



CANDIDATE
NAME

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CIVICS
GROUP

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REGISTRATION
NUMBER

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PHYSICS

Paper 4 Practical

9749/04

12th September 2022

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	16
2	17
Total	33

1 In this experiment, you will investigate the motion of a loaded wooden rod.

(a) (i) Set up the apparatus as shown in Fig. 1.1.

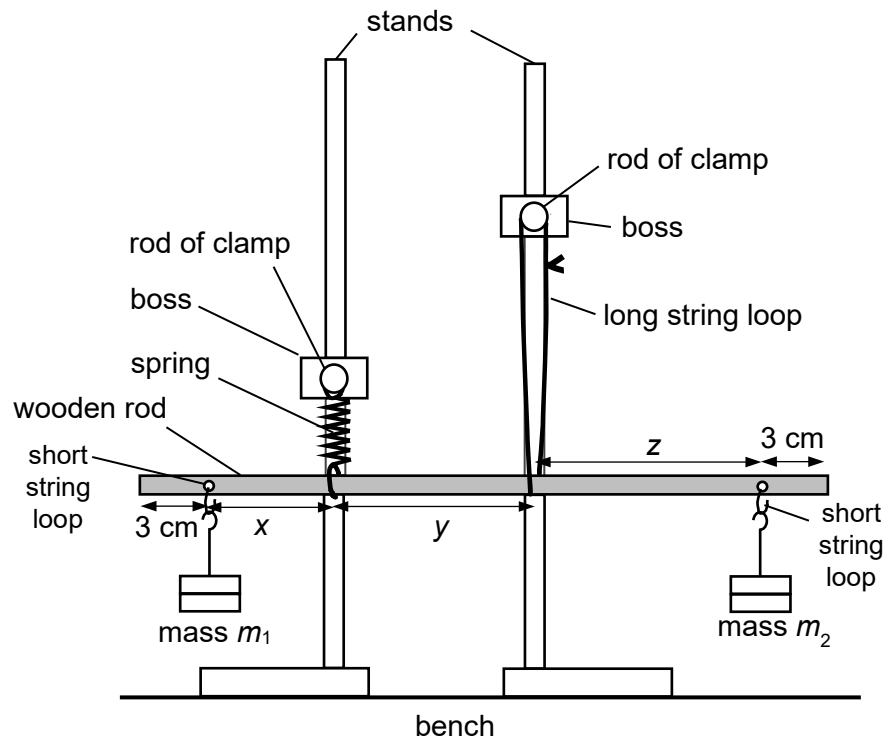


Fig 1.1

Support the wooden rod by passing it through the string loop attached to the spring and also through the long string loop.

Mass m_1 should be 200 g and mass m_2 should be 100 g.

The bottom of mass m_1 should be approximately 5 cm above the bench.

(ii) Adjust the apparatus until the wooden rod is balanced and horizontal. The spring and long string loop should be vertical.

- (iii) Measure and record the distances x , y and z as shown in Fig. 1.1, where
 x is the distance between the loop above m_1 and the spring loop,
 y is the distance between the spring loop and the long string loop,
 z is the distance between the long string loop and the loop above m_2 .

$$\begin{array}{lll} x_1 = 5.9 \text{ cm} & y_1 = 33.4 \text{ cm} & z_1 = 44.2 \text{ cm} \\ x_2 = 6.0 \text{ cm} & y_2 = 33.5 \text{ cm} & z_2 = 44.2 \text{ cm} \\ \langle x \rangle = 6.0 \text{ cm} & \langle y \rangle = 33.5 \text{ cm} & \langle z \rangle = 44.2 \text{ cm} \end{array}$$

$$\begin{array}{l} x = \dots\dots\dots 6.0 \text{ cm} \\ y = \dots\dots\dots 33.5 \text{ cm} \\ z = \dots\dots\dots 44.2 \text{ cm} \end{array} \quad [2]$$

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

$$\frac{0.4}{33.5} \times 100\% = 1.2\%$$

$$\text{percentage uncertainty} = \dots\dots\dots 1.2\% \quad [1]$$

- (b) Calculate C where

$$C = m_1(x + y)^2 + m_2z^2.$$

$$\begin{aligned} C &= (200)(6.0 + 33.5)^2 + (100)(44.2)^2 \\ &= 5.07 \times 10^5 \text{ g cm}^2 \end{aligned}$$

$$C = \dots\dots\dots 5.07 \times 10^5 \text{ g cm}^2 \quad [1]$$

- (c) (i) Pull the left side of the wooden rod down by 2 cm.

Release the wooden rod and watch the movement.

The wooden rod will move up and down again, completing a cycle as shown in Fig. 1.2.

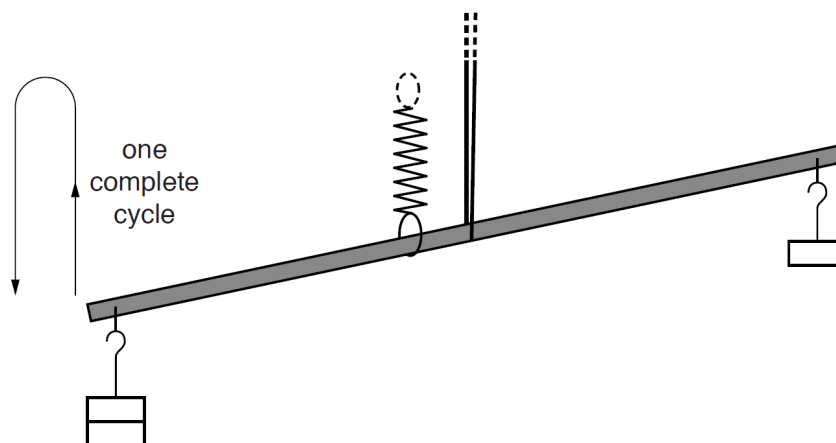


Fig 1.2

- (ii) The time taken for one complete cycle is T .

By timing several of these complete cycles, determine an accurate value for T .

No of oscillations = 15

$$t_1 = 13.71 \text{ s}$$

$$t_2 = 13.44 \text{ s}$$

$$\langle t \rangle = 13.58 \text{ s}$$

$$T = \frac{13.58}{15} = 0.9053 \text{ s}$$

$$T = 0.9053 \text{ s} \quad [3]$$

- (iii) Calculate T^2 .

$$T^2 = (0.9053)^2 = 0.8196 \text{ s}^2$$

$$T^2 = 0.8196 \text{ s}^2 \quad [1]$$

- (iv) Justify the number of significant figures that you have given for your value of T and T^2 .

T^2 follows the significant figure of T , which follows the s.f. of the time taken for several oscillations.

.....[1]

- (d) **Keeping distance y constant**, change m_2 to 50 g and repeat (a)(ii), (a)(iii), (b), (c)(i), (c)(ii) and (c)(iii).

$$\begin{array}{lll} x_1 = 1.3 \text{ cm} & y_1 = 33.4 \text{ cm} & z_1 = 48.9 \text{ cm} \\ x_2 = 1.4 \text{ cm} & y_2 = 33.5 \text{ cm} & z_2 = 48.9 \text{ cm} \\ \langle x \rangle = 1.4 \text{ cm} & \langle y \rangle = 33.5 \text{ cm} & \langle z \rangle = 48.9 \text{ cm} \end{array}$$

$$\begin{array}{l} x = \dots\dots\dots 1.4 \text{ cm} \\ y = \dots\dots\dots 33.5 \text{ cm} \\ z = \dots\dots\dots 48.9 \text{ cm} \end{array}$$

$$\begin{aligned} C &= (200)(1.4 + 33.5)^2 + (50)(48.9)^2 \\ &= 3.63 \times 10^5 \text{ g cm}^2 \end{aligned}$$

$$C = \dots\dots\dots 3.63 \times 10^5 \text{ g cm}^2$$

No of oscillations = 15

$$\begin{array}{l} t_1 = 11.64 \text{ s} \\ t_2 = 11.98 \text{ s} \\ \langle t \rangle = 11.81 \text{ s} \end{array} \quad T = \frac{11.81}{15} = 0.7873 \text{ s}$$

$$T^2 = (0.7873)^2 = 0.6198 \text{ s}$$

$$T = \dots\dots\dots 0.7873 \text{ s}$$

$$T^2 = \dots\dots\dots 0.6198 \text{ s}^2$$

[3]

- (e) It is suggested that the relationship between T and C is

$$T^2 = kC$$

where k is a constant.

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

$$k_1 = \frac{0.8196}{5.07 \times 10^5} = 1.62 \times 10^{-6} \text{ s}^2 \text{ g}^{-1} \text{ cm}^{-2}$$

$$k_1 = \frac{0.6189}{3.63 \times 10^5} = 1.71 \times 10^{-6} \text{ s}^2 \text{ g}^{-1} \text{ cm}^{-2}$$

$$\text{first value of } k = \frac{1.62 \times 10^{-6} \text{ s}^2 \text{ g}^{-1} \text{ cm}^{-2}}{\dots\dots\dots}$$

$$\text{second value of } k = \frac{1.71 \times 10^{-6} \text{ s}^2 \text{ g}^{-1} \text{ cm}^{-2}}{\dots\dots\dots} \quad [2]$$

- (ii) Explain whether your results in (e)(i) support the suggested relationship.

$$\% \text{ difference in } k = \frac{1.71 - 1.62}{1.62} \times 100\%$$

Since percentage difference is larger than the percentage uncertainty of 1.2%, the results do not support the suggested relationship.

 [2]

[Total: 16 Marks]

2 In this experiment, you will investigate forces in equilibrium.

(a) Assemble the apparatus as shown in Fig. 2.1.

The angle θ should be approximately 160° . String AB should be parallel to the bench, and the bottom of mass M should be above the bench. Mass M should have a total mass of 100 g. Use the G-clamp to secure the stand on the right.

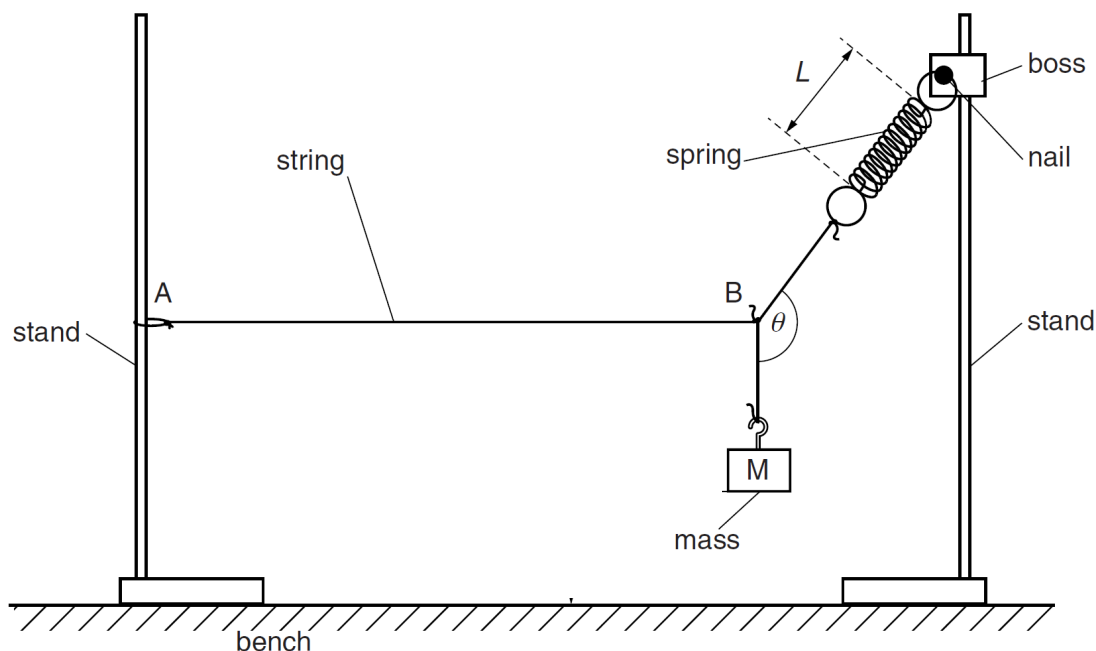


Fig 2.1

(b) (i) Measure and record the angle θ between the string attached to mass M and the string attached to the spring, as shown in Fig. 2.1.

$$\theta_1 = 160^\circ$$

$$\theta_2 = 160^\circ$$

$$\langle \theta \rangle = 160^\circ$$

$$\theta = 160^\circ [1]$$

(ii) Measure and record the length L of the coiled part of the spring, as shown in Fig. 2.1.

$$L_1 = 5.5 \text{ cm}$$

$$L_2 = 5.5 \text{ cm}$$

$$\langle L \rangle = 5.5 \text{ cm}$$

$$L = 5.5 \text{ cm} [1]$$

- (c) Change the distance between the stands.

Adjust the height of A until string AB is parallel to the bench.

Repeat (b) until you have six sets of values of θ and L where θ is at least 110° . Include your values from (b) and (c).

Also include values of $\frac{1}{\sin(\theta - 90^\circ)}$ in your table.

$\theta / ^\circ$	L_1 / cm	L_2 / cm	L / cm	$\frac{1}{\sin(\theta - 90^\circ)}$
110	13.0	13.0	13.0	2.92
120	8.5	8.5	8.5	2.00
130	7.5	7.5	7.5	1.56
140	6.5	6.5	6.5	1.31
150	6.0	6.0	6.0	1.15
160	5.5	5.5	5.5	1.06

[7]

- (d) (i) The quantities θ and L are related by the equation

$$\frac{1}{\sin(\theta - 90^\circ)} = aL + b$$

where a and b are constants.

Determine the values of a and b .

By plotting a graph of $\frac{1}{\sin(\theta - 90^\circ)}$ against L , a straight line graph will be obtained with gradient a and y-intercept b .

$$\text{gradient} = \frac{2.44 - 1.40}{11.00 - 6.90} = 0.254$$

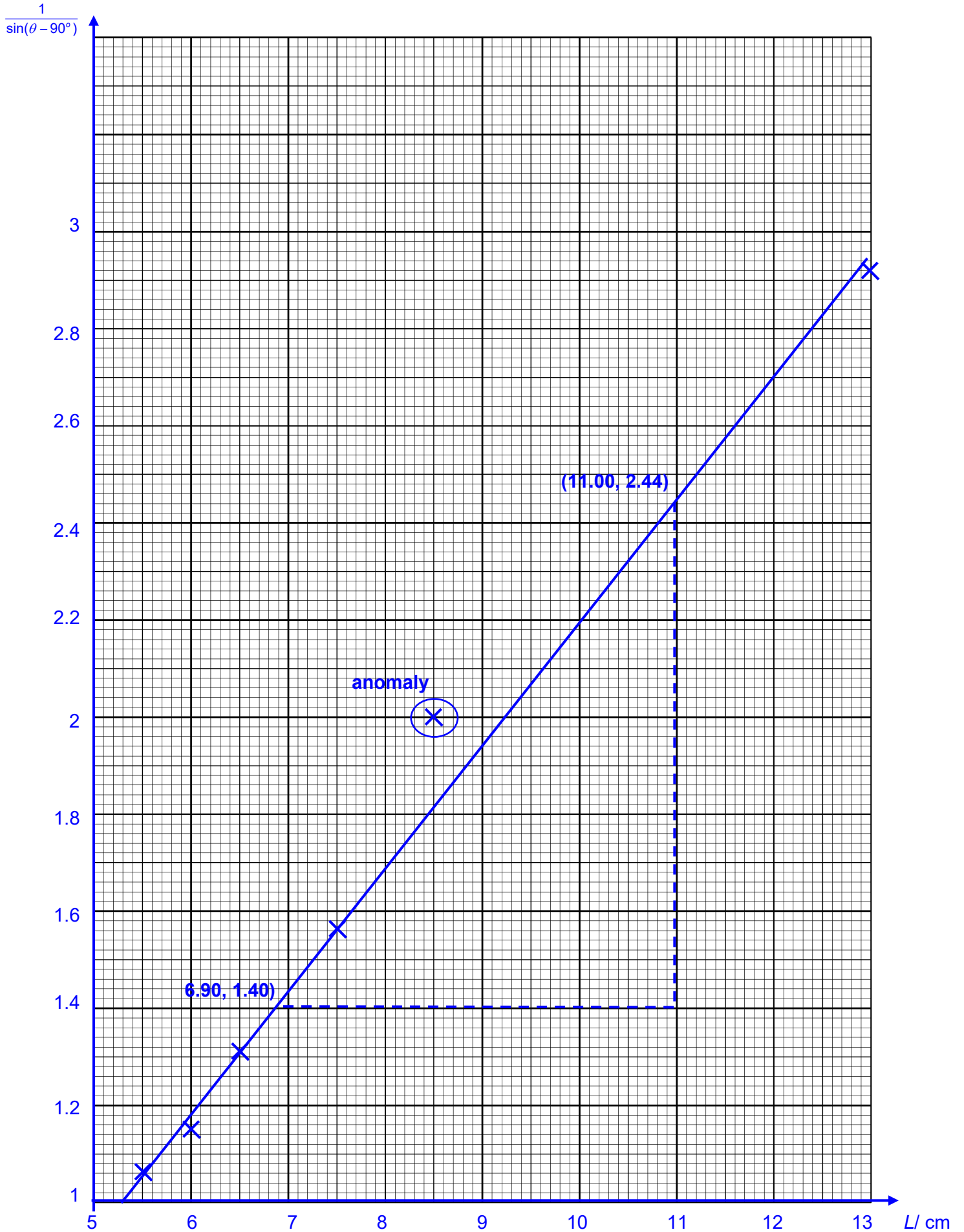
$$a = \text{gradient} \\ = 0.254 \text{ cm}^{-1}$$

$$\text{Using } (11.00, 2.44), \\ 2.44 = (0.254)(11.00) + b \\ b = 0.873$$

$$a = \dots\dots\dots 0.254 \text{ cm}^{-1}$$

$$b = \dots\dots\dots 0.873$$

[4]



- (ii) Comment on any anomalous data or results that you may have obtained.

There is an anomalous data at (8.50, 2.00).

The data point does not follow the trend of the best fit line.

It is significantly far from the best fit line relative to other points.

[1]

[Total: 17 Marks]

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