Centre Number	Class Index Number	Name	Class
S3016			

RAFFLES INSTITUTION

2023 Preliminary Examination

PHYSICS	**9749/04**
Higher 2	**August 2023**
Paper 4 Practical	**2 hours 30 minutes**
Candidates answer on the Question Paper.	

READ THESE INSTRUCTIONS FIRST

Write your index number, name and class in the spaces provided 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	/ 11
2	/ 11
3	/ 21
4	/ 12
Total	/ 55

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

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

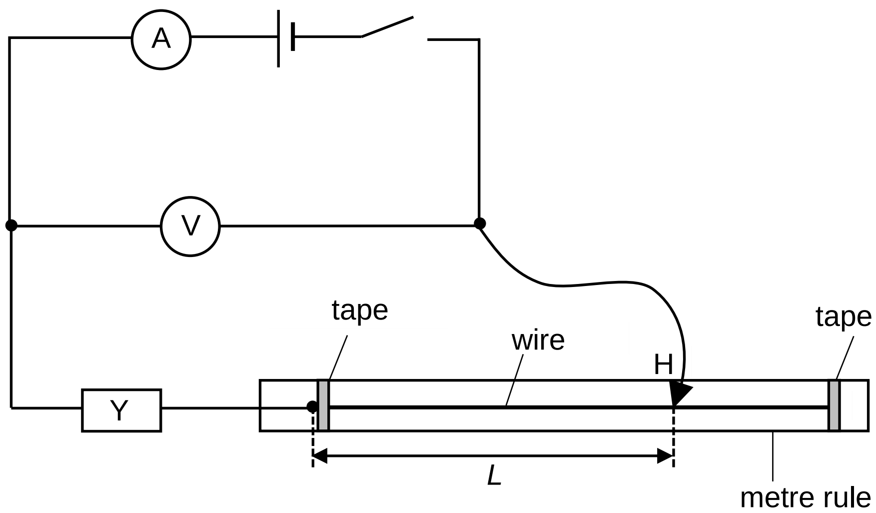

Fig. 1.1

H is a crocodile clip that is free to move along the wire.

Y is a resistor with resistance R.

(b) Adjust length L to approximately 0.10 m.

Measure and record L.

L = ...

(c) Close the switch.

Measure and record the current I and the potential difference V.

I = ...

V = ... [1]

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(d) Repeat **(b)** and **(c)** for different values of L by varying the position of H.

[4]

(e) V and L are related by the expression

$$V = IR + kIL$$

where k is a constant.

Plot a suitable graph to determine R and k.

R = ...

k = ... [6]

[Total: 11]

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

(a) **(i)** You have been provided with a metre rule with a spring attached, as shown in Fig. 2.1.

Fig. 2.1

(ii) The length of the unstretched spring is L_0, as shown in Fig. 2.2.

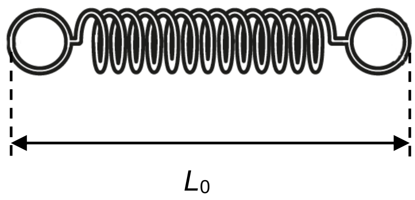


Fig. 2.2

Measure and record L_0.

L_0 = ... [1]

(b) Set up the apparatus as shown in Fig. 2.3.

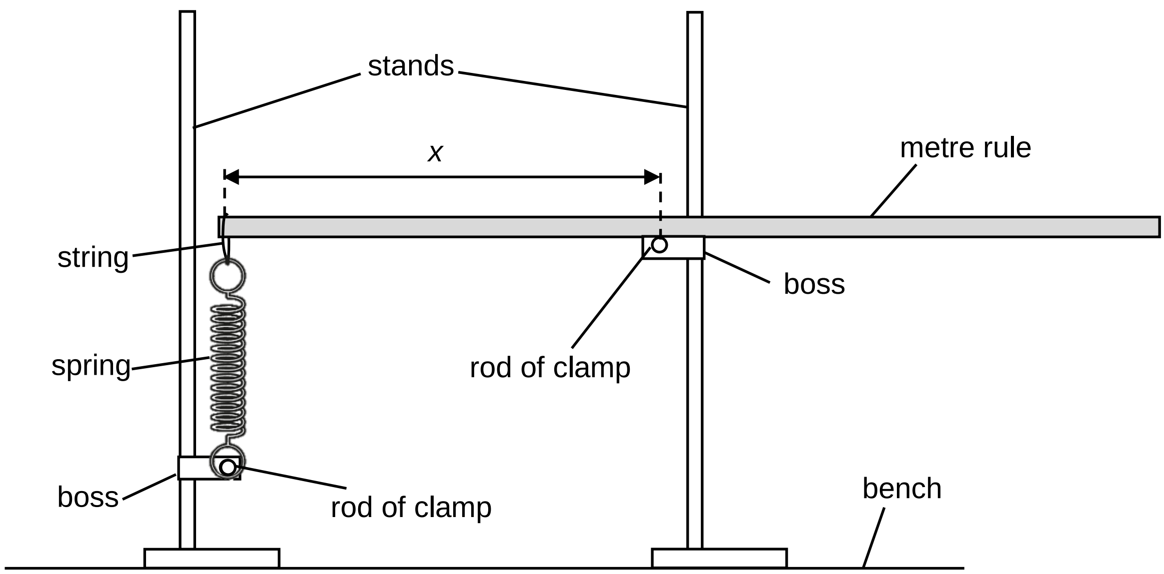


Fig. 2.3

The metre rule is placed on top of one of the rods.

The distance x between the hole with the string and the centre of the rod is shown in Fig. 2.3.

Set x to be about 50 cm and adjust the apparatus until the metre rule is horizontal and the spring is vertical and unstretched.

Without changing the heights of the rods of the clamps, gradually shift one of the retort stands until x is 30 cm. The metre rule will tilt and the spring will stretch as shown in Fig. 2.4.

(i) Make the necessary adjustment to the apparatus so that the spring remains vertical.

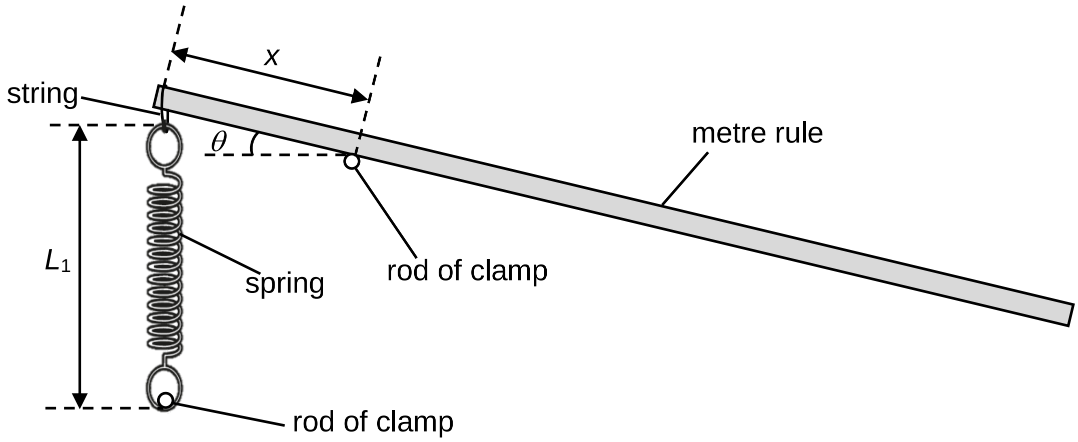


Fig. 2.4

The length of the stretched spring is L_1.

The angle between the rule and the horizontal is θ, as shown in Fig. 2.4.

Measure and record x and L_1 and hence, determine $\sin\theta$.

x = ...

L_1 = ...

$\sin\theta$ = ...

[2]

(ii) Decrease distance x and repeat **(b)(i)**.

x = ...

L_1 = ...

$\sin\theta$ = ...

[1]

(iii) It is suggested that the relationship between $\sin\theta$ and x is given by:

$$\sin\theta = P\left(\frac{l}{2x^2} - \frac{1}{x}\right)$$

where l is the length of the metre rule and P is a constant.

Determine the average value of P using your values in **(b)(i)** and **(b)(ii)**.

P = ... [2]

(iv) Theory suggests that:

$$P = \frac{mg}{k}$$

where k is the spring constant of the spring, g is 9.81 m s^{-2} and m is the mass of the metre rule with a value of 80 g.

Calculate k.

k = ... [2]

(c) **(i)** The experiment is repeated for more values of x.

Assuming the relationships in **(b)(iii)** and **(b)(iv)** are correct, state the graph that you would plot in order to determine the value of the spring constant k.

Explain how k is determined from the graph.

....

....

....

....

....

.... [2]

(ii) Use the relationship in **(b)(iii)** to determine the value of x when $\theta = 0$.

State the significance of this value of x.

....

.... [1]

[Total: 11]

3 In this experiment you will investigate the behaviour of an oscillating system.

(a) Measure and record the length of the metal rod.

length of metal rod = ...

(b) **(i)** Measure and record the diameter d of the wire.

d = ... [1]

(ii) Measure and record the length of the wire.

length of wire = ... [1]

(iii) Coil the wire evenly on to the plastic tube to form a uniform spiral leaving two straight lengths of about 5 cm at the ends as shown in Fig. 3.1.

Fig. 3.1

Measure the lengths of the straight parts and hence, calculate the length l of the wire in the spiral.

l = ... [1]

(iv) Estimate the percentage uncertainty in the value of l.

percentage uncertainty in l = ... [1]

(c) Bend one end of the wire by 90° from about 2 cm from the end of the wire as shown in Fig. 3.2.

Using scotch-tape, attach the bent end to the centre of the metal rod as shown in Fig. 3.3.

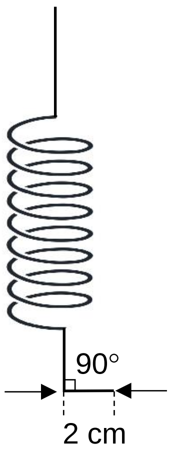


Fig. 3.2

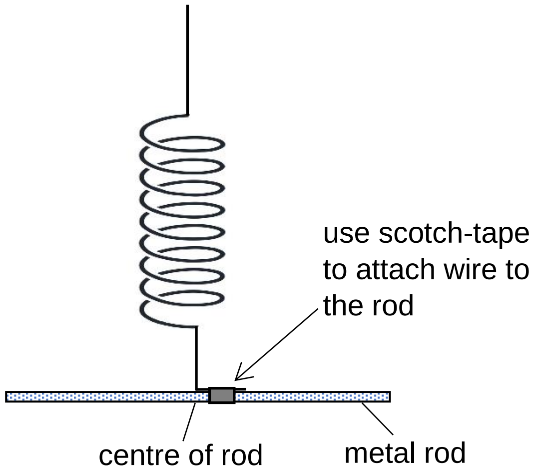


Fig. 3.3

Attach the plasticine spheres to the ends of the metal rod such that their centres coincide with the ends of the rod as shown in Fig. 3.4.

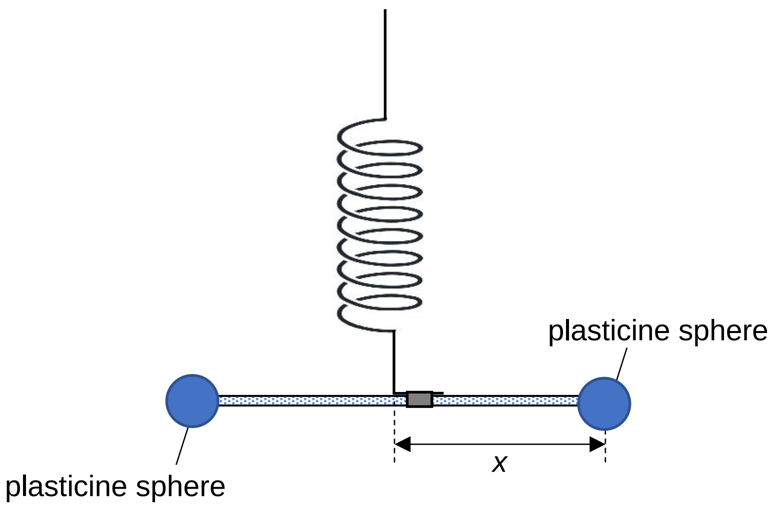


Fig. 3.4

(i) Record the distance x between the centre of each plasticine sphere and the centre of the rod.

x = ... [1]

(ii) Clamp the spring as shown in Fig. 3.5, such that the rod is horizontal.

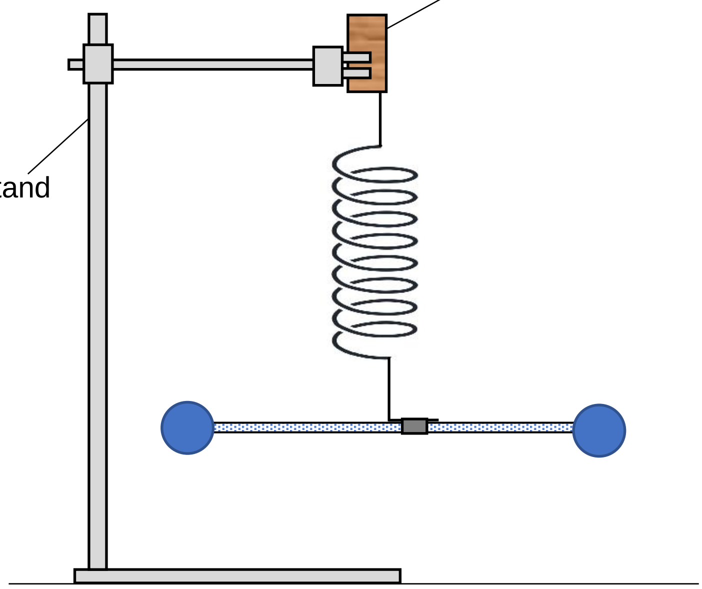


Fig. 3.5

Move one of the plasticine spheres so that the rod turns about a vertical axis. Release the sphere.

The rod will oscillate about a vertical axis.

Determine the period T of these oscillations.

T = ... [1]

(iii) Estimate the percentage uncertainty in the value of T.

percentage uncertainty in T = ... [1]

(d) Move the plasticine spheres closer to the centre of the rod such that x is now 9 cm. The two spheres should be equidistant from the centre of the metal rod.
Repeat **(c)(i)** and **(c)(ii)**.

$x =$ ....

$T =$ .... [1]

(e) It is suggested that

$$T^2 = k\frac{l}{d^4}\left(0.012 + x^2\right)$$

where k is a constant and d, x and l are in metres.

(i) Use your values from **(b)(i)**, **(b)(iii)**, **(c)(i)**, **(c)(ii)** and **(d)** to determine two numerical values of k.

first numerical value of k = ...

second numerical value of k = ...

[1]

(ii) State whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your answers in **(b)(iv)** and **(c)(iii)**.

....

....

.... [1]

(iii) The constant k is related to the shear modulus G of the material of the wire by the equation,

$$k = \frac{64\pi}{25G}$$

and the units of k are $kg^{-1}\ m\ s^2$.

Calculate the value of G.

G = ... [2]

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

....

....

....

.... [1]

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

....

....

....

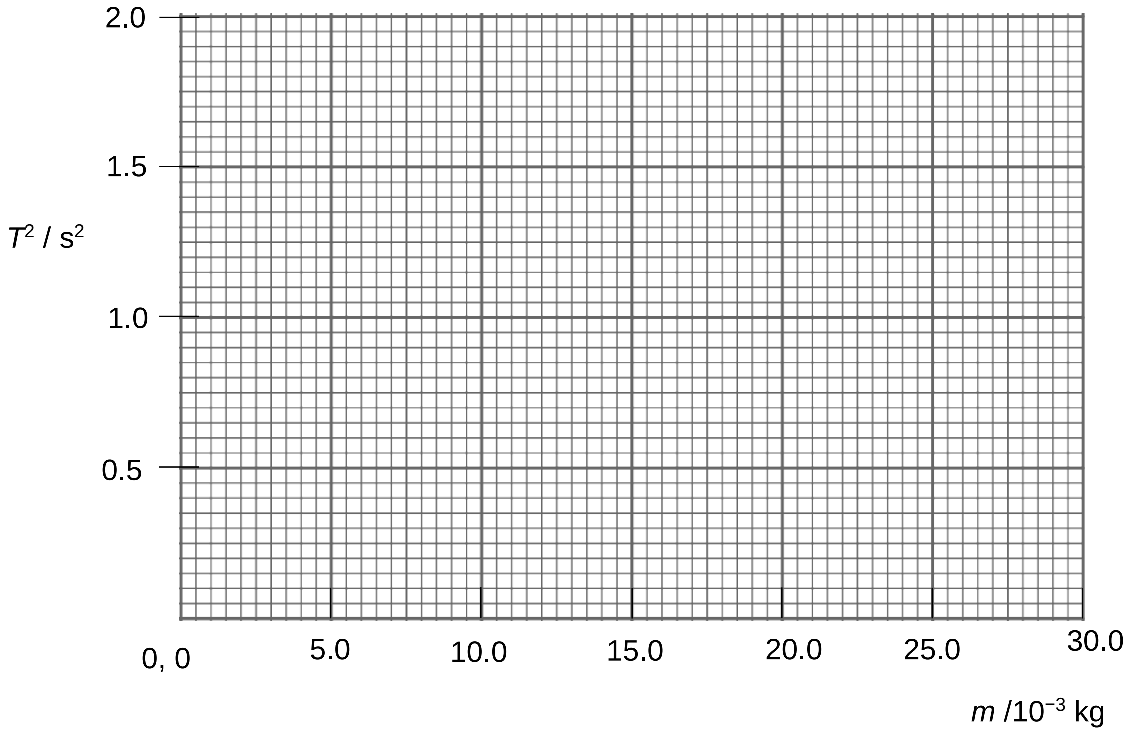
.... [1]

(g) The experiment is repeated without the plasticine spheres but with rods of different masses.

The following results for m and T^2 were recorded.

m / 10^{-3} kg	7.80	12.71	18.62	24.58	30.00
T^2 / s^2	0.4802	0.8124	1.192	1.575	1.922

(i) Plot T^2 against m on the grid provided and draw the line of best fit.



[2]

(ii) Deduce the relationship between T^2 and m.

....

....

.... [1]

(h) The behaviour of the oscillating system with the plasticine spheres also depends on the elasticity of the material of the wire.

It is suggested that the period T is inversely proportional to the elasticity E of the material of the wire.

Explain how you would investigate this relationship.

You are provided with wires of known elasticity.

Your account should include:

- your experimental procedure
- control of variables
- how you would use your results to show inverse proportionality.

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.... [4]

[Total: 21]

4 Fig. 4.1 shows a setup used to illustrate the operation of an eddy current brake.

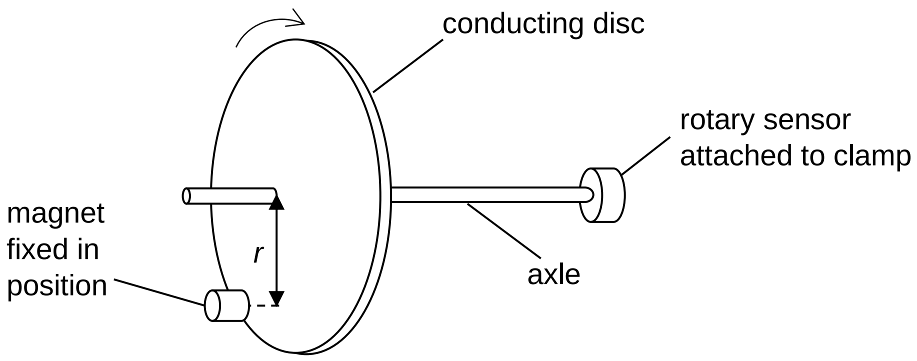

Fig. 4.1

The magnet is at a distance r from the centre of the axle and close to the conducting disc. The magnetic field at the disc due to the magnet has a flux density B. As the disc rotates about its axle, an eddy current is induced in the disc which slows down the rotation.

Regardless of how fast the disc is rotating, the time T taken for the disc to slow down to half its original angular speed is given by

$$T = kB^m r^n$$

where k and m and n are constants.

Design an experiment to determine the values of m and n.

Draw a diagram to show the arrangement of your apparatus. The axle of the disc is connected to a rotary sensor that will measure and display the angular speed of the disc.

Pay particular attention to

(a) the equipment you would use
(b) the material to be used for the conducting disc
(c) the procedure to be followed
(d) the control of variables
(e) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

[Total: 12]

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