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9702/31

May/June 2022

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential 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, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You will be allowed to work with the apparatus for a maximum of 1 hour for each question.
- You should record all your observations in the spaces provided in the question paper as soon as these observations are made.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [].

For Examiner's Use	
1	
2	
Total	

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[Turn over

You may not need to use all of the materials provided.

- 1** In this experiment, you will investigate the motion of a spring system.

You have been provided with two springs connected by string.

- (a)** • Set up the apparatus as shown in Fig. 1.1.

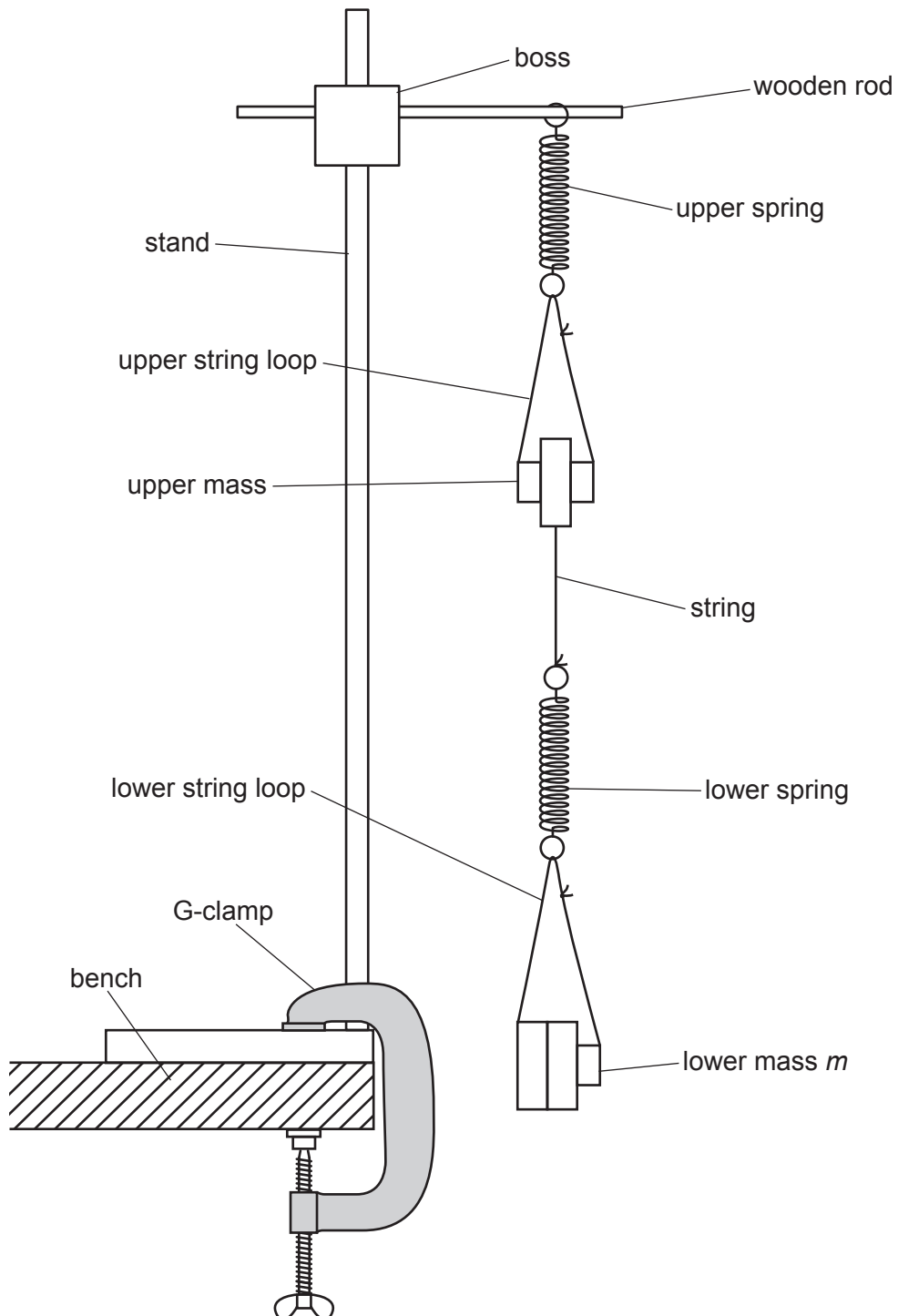


Fig. 1.1

- The lower mass is m . Arrange **all** of the slotted masses so that m is 250g and the remaining slotted masses are in the upper string loop.
- Pull the **lower** mass down through a short distance.
- Release the mass. The system will oscillate.
- Determine the period T of the oscillations of the **upper** mass.

$T = \dots\dots\dots$ [2]

- (b)
- Transfer some of the slotted masses from the lower string loop to the upper string loop.
 - Record the value of the upper mass.

upper mass = $\dots\dots\dots$

- Record the value of m .

$m = \dots\dots\dots$

- Determine the period T of the oscillations of the **upper** mass.

$T = \dots\dots\dots$ [1]

- (c) Change m by moving slotted masses between the two string loops and then determine T .

Repeat until you have six sets of values of m and T . You may include your results from (a) and (b).

Record your results in a table. Include values of $\sqrt{T}$ in your table.

[9]

- (d) (i) Plot a graph of $\sqrt{T}$ on the y -axis against m on the x -axis.

[3]

- (ii) Draw the straight line of best fit.

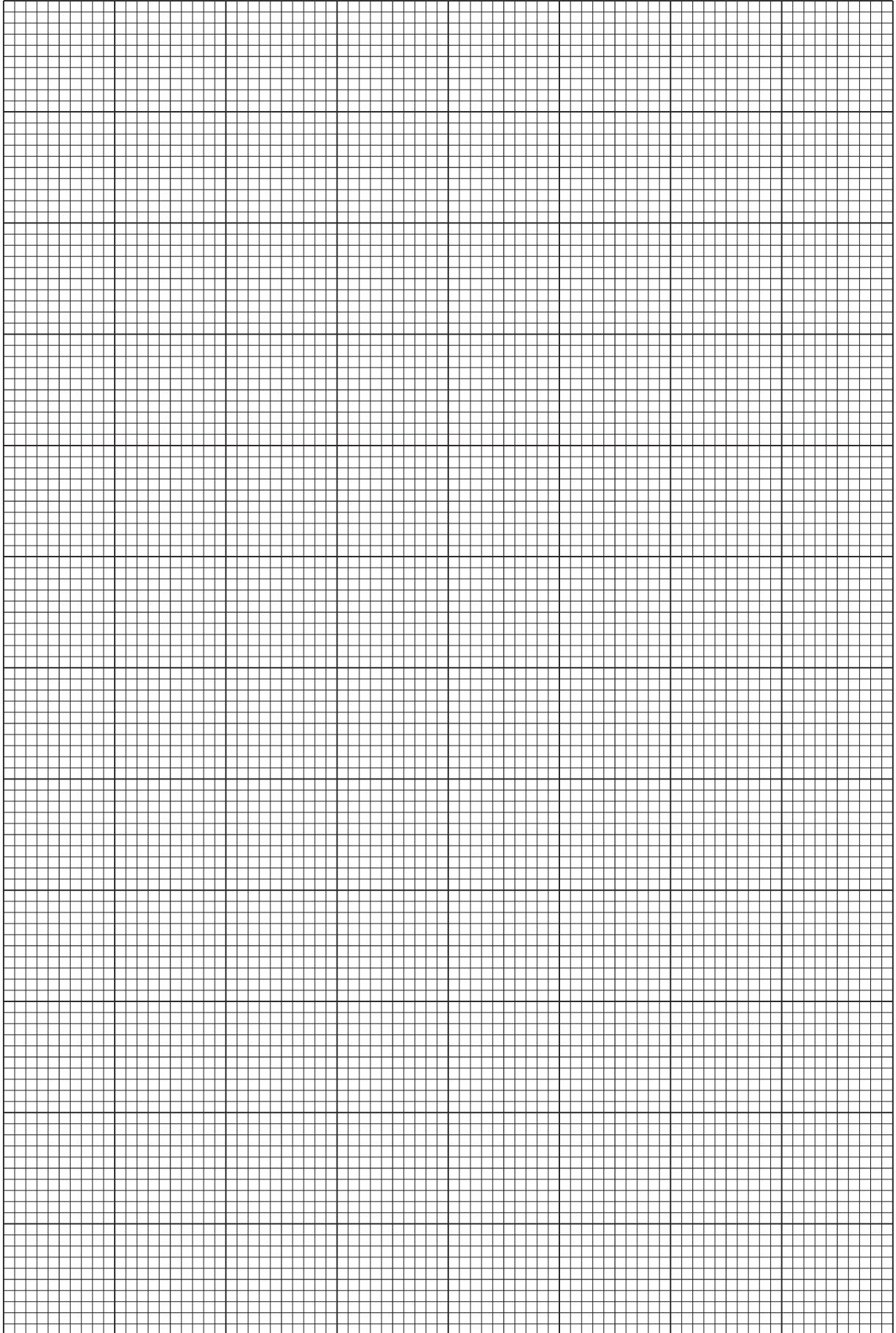
[1]

- (iii) Determine the gradient and y -intercept of this line.

gradient =

y -intercept =

[2]



- (e) It is suggested that the quantities T and m are related by the equation

$$\sqrt{T} = Pm + Q$$

where P and Q are constants.

Using your answers in (d)(iii), determine the values of P and Q .
Give appropriate units.

$P =$

$Q =$ [2]

[Total: 20]

You may not need to use all of the materials provided.

- 2** In this experiment, you will investigate the equilibrium of a metre rule.

You have been provided with a metre rule and a tube.

- (a) (i) • The distance between the centre of the hole in the metre rule and the 50 cm mark on the metre rule is L , as shown in Fig. 2.1.

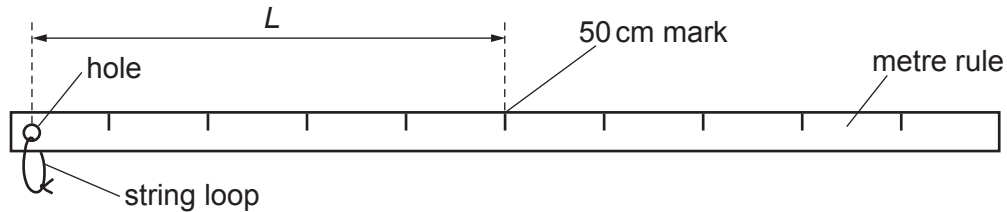


Fig. 2.1

Determine L . Give your value in metres.

$L = \dots\dots\dots$ m

- The outer diameter of the tube is d , as shown in Fig. 2.2.

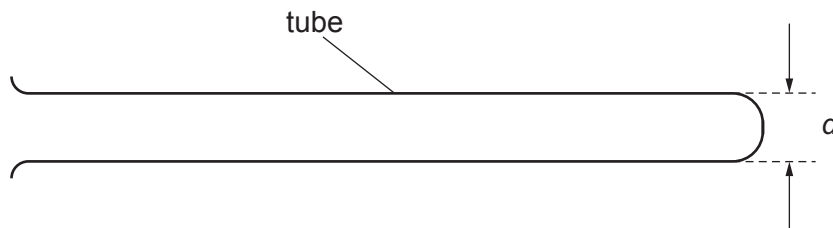


Fig. 2.2

Measure and record d . Give your value in metres.

$d = \dots\dots\dots$ m
[1]

- (ii) Calculate the cross-sectional area A of the tube where

$$A = \frac{\pi d^2}{4}.$$

$A = \dots\dots\dots$ m² [1]

- (b) (i) • Add sand to the tube as shown in Fig. 2.3.

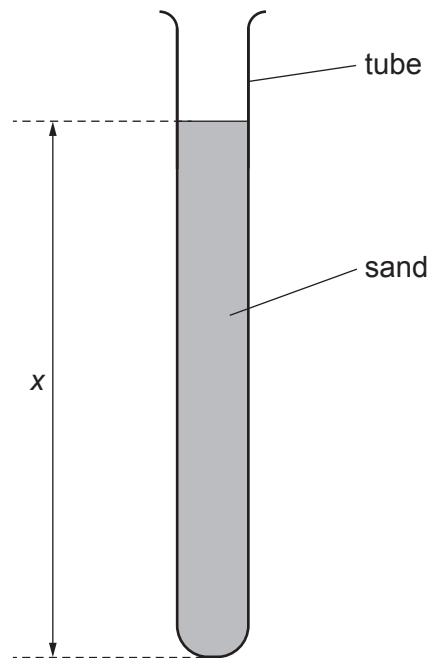


Fig. 2.3

- The height of sand in the tube is x .

Adjust the amount of sand in the tube until x is approximately 12 cm.

- Measure and record x . Give your value in metres.

$x = \dots\dots\dots$ m

- Push the stopper securely into the tube.

- Set up the apparatus as shown in Fig. 2.4. Place the beaker containing water inside the tray.

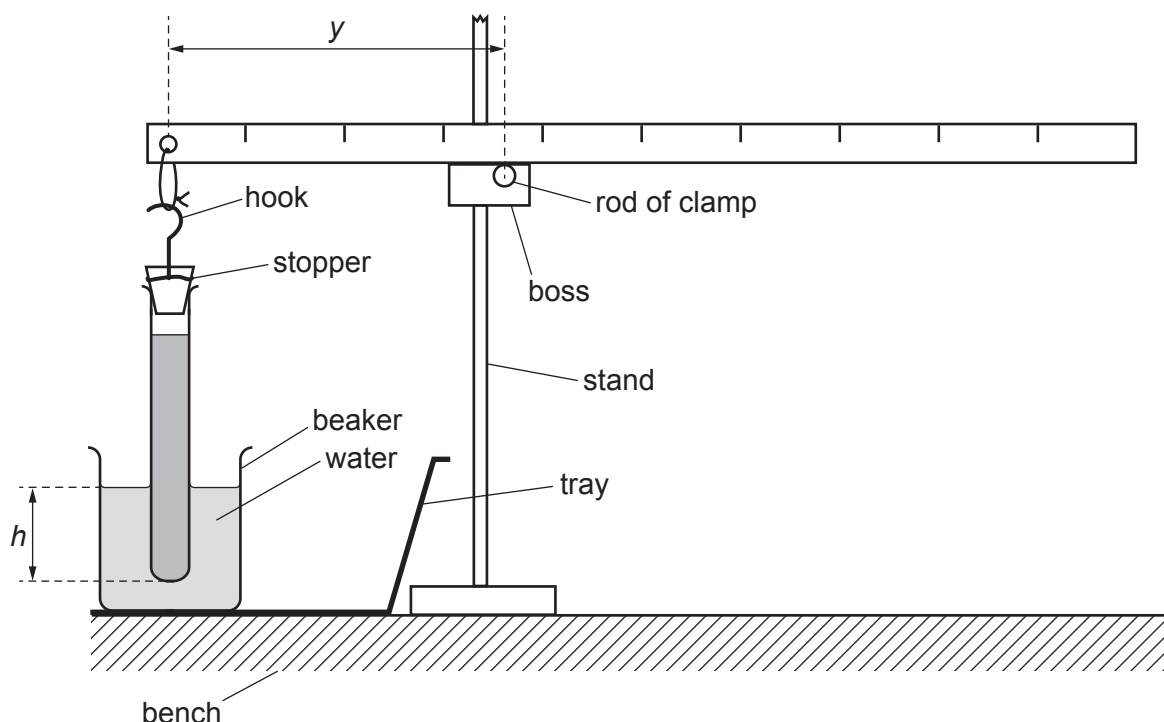


Fig. 2.4 (not to scale)

- Using the hook, suspend the tube from the string loop and place the tube in the water.
- The distance between the bottom of the tube and the surface of the water in the beaker is h .

Adjust the apparatus so that the rule is balanced on the rod of the clamp, the rule is parallel to the bench and the value of h is approximately 5 cm.

- The distance between the rod of the clamp and the hole in the rule is y .

Measure and record h and y . Give your values in metres.

$h = \dots\dots\dots$ m

$y = \dots\dots\dots$ m
[2]

- (ii) Estimate the percentage uncertainty in your value of h . Show your working.

percentage uncertainty = % [1]

- (iii) • The mass M of the metre rule and string is given on the card.

Write down the value of M .

$M =$ kg

- Calculate C using

$$C = \frac{1}{L} \left(1 - \frac{Ah\rho}{M} \right)$$

where $\rho = 1.0 \times 10^3 \text{ kg m}^{-3}$.

$C =$ m^{-1}
[1]

- (iv) Justify the number of significant figures that you have given for your value of C .

.....

 [1]

- (c) • Remove some of the sand from the tube so that x is approximately 8 cm.

Measure and record x .

$x =$ m

- Set up the apparatus as shown in Fig. 2.4.
- Adjust the apparatus so that the rule is parallel to the bench and h has the same value as in (b)(i).
- Measure and record y .

$y =$ m
[3]

- (d) It is suggested that the relationship between y , x and C is

$$\frac{1}{y} = kx + C$$

where k is a constant.

Using your data, calculate two values of k .

first value of k =

second value of k =

[1]

- (e) It is suggested that the percentage uncertainty in the values of k is 10%.

Using this uncertainty, explain whether your results support the relationship in (d).

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..... [1]

- (f) (i) Describe **four** sources of uncertainty or limitations of the procedure for this experiment.

For any uncertainties in measurement that you describe, you should state the quantity being measured and a reason for the uncertainty.

1

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2

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3

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4

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[4]

- (ii) Describe **four** improvements that could be made to this experiment. You may suggest the use of other apparatus or different procedures.

1

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2

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3

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4

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[4]

[Total: 20]

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