Civics Group	Index Number	Name
25S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2026
Preliminary Examinations

PHYSICS **9478/04**
Paper 4 Practical **18 August 2026**
2 hours 30 minutes

You must answer on the Question Paper.
You will need: The materials and apparatus listed in the Confidential Instructions.

INSTRUCTIONS

- Answer all questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, index number and Civics Group in the boxes at the top of this page.
- Write your answer to each question in the space provided.
- Do not use an erasable pen. Do not use correction fluid or tape.
- Do not write on any bar codes.
- You may use an approved calculator.
- You may use a spreadsheet to process and analyse data.
- Write the details of the shift and laboratory in the boxes provided.
- You will be allowed to work with the apparatus for a maximum of 1 hour 15 min for each section.

Shift
Laboratory

INFORMATION

- The total mark for this paper is **50**.
- The number of marks for each question or part question is shown in brackets [ ].

For Examiner's Use	
1	/12
2	/14
3	/24
Total	/50

This document has **16** pages. Any blank pages are indicated.

1 In this experiment, you will investigate an electrical circuit.

(a) You have been provided with two metre rules, **F** and **G**, with wires of different diameters attached.

(i) The diameter of the wire attached to **F** is d_F.
Using the micrometer, measure and record d_F.

d_F = …………………………….. [2]

(ii) Set up the circuit as shown in Figure 1.1.

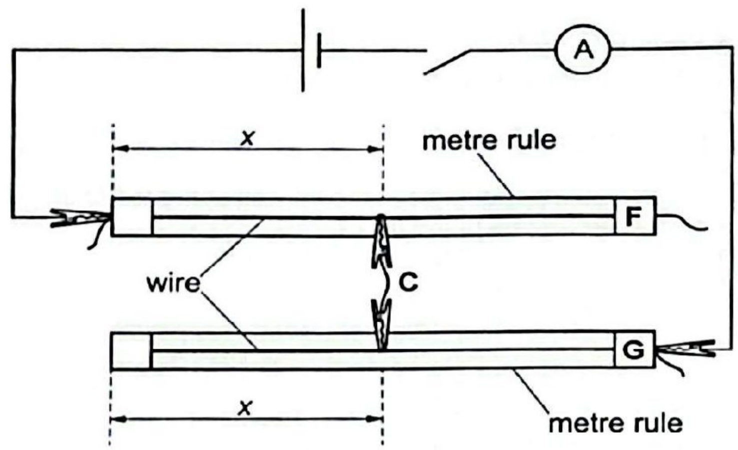

Figure 1.1

Position connecting lead **C** so that distance *x* is 50.0 cm on both rules.
Close the switch. The ammeter reading is I.
Record *x* and I.

x = …………………………………

I = ……………………………..……..
[2]

Open the switch.

(b) Vary x and repeat **1(a)(ii).**
Present your results clearly.

[3]

(c) The quantities I and x are related by the expression:

$$\frac{1}{I} = Px + Q$$

where P and Q are constants.

Plot a suitable graph using a spreadsheet to determine P and Q.
Sketch the graph in the space below. Write down the equation of the trendline.

P = ……………………………………

Q = ……………………………..……..

[3]

(d) It is suggested that:

$$\frac{P}{Q} = \frac{\left(\frac{d_G^2}{d_F^2} - 1\right)}{L}$$

where d_G is the diameter of the wire attached to **G** and L = 1.000 m.

Determine a value for d_G.

Show your working.

d_G = ……………………………... [2]

[Total: 12 marks]

2 In this experiment, you will investigate stretched rubber bands.

(a) Set up the apparatus as shown in Figure 2.1.

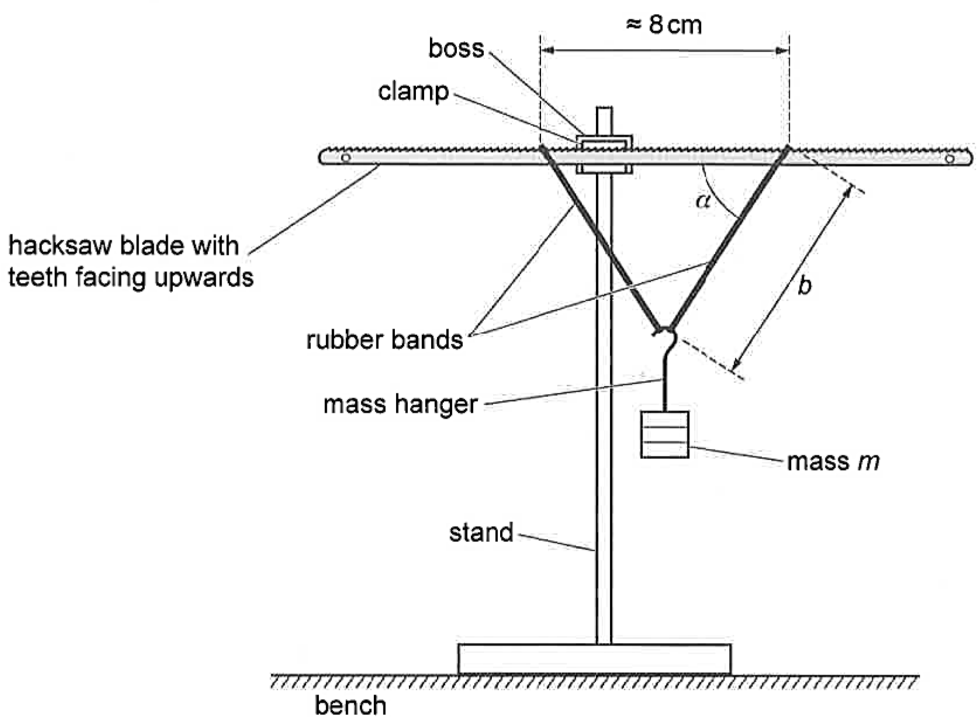

Figure 2.1

Clamp the hacksaw blade with its teeth facing upwards.

Place the rubber bands on the blade so that the tops of the rubber bands are approximately 8 cm apart. You may wish to use some of the Blu-Tack to secure the tops of the rubber bands on the blade.

Suspend mass m from the rubber bands where m = 300 g. Record m.

m = ……………………………..

The angle between **one** of the rubber bands and the hacksaw blade is α, as shown in Figure 2.1. The length of **one** of the stretched rubber bands is b.

Measure and record α and b.

α = ……………………...……..

b = ………………………………

[2]

(b) Change m to 200 g.

Adjust the position of the tops of the rubber bands on the blade so that b has the same value as in **2(a)**.

Record m.

m = ………………………………..…..

Measure and record α.

α = ……………….……………..….

[1]

(c) It is suggested that

$$\sin \alpha = Cm$$

where C is a constant.

Use your values from **2(a)** and **2(b)** to determine two values of C.

first value of C = ……………………………….

second value of C = …………………………..…..

[2]

(d) It is suggested that:

$$C = \frac{g}{2ek}$$

where e is the extension of the rubber band with extended length b, k is the force constant of this rubber band and the acceleration of free fall g = 9.81 m s^{-2}.

Determine a value for k. Show your working.

k = ……………………………….

[3]

(e) Suggest one significant source of error in this experiment.

……………………………………………………………………………………………

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

(f) A materials engineer is characterising the performance of a high-grade industrial material that does not obey Hooke's Law.

The measured force-extension data for the loading phase only is **recorded in the digital file: Prelim_datasetforceext.excel**

Imagine you are the engineer.

(i) Use the engineer's data to estimate the total work done during the loading phase.

work done = ……………………………….J [1]

(ii) Explain how you obtained the value of the total work done.

……………………………………………………………………………………………

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

(iii) When a sample of the material is tested for its mechanical properties, it is subjected to a force that gradually increases to a maximum value (loading), and then is smoothly decreased back to zero (unloading), as illustrated in Figure 2.2 below.

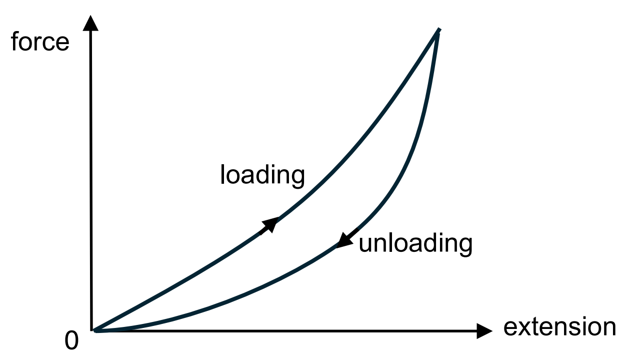

Figure 2.2

It is observed that the unloading curve does not retrace the loading curve, forming a distinct closed loop. Explain the physical significance of this closed loop.

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

(iv) The loading curve of the material is modeled by the equation:

$$F = A\,(e^{Bx} - 1)$$

where:

- *F* is the loading force applied to the material,
- *x*, measured in metres, is the extension of the material,
- *A* is a constant equal to 2.0 N,
- *B* is a constant.

Plot a suitable linear graph using the dataset to determine *B.*

Sketch the graph in the space below. Write down the equation of the trendline.

B = ………………………….. [2]

[Total: 14 marks]

3 This experiment concerns a coupled pendulum system.

Figure 3.1 shows six pendulums, 1, 2, 3, 4, 5 and 6, connected to a common string.

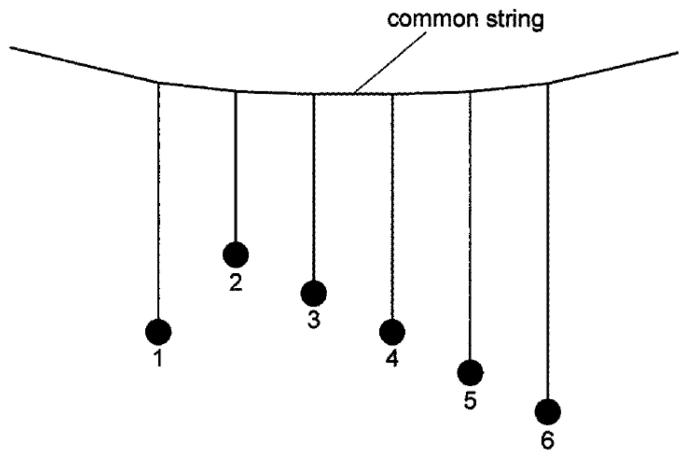

Figure 3.1

When pendulum 1 is set swingling, the other pendulums move.

You will investigate how these properties affect the behaviour of a coupled pendulum system:
- The distance between pendulums
- The tension in the common string
- The difference in pendulum lengths
- The mass of the pendulum bobs

(a) **(i)** Set up two pendulums A and B as shown in Figure 3.2. Place the loops of the common string on the rods of the clamps. The distance x between the pendulum strings is shown.

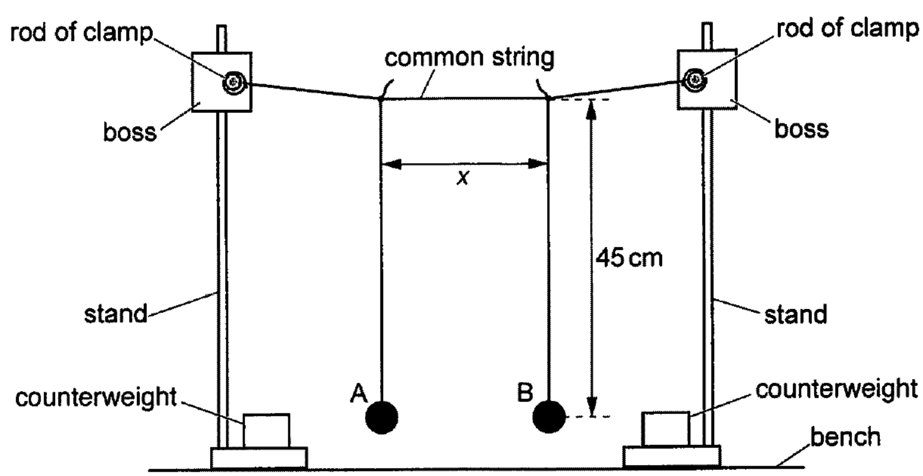

Figure 3.2

Adjust the distance between the stands so that the common string is taut but **not** as taut as possible.

Adjust the knots until each pendulum has a length equal to 45 cm and x is approximately 15 cm.

Measure and record x.

x = ……………………….. cm [1]

Pull pendulum A towards you, perpendicular to the plane containing both pendulums. Release the pendulum. Pendulum A will swing then pendulum B will start to swing. After some time, A will stop swinging while B carries on swinging.

The time t is the time between releasing A and A stopping for the first time.

Measure and record t.

t = ………………………….. s [1]

(ii) Estimate the percentage uncertainty in your value of t.

percentage uncertainty in t = ………………………….. [1]

(iii) It is also possible to determine t using B. The time $2t$ is the time between releasing A and B stopping for the first time.

Discuss whether this second method of determining t is better or worse than the method used in **3(a)(i).**

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…………………………………………………………………………………………..…[2]

(b) **(i)** Repeat **3(a)(i)** for at least two more values of *x* in the range 5 cm to 25 cm.

Tabulate these results. Include the results from **3(a)(i)**.

[2]

(ii) Comment on the trend in your results.

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

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

(c) In part **3(d),** you will use a certain **value of *x***. Choose **one** value of *x* from the values in **3(b)(i)** to use.

State and explain your choice of *x*.

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

(d) For the arrangement shown in Figure 3.2, adjust the positions of the pendulums to make *x* equal to the value chosen in **3(c)**.

Gently move the stands apart so that the common string Is as taut as possible without the stands falling over. This will increase the tension in the common string.

Measure and record *t*.

t = ………………………….. s [1]

Comment on the effect on *t* of increasing the tension in the common string.

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(e) The distance *y* is the difference in length between the two pendulums, as shown in Figure 3.3 for a chosen value of *x*.

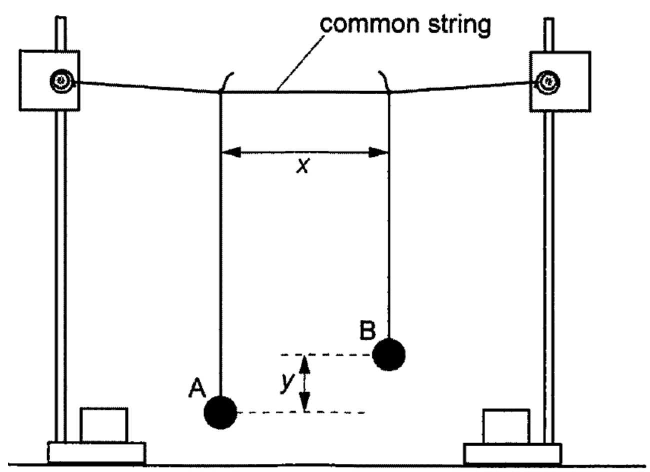

Figure 3.3

Table 3.1 shows data for *y* and *t*.

Table 3.1

***y* / cm**	4.0	8.0
***t* / s**	31	12

(i) It is suggested that:

$$t = \frac{k}{y}$$

where k is a constant.

Use the values from Table 3.1 to determine **two** values of k.

first value of k = ……………………………..……..

second value of k = ……………………………..……..

[2]

(ii) Justify the number of significant figures given in your values of k.

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(iii) State whether the results shown in Table 3.1 support the relationship suggested in **3(e)(i)**.

Justify your conclusion by referring to your answer in **3(a)(ii)**.

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(f) Figure 3.4 shows two pendulums of equal length. The pendulum bobs consist of a number of slotted masses.

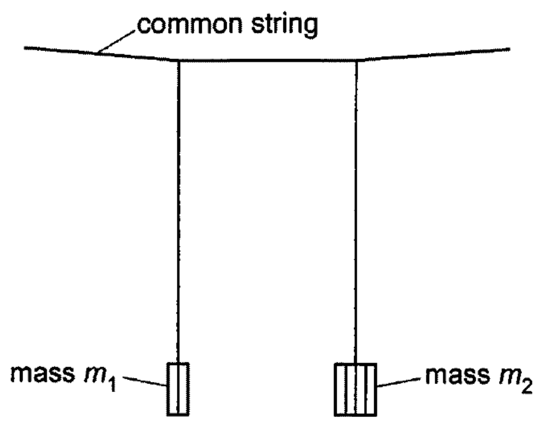

Figure 3.4

In an investigation, mass m_1 is fixed at 40 g, mass m_2 is varied and t is measured.

Table 3.2 shows data for m_2 and t.

Table 3.2

m_2 / g	80	100	120	140	160
t / s	38	31	27	22	17
$(m_2 - m_1)$ / g					

Complete Table 3.2.

Plot the graph of t against $(m_2 - m_1)$ using a spreadsheet to determine t when the two masses are equal.

Sketch the graph in the space below. Write down the equation of the trendline.

t = …………………………….. s

[4]

(g) It is suggested that the time t for one complete energy transfer (i.e. the time between releasing A and A stopping for the first time) between the two pendulums in **3(a)** is <u>independent</u> of the initial release angle θ. Describe an investigation to determine if this relationship is valid.

Include in your plan:

- details of the measurements,
- how you might use the results to show the validity of the relationship.

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[Total: 24 marks]