane determined by the rule and string. Release the mass so that it performs oscillations as shown in Fig. 2.2.

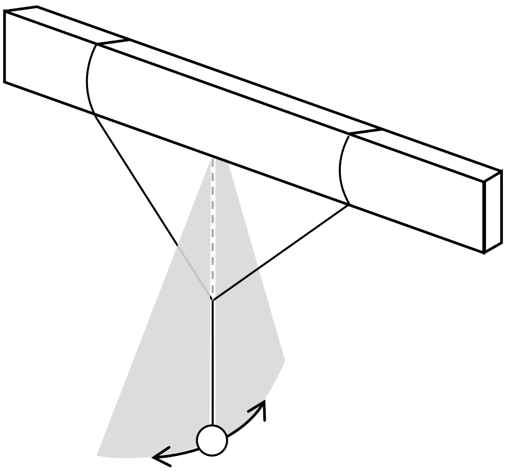


Fig. 2.2

Determine the period T of these oscillations.

Let number of oscillations be N

N	t_1 / s	t_2 / s	$\langle t \rangle$ / s	T / s
25	25.82	25.61	25.72	1.029

- t is recorded with the *correct* precision (2 d.p.) and unit.
- T is calculated correctly and given to the correct s.f. with an appropriate unit.
- Evidence of repeated measurements of t and average calculated.

T = 1.029 s .... [1]

(ii) Repeat **(b)(i)** for five more values of θ in the range of 50° to 150° by adjusting the distance between the two tied ends of the longer string.

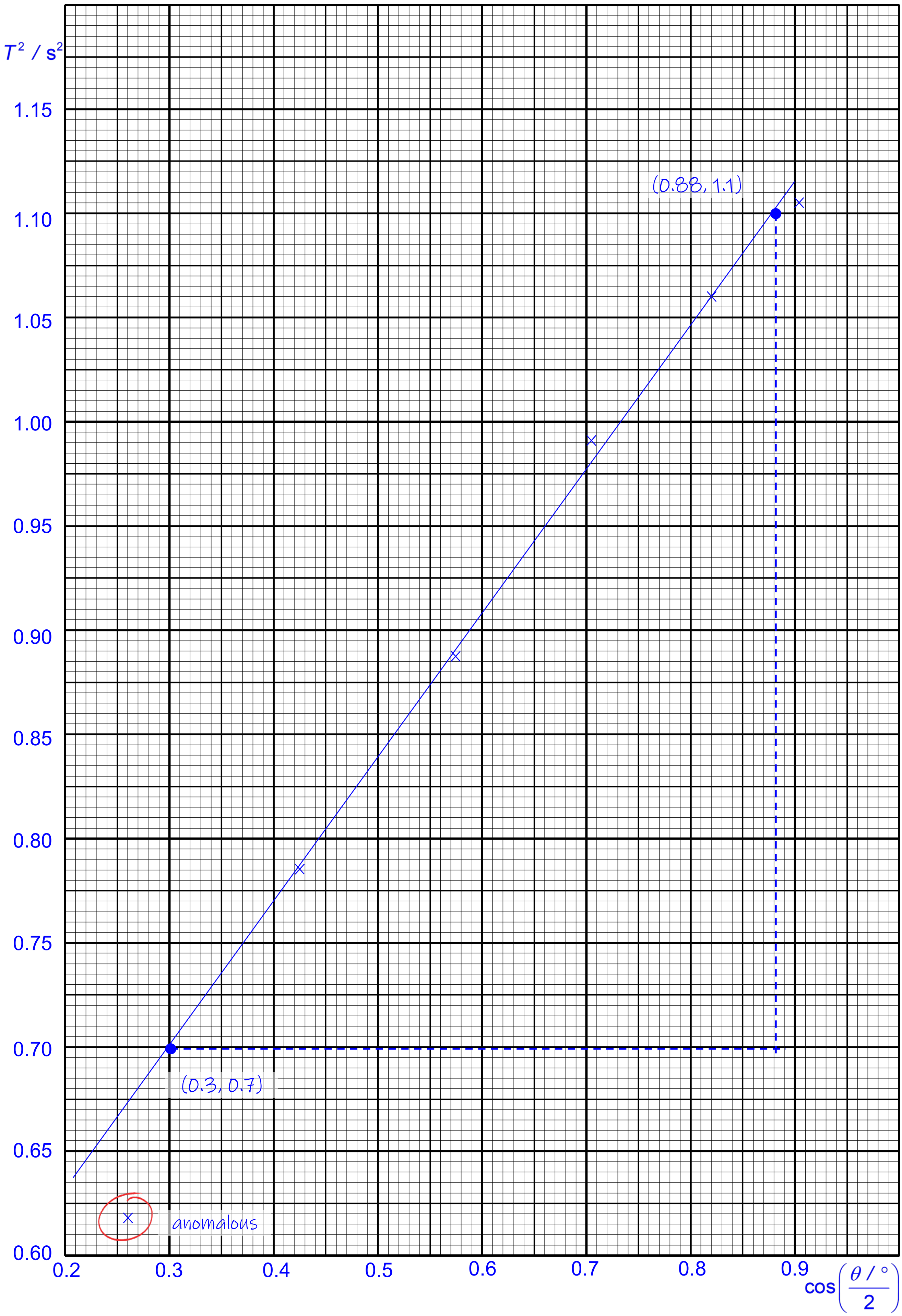
Tabulate these results. Include the results from **(b)(i)**.

Let number of oscillations be N

θ / °	N	t_1 / s	t_2 / s	$\langle t \rangle$ / s	T / s	T^2 / s^2	$\cos\left(\frac{\theta / °}{2}\right)$
50	20	21.15	21.08	21.12	1.056	1.115	0.91
70	25	25.82	25.61	25.72	1.029	1.059	0.82
90	25	24.88	24.95	24.89	0.9956	0.9912	0.71
110	25	23.50	23.56	23.56	0.9424	0.8881	0.574
130	25	21.74	21.70	21.70	0.8680	0.7534	0.423
150	30	23.46	23.56	23.56	0.7853	0.6167	0.259

- 2 marks if 6 sets of data taken independently, 1 m or 5 sets of data, 0 marks if less. [2]
- Trend is correct (i.e. θ decrease, T increase) [1]
- Heading and units correctly indicated [eg. T^2 / s^2, cos ((θ/°)/2)], including number of oscillations (no mark if table is split) [1]
- Value of measured independent variable θ and t to the correct precision, and t > 20s, and range of θ > 50° [1]
- Value of calculated variables [eg. cos (θ/2) and T^2] to the correct precision [1]
- Accurate calculation of calculated variables [1]

[7]


T^2 / s^2
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
$\cos\left(\frac{\theta / °}{2}\right)$
(0.88, 1.1)
(0.3, 0.7)
anomalous

(c) The quantities T and θ are related by the equation

$$T^2 = k\cos\left(\frac{\theta}{2}\right) + c$$

where k and c are constants.

Plot a suitable graph to determine the values of k and c.

- Linearising equation and statement.
- Gradient calculation:

Coordinates used in determining the gradient of graph should be:
- read accurate to ½ the smallest square (accept exclusion of trailing zeros)
- sufficiently far apart (i.e. gradient triangle larger than half of the line drawn)
- substituted correctly

[no award] if points used for gradient calculation is marked with same symbols as points in table.

- Intercept determination:
  - EITHER correct reading off graph OR
  - correct calculation
- k and c give to correct s.f., with correct units
- 6 plotted data points spans more than half grid along both correctly-labelled axes
- best fit line balanced.

Plot of T^2 / s^2 against $\cos\left(\frac{\theta / ^\circ}{2}\right)$ gives a straight line graph with gradient k / s^2 and y-intercept c / s^2

$$\text{gradient} = \frac{1.1 - 0.7}{0.88 - 0.3} = 0.690\ \text{s}^2$$

$$\frac{1.1 - 0.7}{0.88 - 0.3} = \frac{c - 0.7}{0 - 0.3}$$

$$c = 0.493\ \text{s}^2$$

Some read off y-intercept from the graph even though x-axis does not start from 0. When calculating y-intercept value, should use points on best fit line, not points from table. Cannot use same symbols (e.g. crosses) for both data points and gradient read-offs. Gradient read-offs need to be sufficiently far apart on best fit line. Many candidates did not give units for k and c.

k = 0.690 s^2

c = 0.493 s^2

[6]

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

[answer question]	No anomalous point.	OR	(x, y)* is an anomalous point.
[compare to trend of best fit line]	All points follow trend of best fit line.		It does not follow trend of best fit line.
[compare to other data points]	No data point is significantly further from best fit line compared to other points.		It lies significantly further away from best fit line compared to other points.

No mark if anomalous point is not circled and labelled 'anonymous' in the grid. A number of candidates missed out the 'compared to other points'.

[1]

(e) Theory suggests that

$$c = \frac{4\pi^2}{g}L$$

where g is 9.81 N kg^{-1}.

Use your value from **(a)(ii)** to determine the theoretical value of c.

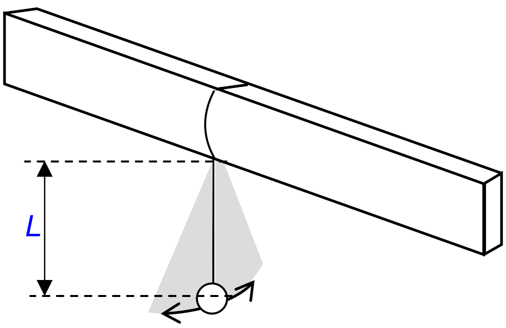
$$c = \frac{4\pi^2}{9.81}\left(9.5 \times 10^{-2}\right) = 0.382\ \text{s}^2$$

- Correct s.f. and units

Many candidates gave the units as cm N^{-1} kg, note that units of c is equivalently just s^2 which could have been deduced from part (c).

theoretical value of c = ... [1]

(f) **(i)** Suggest how you would modify the set up to make measurement(s) that allow you to directly verify the theoretical value of *c*. You may wish to include a diagram.



Repeat the experiment using a simple pendulum of length *L*. [1]

(ii) Suggest why obtaining *c* via **(b)** might be more accurate than via **(f)(i)**.

Relevant points include:

easier to keep oscillations in (b) within 1 plane

y-intercept is the derived from a relationship that considers the weighted average of multiple data points.

Common errors include:

- varying L (varying *L* will result in varying *c*)
- when longer string is stretched till θ = 180 (there is no modification to experiment in this case)

[1]

[Total: 21]

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