TAMPINES MERIDIAN JUNIOR COLLEGE
JC2 Practical Preliminary Examination
Higher 2

H2 Physics 9749/04

Paper 4 Practical

22 Aug 2024

2 hours 30 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

Candidate Name: ______________________

Class	Index No

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page, page **9** and page **15**.
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** the questions.

You are allowed 1 hour to answer Questions 1 and 2; and you are allowed another 1 hour to answer Question 3.

Question 4 is a question on the planning of an investigation and does not require apparatus.

Write your answers in the space provided in 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.

The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	**/8**
2	**/14**
3	**/21**
4	**/12**
Total	**/55**

1 In this experiment, you will investigate how the frictional force between a plastic pipe and string varies with the length of string in contact with the pipe.

(a) Use the vernier calliper to measure and record the outer diameter d of the plastic pipe.

No zero error.
d = (2.70 + 2.70)/2 = 2.70 cm

[1] Check zero error;
2 d.p. and repeated.
Accept 2.65 cm ≤ d ≤ 2.75 cm.

Comments

Common mistakes include not writing zero error and no repeat for d.

d = ………………………………cm [1]

(b) Estimate the percentage uncertainty in your value of d.

% uncertainty in d = (0.02 / 2.70) × 100%
= 0.74%

percentage uncertainty in d = .

[1] Correct absolute uncertainty of
0.02 cm ≤ Δd ≤ 0.05 cm (1 s.f)
% uncertainty calculated correctly with same precision (of numerator and denominator) and correct s.f (2.s.f)

(c) Assemble the apparatus as shown in Fig. 1.1.

Tie the 20 g mass to the one end of the string and the 50 g mass hanger to the other end.

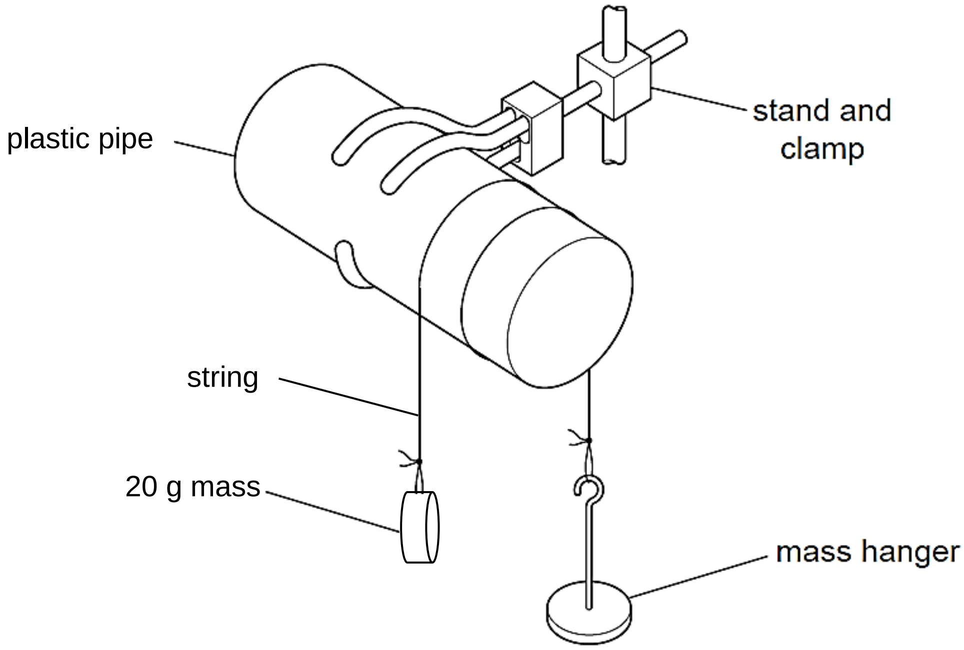

Fig. 1.1

Wrap the string 1.5 times around the pipe. The turns of string must not touch each other.

(d) Use your values from **(a)** to calculate the length l of string in contact with the pipe.

$l = \pi\, d \times 1.5 = 12.7$ cm

[1] Correct calculation and s.f. (3 s.f.)

Comments [1]

Common mistakes include wrong calculation/formula for l

l = ...

(e) Gently add masses to the hanger until the hanger just starts to move down to the bench.

Record this mass m (including the mass of the hanger).

$m_1 = 200$ g
$m_2 = 200$ g
$m_{ave} = 200$ g

[1] Correct unit and d.p. Repeated values

Comments

Common mistakes include no repeat for m.

(f) Remove the masses from the hanger and then wrap the string one more time around the pipe, so that it is now wrapped around the pipe 2.5 times.

Repeat steps **(d)** and **(e)**.

$l = \pi\, d \times 2.5 = 21.2$ cm

$m_1 = 500$ g
$m_2 = 500$ g
$m_{ave} = 500$ g

[1] Correct calculation and s.f. of l (3 s.f.)
[1] Repeat reading, correct unit and d.p. of m (nearest g or kg), value in (f) > value in (e)

l = ...

m = ... [2]

(g) It is suggested that m and l are related by the equation

$$m^2 = k\, l^3$$

where k is a constant.

(i) Use your values from **(d)**, **(e)**, and **(f)** to determine two values of k.

$k_1 = (200)^2 / 12.7^3 = 19.5$ g^2 cm^{-3}

$k_2 = (500)^2 / 21.2^3 = 26.2$ g^2 cm^{-3}

[1] 2 values of k correctly calculated, correct unit and s.f. (3 s.f.)

first value of k = ...

second value of k = ... [1]

(ii) State whether or not the results of your experiment support the suggested relationship. Justify your conclusion by referring to your value in (**b**).

% difference of k = (26.2 - 19.5) / 19.5

= 34%

The percentage difference of the two k values is 34% which is larger than the percentage uncertainty of 0.74% determined in (b).

Thus, we can conclude that the results the experiment do not support the suggested relationship, within limits of the experiment.

[1]

[Total: 8]

[1] Compare k percentage difference with percentage uncertainty in (b) and make conclusion.

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2 In this experiment, you will investigate the relationship between the potential difference across a resistance wire and a filament bulb.

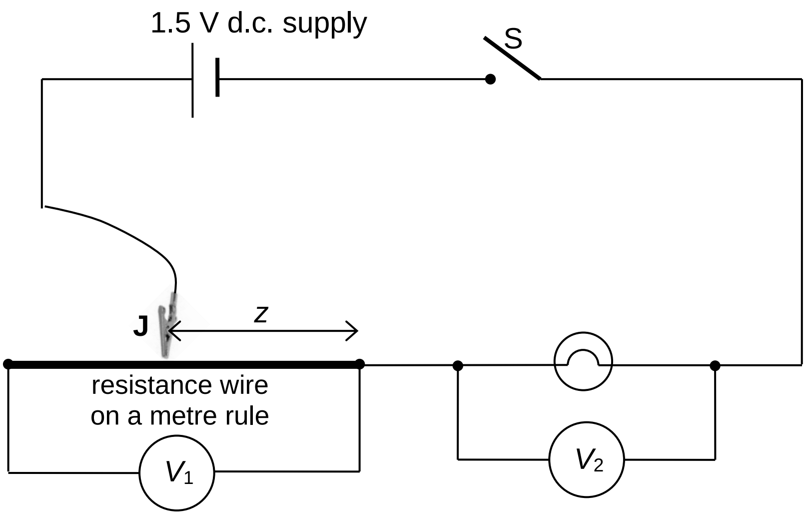


Fig. 2.1

Fig. 2.1 shows a circuit consisting of a resistance wire on a metre rule and a light bulb arranged in series.

(a) **(i)** Connect the circuit as shown in Fig. 2.1.

(ii) Position the clip **J** at a position half way along the wire. Close the switch S.

Record the length z, voltmeter reading V_1 across the resistance wire and the voltmeter reading V_2 across the light bulb.

z = 40.0 cm

V_1 = 0.698 V

V_2 = 0.458 V

[1] z, V_1, V_2: Correct d.p. and units.
Accept 38.0 cm ≤ z ≤ 42.0 cm.

z = ...

V_1 = ...

V_2 = ... [1]

(b) Repeat steps **(a)(ii)** to obtain further sets of values of z, V_1 and V_2.

z/cm	V_1/V	V_2/V	$\frac{V_2}{V_1}$	$\frac{1}{z}$/cm^{-1}
20.0	0.389	0.740	1.90	0.0500
30.0	0.553	0.576	1.04	0.0333
40.0	0.698	0.458	0.656	0.0250
60.0	0.857	0.388	0.453	0.0167
70.0	0.920	0.210	0.228	0.0143
80.0	0.990	0.164	0.166	0.0125

[2] Able to setup experiment to obtain 6 readings with correct trend
Award one mark if student only obtained 5 sets of reading
Deduct 1 mark if range is not at least 75% (i.e. 60 cm).
Deduct 1 mark if the max value of z is more than 80 cm.
Deduct 1 mark if the first reading of z, V_1 and V_2 values from (a)(ii) is not in table.
Deduct 1 mark if min z value given is 0 cm (implying not having wire in circuit).
Deduct 2 marks if trend is negative (referring to wrong raw data obtained)
Deduct 2 marks if V_1 or V_2 remains unchanged.
Ignore if V_1 or V_2 is negative but must be negative throughout the column (if not, deduct 1 mark)

[1] Correct quantity and units in headers (according to symbols given in qn)
[1] Correct d.p for raw data
[1] Correct calculation and s.f for derived data

[5]

(c) It is suggested that z, V_1 and V_2 are related by the equation

$$\frac{V_2}{V_1} = \frac{G}{z} + H$$

where G and H are constants.

Plot a suitable graph to obtain values for G and H.

Plot a graph of $\frac{V_2}{V_1}$ vs $\frac{1}{z}$. If the above relationship is valid, a straight line with G as gradient and H as vertical intercept will be obtained.

Gradient = y1-y2/x1-x2 = …. = 45.1; G = 45.1 cm

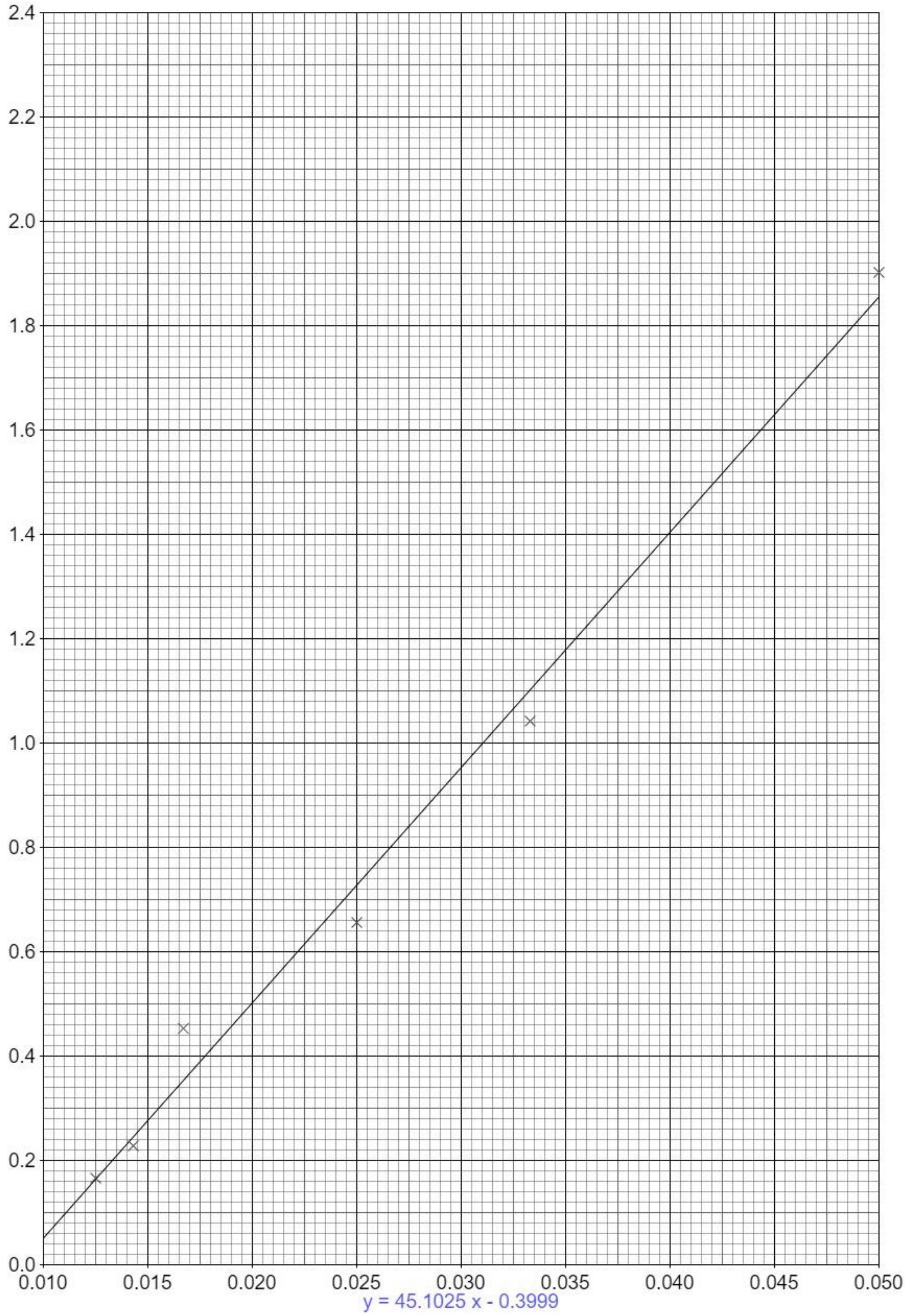
vertical-intercept = y1-mx1 = …. = -0.400; H = -0.400

[1] Correct statement of linearisation (underlined words above).
[1] Gradient triangle covers more than ½ of BFL. Correct read-off of gradient coordinates. Correct calculation, units and s.f. of G. (e.c.f for wrong units)
Deduce marks if use data point that does not fall on BFL. Gradient coordinates must be shown on graph.

[1] Correct calculation, units and s.f. of H (no units for H). Allow ecf from wrong calculation of G. (e.c.f for wrong units)

[6]

Graph plotting
[1] Correct axis label (with units) and choice of scale (Acceptable 1:2, 2.5, 4, 5 and 10).
[1] All data plotted accurately within half the smallest square
[1] BFL line drawn correctly. Anomalous point needs to be labelled/circled, max of 1.



(d) Determine the value of z when V_1 = 100 V_2. Comment on this value of z.

$V_2/V_1 = 0.01$
$0.01 = (45.1)(1/z) - 0.400$
z = 110 cm

The value of z is not possible with this setup as it exceeds the length of the 80 cm wire.

....

[2]

[B1] Correct calculation and units of z (no need for correct s.f). Allow reading off from graph if scale allows it. (allow ecf if graph is plotted wrongly.)
[B1] Sensible reasoning/comment based on calculated z (even if calculation is wrong).

One of the following can be accepted:

- The value of z is not possible with this setup as it exceeds the length of the 80 cm wire.
- Cannot measure value greater than 80 cm.
- Calculated value is off wire.
- Even when z is approximately 1 m, $V_1 > V_2$.
- z cannot be negative (if a negative value is obtained for z).

Or alternative answer – if z is positive and within 80 cm, reasonable explanation.

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Candidate Name: ____________________________ **Civics Group:** ____________

3 In this experiment, you will investigate how the motion of two pendulum depends on the tension in a spring connecting them.

(a) A spring is suspended by two loops of strings to the retort stands.

Measure and record the unstretched length l_0 of the coiled part of the suspended spring as shown in Fig. 3.1.

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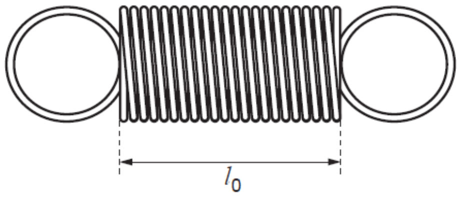


Fig. 3.1

l_0 = (2.0 + 2.0)/2 = 2.0 cm

[1] Correct d.p. and unit and repeated values.
Accept 1.8 cm ≤ l_0 ≤ 2.6 cm.

Comments

Generally well-done.

(b) Set up the apparatus as shown in Fig. 3.2 by tying the two pendulum bobs to the ends of the horizontal spring with each pendulum having a length of approximately 25 cm.

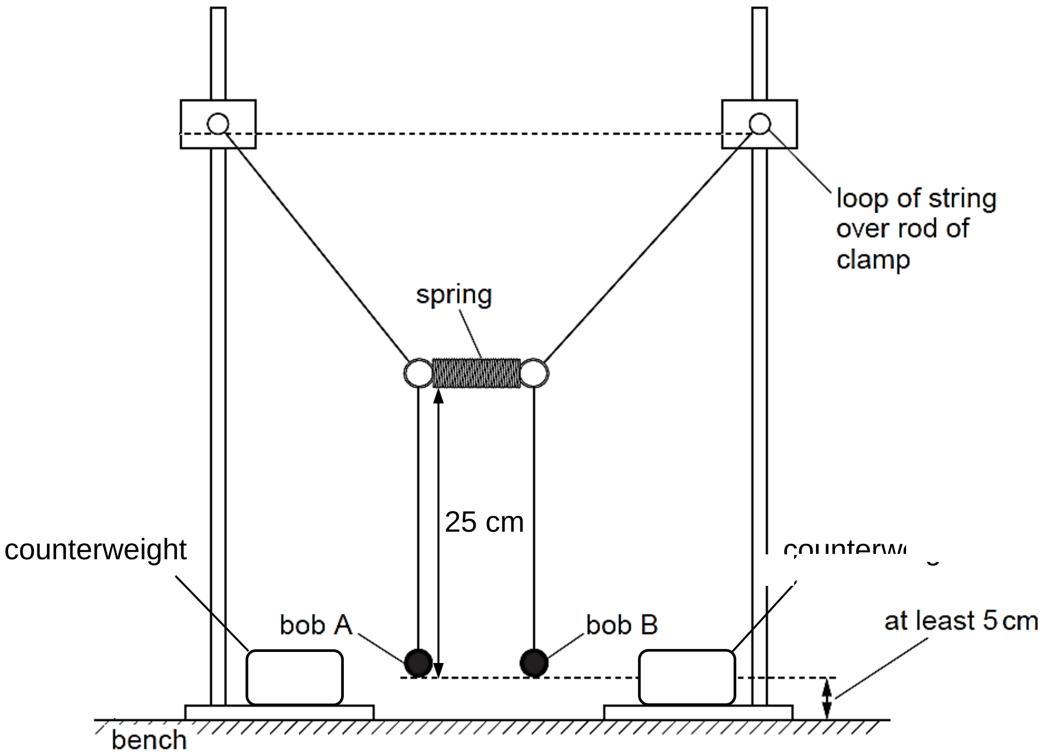


Fig. 3.2

(i) Position the stands so that the coiled part of the spring is extended by approximately 2 cm.

(ii) Measure and record the extended length l of the coiled part of the spring.

Calculate the extension x of the spring.

l = (4.0 + 4.0)/2 = 4.0 cm

$x = l - l_0$ = 4.0 - 2.0 = 2.0 cm

[1] l: Correct d.p and units and repeated.
[1] x: Correct calculation, d.p and units
Accept 1.8 cm ≤ x ≤ 2.2 cm

x = ... [2]

Comments

Generally well-done.

(iii) Pull bob A towards you, perpendicular to the plane containing both bobs. Release the bob. Bob A will swing then bob B will start to swing.
Bob B will eventually stop and start moving again. It will then stop for a second time.
Determine and record the time T between these two stops.

T = (9.0 + 8.9)/2 = 9.0 s (1 d.p.)
Or
Number of cycles, N = 2
t_1 = 18.0 s
t_2 = 17.9 s
t = 18.0 s
T = 18.0/2 = 9.00 s (3 s.f.)

[1] Correct d.p and units and repeated.
Accept 5.0 s ≤ T ≤ 13.0 s
Or
Measure and record repeated t = NT where N is the cycles of T and t > 10.0 s;
Determine T (3 s.f.) = t/N
Accept 5.00 s ≤ T ≤ 13.0 s

[1]

Comments

Some students obtained inaccurate values of T which could be due to incorrect experimental procedure.

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

% uncertainty in T = (0.2 / 9.0) × 100%
= 2.2%
Or
% uncertainty in T = (0.2 / 18.0) × 100%
= 1.1%

[1] 0.2 s ≤ ΔT ≤ 0.5 s
ΔT and T presented with the same precision
%uncertainty calculated correctly, and presented to 2 s.f.

percentage uncertainty in T = ... [1]

Comments

Common mistakes include ΔT and T were not presented with same precision and wrong T value used for method 2.

(c) **(i)** By moving the stands further apart, repeat **(b)(ii)** and **(b)(iii)** to obtain further sets of values of l, x and T, with x in the range of 2 cm $\leq x \leq$ 12 cm.

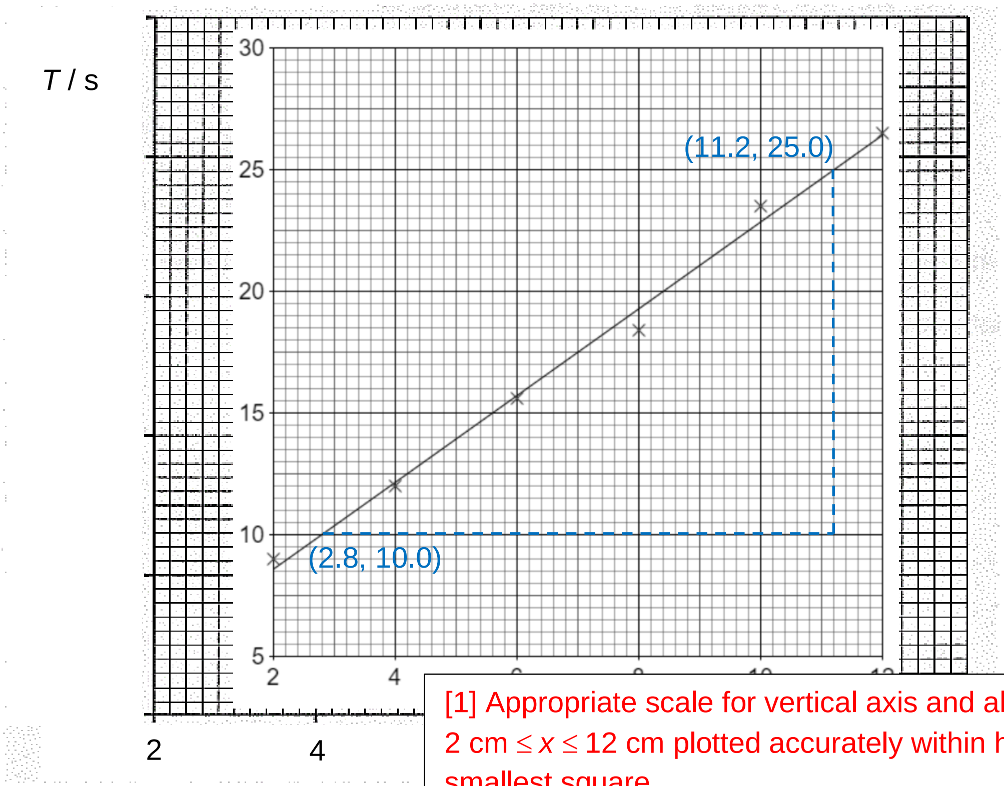
l_1 / cm	l_2 / cm	l / cm	x / cm	T_1 / s	T_2 / s	T / s
4.0	4.0	4.0	2.0	9.0	8.9	9.0
6.0	6.0	6.0	4.0	12.0	11.9	12.0
8.0	8.0	8.0	6.0	15.1	16.0	15.6
10.0	10.0	10.0	8.0	18.8	18.0	18.4
12.0	12.0	12.0	10.0	24.0	23.0	23.5
14.0	14.0	14.0	12.0	27.3	25.6	26.5

[2] At least 6 sets of data for 2 cm $\leq x \leq$ 12 cm.
Zero mark if 4 sets or less;
Deduct one mark for only 5 sets;
Deduct one mark if data in (b) not tabulated;
Deduct one mark if the range is less than 75% (x range less than 7.5 cm);
Deduct one mark if wrong trend;
Deduct one mark if **Assistance Rendered**.
[1] Correct headers (symbol / units).
[1] l and T recorded in correct d.p. and T repeated.
Or l and t recorded in correct d.p. and t repeated.
[1] x correctly calculated and in correct d.p.
T calculated to the correct s.f. where $T = t/N$

Comments

Common mistakes include repeated T or t not presented in table and range of x less than 75%.

(ii) Plot T against x on the grid and draw the straight line of best fit.



[1] Appropriate scale for vertical axis and all data sets for 2 cm $\leq x \leq$ 12 cm plotted accurately within half the smallest square.
[1] Line of best fit drawn correctly. Anomalous point needs to be labelled and circled, max of 1 anomaly.

<u>Comments</u>

Some students plotted the points incorrectly.

(iii) Use your graph to determine T when the length of the coiled part of the spring is l_0.

Present your working clearly.

Gradient
= (25.0 - 10.0)/(11.2 - 2.8)
= 1.786 = 1.8

Vertical intercept
= 25.0 - 1.786(11.2) = 5.0

For $l = l_0$, $x = 0$.
$\Rightarrow T$ = vertical intercept = 5.0 s

[1] Gradient triangle covers more than ½ of BFL; Correct read-off of gradient coordinates and correct calculation of gradient.
[1] Correct calculation of vertical intercept.
[1] Correct determination of T (i.e. same value as vertical intercept); 2 or 3 s.f. and correct unit.

T = ... [3]

<u>Comments</u>

- Common mistakes include inaccurate gradient coordinates or not labelling the gradient coordinates, vertical intercept wrongly determined without calculation or wrongly calculated.
- Some students did not recognise that T is the vertical intercept of the plotted graph.

(d) The behaviour of the oscillating system depends on the distribution of mass in the system.
In an investigation, Fig. 3.3 shows two pendulums of equal length separated by a spring with an extension *x*. The pendulum bobs consist of a number of slotted masses.

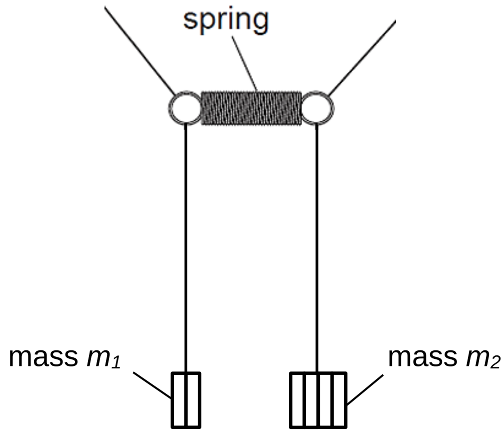


Fig. 3.3

(i) Suggest one value of *x* from the values in **(c)** you would use in the investigation. Record and explain your choice of *x*.

[1] Choice of *x* with unit such that the time interval *T* for bob B to stop is the longest so that the percentage uncertainty of *T* will be smallest.
Or
Choice of *x* with unit such that the time interval *T* for bob B to stop is the shortest so as to complete the experiment within time limit (if the experiment were to carried out in exam).

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

Comments

- Many students were unable to provide the correct reason for their choice of *x*.
- Some students forgot to include the units of *x*.

(ii) Plan an investigation to examine the relationship between T and the distribution of masses $(m_2 - m_1)$.

Your account should include:

- your experimental procedure
- control of variables
- how you would use your results to verify the linear relationship
- one suggestion to improve the accuracy of the results.

[M][1] Setup as shown in Figs 3.2 and 3.3 (or by drawing) and carry out the experiment as mentioned in b)(iii). Only change is to replace bobs with slotted masses.

[C][1] Controls: Use appropriate instrument (e.g. ruler) to measure length of strings / spring and ensure the length is constant.

[B][1] Vary the distribution of the masses, $(m_2 - m_1)$ (independent variable). (Use a weighing scale to measure and record the masses.)
Use a stopwatch to measure different values of T (dependent variable) to obtain at least 6 sets of readings each.

[A][1]
Plot a graph of T against $(m_2 - m_1)$.
If the trend presented by the plotted points is a straight line, the relationship is linear.
Or
Assume T and $(m_2 - m_1)$ are related by the equation $T = a(m_2 - m_1)^b$, where a and b are constants. $\lg T = b \lg (m_2 - m_1) + \lg a$. Plot $\lg T$ vs $\lg (m_2 - m_1)$ to determine the relationship between T and $(m_2 - m_1)$.
Relationship is linear if $b = 1$.

[R][1] Any one of the following:

- Repeat measurement of T to obtain average readings of T (to reduce random errors).
- Do preliminary experiments to ensure that T vary significantly with the masses used. (Else increase range of masses.)
- Use of slow-motion camera to capture the motion with motion playback timed.
- Use a fiducial marker to facilitate observation of the oscillations coming to a stop.
- Place a contrasting coloured background behind the string/spring/masses so that the lengths/motion are more visible to see.

Comments

- Common mistakes include not specifying the appropriate apparatus (metre rule and stopwatch) used in the measurements.
- Some students did not describe the correct setup and/or procedure.
- Reference should be made to straight line graph and/or constant gradient to establish the linear relationship.

[Total: 21]

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Candidate Name: ___________________________ **Civics Group:** ____________

4 Fig. 4.1 shows a light-dependent resistor (LDR) submerged under water.

A source of light shines towards the LDR through the water.

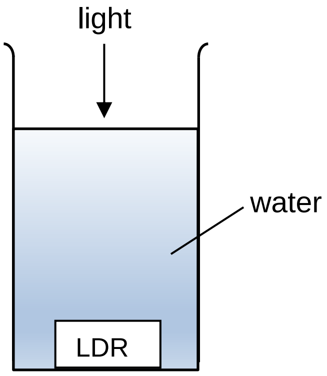


Fig. 4.1

The resistance R of the LDR depends on the power P of the light and the depth h of water within the container.

The resistance R is given by:

$$R = K\ P^x h^y$$

where K, x and y are constants.

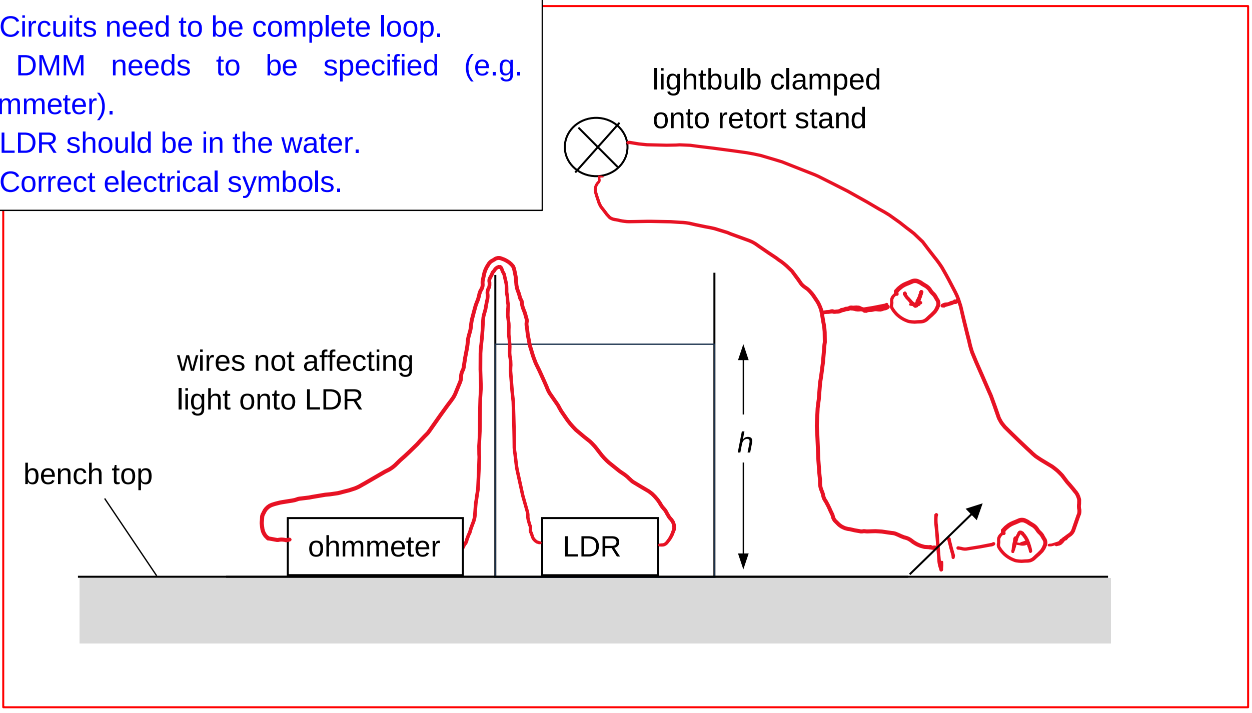
Design an experiment to determine the values of x and y.

You are provided with a LDR and a light bulb. You may also use any of the other equipment usually found in a physics laboratory.

Draw a diagram to show the arrangement of your apparatus. You should pay particular attention to:

- the equipment you would use
- the procedure to be followed
- the control variables
- any precautions that should be taken to improve the accuracy and safety of the experiment.

Comments:
1) Lightbulb needs to be secured (e.g. clamped)
2) Wires cannot cross container.
3) Circuits need to be complete loop.
4) DMM needs to be specified (e.g. ohmmeter).
5) LDR should be in the water.
6) Correct electrical symbols.



(Note: - equipment (ammeter, voltmeter, variable power supply & ohmmeter to be placed on bench top)

Procedure:

1. Set up the experiment as shown above.
2. In this experiment, the variables are:
   a. Dependent variable: resistance R of the LDR
   b. Independent variables: power P of light bulb r and depth h of water
3. Measure the depth of water h, using a metre rule.
4. Measure the power P of light bulb, by multiplying the voltmeter reading V and the ammeter reading I, where $P = VI$.
5. Measure the resistance R of the LDR using the ohmmeter.
6. Keep the distance between the lightbulb and top of LDR constant, using a metre rule.

Experiment 1: Keep *P* constant and vary *h*

7. Ensure that the power P of light bulb is same by checking the values V and I remain same.
8. Add water to the container, repeat steps 3 to 6 to carry out the experiment for a further 6 sets of varying h.
9. $R = K\,P^{x}h^{y}$

   $\lg R = x\lg P + y\lg h + \lg K$

   Plot a graph of lg R against lg h. The value of y can be found from the gradient (the value of the vertical intercept is $x\lg P + \lg K$)

Experiment 2: Keep *h* constant and vary *P*

10. Keep the depth of water *h* constant, check using a metre rule.
11. Change the variable power source, repeat steps 3 to 6 to carry out the experiment for a further 6 sets of varying *P*.
12. Plot a graph of lg *R* against lg *P*. The value of *x* can be found from the gradient (the value of the vertical intercept is $y \lg h + \lg K$)

Reliability

13. Conduct the experiment in a dark room to void other light affecting the results.
14. Adjust the wires (within the water) such that they are not obstructing light imposed on LDR.
15. Repeat experiment (for each value of *h* and *P*) to obtain average readings of *R*, to reduce random errors.
16. Ensure ruler is vertical (while measuring heights) by using a set square/ spirit level.
17. Do preliminary experiments to ensure that resistance R varies significantly with varying power *P* and varying depths *h*.

Safety

18. Wear dark glasses to prevent damage to eyes due to light source.
19. Do not touch hot light bulb/ use gloves when handling hot light bulb.
20. Ensure electrical connections to the LDR to be waterproof to prevent possible shock.

Annotation	**Rubrics**	**Max**	**Actual**
Basic Procedure	In the process of measuring resistance R of the LDR, **BP1:** mention of keeping power P of light bulb constant, vary depth of water h. Repeat for 6 sets of data. **BP2:** mention of keeping depth of water h constant, vary power P of light bulb. Repeat for 6 sets of data.	2	
Diagram	**D1:** Labelled diagram of workable setup including • LDR connected to ohmmeter or circuit with V & I method to measure/ determine resistance R of LDR. • Clamped/supported light bulb connected to source (variable or fixed power source), or variable resistors to vary power to bulb	1	
Measurements	**M1:** method to determine R, e.g. read off ohmmeter or using equation $R = \frac{\text{p.d. across LDR}}{\text{Current in LDR}}$, with correct positions of voltmeter & ammeter **M2:** method to determine h, using ruler **M3:** method to determine P, using equations e.g. $P = VI$, where p.d.(V) across lamp and current (I) in lamp were measured. with correct positions of voltmeter & ammeter.	3	
Control variable	**C1:** Keep position of light source constant (relative to the LDR) using clamp or check with metre rule. explicit mention of control needed.	1	
Analysis of data	**A1:** Plot a suitable graph of ln R vs ln h (keeping P constant) gradient = y (vertical intercept = x ln P + ln K) **A2:** Plot a suitable graph of ln R vs ln P (keeping h constant) gradient = x (vertical intercept = y ln h + ln K)	2	
Other Reliability	**R1:** dark room or shielding LDR (to avoid light from other sources) **R2:** ensure vertical position of ruler (in measuring heights) using a set square/ spirit level **R3:** Repeat experiment (for each value of h and P) to obtain average values of R (to reduce random error) **R4:** Place light source close to water surface (with reason to increase intensity/ reduce reflections Or Light source placed further away from surface (to make it more directional) **R5:** Use tall container to give a wide range of h (or R) to reduce uncertainties Or Use a wide container to reduce reflections. **R6**: Replace light bulb with high intensity lamp, collimated beam, laser **R7:** Any other relevant points: (must have proper rationale mentioned) 1) Do preliminary experiments that resistance R varies significantly with varying power P and varying depths h. 2) Use horizontal fiducial marker from ruler to meniscus or middle of LDR (e.g. a pin) 3) h = reading on rule at surface minus reading at top of LDR 4) Adjust wires in water so that they are not obstructing light imposed on LDR.	Max 2	
Safety	**S1:** dark glasses to prevent damage to eyes due to light source or do not look directly at light source **S2:** do not touch hot light bulb/ use gloves when handling hot light bulb **S3**: ensure electrical connections/wire to the LDR are waterproof to prevent possible shock. **S4**: Others: wipe spills to avoid slips; overheating of bulb.	Max 1	