1 Some students are investigating the relationship between potential difference and current for a resistor. They are using the circuit shown in Fig. 1.1.

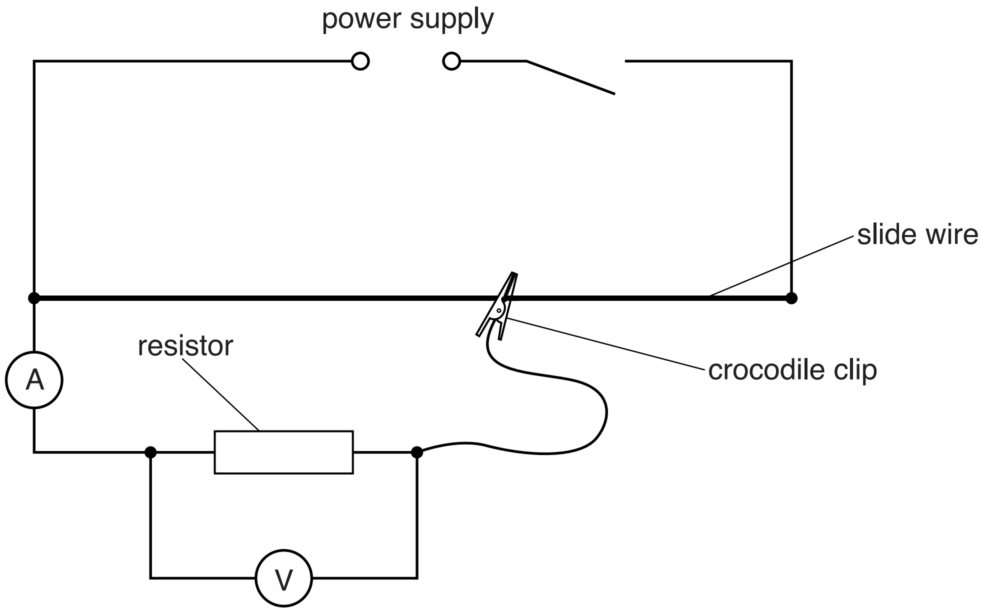


Fig. 1.1

The crocodile clip is connected at various positions on the slide wire, and the current and potential difference for the resistor are measured.

(a) The readings of potential difference V and current I for various positions of the crocodile clip are shown in Table 1.1.

Draw arrows on Figs. 1.2 and 1.3 to show the meter readings for the values of V and I in the first row of the table.

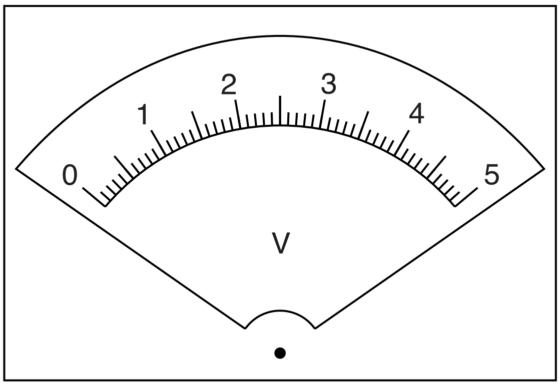


Fig. 1.2

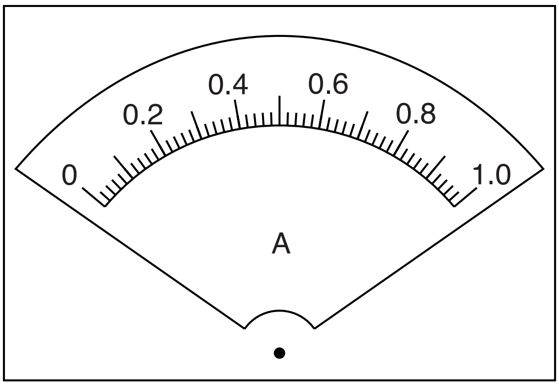


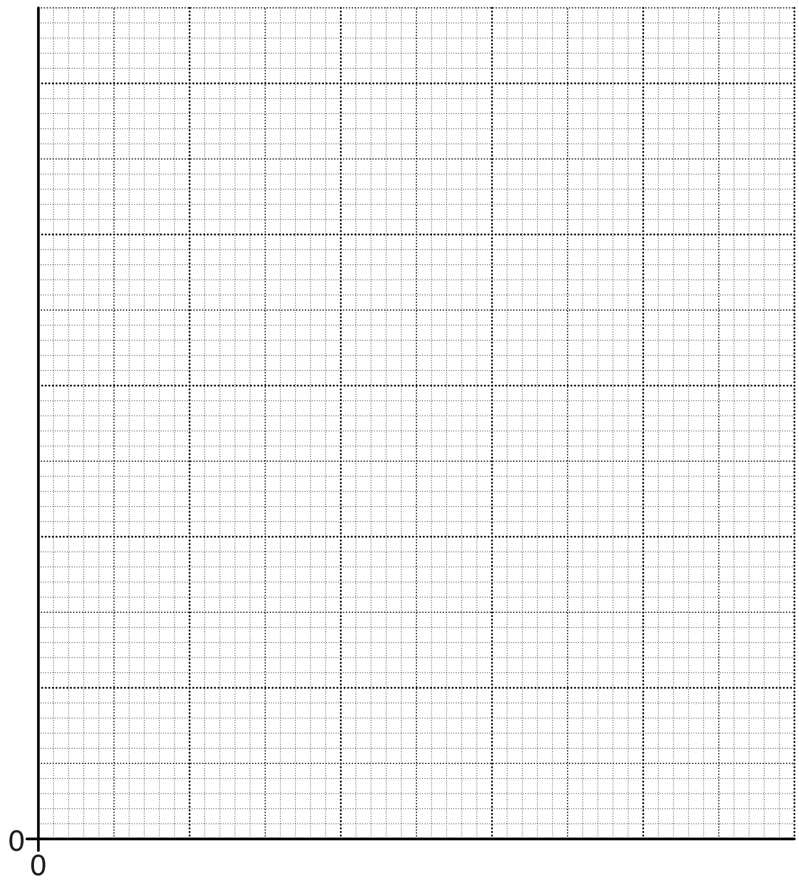
Fig. 1.3

[2]

Table 1.1

V/V	I/A
0.4	0.08
0.8	0.17
1.2	0.25
1.6	0.34
2.0	0.41

(b) Plot a graph of V/V (y-axis) against I / A (x-axis). Start both axes at the origin (0,0).



[4]

(c) **(i)** Determine the gradient G of the graph. Show clearly on the graph how you obtained the necessary information.

G = ...[1]

(ii) The resistance value *R* of the resistor is numerically equal to *G*.

Give a value for *R*, to a suitable number of significant figures for this experiment. Include the unit.

R = ...[2]

(d) A student suggests that potential difference and current for this resistor should be proportional.

State whether your graph supports this suggestion. Justify your statement by reference to your graph.

statement ....

....

justification ....

....

....
[2]

(e) The students notice that the slide wire becomes very hot during the experiment.

Suggest a change to the apparatus or procedure that might prevent this.

....

....

....[1]

[Total: 12]

2 The class is carrying out an experiment to determine the density of glass.

Each student has a test-tube, as shown in Fig. 2.1.

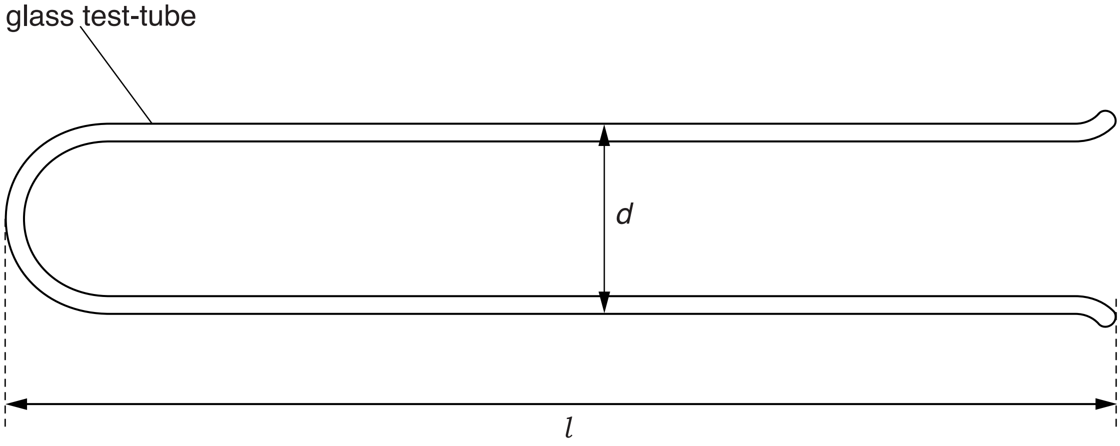


Fig. 2.1

(a) **(i)** • Measure the length l of the test-tube shown in Fig. 2.1.

l = ... cm

• Measure the external diameter d of the test-tube.

d = ... cm
[1]

(ii) A student uses two wooden blocks to help him to measure the diameter d of the test-tube.

Describe his method. You may draw a diagram. Include one precaution which could be taken to ensure that the value of d is as reliable as possible.

....

....

....[2]

(iii) Assuming that the test-tube is an approximate cylinder, calculate a value for its external volume V_1 using the equation $V_1 = \frac{\pi d^2 l}{4}$.

V_1 = ... cm^3 [1]

(b) The test-tube is completely filled with water and then the water from the test-tube is poured into a measuring cylinder.

(i) Read and record the volume V_2 of the water as shown in Fig. 2.2.

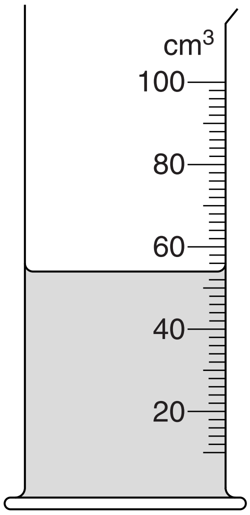


Fig. 2.2

V_2 = ... cm^3 [1]

(ii) Describe briefly how you would read the measuring cylinder to obtain a reliable value for the volume of water. You may add to Fig. 2.2 to illustrate your explanation.

....

....

....[1]

(iii) Calculate the volume V_3 of the glass, using the equation $V_3 = V_1 - V_2$.

V_3 = ... cm^3 [1]

(c) One student uses a balance to measure the mass m of the test-tube, as shown in Fig. 2.3.

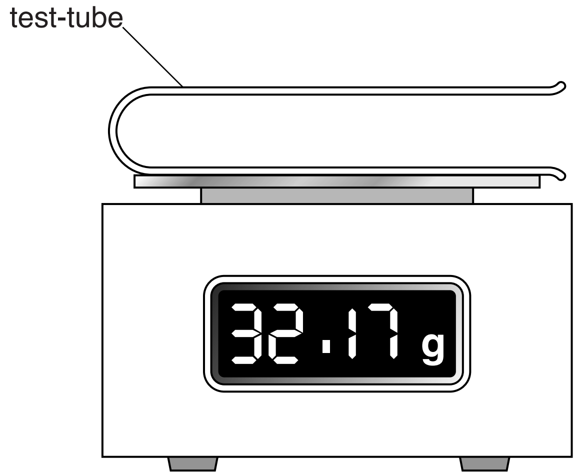


Fig. 2.3

(i) Calculate the density ρ of the glass, using the equation $\rho = \frac{m}{V_3}$.

ρ = ... [2]

(ii) Other students are using a balance which only measures to the nearest gram.

Record the mass m of the test-tube to the nearest gram.

m = ... g [1]

(d) The precision of the balance does not affect the accuracy of this experiment.

State one possible source of inaccuracy in the experiment. Explain what effect this inaccuracy would have on the value obtained for ρ.

....

....

....

....

....[2]

[Total: 12]

3 A student is investigating the refraction of light by a transparent block. She uses her results to determine a quantity known as the refractive index for the material of the block.

The student's ray-trace sheet is shown in Fig. 3.1.

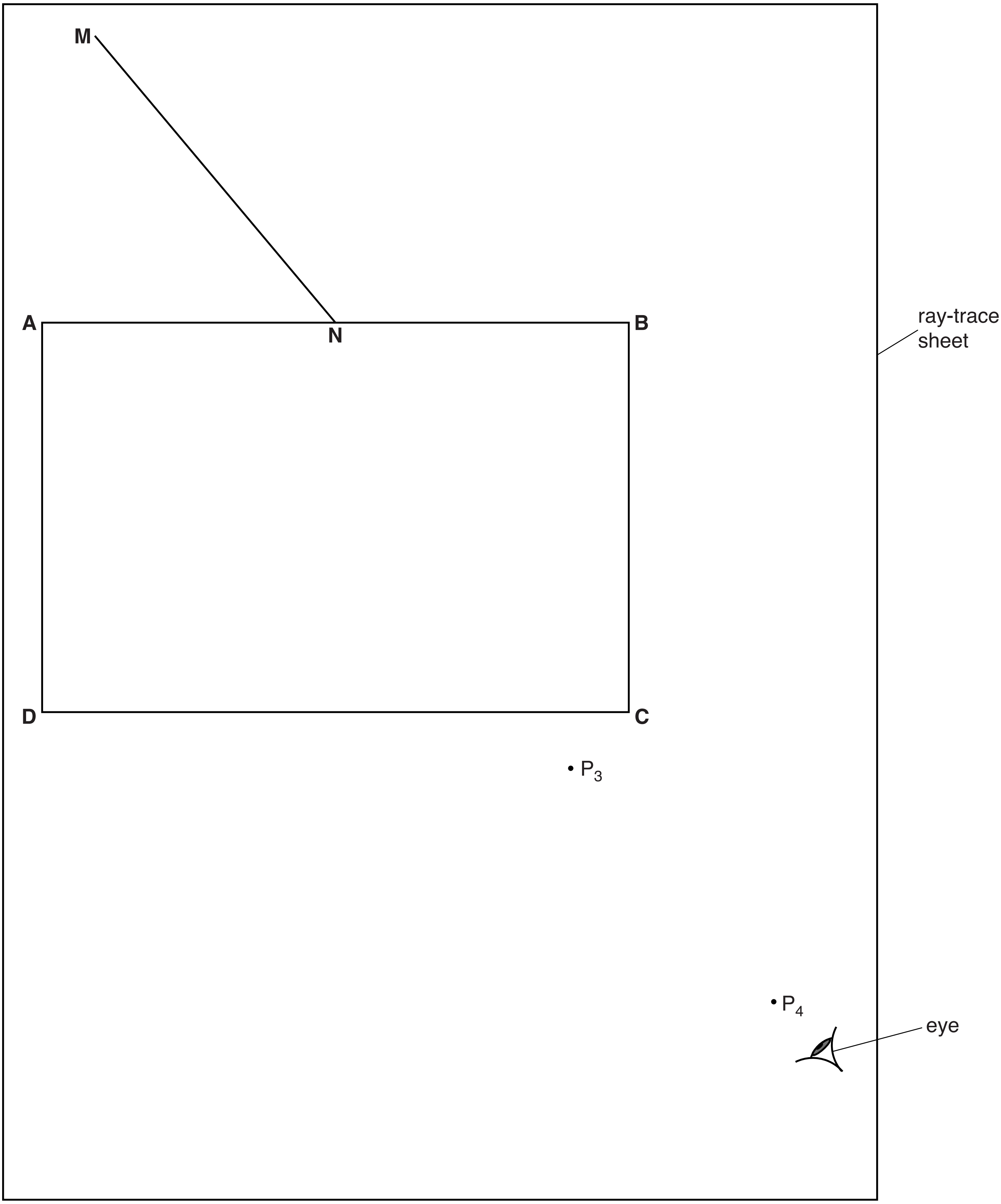


Fig. 3.1

(a) The student places a transparent block **ABCD** on the ray-trace sheet, as indicated in Fig. 3.1. She draws a line **NM**.

(i) • Draw a normal to line **AB** at point **N**. The normal should start above **AB** and extend below **AB** so that it crosses line **CD**.

• Label the point at which the normal crosses **CD** with the letter **L**.

[1]

(ii) Measure the angle θ between the normal and line **NM**.

θ = ...[1]

(b) The student places two pins P_1 and P_2 on line **NM**, a suitable distance apart.

On Fig. 3.1, mark and label appropriate positions for P_1 and P_2. [1]

(c) The student views the images of P_1 and P_2 through the block, from the direction indicated by the eye in Fig. 3.1.

She places two pins P_3 and P_4, as shown in Fig. 3.1, so that pins P_3 and P_4, and the images of P_1 and P_2, all appear exactly one behind the other.

(i) • Draw a line joining P_3 and P_4. Extend this line until it meets **NL**.

• Label the point at which this line crosses **CD** with the letter **E**, and the point at which it meets **NL** with the letter **F**.

• Draw a line joining points **N** and **E**.

• Measure the length *a* of line **NE**.

a = ...

• Measure the length *b* of line **FE**.

b = ...

[2]

(ii) Calculate a value *n* for the refractive index, using the equation $n = \frac{a}{b}$.

n = ...[2]

(d) Describe two precautions that you would take in order to obtain reliable results in this type of experiment.

1. ....

....

2. ....

....

[2]

[Total: 9]

4 A student suggests that the area of the water surface will affect the rate of cooling of hot water in a container.

Plan an experiment to investigate the relationship between surface area and rate of cooling.

Write a plan for the experiment, including:

- the apparatus needed
- how you will obtain a range of surface areas
- instructions for carrying out the experiment
- the measurements you will take
- the precautions you will take to ensure that the results are as reliable as possible
- the graph you will plot from your results – you should sketch the axes, with appropriate labels.

A diagram is not required but you may draw one if it helps to explain your plan.

....

....

....

....

....

....

....

....

....

....

....

....

....

....[7]

[Total: 7]

1 Some students are investigating how the surrounding temperature affects the rate at which water cools.

They are using the apparatus shown in Fig. 1.1.

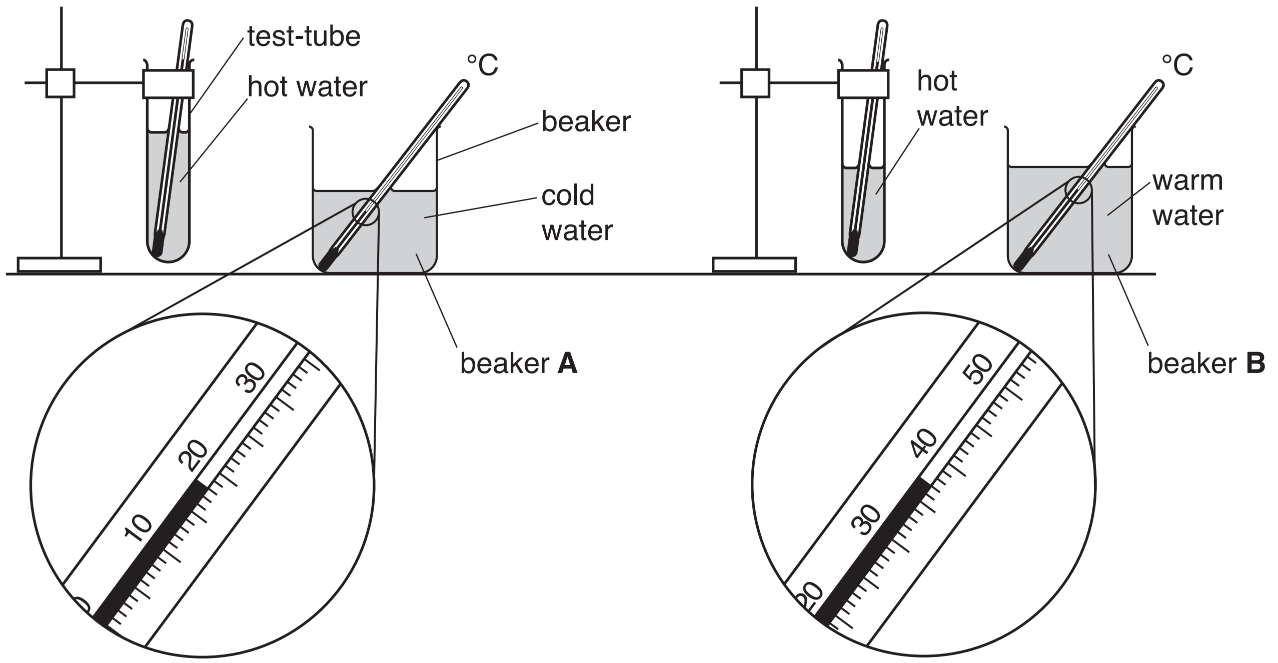


Fig. 1.1

(a) Using Fig. 1.1

- record the temperature θ_A of the cold water in beaker **A**,

θ_A = ...

- record the temperature θ_B of the warm water in beaker **B**.

θ_B = ...

[1]

(b) The test-tubes of hot water are placed into beakers **A** and **B**.

The students record the temperatures θ of the water in the test-tubes every 30 s. Their readings are shown in Table 1.1.

Complete the units and the time column in Table 1.1.

Table 1.1

time	tube in beaker **A** with cold water	tube in beaker **B** with warm water
t /	θ /	θ /
0	80.5	81.0
	52.5	64.5
	42.0	55.0
	36.0	50.5
	32.5	48.0
	30.5	46.5
	29.0	45.5

[2]

(c) Describe **two** precautions that you would take, before reading the thermometer, to ensure that the temperature readings are as accurate as possible in the experiment.

1. ....

....

2. ....

....
[2]

(d) Write a conclusion stating how increasing the temperature of the surrounding water affects the rate of cooling of the water in the test-tube.

Justify your answer by reference to the results in Table 1.1.

....

....

....

....[2]

(e) Suggest **one** change to the experiment shown in Fig. 1.1 to ensure that the comparison of the effect of surrounding temperature on cooling is a fair test.

Explain why the change is an improvement.

change ....

....

explanation ....

....
[2]

(f) The students use a measuring cylinder to measure 200 cm^3 of cold water.

Describe briefly how to read a measuring cylinder to obtain an accurate value for the volume of water. You may draw a diagram.

....

....

....

....[2]

[Total: 11]

2 A student is investigating the resistance of three wires **A**, **B** and **C**. He is using the circuit shown in Fig. 2.1.

The circuit is set up to test wire **A**. The length, l of each wire is measured and recorded.

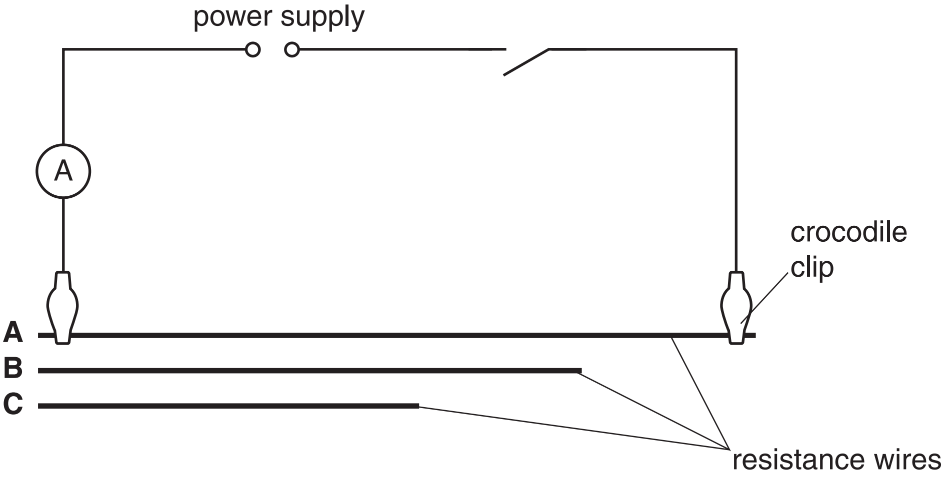


Fig. 2.1

(a) On Fig. 2.1, draw a voltmeter connected so that it will measure the potential difference across wire **A**. [1]

(b) In the first line of Table 2.1, record the potential difference V and current I for wire **A**, as shown in Figs. 2.2 and 2.3. [2]

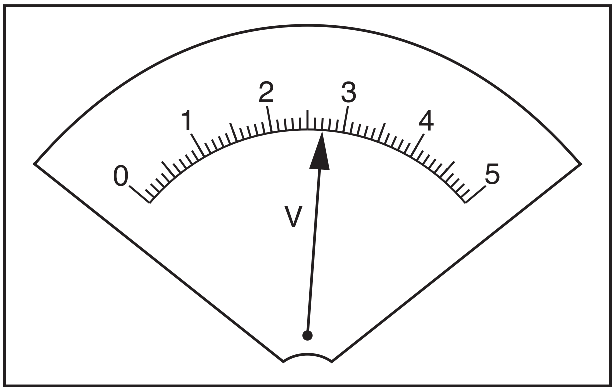


Fig. 2.2

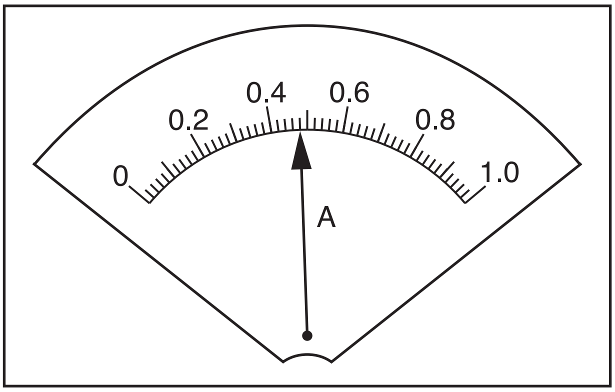


Fig. 2.3

Table 2.1

wire	l/m	V/V	I/A	R/Ω
A	0.900			
B	0.500	2.4	0.75	
C	0.400	2.2	0.85	

(c) The student connects the crocodile clips to wire **B** and then wire **C** in turn. His readings of potential difference and current are shown in Table 2.1.

Calculate, and record in Table 2.1, the resistance R of each wire.

Use the equation $R = \frac{V}{I}$.

[2]

(d) **(i)** Calculate the resistance per unit length r of each wire using the equation $r = \frac{R}{l}$.
Include the unit.

r for wire **A** = ...

r for wire **B** = ...

r for wire **C** = ...
[2]

(ii) Another student suggests that r should be the same for each wire.

State whether your results support this suggestion. Justify your statement with reference to your results.

statement ....

justification ....

....

....[2]

(e) The student measures the length of each wire to be tested.

On Fig. 2.4, draw an arrow (←→) to indicate **precisely** between which two points he should measure l.

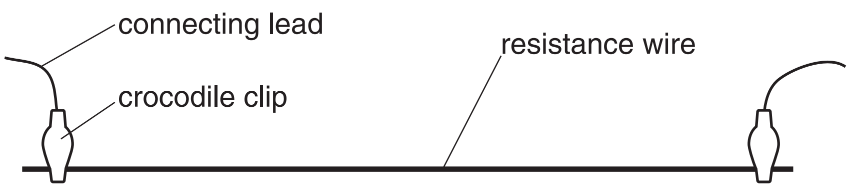


Fig. 2.4

[1]

(f) One possible problem with this type of experiment is heating of the resistance wires.

Suggest a precaution that could be taken to reduce this.

....

....

....[1]

[Total: 11]

3 Some students are investigating the magnification produced by a converging lens.

They are using the apparatus shown in Fig. 3.1.

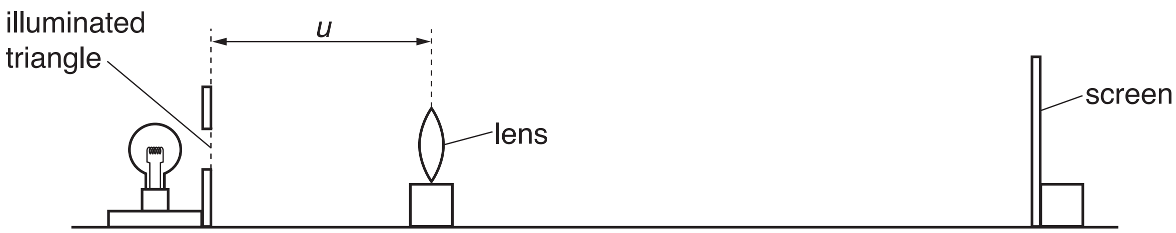


Fig. 3.1

(a) A student sets the distance u between the illuminated triangle and the lens to 20.0 cm. She moves the screen until a sharp image of the triangle is seen on the screen.

The student measures the height of the illuminated triangle h_O.

h_O = ...1.5 cm........

Measure and record, in Table 3.1, the height of the image of the triangle h_I on the screen, as shown in Fig. 3.2. [1]

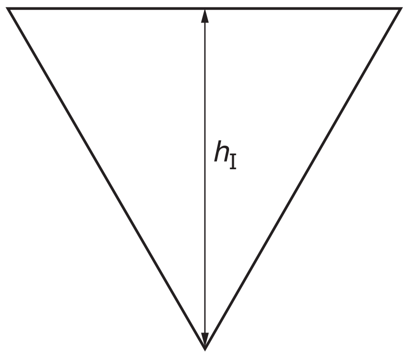


Fig. 3.2

Table 3.1

u / cm	h_I / cm	M
20.0		
25.0	2.25	
35.0	1.10	
45.0	0.75	
55.0	0.55	

(b) The student measures the height h_I of the image for u values of 25.0 cm, 35.0 cm, 45.0 cm and 55.0 cm. Her results are shown in Table 3.1.

For each value of u, calculate and record in Table 3.1 a value for the magnification M.

Use the equation $M = \frac{h_I}{h_O}$ and the value of h_O from **(a)**. [1]

(c) Plot a graph of M (y-axis) against u/cm (x-axis).

[4]

(d) From your graph, determine the value of u when M = 1.0. Show clearly on your graph how you obtained the information.

u = ...[2]

(e) Describe **one** difficulty that might be experienced when measuring the height of the image in this experiment. Suggest **one** improvement to the apparatus to overcome this.

difficulty ....

....

improvement ....

....
[2]

(f) When setting up the apparatus, the student makes sure that the card with the illuminated triangle, the lens and the screen are all perpendicular to the bench.

Explain why this is an important precaution in this experiment.

....

....

....[1]

[Total: 11]

4 A student is investigating how the material of a spring affects its behaviour when stretched.

The following apparatus is available to the student:

wires of different thickness, length and material
a set of 10 g masses and a set of 100 g masses, both with hangers
a wooden rod approximately 1 cm in diameter
other standard laboratory equipment.

Plan an experiment which will enable you to test the extension of springs made from different types of wire.

In your plan, you should include:

- instructions for making a spring from the wire that is provided,
- what you will measure,
- instructions for carrying out the experiment,
- the variables you will keep the same to ensure the comparison is a fair test,
- any precaution which should be taken or difficulty which might occur,
- how you will present your results.

You may draw a diagram if it helps to explain your plan.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....[7]

[Total: 7]

1 A student investigates the motion of an oscillating metre rule.

He uses the apparatus shown in Fig. 1.1.

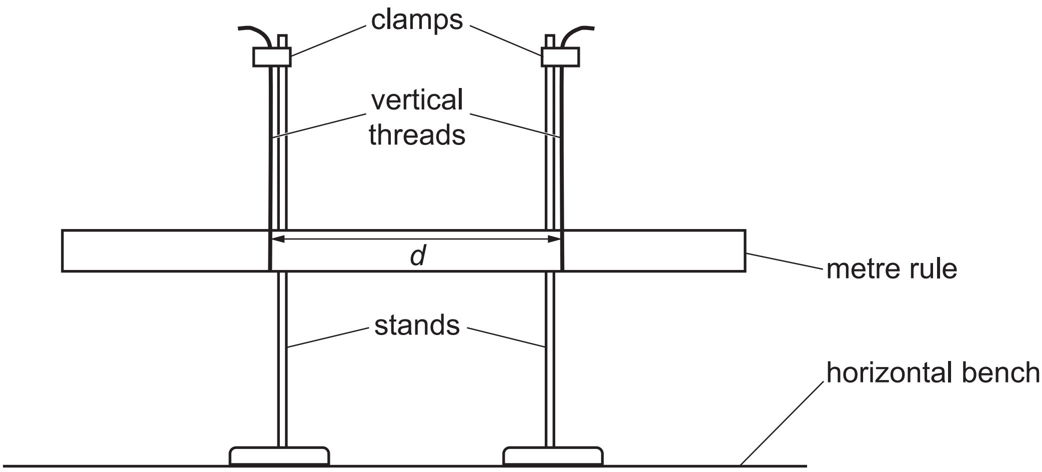


Fig. 1.1

(a) The student ensures that the metre rule is horizontal.

Briefly describe how to check that the metre rule is horizontal. You may draw a diagram or draw on Fig. 1.1 if it helps to explain your answer.

....

....

.... [1]

(b) The student moves the stands so that the vertical threads are at the marks on the metre rule shown in Fig. 1.2.

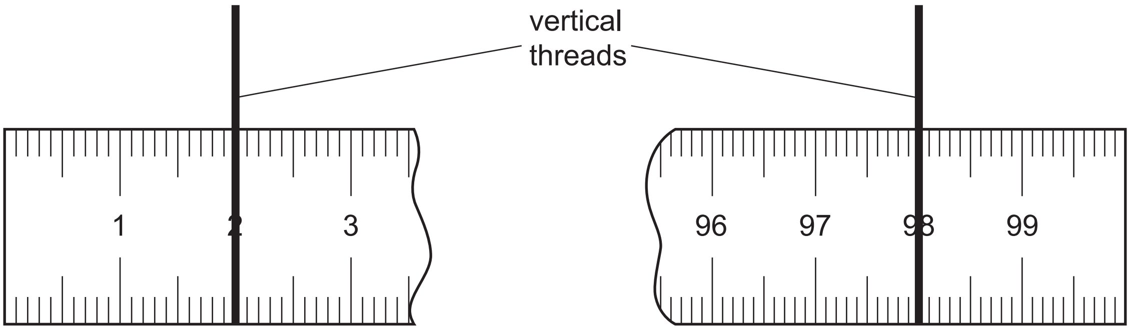


Fig. 1.2

Calculate the distance *d* between the threads.

d = ... cm [1]

(c) He twists the metre rule a small amount, as shown in Fig. 1.3, and then lets it go so that it oscillates in a rotating motion.

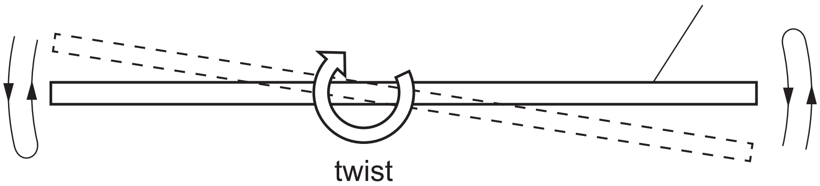


Fig. 1.3

He measures the time *t* for 5 complete oscillations of the metre rule.

t = ...3.63.......................... s

Suggest why it is useful to take a trial reading for this experiment.

....

.... [1]

(d) The student carries out the same procedure for *d* values of 20.0 cm, 30.0 cm, 40.0 cm, 50.0 cm and 60.0 cm. His readings are shown in Table 1.1.

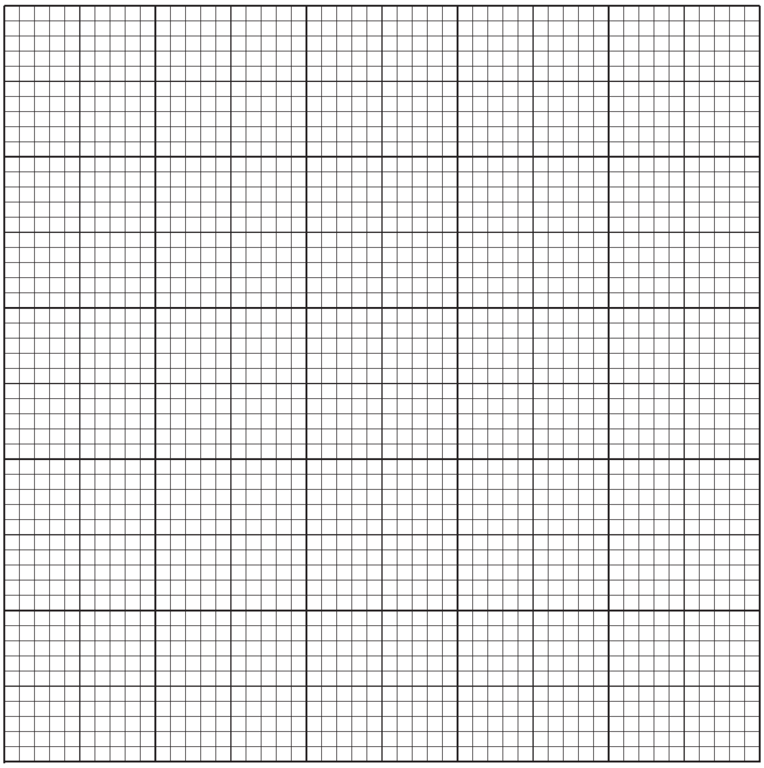
Table 1.1

d / cm	*t* / s	$\frac{1}{T} \Big/ \frac{1}{s}$
20.0	17.85	
30.0	11.36	0.44
40.0	8.77	0.57
50.0	6.93	0.72
60.0	5.68	0.88

For distance *d* = 20.0 cm, calculate and record in Table 1.1, the value of $\frac{1}{T}$ where *T* is the time for 1 oscillation of the metre rule.
Use the value of time *t* from Table 1.1 and the equation $\frac{1}{T} = \frac{5}{t}$.

[1]

(e) Plot a graph of distance *d* / cm (*y*-axis) against $\frac{1}{T} \Big/ \frac{1}{s}$ (*x*-axis).



[4]

(f) Determine the gradient *G* of the graph. Show clearly on the graph how you obtained the necessary information.

G = ... [1]

(g) (i) Explain why it is more accurate to measure the time for 5 oscillations rather than for 1 oscillation.

....

....

.... [1]

(ii) Describe how the experiment could be improved to make the readings more reliable.

....

....

.... [1]

[Total: 11]

2 Students investigate the cooling of hot water in two different cups.

They use the apparatus shown in Fig. 2.1.

Cup A is made from thin plastic. The top of cup A has an inside diameter of 7 cm. Cup B is made from expanded polystyrene. The top of cup B has an inside diameter of 8 cm.

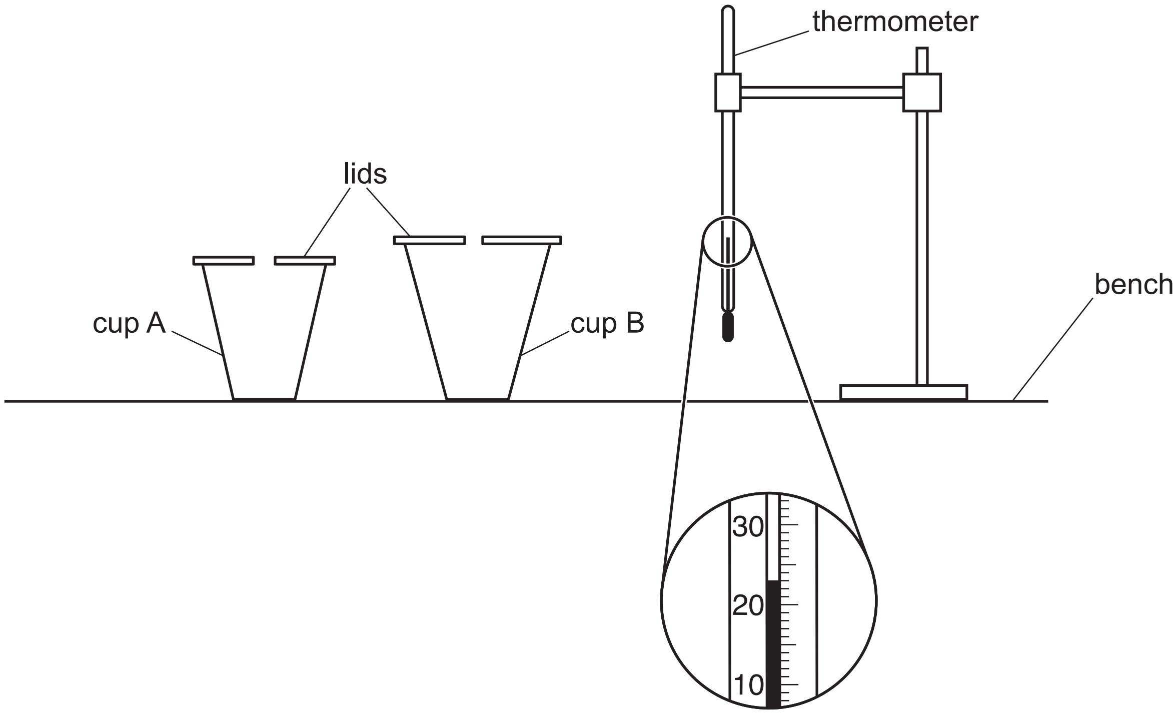


Fig. 2.1

(a) **(i)** Record the room temperature θ_R shown on the thermometer in Fig. 2.1.

θ_R = ... [1]

(ii) Describe **one** precaution that you would take to ensure that temperature readings in the experiment are as accurate as possible.

....

.... [1]

(b) A volume of 100 cm^3 of hot water is poured into each cup and the initial temperature θ is recorded in Table 2.1.
The temperature of the water in each cup is recorded every 30 s. The values are shown in Table 2.1.

Table 2.1

	cup A	cup B
t /	θ /	θ /
0	87.5	88.0
30	84.5	86.0
60	82.0	84.5
90	80.5	83.0
120	79.0	82.0
150	78.0	81.0
180	77.0	80.5

Complete the headings in Table 2.1. [1]

(c) Write a conclusion stating which cup, A or B, is the more effective in reducing the cooling rate of the hot water in this experiment.

Justify your answer by reference to the results.

....

....

....

.... [2]

(d) **(i)** Calculate x_A, the average cooling rate for cup A over the whole experiment. Use the readings for cup A from Table 2.1 and the equation

$$x_A = \frac{\theta_0 - \theta_{180}}{T}$$

where T = 180 s and θ_0 and θ_{180} are the temperatures at time t = 0 and at time t = 180 s. Include the unit for the cooling rate.

x_A =.. [2]

(ii) Suggest an additional experiment to show how the lid affects the cooling rate of cup A.

Explain how to use the additional results to show the effect.

additional experiment ....

....

explanation ....

....

....
[2]

(e) A student wishes to compare the effect of the materials of the cups on cooling rates. Suggest **two** variables that she should control to make this test fair.

1. ....

....

2. ....

....
[2]

[Total: 11]

3 A student investigates a resistor and a lamp connected in series.
She uses the circuit shown in Fig. 3.1.

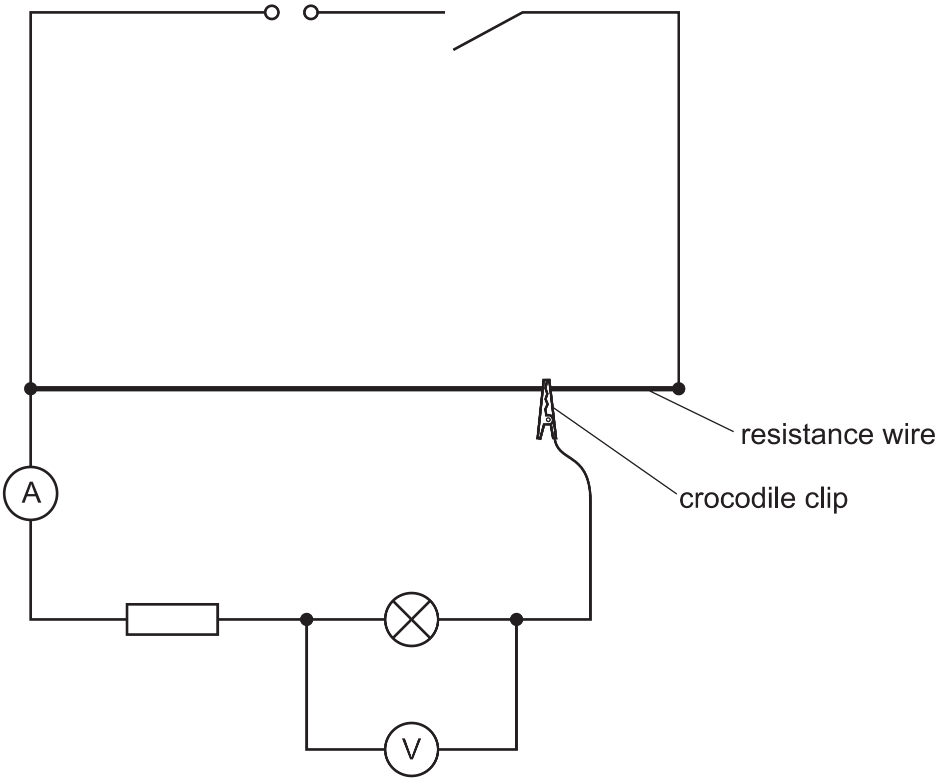


Fig. 3.1

(a) The student moves the crocodile clip on the resistance wire so that the value of the potential difference V_L across the lamp is 2.0 V.

She measures the current I for the lamp and resistor in series.

She then connects the voltmeter to measure the potential difference V_R across the resistor.

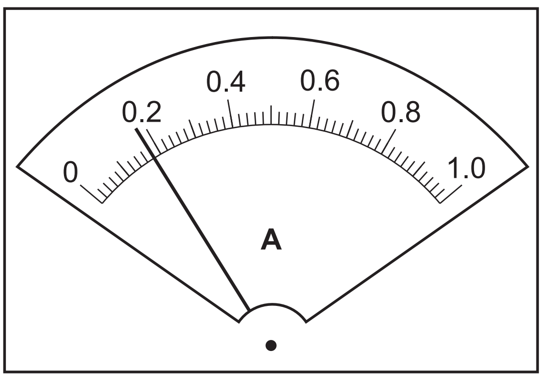


Fig. 3.2

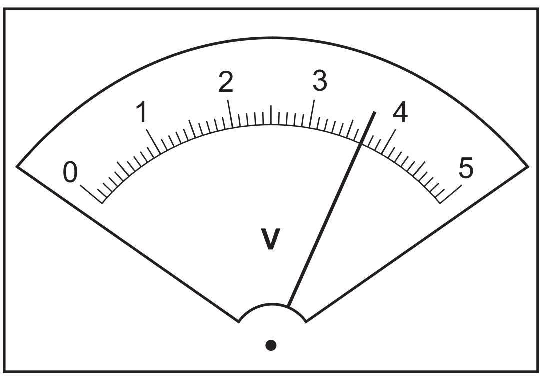


Fig. 3.3

Read, and record in Table 3.1, the values of I and V_R shown on the meters in Fig. 3.2 and Fig. 3.3.

[2]

(b) The student repeats the steps in **(a)** for values of V_L = 1.0 V and V_L = 0.5 V.
Her readings are shown in Table 3.1.

Table 3.1

V_L/V	I/A	V_R/V	R_L/Ω	R_R/Ω
2.0				
1.0	0.15	3.0		
0.5	0.12	2.4		

Calculate, and record in Table 3.1, the resistance of the lamp R_L for each value of V_L.

Use the values of V_L and I from Table 3.1 and the equation $R_L = \frac{V_L}{I}$.

Calculate, and record in Table 3.1, the resistance of the resistor R_R for each value of V_L.

Use the values of V_R and I from Table 3.1 and the equation $R_R = \frac{V_R}{I}$.

[2]

(c) **(i)** Describe the pattern of any change in the value of R_L as V_L decreases.

....

.... [1]

(ii) A student suggests that R_R should be constant.

State whether your results support this suggestion.
Justify your statement by reference to values from Table 3.1.

statement ....

....

justification ....

....

....

[2]

(d) A student wishes to determine the resistance of the lamp R_L when the potential difference across the lamp $V_L = 0.0\,V$.

Describe how the experiment can be extended to do this with the help of a suitable graph.

....

....

....

.... [2]

(e) It is possible to use a variable resistor instead of a resistance wire to change the potential difference across the lamp.

Complete the circuit in Fig. 3.4 to show:

- a variable resistor used for this purpose
- the voltmeter connected to measure the potential difference across the resistor

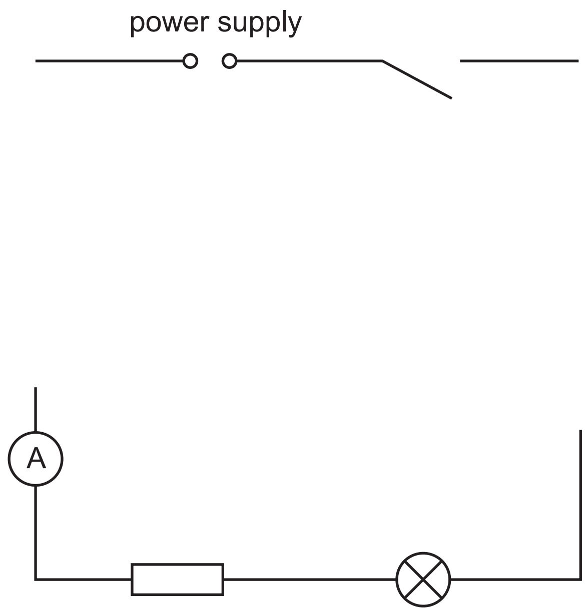


Fig. 3.4 [2]

[Total: 11]

4 A student investigates the motion of a ball rolling down a slope.

Plan an experiment which enables him to investigate how **one** factor affects the average speed of the ball.

Average speed can be calculated using the equation:

$$\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

The apparatus available includes:

balls of various sizes and materials
a board which can act as a slope
blocks to support one end of the board.

In your plan, you should:

- state a factor which can be measured
- list any additional apparatus needed
- explain briefly how to carry out the experiment including exactly which measurements are to be taken
- state the key variables to be kept constant
- draw a table, or tables, with column headings, to show how to display the readings (you are **not** required to enter any readings in the table)
- explain how to use the readings to reach a conclusion.

You may draw a diagram if it helps to explain your plan.

[7]

[Total: 7]

1 A student investigates the extension of a spring and uses it to determine the weight of a metre rule.

The spring is shown full size in Fig. 1.1 and Fig. 1.2.

Fig. 1.1 shows the spring without any load.
Fig. 1.2 shows the spring with a load of 1.0 N suspended from it.

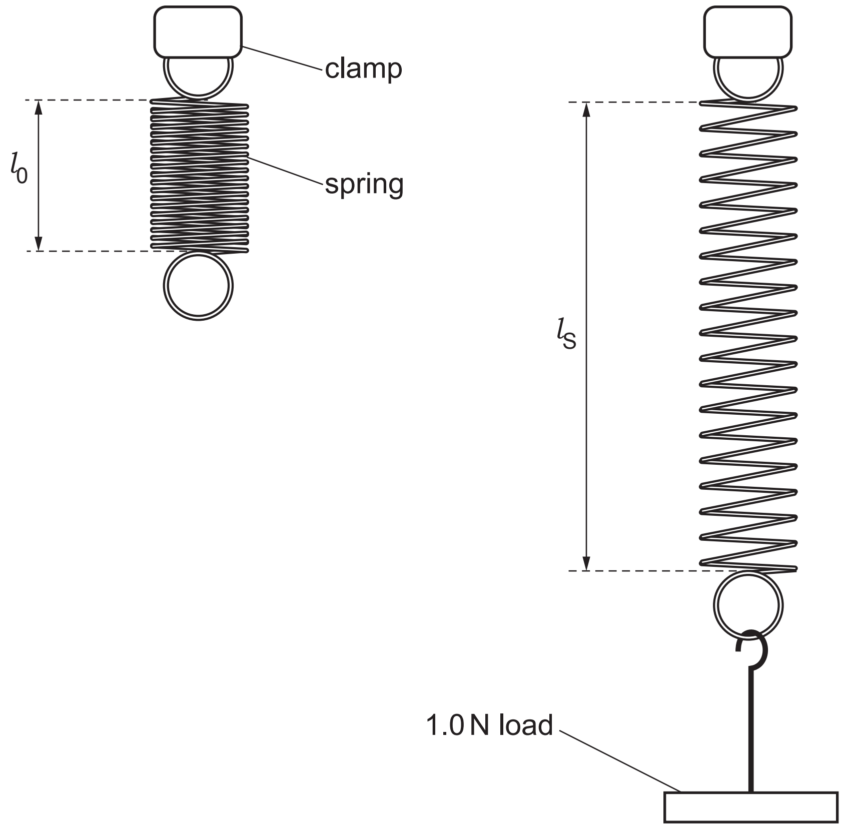


Fig. 1.1 **Fig. 1.2**

(a) On Fig. 1.1, measure the length l_0 of the spring without any load.

l_0 = ... cm

On Fig. 1.2, measure the stretched length l_S of the spring.

l_S = ... cm
[2]

(b) The student attaches a metre rule to the spring with a wire hook, as shown in Fig. 1.3. The scale of the metre rule faces upwards.

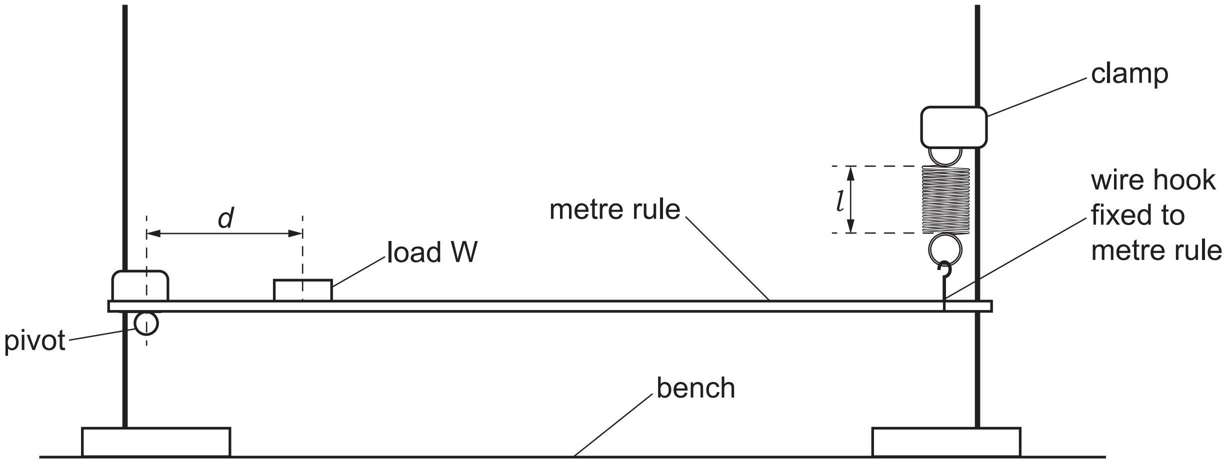


Fig. 1.3

She ensures that the metre rule is horizontal.

Briefly describe how to check that the rule is horizontal. You may draw a diagram if it helps to explain your answer.

....

....

.... [1]

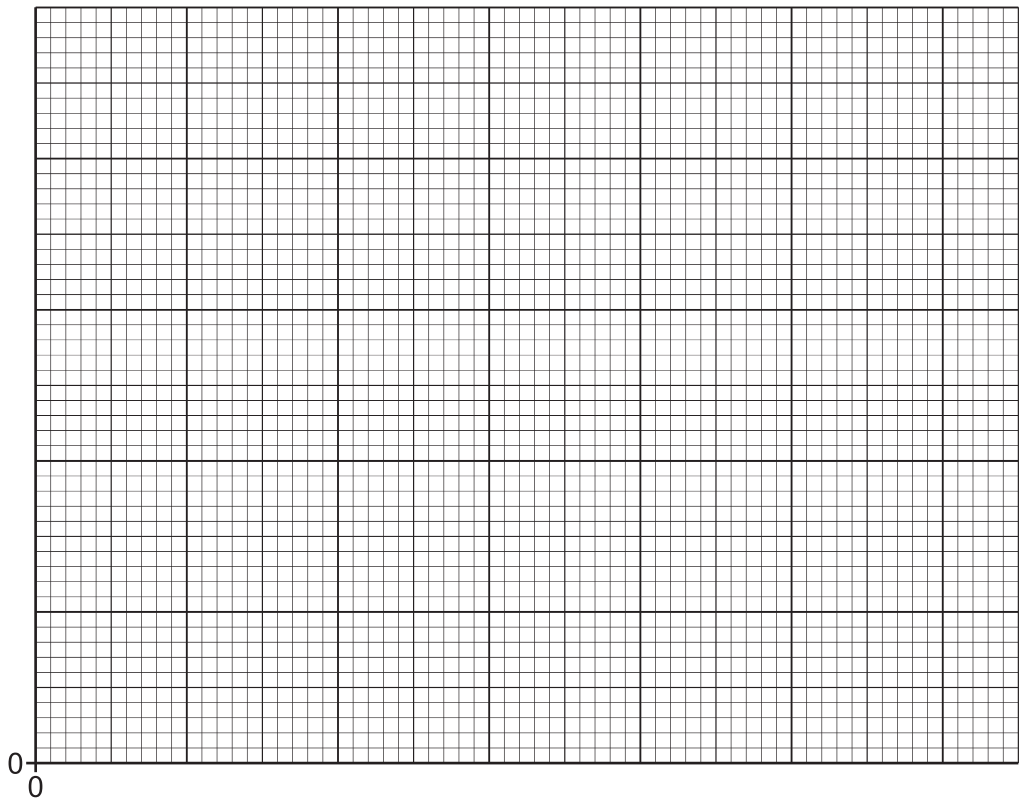
(c) The student moves load W to distances d = 20.0 cm, d = 30.0 cm, d = 40.0 cm, d = 50.0 cm and d = 60.0 cm from the pivot.

She reads the length l of the spring for each value of d.
Her readings are shown in Table 1.1.

Table 1.1

d / cm	l / cm
20.0	6.2
30.0	7.1
40.0	7.6
50.0	8.3
60.0	9.0

(i) Using the values from Table 1.1, plot a graph of l / cm (y-axis) against d / cm (x-axis). Start the axes at the origin (0,0).



[4]

(ii) From your graph, determine L, the value of l when d = 0.0 cm.

L = ... [1]

(iii) Calculate W_R, the weight of the metre rule, using your value of L from **(c)(ii)**, the values of l_0 and l_S from **(a)** and the equation

$$W_R = \frac{2(L - l_0)}{(l_S - l_0)} \times k$$

where k = 1.0 N.

W_R = ... [1]

(d) **(i)** It is sometimes difficult to position the load W on the scale of the metre rule at the correct distance d from the pivot.

Suggest **one** change to the apparatus to overcome this difficulty.

....

.... [1]

(ii) Suggest **one** possible source of inaccuracy other than the difficulty described in **(d)(i)**. Assume that the experiment is carried out carefully.

....

.... [1]

[Total: 11]

2 A student investigates the thermal insulation properties of air. He places a thermometer in a clamp, as shown in Fig. 2.1.

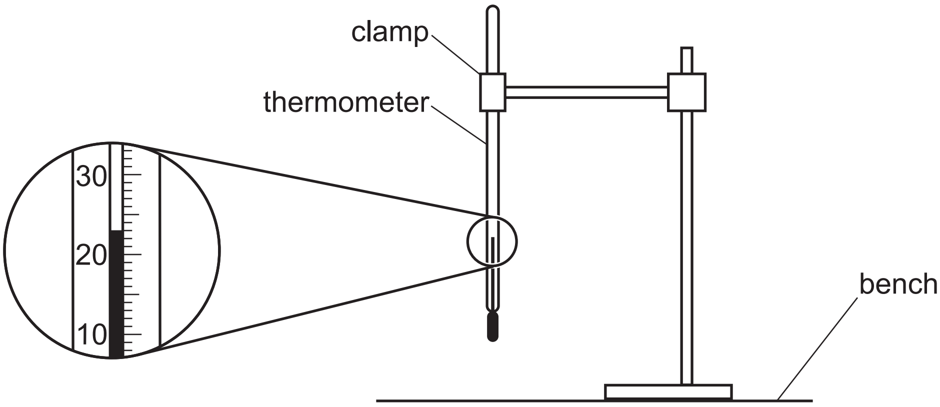


Fig. 2.1

(a) Record room temperature θ_R shown on the thermometer in Fig. 2.1.

θ_R = ... [1]

(b) The student uses the apparatus shown in Fig. 2.1, Fig. 2.2 and Fig. 2.3 to investigate the thermal properties of air.

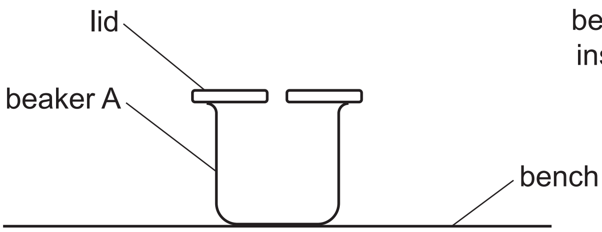


Fig. 2.2

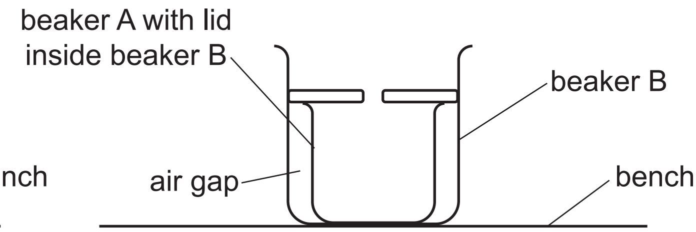


Fig. 2.3

Beakers A and B are made of glass.
Beaker A is placed inside beaker B for the second part of the experiment, as shown in Fig. 2.3.
The lid fits tightly in beaker B.

(i) The student removes the lid from beaker A. He pours 150 cm^3 of hot water into beaker A and replaces the lid. He inserts the thermometer into the hot water and records the temperature θ at time t = 0 and then every 30 s.

Describe **two** precautions that can be taken to ensure that the temperature reading is as accurate as possible.

1. ....

....

2. ....

.... [2]

(ii) The student pours away the water from beaker A. He then places beaker A inside beaker B so that there is an air gap between the two beakers, as shown in Fig. 2.3.

He repeats the process described in **(b)(i)**. His readings are shown in Table 2.1.

Add units to the column headings in Table 2.1.

Table 2.1

	beaker A	beaker A inside beaker B
t /	θ /	θ /
0	85.0	85.5
30	79.5	83.5
60	75.0	82.0
90	72.0	81.0
120	70.0	80.0
150	68.5	79.5
180	67.5	79.0

[1]

(c) Write a conclusion stating whether the air gap affects the rate of cooling of the water. Justify your answer by reference to values from Table 2.1.

....

....

....

.... [2]

(d) A student suggests that glass is a thermal insulator and the experiment does not just test the effect of the air gap.

Suggest **one** change to the apparatus that would test the air gap more effectively.

....

.... [1]

(e) Another student repeats this experiment using the same apparatus shown in Fig. 2.1, Fig. 2.2 and Fig. 2.3.

State **two** variables that she should control in order to obtain readings as close as possible to the readings in Table 2.1.

1. ....

....

2. ....

.... [2]

(f) Calculate the average cooling rate R for beaker A cooling on its own. Use the readings for **beaker A** in Table 2.1 and the equation

$$R = \frac{\theta_0 - \theta_{180}}{T}$$

where T = 180 s and θ_0 and θ_{180} are the temperatures of the water in beaker A at t = 0 and t = 180 s.
Include the unit for the cooling rate.

R = ... [2]

[Total: 11]

3 A student investigates the refraction of light by a transparent block.

The student's ray-trace sheet is shown full size in Fig. 3.1.

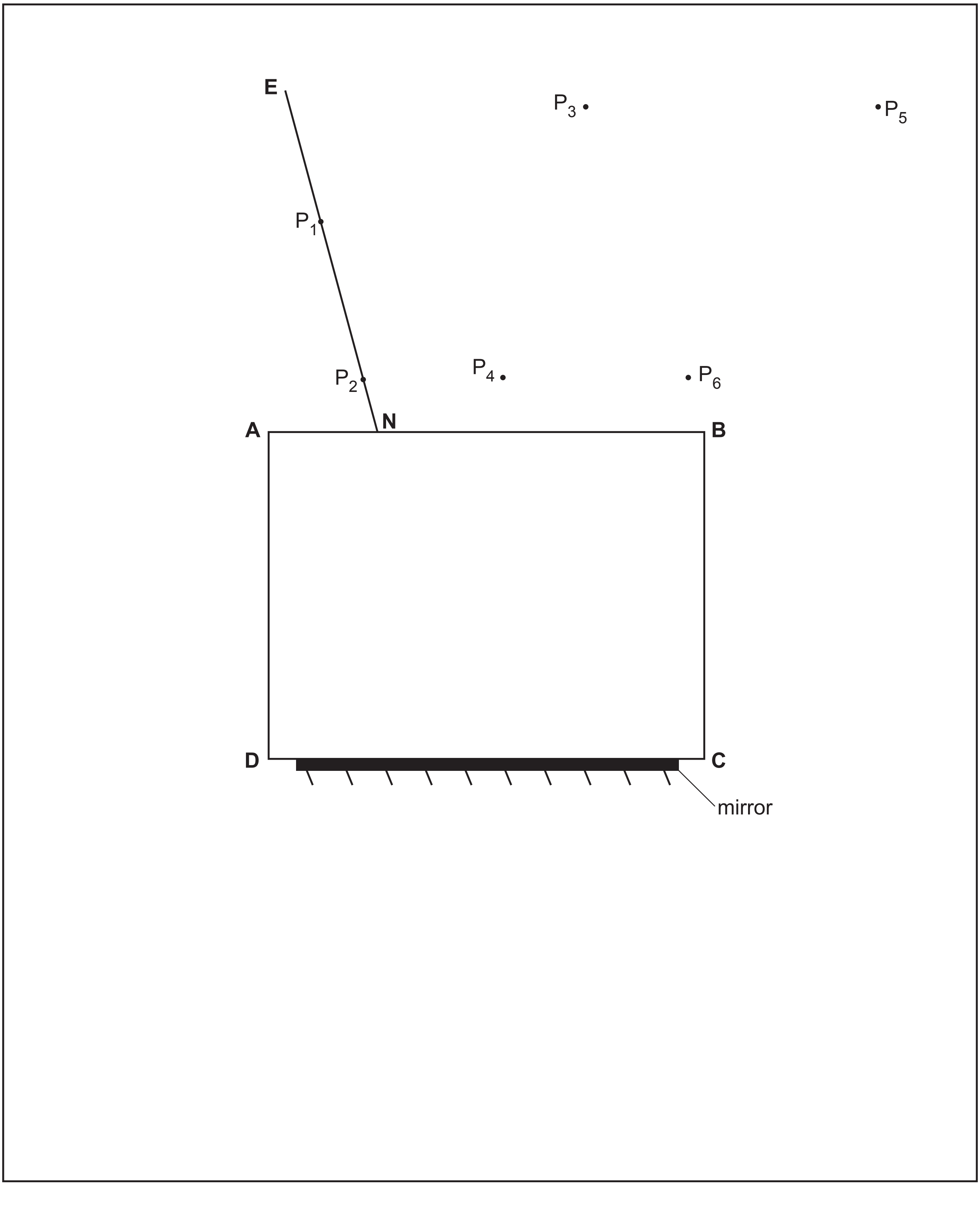


Fig. 3.1

(a) The student places a transparent block **ABCD** near the centre of the ray-trace sheet, as indicated in Fig. 3.1.

(i) Draw a normal to point **N** extending above **AB**. Label the upper end of the normal with the letter **L**. [1]

(ii) The student draws the line **EN**, as shown in Fig. 3.1.

On Fig. 3.1, measure the angle θ_1 between the lines **LN** and **EN**.

θ_1 = ... [1]

(b) The student places two pins, P_1 and P_2, on the line **EN**, as shown in Fig. 3.1.

(i) Measure the distance d between pins P_1 and P_2.

d = ... [1]

(ii) Suggest whether the two pins are a suitable distance apart for accurate ray tracing. Explain your answer.

statement ....

explanation ....

....
[1]

(c) The student places a plane mirror on line **CD** and views the images of pins P_1 and P_2 through the transparent block.

She places two pins, P_3 and P_4, so that these pins, and the images of pins P_1 and P_2, all appear exactly one behind the other.

On Fig. 3.1:

- Draw a line through points P_3 and P_4 and extend the line 3 cm below **CD**.
- Label the point at which this line meets **AB** with the letter **G**.
- Label the lower end of the line with the letter **H**.

[1]

(d) The student repeats the procedure for an angle θ_2 = 35°.

She places two pins, P_5 and P_6, so that these pins, and the images of pins P_1 and P_2, all appear exactly one behind the other.

On Fig. 3.1:

- Draw a line through points P_5 and P_6 and extend the line 3 cm below **CD**.
- Label the point at which this line meets **AB** with the letter **R**.
- Label the lower end of this line with the letter **S**.
- Label the point at which **GH** and **RS** cross with the letter **T**.

(i) Measure the angle β, where β is the angle between lines **GT** and **RT**.

β = ... [1]

(ii) A student suggests that the angle β should be equal to θ_s, where θ_s is calculated using the equation

$$\theta_s = \theta_2 - \theta_1.$$

State whether your results from **(a)(ii)** and **(d)** support this suggestion. Justify your answer by reference to values from your results.

statement ....

justification ....

.... [2]

(e) Suggest **two** precautions to take in this type of experiment to ensure accurate results.

1. ....

....

2. ....

.... [2]

(f) Suggest **one** reason why different students, all carrying out this experiment carefully, may **not** obtain identical results.

....

.... [1]

[Total: 11]

4 A student investigates the heating of water using an immersion heater.
An immersion heater is an electrical heater that can be placed directly into water.

Plan an experiment to investigate how **one** factor affects the rate at which the temperature of the water rises when heated using an immersion heater.

The apparatus available includes:

- an immersion heater
- equipment to connect the circuit, part of which is shown in Fig. 4.1
- a stop-clock
- a beaker to contain the water.

In your plan, you should:

- state the **one** factor which you have chosen and list any additional apparatus needed to measure the factor
- complete the circuit diagram in Fig. 4.1
- explain how to do the experiment, including any precautions to ensure reliable results
- state the key variables to be kept constant
- draw a table, or tables, with column headings, to show how to display the readings (you are **not** required to enter any readings in the table)
- explain how to use the readings to reach a conclusion.

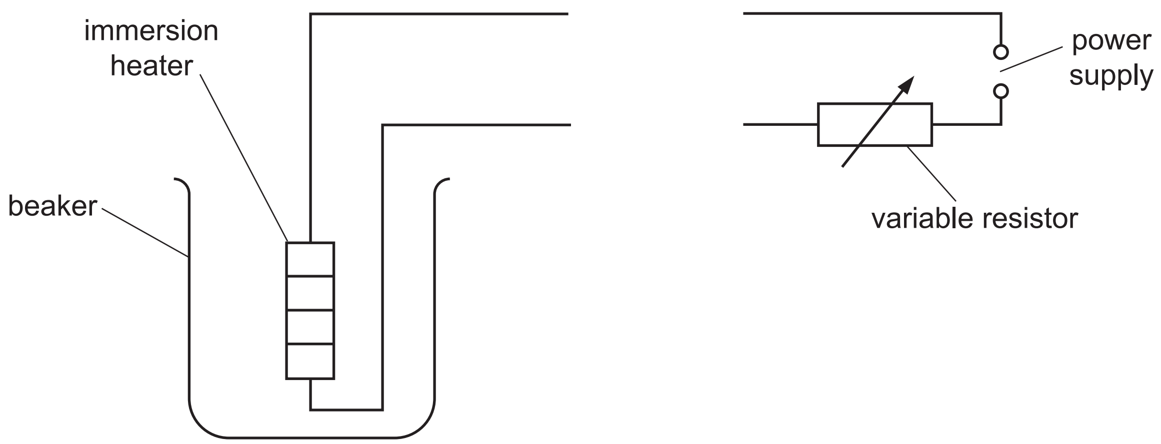


Fig. 4.1

[7]

1 A student is investigating the stretching of a spring.

The apparatus is shown in Fig. 1.1.

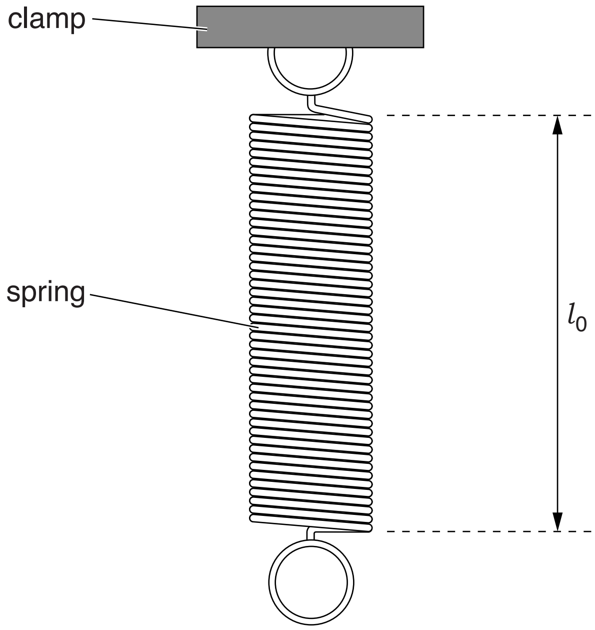


Fig. 1.1

(a) On Fig. 1.1, measure the unstretched length l_0 of the spring. Record l_0 in the first row of Table 1.1. [1]

(b) The student hangs a load *L* of 1.0 N on the spring and measures the new length l of the spring. She repeats the measurements using loads of 2.0 N, 3.0 N, 4.0 N and 5.0 N. The readings are shown in Table 1.1.

(i) For each set of readings, calculate the extension *e* of the spring using the equation $e = (l - l_0)$. Record the values of *e* in the table.

Table 1.1

L/N	l/mm	e/mm
0.0		0
1.0	59	
2.0	64	
3.0	69	
4.0	74	
5.0	78	

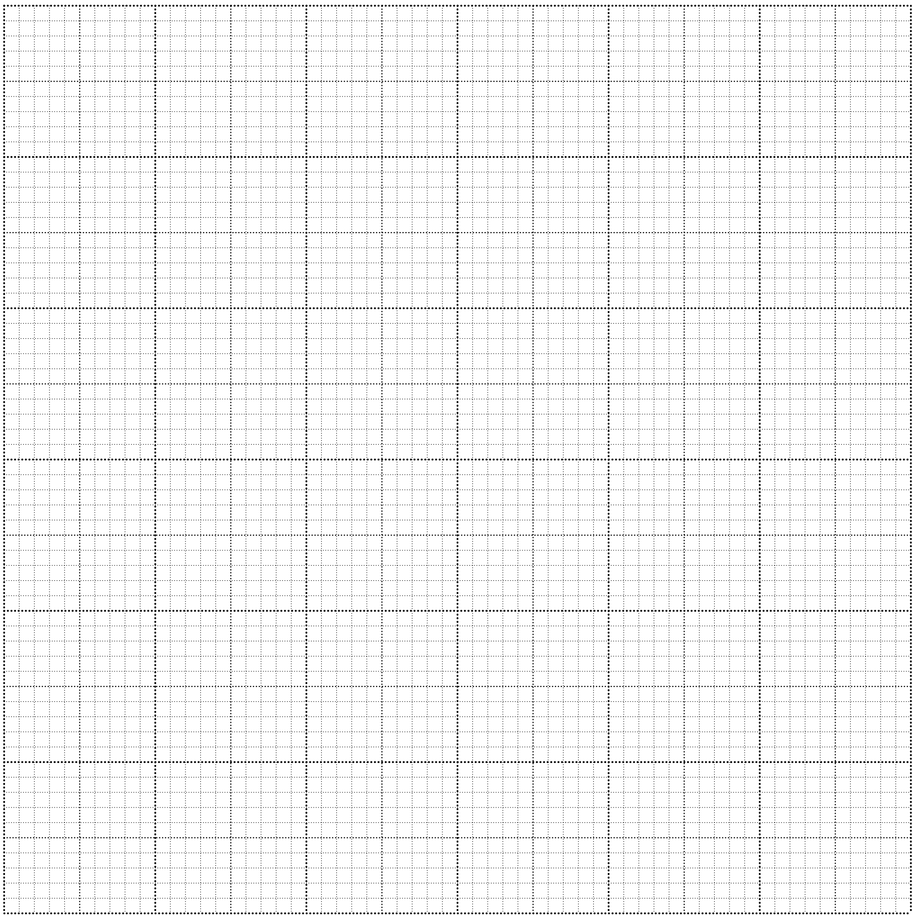
[1]

(ii) Explain briefly one precaution that you would take in order to obtain reliable readings.

....

....[1]

(c) Plot a graph of *e*/mm (*y*-axis) against *L*/N (*x*-axis).



[4]

(d) The student removes the load from the spring and hangs an unknown load **X** on the spring. She measures the length *l* of the spring.

l = 72 mm

(i) Calculate the extension *e* of the spring.

e = ... [1]

(ii) Use the graph to determine the weight *W* of the load **X**. Show clearly on the graph how you obtained the necessary information.

W = ... [2]

[Total: 10]

2 A student is using a balancing method to determine the weight of a piece of soft modelling clay. The apparatus is shown in Fig. 2.1.

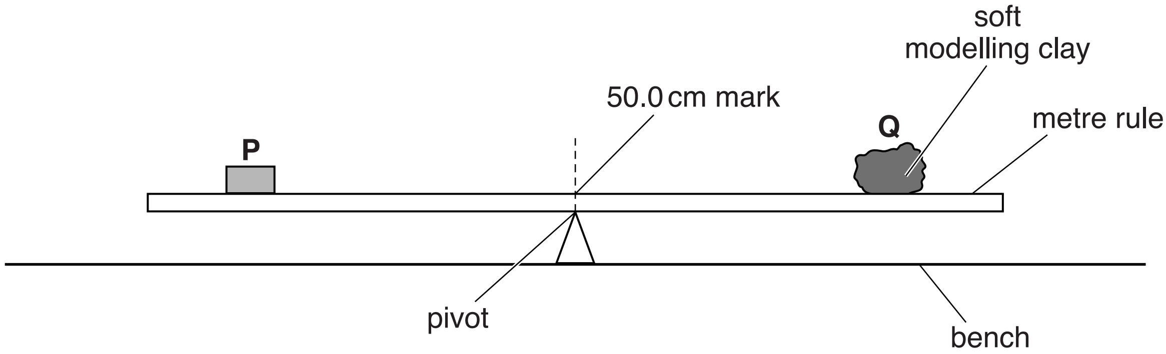


Fig. 2.1

P is a metal cube of weight $P = 1.0\,\text{N}$. **Q** is the piece of soft modelling clay.

The student places the cube **P** so that its weight acts at a distance *x* from the pivot.

He adjusts the position of **Q** to balance the rule and measures the distance *y* from the centre of **Q** to the pivot. He calculates the weight *W* of **Q** using the equation $W = \frac{Px}{y}$.

(a) **On Fig. 2.1**, mark clearly the distance *x*. [1]

(b) Suggest a change to **Q** that would make it easier to find the value of *y* accurately.

....

....[1]

(c) It is difficult to achieve an exact balance of the metre rule in this type of experiment. This can make the result unreliable.

Explain how you would reduce the effect of this problem to improve the reliability of the experiment.

....

....

....[1]

(d) The metal cube **P** is larger than the width of the metre rule.

Explain briefly how you would determine the reading of the metre rule scale at the position of the centre of mass of **P**. You may draw a diagram.

....

....

....[2]

(e) Before starting the experiment, the student determines the position of the centre of mass of the metre rule.

Explain briefly how you would do this.

....

....[1]

[Total: 6]

3 A student is investigating the magnification of images produced by a lens.

The apparatus is shown in Fig. 3.1.

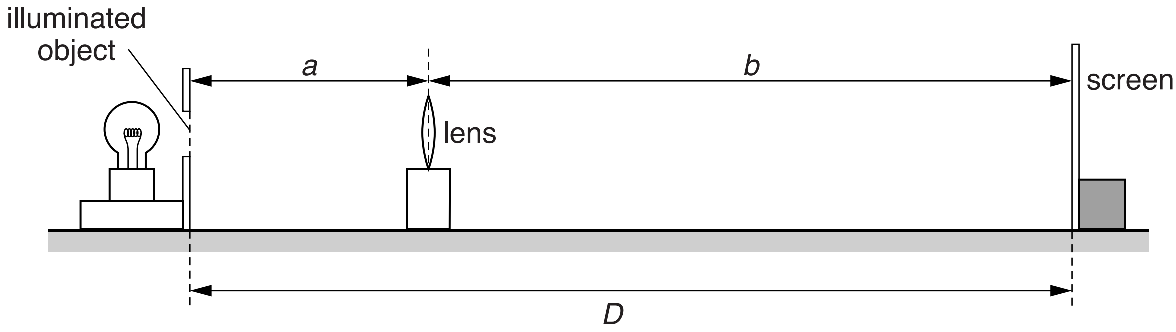


Fig. 3.1

The student places a screen at a distance D = 80.0 cm from an illuminated object. The screen and the illuminated object remain in the same positions throughout the experiment.

(a) She places the lens close to the illuminated object. She moves the lens until she sees a sharply focused, **enlarged** image of the object on the screen.

She measures the distance a from the illuminated object to the centre of the lens.

a = ...20.3 cm........................

She measures the distance b from the centre of the lens to the screen.

b = ...59.7 cm........................

Calculate the magnification m_1 of the image, using the equation $m_1 = \frac{b}{a}$.

m_1 = ... [1]

(b) The student then moves the lens towards the screen until a **smaller**, sharply focused image of the object is seen on the screen.

She measures the distance x from the illuminated object to the centre of the lens.

x = ...60.2 cm........

She measures the distance y from the centre of the lens to the screen.

y = ...19.8 cm........

Calculate the magnification m_2 of the image, using the equation $m_2 = \frac{y}{x}$.

m_2 = ... [1]

(c) A student suggests that $m_1 \times m_2$ should equal 1.

State whether the results support this suggestion. Justify your answer by reference to the results.

statement ....

justification ....

....
[2]

(d) State two precautions that you would take in this experiment to obtain reliable results.

1. ....

....

2. ....

....
[2]

(e) Suggest one reason why it is difficult, in this type of experiment, to decide on the best position of the lens to obtain a sharply focused image on the screen.

....

....[1]

[Total: 7]

4 A student is investigating how the resistance of a wire depends on the length of the wire. The student aims to plot a graph.

The following apparatus is available to the student:

ammeter
voltmeter
power supply
variable resistor
switch
connecting leads
resistance wires of different lengths
metre rule.

Plan an experiment to investigate how the resistance of a wire depends on the length of the wire.

You should

- draw a diagram of the circuit you could use to determine the resistance of each wire
- explain briefly how you would carry out the investigation
- suggest suitable lengths of wire
- state the key variables that you would control
- draw a table, or tables, with column headings to show how you would display your readings. You are not required to enter any readings in the table.

[7]

[Total: 7]

5 A student is investigating the cooling of water.

Some of the apparatus is shown in Fig. 5.1.

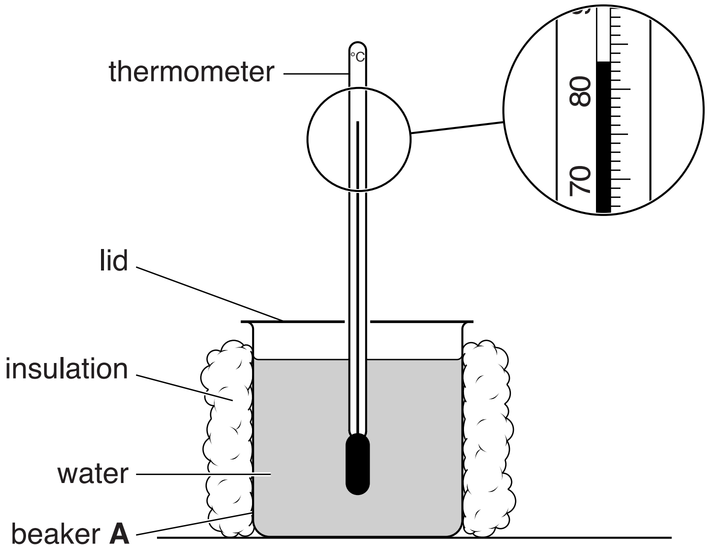


Fig. 5.1

(a) The student pours 200 cm^3 of hot water into a 250 cm^3 insulated beaker labelled **A**. He covers the top of the beaker with a lid.

The student takes a temperature reading every 30 s as the water cools. The readings are shown in Table 5.1.

(i) Complete the column headings in the table. [1]

(ii) The starting temperature θ of the hot water in beaker **A** is shown on Fig. 5.1.

Record this temperature in the table at time t = 0 s. [1]

Table 5.1

	beaker **A** insulation and lid	beaker **B** insulation, no lid	beaker **C** lid, no insulation
t/	θ/	θ/	θ/
0		85	78
30	80	79	74
60	77	74	71
90	75	70	68
120	73	67	66
150	71	64	64

(b) The student repeats the procedure using a 250 cm^3 beaker labelled **B**. This beaker is insulated but has no lid.

He repeats the procedure again using a 250 cm^3 beaker labelled **C**. This beaker has a lid but no insulation.

All the readings are shown in Table 5.1.

(i) Tick the statement that best describes the results of the investigation.

☐ Removing the lid speeds up the rate of cooling significantly more than removing the insulation.

☐ Removing the insulation speeds up the rate of cooling significantly more than removing the lid.

☐ There is no significant difference between removing the lid and removing the insulation.

[1]

(ii) Justify your answer by reference to the readings.

....

....

....[1]

(c) State two of the conditions that should be kept the same in this experiment in order for the comparison to be fair.

1. ....

....

2. ....

....

[2]

(d) Suggest a suitable material for the lid. Give a reason for your choice of material.

material ....

reason ....

....

[2]

(e) Describe briefly how a measuring cylinder is read in order to obtain a reliable value for the volume of water. You may draw a diagram.

....

....

....

....[2]

[Total: 10]

1 The class is investigating the resistances of two resistance wires.

The circuit used is shown in Fig. 1.1.

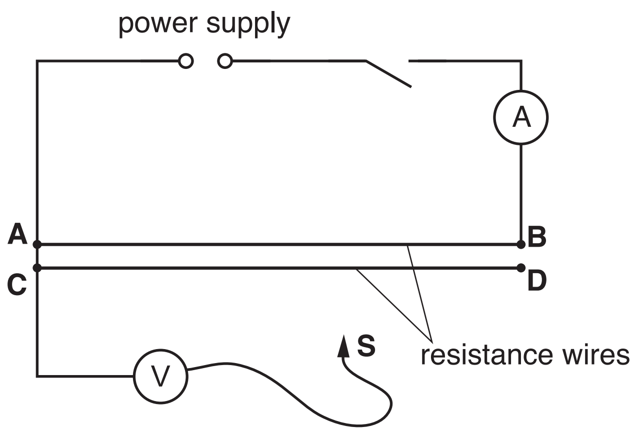


Fig. 1.1

(a) A student places a sliding contact **S** on the resistance wire **AB** at a distance $l = 0.200\,\text{m}$ from point **A**. She measures the current I in the circuit and the potential difference V across the length $l = 0.200\,\text{m}$ of resistance wire.

Figs. 1.2 and 1.3 show the voltmeter and ammeter readings.

(i) Write down the readings shown on the meters in Figs. 1.2 and 1.3.

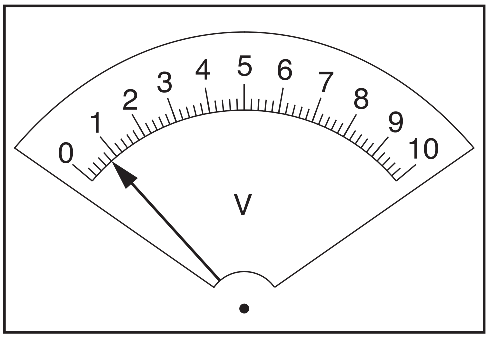


Fig. 1.2

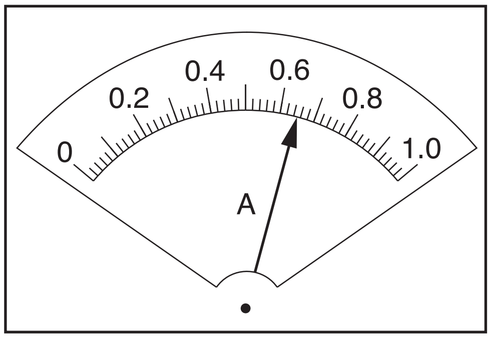


Fig. 1.3

V = ... I = ...

[2]

(ii) Calculate the resistance R of the length $l = 0.200\,\text{m}$ of resistance wire, using the equation $R = \dfrac{V}{I}$.

R = ...[1]

(b) The student repeats the procedure using the distance $l = 0.400$ m. Her result is shown.

R = ...2.54 Ω........................

(i) Calculate the difference between the two values for R.

difference = ...[1]

(ii) Suggest a relationship between the length l and the resistance R of the wire that matches the results, within the limits of experimental accuracy.

....

....[1]

(c) Using the same method as in **(a)**, the student determines the resistance R_1 of the resistance wire **AB** of total length $l = 0.500$ m.

R_1 = ...3.08 Ω........................

She then uses a short lead to connect points **B** and **D**. She uses the same method again to determine the combined resistance R_2 of the resistance wires **AB** and **CD** connected together.

R_2 = ...1.50 Ω........................

Use the student's results to compare the resistance R_1 of wire **AB** with the resistance R_2 of wires **AB** and **CD** connected together.

Tick the box next to the description that most closely matches the results.

☐ $R_1 = R_2$

☐ $R_1 = 2R_2$

☐ $2R_1 = R_2$

☐ There is no simple relationship between R_1 and R_2.

[1]

(d) Suggest **two** reasons why different students, all carrying out this experiment carefully, with the same apparatus, may **not** obtain identical results.

1. ....

....

2. ....

....

[2]

[Total: 8]

2 The class is investigating the refraction of light passing through a transparent block. A student is using optics pins to trace the paths of rays of light.

Fig. 2.1 shows the student's ray-trace sheet.

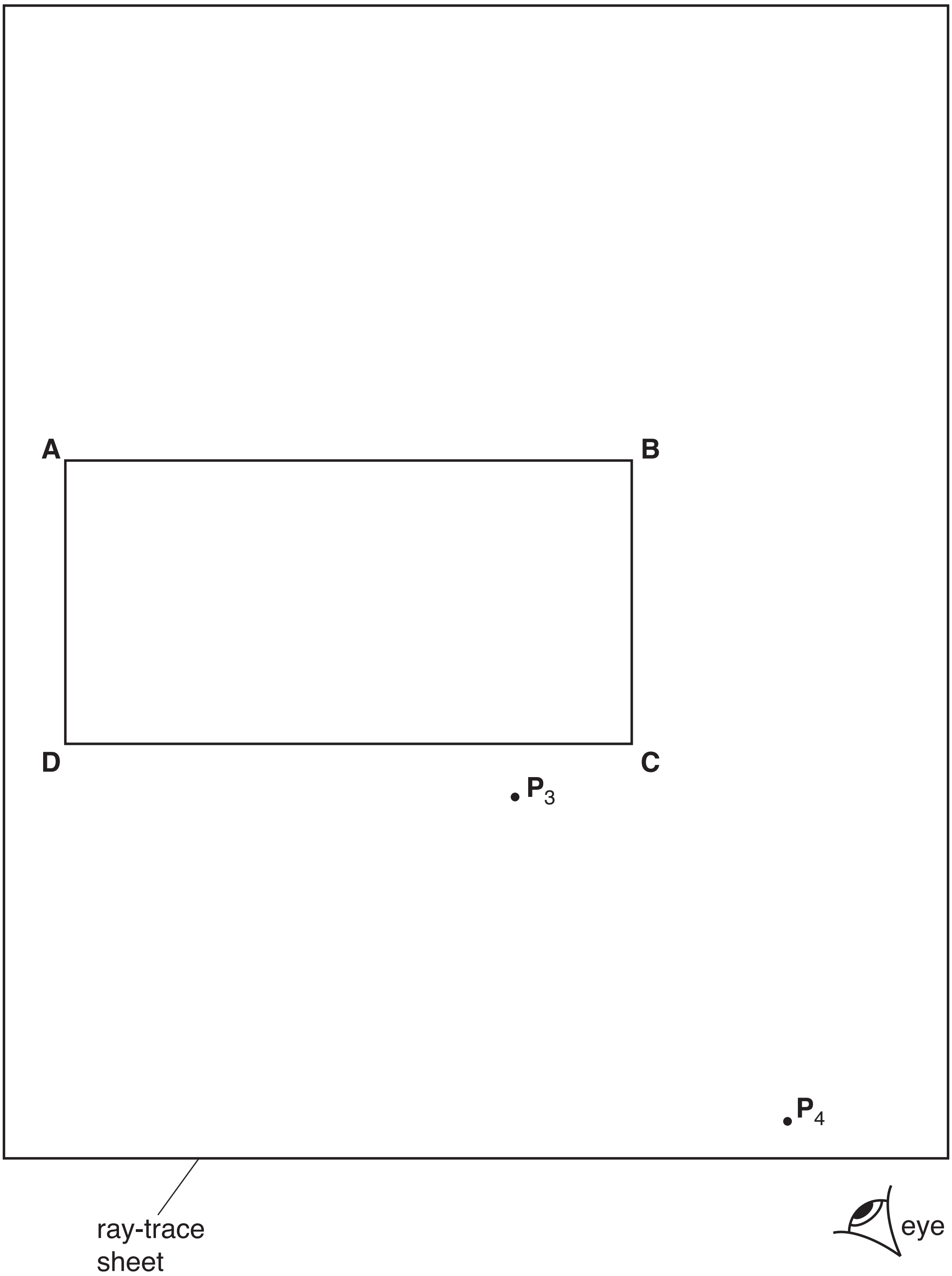


Fig. 2.1

(a) • On Fig. 2.1, draw and label a normal **NL** at the centre of side **AB**. Label the point **E** where the normal crosses **AB**. Label the point **M** where the normal crosses **CD**. [1]

• Draw a line **FE**, to the left of the normal and at an angle of incidence *i* = 40° to the normal.

• Label the positions of two pins P_1 and P_2 on **FE** placed a suitable distance apart for accurate ray tracing. [2]

(b) The student observes the images of P_1 and P_2 through side **CD** of the block so that the images of P_1 and P_2 appear one behind the other.

He places two pins P_3 and P_4 between his eye and the block so that P_3 and P_4, and the images of P_1 and P_2 seen through the block, appear one behind the other.

The positions of P_3 and P_4 are marked on Fig. 2.1.

Draw a line joining the positions of P_3 and P_4. Continue the line until it meets the normal **NL**. Label the point **K** where this line crosses **CD**. [1]

(c) • Measure and record the angle α between the line joining the positions of P_3 and P_4 and the normal line.

α = ...

• Measure and record the length x between points **M** and **K**.

x = ...

[2]

(d) The student repeats the procedure but with the line **FE** to the right of the normal.

He measures the angle β between the line joining the new positions of P_3 and P_4 and the normal.

β = ... 41° ....

He measures the length y between **M** and the new position of **K**.

y = ... 21 mm ....

A student suggests that the results for α and x should be the same as the results for β and y.

State whether the results support this suggestion. Justify your answer by reference to the results.

statement ....

justification ....

....

[2]

(e) Suggest **one** precaution that you would take with this experiment to obtain reliable results.

....

....

....[1]

[Total: 9]

3 The class is investigating images formed on a screen using a lens.

Fig. 3.1 shows the apparatus.

Fig. 3.1

(a) The lens has a focal length of 15.0 cm.

Suggest a suitable distance *D* between the illuminated object and the screen in order to form a clearly focused image on the screen.

D = ... [1]

(b) The student places the lens as shown in the diagram a distance *u* from the object. She then moves the screen until she obtains a clearly focused image on the screen.

It is difficult to decide on the exact position of the screen that gives the best image.

Explain how you would find the best position for the screen as reliably as possible.

....

.... [1]

(c) Another student uses a different lens and obtains these readings:

u = ...15.0 cm............

v = ...29.7 cm............

Calculate the focal length *f* of the lens using the equation $f = \frac{uv}{(u + v)}$.

Include the unit and give your answer to a suitable number of significant figures.

f = ... [2]

(d) Suggest **one** difference that you would expect to see in this experiment between the appearance of the object and the image.

....[1]

(e) Which of the following procedures, **A**–**F**, are sensible for this experiment?
Circle one or more of the letters.

A Carry out the experiment in a darkened room.

B Close one eye when taking readings.

C Draw thin lines.

D Fix the rule in position on the bench.

E Make sure the pins are at least 5 cm apart.

F Repeat the experiment using different values of *u* and determine an average value for *f*.
[3]

[Total: 8]

4 The class is investigating the principle of moments.

Fig. 4.1 shows the apparatus used.

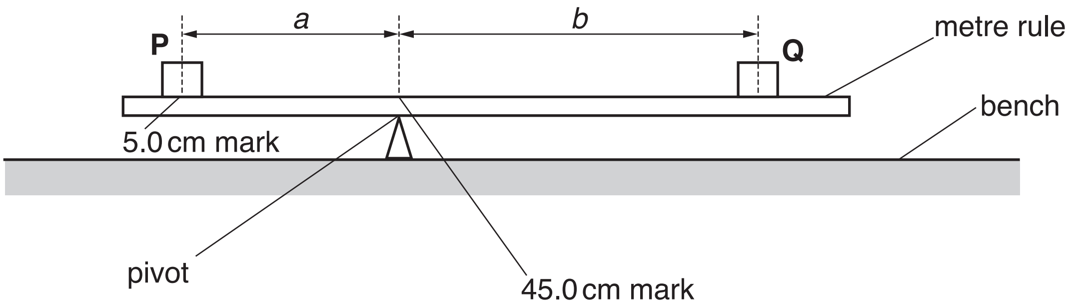


Fig. 4.1

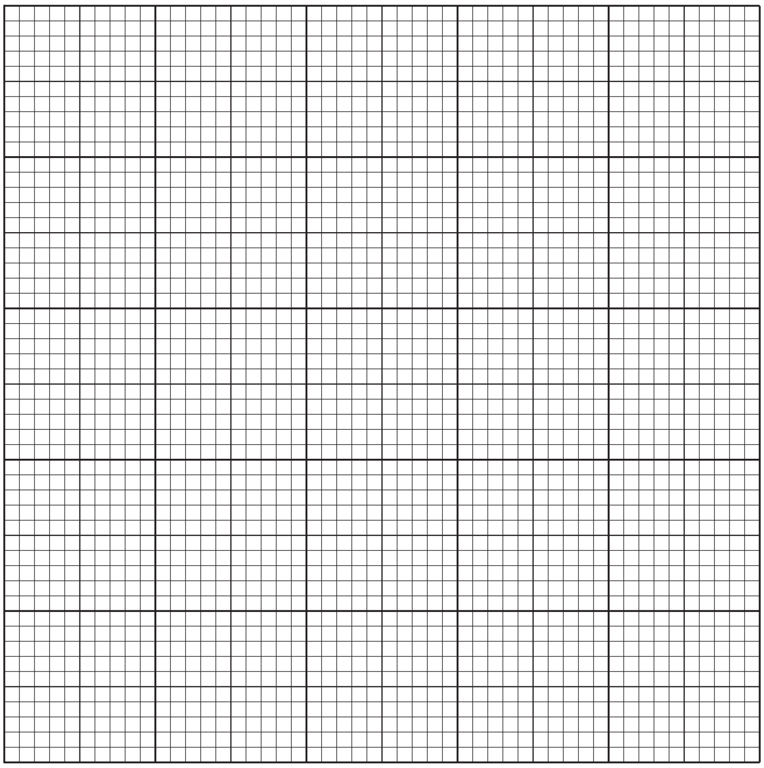
(a) A student places a load **P** on the metre rule at the 5.0 cm mark. He places the metre rule on the pivot at the 45.0 cm mark. He places a load **Q** on the rule and adjusts its position so that the metre rule is as near as possible to being balanced.

- He measures the distance *a* between the centre of load **P** and the pivot.
- He measures the distance *b* from the centre of load **Q** to the pivot.
- He repeats the procedure placing the load **P** at the 10.0 cm mark, the 15.0 cm mark, the 20.0 cm mark and at the 25.0 cm mark. He keeps the pivot at the 45.0 cm mark each time. The readings are recorded in Table 4.1.

Table 4.1

a / cm	*b* / cm
40.0	42.5
35.0	36.4
30.0	30.1
25.0	23.9
20.0	17.5

(i) Plot a graph of *b*/cm (*y*-axis) against *a*/cm (*x*-axis). Start both axes at the origin (0,0).



[3]

(ii) Draw the line of best fit. [1]

(b) A student suggests that *a* is directly proportional to *b*.

State whether the readings support this suggestion. Justify your answer by reference to the graph line.

....

....

....[1]

(c) The student uses a balance to measure the mass *m* of the metre rule.

m = ...120 g..........................

- Calculate the value of *mX*, where *X* = 0.05 N cm / g.

mX = ... N cm

- Use the value of *a* in the first row of Table 4.1 to calculate *Pa*, where *P* = 1.00 N. *P* is the weight of load **P**. Include the unit.

Pa = ...

- Use the value of *b* in the first row of Table 4.1 to calculate *Qb*, where *Q* = 0.80 N. *Q* is the weight of load **Q**.

Qb = ...
[2]

(d) A student states that *Pa* should be equal to *Qb*.

Look carefully at Fig. 4.1 and the information in **(c)** and suggest what the student has not realised.

....

....[1]

[Total: 8]

5 A student is investigating the effect of draughts (moving air) on the rate of cooling of hot water.

The following apparatus is available to the student:

an electric fan with four speed settings
a supply of hot water
thermometer
250 cm^3 beaker
250 cm^3 measuring cylinder
stopwatch
clamp, boss and stand.

Plan an experiment to investigate the effect of draughts on the rate of cooling of hot water.

You should:

- explain briefly how you would carry out the investigation
- state the key variables that you would control
- draw a table, or tables, with column headings, to show how you would display your readings (you are **not** required to enter any readings in the table)
- explain how you would use your readings to reach a conclusion.

You may draw a diagram if it helps your explanation.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....[7]

[Total: 7]

1 A student determines the density of sand.

Fig. 1.1 shows a beaker with a mark at the 250 cm^3 level.

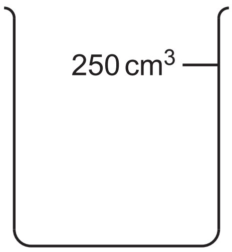


Fig. 1.1

(a) Estimate the volume of water V_W that the beaker would hold when filled to the top.

V_W = ... cm^3 [1]

(b) The student uses string and a metre rule to determine the circumference *c* of the beaker.

c = ... 21.3 cm ....

Explain briefly how to use the string and the metre rule to determine the circumference *c* as accurately as possible. You may draw a diagram.

....

....

....

.... [2]

(c) The student measures the height *h* of the beaker.

(i) Show clearly on Fig. 1.1, the height *h* that he should measure. [1]

His reading is *h* = ... 9.0 cm ....

(ii) Calculate the external volume V_B of the beaker using the equation

$$V_B = \frac{hc^2}{12.6}.$$

V_B = ... cm^3 [2]

(d) The student measures the mass of the beaker on a balance, as shown in Fig. 1.2.

(i) Write down the mass m_B of the beaker, to the nearest gram.

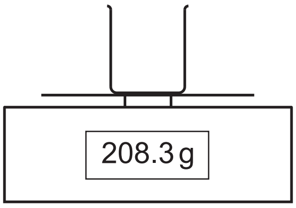


Fig. 1.2

m_B = ... g [1]

The student fills the beaker to the top with dry sand. He measures the mass m of the beaker containing the sand.

m = 724 g

(ii) Calculate the mass m_S of sand in the beaker. Use the equation $m_S = (m - m_B)$.

m_S = ... g [1]

(iii) Calculate the density ρ of the sand using the equation

$$\rho = \frac{m_S}{V_B}.$$

Include the unit.

ρ = ... [2]

(e) The student uses a measuring cylinder to measure the volume of dry sand. Draw a diagram of the measuring cylinder and show the line of sight that the student must use to obtain an accurate volume reading.

[1]

[Total: 11]

2 A student investigates the position of the image in a plane mirror.

Fig. 2.1 shows the ray-trace sheet that the student uses.

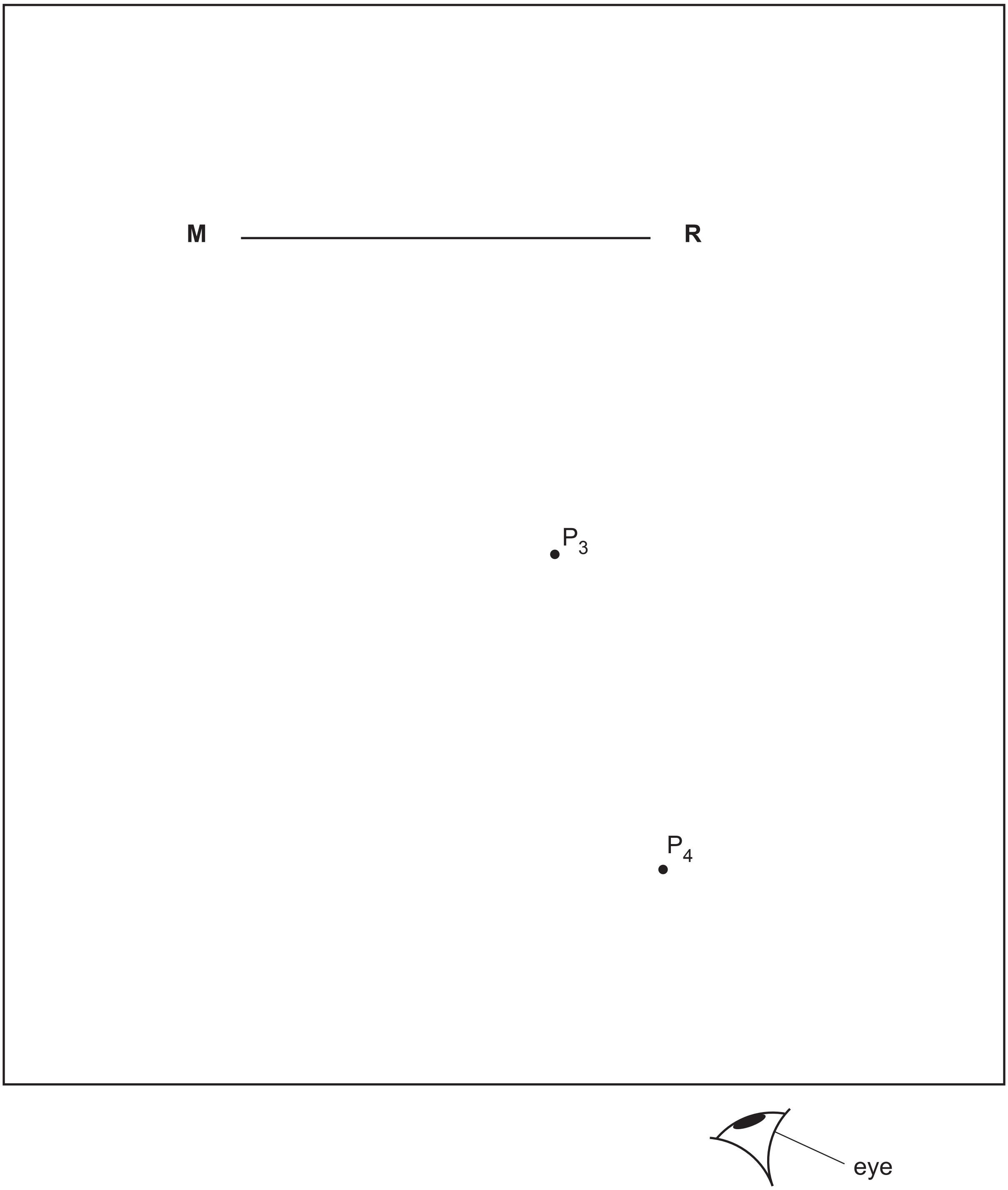


Fig. 2.1

(a) • The line **MR** shows the position of a plane mirror. Draw a normal to this line that passes through its centre. Continue the normal so that it reaches the bottom of the ray-trace sheet. Label the normal **NL**. Label the point at which **NL** crosses **MR** with the letter **B**.

- Draw a line **CD** 5.0 cm below **MR** and parallel to **MR**.
- Label the point **X** where **CD** crosses **NL**.
- Draw a line **EF** 5.0 cm below **CD** and parallel to **CD**.
- Label the point **Y** where **EF** crosses **NL**.

[2]

(b) Draw a line 7.0 cm long from **B** at an angle of incidence θ_1 = 20° to the normal below **MR** and to the left of the normal. Label the end of this line **A**. [1]

(c) The student places two pins, P_1 and P_2, on line **AB**. Suggest a suitable distance *x* between the pins for this type of ray-trace experiment.

x = ... [1]

(d) The student views the images of pins P_1 and P_2 from the direction indicated by the eye in Fig. 2.1. She places pin P_3 on line **CD** so that the images of P_2 and P_1 appear exactly behind pin P_3.

She places pin P_4 on line **EF** so that pin P_3, and the images of P_2 and P_1, all appear exactly behind pin P_4. The positions of P_3 and P_4 are shown on Fig. 2.1.

(i) Measure and record the distance *a* from **X** to P_3.

a = ... [1]

(ii) Measure and record the distance *b* from **Y** to P_4.

b = ... [1]

(iii) Calculate $\frac{a}{b}$.

$\frac{a}{b}$ = ... [1]

(e) The student repeats the procedure using an angle of incidence $\theta_2 = 40°$. She records the new values of *a* and *b*.

a = ...4.2 cm..........

b = ...8.3 cm..........

Calculate the new value $\frac{a}{b}$.

$\frac{a}{b}$ = ... [2]

(f) State and explain whether the two values of $\frac{a}{b}$ can be considered to be equal in this experiment.

....

.... [1]

(g) A student carries out this experiment with care. Suggest a practical reason why the results may **not** be accurate.

....

.... [1]

[Total: 11]

3 A student investigates resistance.

Fig. 3.1 shows the circuit used.

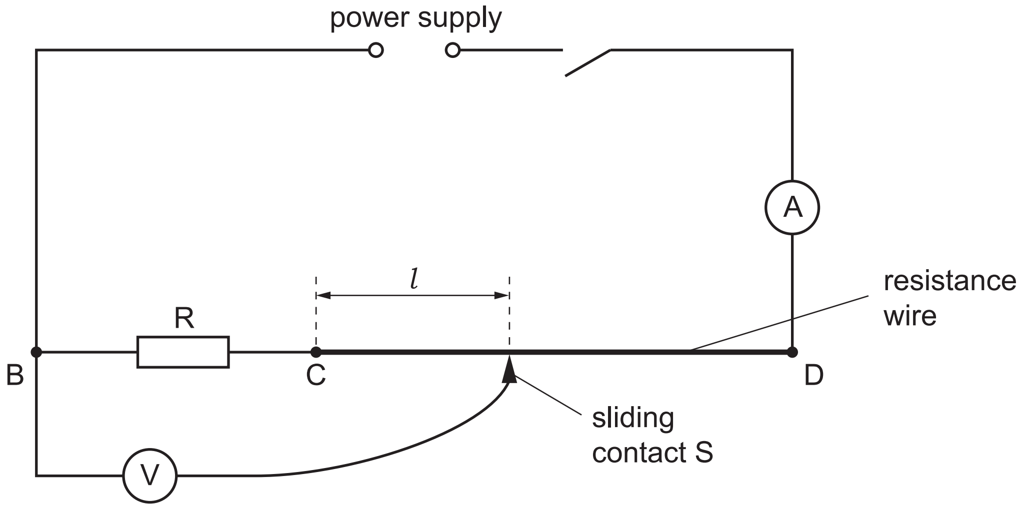


Fig. 3.1

(a) The student measures the current I in the circuit.

He places the sliding contact S at C and measures the potential difference (p.d.) V_1 across the resistor R.

The voltmeter and ammeter are shown in Fig. 3.2 and Fig. 3.3.

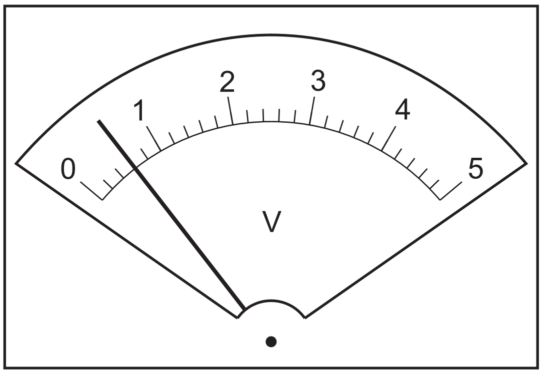


Fig. 3.2

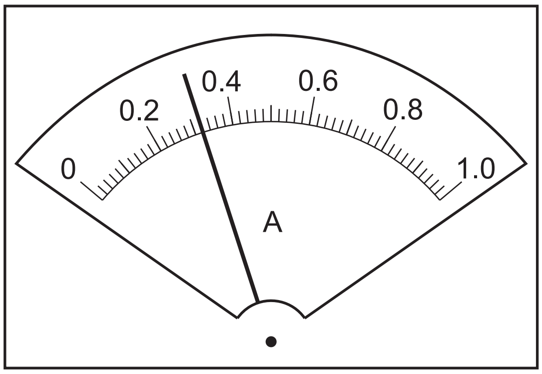


Fig. 3.3

(i) Write down the readings.
Include the units for potential difference, current or resistance where appropriate in all parts of the question.

V_1 = ...

I_1 = ...
[2]

(ii) Calculate the resistance R_1 of the resistor using the equation $R_1 = \frac{V_1}{I_1}$.

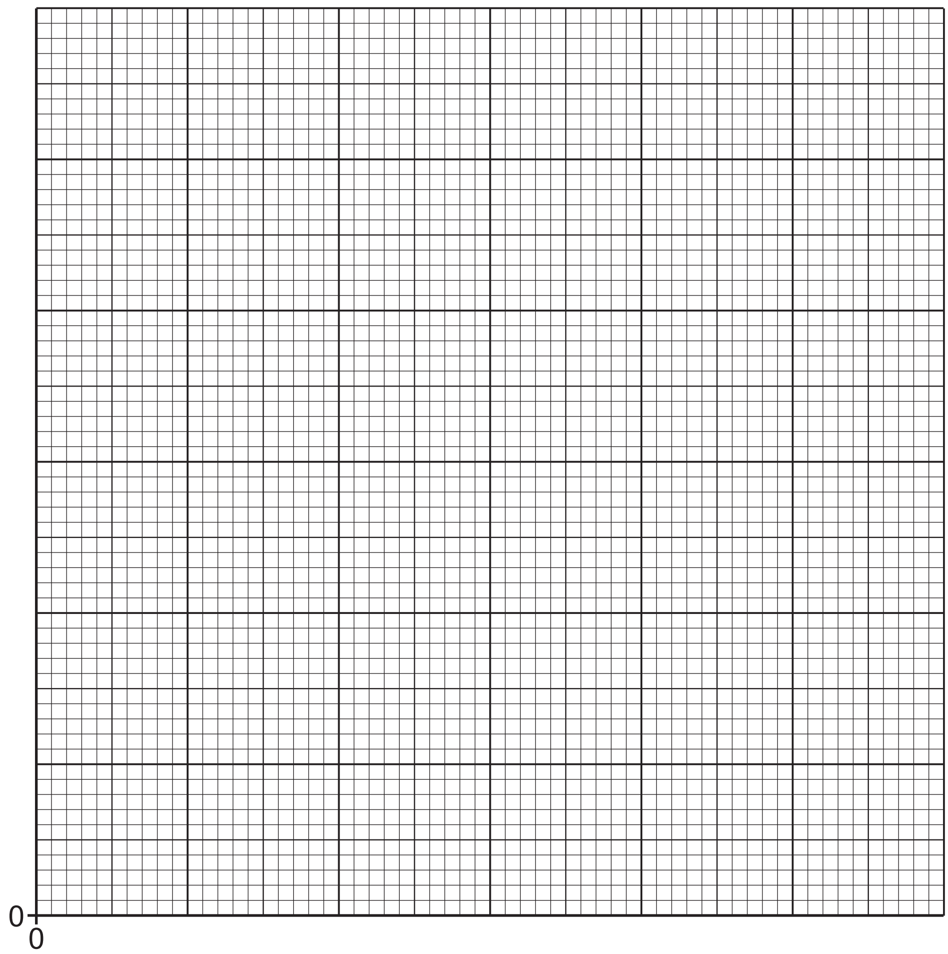
R_1 = ...
[2]

(b) The student disconnects the voltmeter from terminal B and connects the voltmeter to terminal C.
He places the sliding contact S at a distance l = 20.0 cm from C. He records, in Table 3.1, the reading on the voltmeter.
He repeats the procedure using l = 40.0 cm, 60.0 cm, 80.0 cm and 100.0 cm. His readings are shown in Table 3.1.

Table 3.1

l / cm	V / V
20.0	0.4
40.0	0.8
60.0	1.1
80.0	1.5
100.0	1.9

Plot a graph of V / V (y-axis) against l / cm (x-axis). Start both axes at the origin (0,0).



[4]

(c) Use your value of V_1 from **(a)(i)** to find the length l_R of resistance wire that has the same resistance as resistor R. Show clearly on the graph how you obtained the necessary information.

l_R = ... cm [2]

(d) The resistance of the resistance wire is proportional to its length. Estimate the resistance of 100 cm of the resistance wire.

estimate .... [1]

[Total: 11]

4 A student investigates springs made from different metals.

Plan an experiment to investigate the extension of springs made from different metals.

The following apparatus is available:

boss, clamp and stand
metre rule
springs made from different metals
selection of loads with hangers.

You can also use other apparatus and materials that are usually available in a school laboratory.

In your plan, you should:

- write a list of suitable metals for the springs
- draw a diagram of the set up you would use
- explain briefly how to carry out the investigation
- state the key variables to keep constant
- draw a table, or tables, with column headings, to show how to display your readings (you are **not** required to enter any readings in the table)
- explain how you would use the readings to reach a conclusion.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

.... [7]

1 A student investigates the balancing of a metre rule.

Fig. 1.1 shows the apparatus.

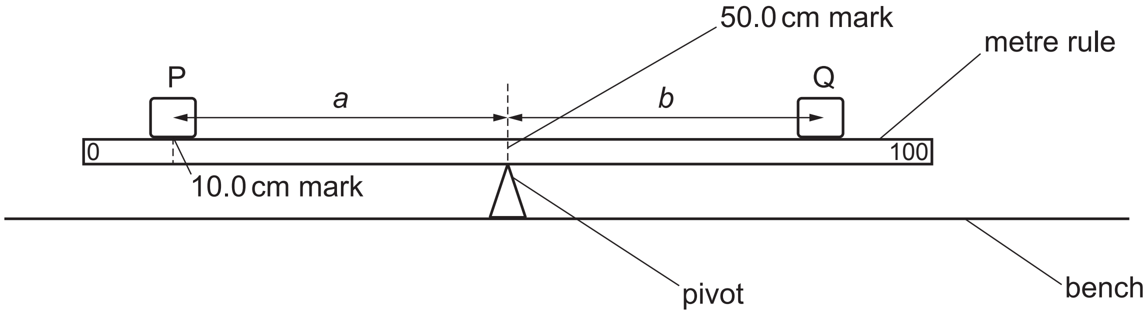


Fig. 1.1

(a) The student places the metre rule on the pivot at the 50.0 cm mark.

She places object P with its centre on the metre rule at the 10.0 cm mark.

The object covers the scale markings on the metre rule, as shown in Fig. 1.2.

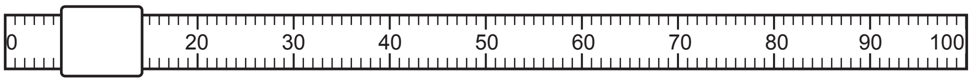


Fig. 1.2

Explain briefly how to place object P as accurately as possible with its centre at the 10.0 cm mark.

You may add to Fig. 1.2, or draw another diagram, to help your explanation.

....

....

....

.... [1]

(b) The student places object Q on the metre rule and adjusts its position until the metre rule is as close to balancing as possible.

She records the distance *a* = 40.0 cm between the centre of object P and the pivot.

The centre of object Q is at the 71.2 cm mark.

Determine, and record in Table 1.1, the distance *b* between the centre of object Q and the pivot. Show your working.

[2]

(c) She repeats the procedure with object P placed at the 15.0 cm mark, 20.0 cm mark, 25.0 cm mark and 30.0 cm mark. All the values of *a* and *b* are shown in Table 1.1.

Table 1.1

a / cm	*b* / cm
40.0	
35.0	17.8
30.0	15.1
25.0	12.3
20.0	9.7

Plot a graph of *a* / cm (*y*-axis) against *b* / cm (*x*-axis). You do **not** need to start your graph from the origin (0,0).

[4]

(d) Determine the gradient *G* of the graph. Show clearly on the graph how you obtained the necessary information.

G = ... [2]

(e) The gradient *G* of the graph is equal to the ratio of the masses of P and Q.

Record the ratio *R* of the masses of P and Q. Give your answer to a suitable number of significant figures for this experiment.

R = ... [2]

[Total: 11]

2 A student investigates the resistances of combinations of resistors.

The first circuit arrangement is shown in Fig. 2.1.

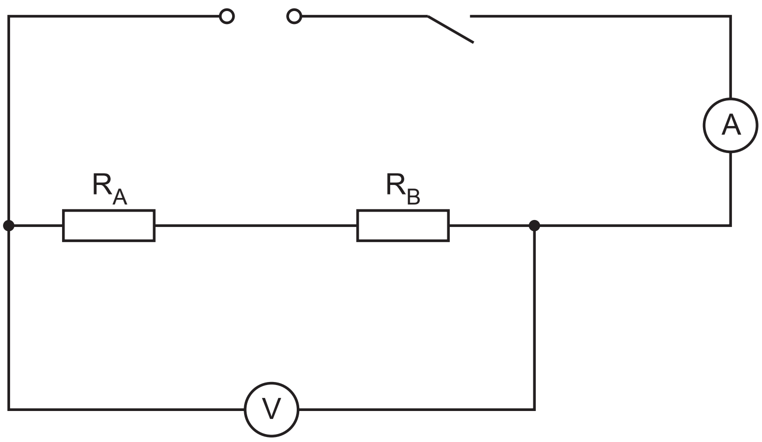


Fig. 2.1

(a) The student measures the current and decides to use a lower current. He adds a variable resistor to the circuit to reduce the current.

On Fig. 2.1, mark with an **X** a suitable position in the circuit for the variable resistor. [1]

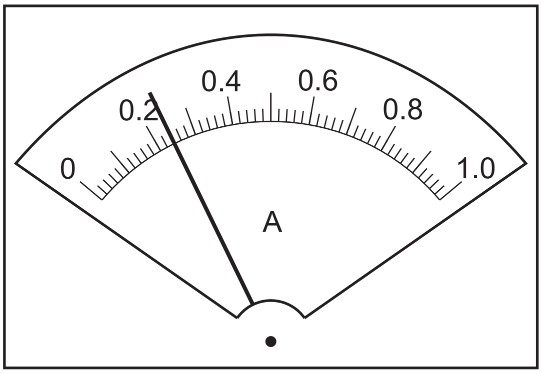


Fig. 2.2

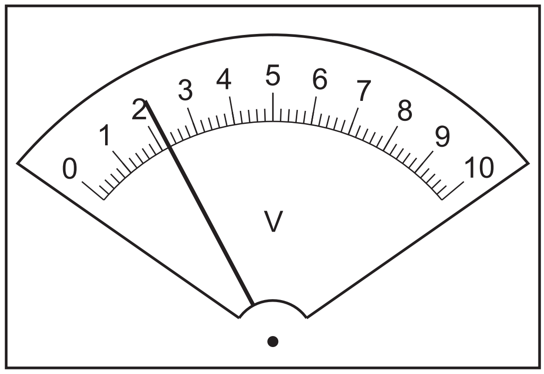


Fig. 2.3

(b) **(i)** The student measures the current I_1 in the circuit. Record the current shown in Fig. 2.2.

I_1 = ... A [1]

(ii) He measures the potential difference (p.d.) V_1 across resistors R_A and R_B in series.

Record the potential difference V_1 shown in Fig. 2.3.

V_1 = ... V [1]

(c) Calculate the resistance R_1 of the combination of resistors in series. Use the equation

$$R_1 = \frac{V_1}{I_1}.$$

Include the unit.

R_1 = ... [1]

(d) The student connects a resistor R_C in parallel with resistors R_A and R_B.

He does **not** change the series combination of resistors R_A and R_B.

He connects the voltmeter across the combination of all three resistors.

(i) Draw a circuit diagram showing the circuit described in **(d)**.

[2]

(ii) The student measures the current I_2 in the circuit.

I_2 = ...0.68.......................... A

He measures the potential difference V_2 across the combination of the three resistors.

V_2 = ...2.1.......................... V

Calculate the resistance R_2 of the combination of resistors. Use the equation

$$R_2 = \frac{V_2}{I_2}.$$

Include the unit.

R_2 = ... [1]

(e) The student rearranges the resistors to set up the circuit shown in Fig. 2.4.

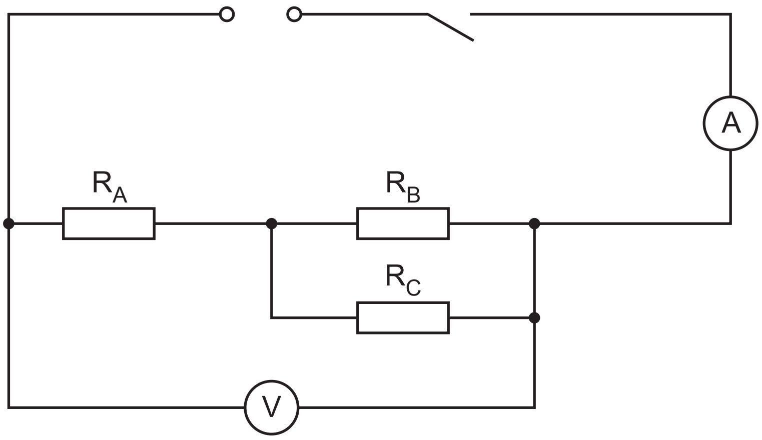


Fig. 2.4

He measures the current I_3 in the circuit.

I_3 = ...0.29.......... A

He measures the potential difference V_3 across the combination of the three resistors.

V_3 = ...2.1.......... V

Calculate the resistance R_3 of the combination of resistors. Use the equation

$$R_3 = \frac{V_3}{I_3}.$$

Include the unit. Give your answer to a suitable number of significant figures for this experiment.

R_3 = ... [1]

(f) A student thinks the three resistors R_A, R_B and R_C have the same resistance within the limits of experimental accuracy.

(i) Suggest how the student could use the apparatus provided to test his idea.

....

....

....

.... [2]

(ii) Explain how the student can decide whether the values of resistance are the same within the limits of experimental accuracy.

....

....

.... [1]

[Total: 11]

3 A student determines the focal length *f* of a lens.

Fig. 3.1 shows the set-up.

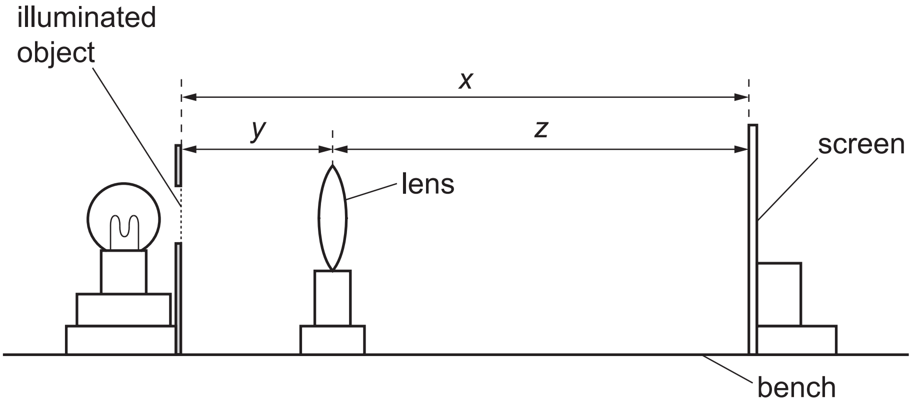


Fig. 3.1

(a) **(i)** On Fig. 3.1, measure the distance *x* from the screen to the illuminated object.

x = ...

Fig. 3.1 is drawn to scale. The actual distance *D* between the illuminated object and the screen is 75.0 cm.

She places the lens between the object and the screen so that the lens is close to the illuminated object.

She moves the lens away from the object until a clearly focused image is formed on the screen.

On Fig. 3.1, measure the distance *y* between the centre of the lens and the illuminated object.

y = ...

On Fig. 3.1, measure the distance *z* between the centre of the lens and the screen.

z = ...
[2]

Table 3.1

D / cm	*u* / cm	*v* / cm	*f* / cm
75.0			
85.0	19.1	64.1	14.4

(ii) Calculate, and record in Table 3.1, the actual distance u between the centre of the lens and the illuminated object.

Calculate, and record in Table 3.1, the actual distance v between the centre of the lens and the screen.

[1]

(iii) Calculate, and record in Table 3.1, the focal length f of the lens using the equation

$$f = \frac{uv}{D}.$$

[1]

(b) The student places the screen at a distance D = 85.0 cm from the illuminated object.

She repeats the procedure described in **(a)**. The results are shown in Table 3.1.

Calculate the average value f_A of the focal length of the lens. Show your working.

f_A = ... cm [2]

(c) State **two** precautions that you would take to obtain accurate readings in this experiment.

1. ....

....

2. ....

....

[2]

(d) A student states that a more accurate value for the focal length f of the lens can be determined by plotting a graph of uv against D. The gradient of the graph is numerically equal to the focal length.

(i) Suggest a suitable number of sets of readings that the student should take.

.... [1]

(ii) Explain briefly how this graphical method can give a more accurate value for the focal length.

....

....

....

[2]

[Total: 11]

4 A student investigates insulators.

Plan an experiment to list insulating discs in order from best insulator to worst insulator.

The following apparatus is available:

- five discs made from different insulating materials
- a thermometer
- a stop-watch
- a heated metal cylinder (see Fig. 4.1)
- a second metal cylinder with a hole for the thermometer (see Fig. 4.1).

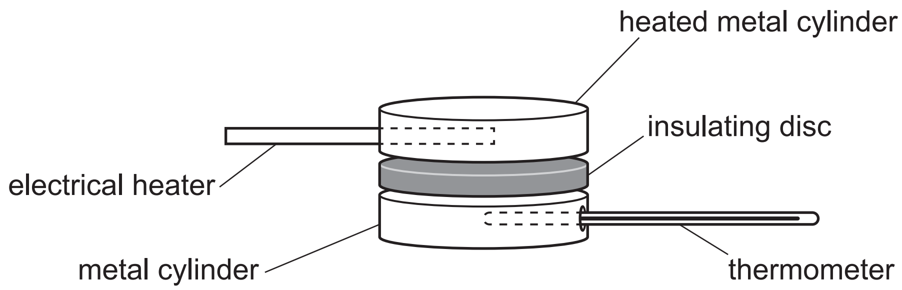


Fig. 4.1

You can also use other apparatus and materials that are usually available in a school laboratory.

In your plan, you should:

- explain briefly how you would carry out the investigation
- state the key variables that you would control
- draw a table, or tables, with column headings, to show how you would display your readings (you are **not** required to enter any readings in the table)
- explain how you would use your readings to reach a conclusion.

[7]

1 A student is determining the weight of a load using a balancing method.

Fig. 1.1 shows the apparatus. It is not drawn to scale.

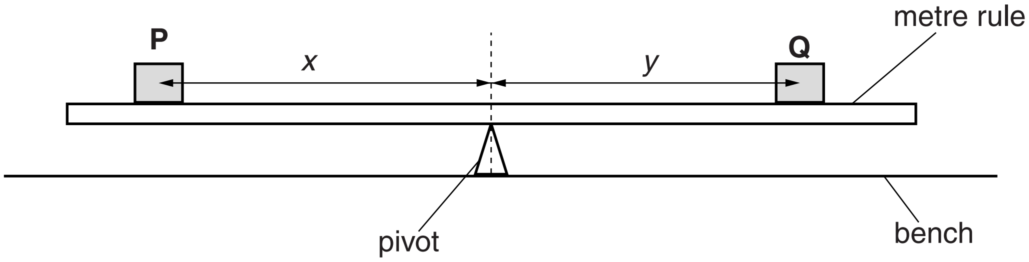


Fig. 1.1 (not to scale)

(a) The student places the metre rule on the pivot and adjusts its position so that the metre rule is as near as possible to being balanced. He records the scale reading of the metre rule at the point where the rule balances on the pivot.

scale reading = ...50.2 cm............

He places a 2.00 N load **P** on the metre rule so that its centre is exactly at the 20.0 cm mark on the rule.

(i) Use this information to determine the distance *x*.

x = ... cm [1]

(ii) Explain how you would ensure that the centre of the load **P** is exactly at the 20.0 cm mark on the rule. You may draw a diagram.

....

....

....

.... [2]

(b) The student places a load **Q** on the metre rule and adjusts its position so that the metre rule is as near as possible to being balanced.

He measures the distance y between the centre of load **Q** and the pivot.

y = ...15.3 cm..........

Calculate the weight W of load **Q** using the equation $W = \frac{kx}{y}$, where $k = 2.00\,N$.

W = ...[1]

(c) The student repeats the procedure using a different, suitably chosen, distance x.

Suggest a suitable distance x.

x = ...cm [1]

(d) The student calculates a new value of W.

W = ...4.04 N..........

Suggest two reasons why the values determined for W may not be the same.

1. ....

2. ....

[2]

(e) Calculate the average W_{AV} of the values for W, the weight of load **Q**. Give your answer to a suitable number of significant figures for this experiment.

W_{AV} = ...N [2]

[Total: 9]

2 A student is investigating the resistance of a resistor.

The circuit is shown in Fig. 2.1. **AB** and **CD** are lengths of resistance wire.

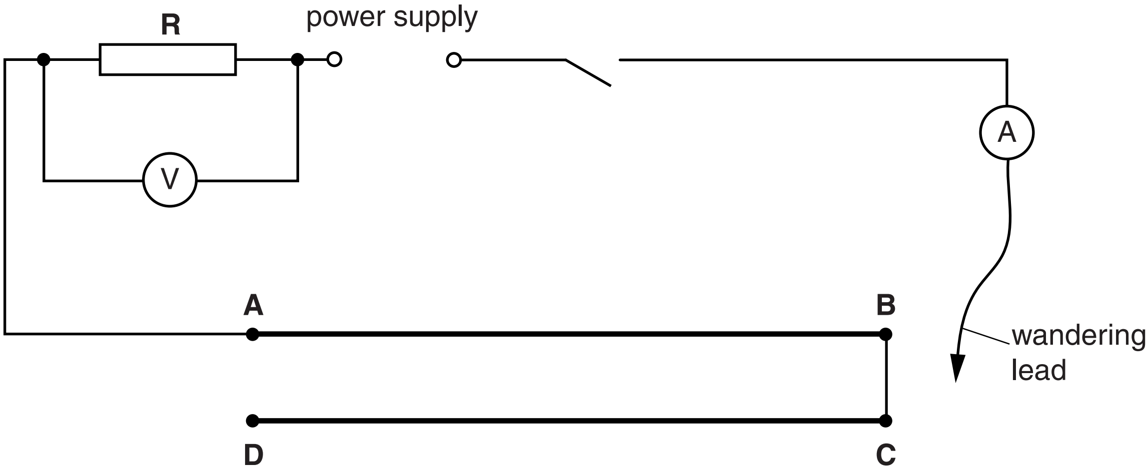


Fig. 2.1

(a) The student connects the wandering lead to point **B** in the circuit. The readings of potential difference V_1 and current I_1 are shown in Figs. 2.2 and 2.3.

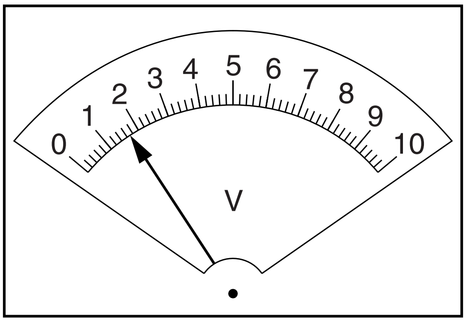


Fig. 2.2

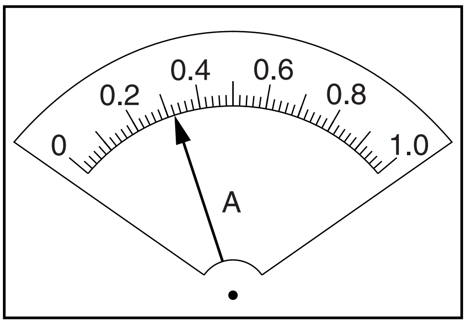


Fig. 2.3

(i) Record the readings shown on the meters.

V_1 = ...

I_1 = ...
[2]

(ii) Calculate the resistance R of the resistor **R** using the equation $R = \frac{V_1}{I_1}$.

R = ...[1]

(b) The student connects the wandering lead to point **D** in the circuit and repeats the readings.

She connects points **A** and **D** together. She connects the wandering lead to point **B** and repeats the readings.

Finally, she connects the wandering lead to point **A** and repeats the readings.

The new values for the resistance R of resistor **R** that she obtains are:

R = ... 4.96 Ω, 5.12 Ω, 4.89 Ω ....

A student suggests that the resistance R should be constant throughout the experiment.

State whether the results agree with this suggestion. Justify your answer by reference to the results.

statement ....

justification ....

....

....
[2]

(c) **(i)** Name a component that could be used to control the current in the circuit, in place of the wires **AB** and **CD**.

....[1]

(ii) In the space below, draw the circuit with this component in place of the wires **AB** and **CD**. Show one end of the component connected at **A** and the wandering lead connected to the other end of the component.

[2]

[Total: 8]

3 **(a)** A student hangs a mass on a spring and observes it as it oscillates up and down.

The student wants to find the factors that affect the time taken for one complete oscillation. She finds that increasing the mass increases the time.

Suggest two other variables that the student could investigate.

1. ....

2. ....
[2]

(b) Another student is investigating the oscillations of the pendulum shown in Fig. 3.1.

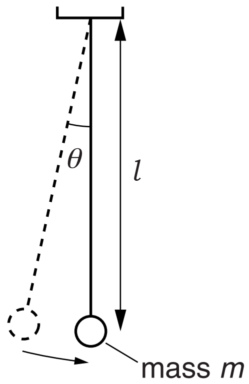


Fig. 3.1

The variables are

- the length l of the pendulum
- the mass m of the pendulum bob
- the amplitude θ of the swing.

The time taken for one complete oscillation is called the period T.

She carries out three experiments. Each experiment investigates the effect on the period T of changing one variable.

Her results are shown in Tables 3.1, 3.2 and 3.3.

Table 3.1

l/m	T/s
0.200	0.89
0.400	1.25
0.600	1.54
0.800	1.78
1.000	1.99

Table 3.2

m/g	T/s
50	1.40
60	1.42
70	1.39
80	1.41
90	1.38

Table 3.3

θ/°	T/s
4	2.00
6	1.98
8	2.06
10	2.02
12	1.97

(i) Study the results tables and use words from this list to complete the sentences.

increases

decreases

has no effect on

is proportional to

- An increase in length l .... the period T.
- An increase in mass m .... the period T.
- An increase in amplitude θ .... the period T.

[3]

(ii) Suggest a precaution you would take in this pendulum experiment to obtain T values that are as reliable as possible.

....

....

....[1]

[Total: 6]

4 A student is investigating whether using a lid reduces the time taken to heat a beaker of water to boiling point.

The student has the following apparatus available:

thermometer
250 cm^3 glass beaker
250 cm^3 measuring cylinder
heatproof mat
lid to fit the beaker
clamp, boss and stand.

Plan an experiment to investigate whether using a lid reduces the heating time.

You should

- list the additional apparatus that you would require
- explain briefly how you would carry out the investigation
- state the key variables that you would control
- draw a table, with column headings, to show how you would display your readings; you are not required to enter any readings in the table
- explain how you would use your readings to reach a conclusion.

A diagram is not required but you may draw a diagram if it helps your explanation.

....

....

....[7]

[Total: 7]

5 A student is investigating reflection using a plane mirror.

Fig. 5.1 shows the student's ray-trace sheet.

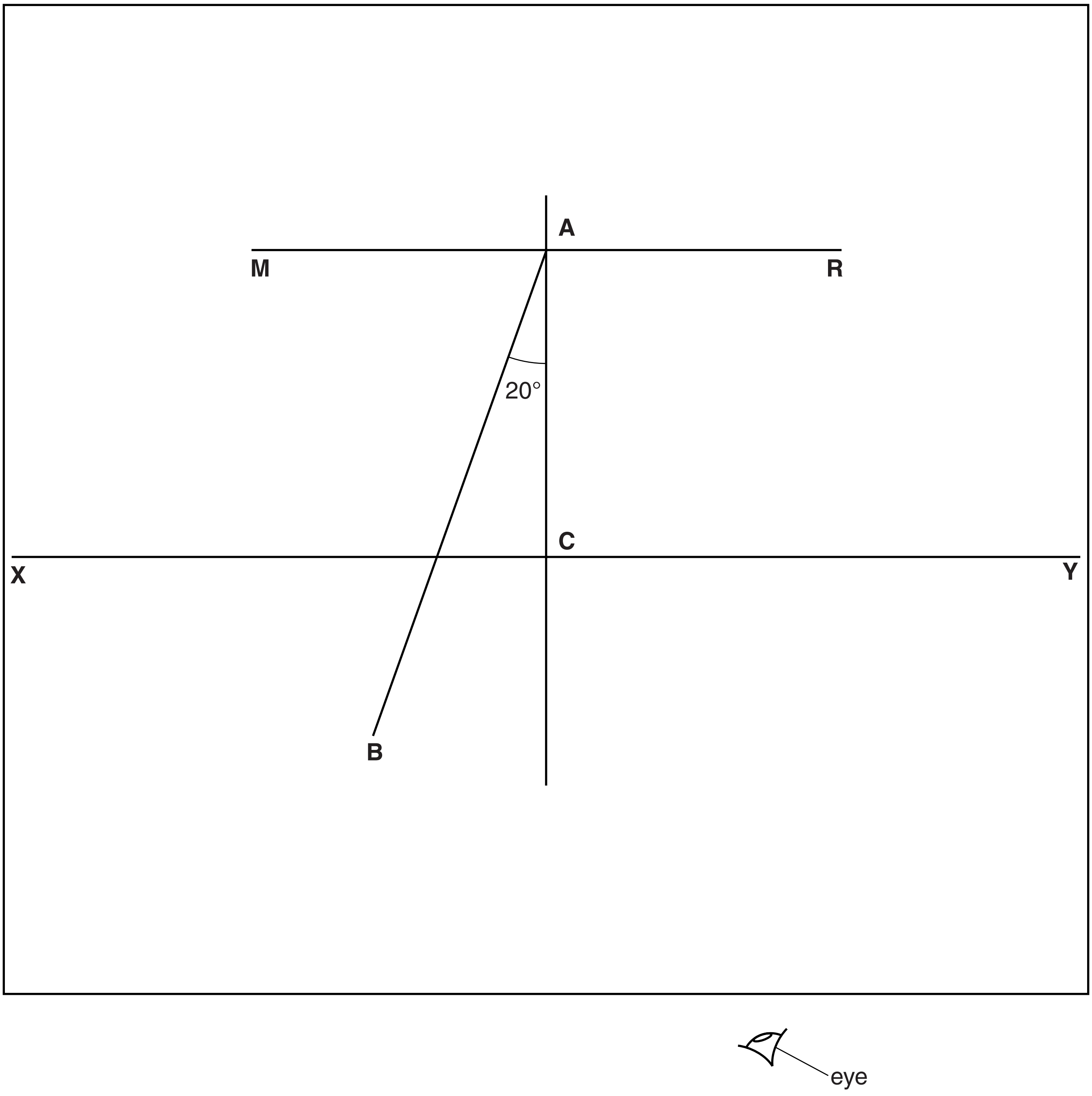


Fig. 5.1

(a) The line **MR** marks the position of the mirror. The student draws another line **XY** parallel to line **MR**. He draws a line from **A** at an angle of incidence $i = 20°$. He labels the end of this line **B**. The student places a pin P_1 at point **B**. He places a pin P_2 on line **AB** at a suitable distance from pin P_1 to produce a ray trace.

(i) On Fig. 5.1, measure the length l of line **AB**.

l = ...[1]

(ii) On Fig. 5.1, mark with a cross (x) a suitable position for pin P_2. [1]

(b) The student views the images of pins P_1 and P_2 from the direction indicated by the eye in Fig. 5.1. He places two pins P_3 and P_4, a suitable distance apart, so that pins P_3 and P_4, and the images of P_2 and P_1, all appear exactly one behind the other.

He draws a line joining the positions of P_3 and P_4. He labels the point at which this line crosses **XY** with the letter **D**. He measures the distance *d* between **C** and **D**.

He repeats the procedure using *i* values of 0°, 30°, 40°, 50° and 60°. The readings are shown in Table 5.1.

Table 5.1

i/°	*d*/cm
0	0.0
20	1.8
30	2.9
40	4.2
50	6.0
60	8.7

Plot a graph of *d*/cm (*y*-axis) against *i*/° (*x*-axis).

[4]

(c) A student suggests that *i* should be directly proportional to *d*.

State whether the graph supports this suggestion. Justify your answer by reference to the graph.

statement ....

justification ....

.... [2]

(d) Suggest two practical difficulties in obtaining accurate readings in this experiment.

1. ....

....

2. ....

.... [2]

[Total: 10]

1 A student is comparing the oscillations of two pendulums. Fig. 1.1 shows the first pendulum.

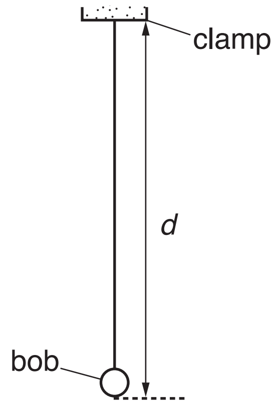


Fig. 1.1

(a) **(i)** On Fig. 1.1, measure the distance *d*, from the bottom of the clamp to the bottom of the bob.

d = ... cm [1]

(ii) Fig. 1.1 is drawn 1/10th actual size. Calculate the actual distance *D* from the bottom of the clamp to the bottom of the bob.

D = ... cm [1]

(iii) Explain briefly how to use a set-square to avoid a parallax (line-of-sight) error when measuring the length of this pendulum. You may draw a diagram.

....

....[1]

(b) The student displaces the bob slightly and releases it so that it swings. She measures the time t for 20 complete oscillations. The time t is shown on the stopwatch in Fig. 1.2.

Fig. 1.2

(i) Write down the time t shown in Fig. 1.2.

t = ...[1]

(ii) Calculate the period T_1 of the pendulum. The period is the time for one complete oscillation.

T_1 = ...[2]

(c) The student repeats the procedure using another pendulum as shown in Fig. 1.3. This has a long, thin pendulum bob. The distance *D* from the bottom of the clamp to the bottom of the pendulum bob is the same as for the first pendulum.

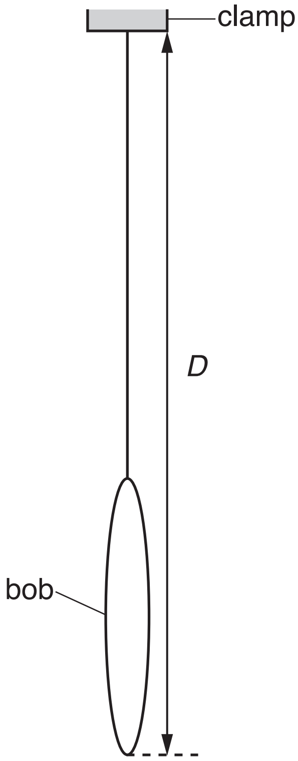


Fig. 1.3

She determines the period T_2 of this pendulum.

T_2 = ...1.37 s..........................

In this experiment, both pendulum bobs have the same mass. A student suggests that since both pendulums have the same overall length *D* and mass, the periods T_1 and T_2 should be equal. State whether the results support this suggestion. Justify your answer by reference to the results.

statement ....

justification ....

....

....[2]

(d) The period *T* of a pendulum can be determined by measuring the time *t* for 20 complete oscillations and then calculating the period. Some students are asked to explain the reason for this method being more accurate than measuring the time taken for a single oscillation.

Tick the box next to the sentence that gives the best explanation.

☐ The method eliminates errors from the measurements.

☐ The method is more accurate because the experiment is repeated.

☐ The method includes more readings so there is less chance for errors.

☐ The method reduces the effect of errors when starting and stopping the stopwatch.

[1]

(e) A student plans to carry out more pendulum experiments. He considers possible variables and precautions to improve accuracy.

In the following list, mark the possible variables with the letter **V** and the precautions with the letter **P**.

☐ amplitude of swing

☐ length of pendulum

☐ mass of pendulum bob

☐ shape of pendulum bob

☐ use of a reference point to aid counting

☐ viewing the rule at right-angles when measuring the length

[2]

[Total: 11]

2 A student is investigating the cooling of water.

(a) The thermometer in Fig. 2.1 shows room temperature θ_R at the beginning of the experiment. Record θ_R.

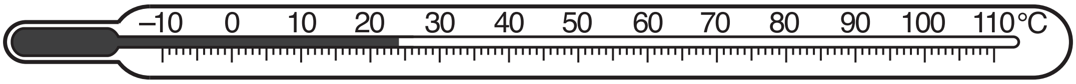


Fig. 2.1

θ_R = ... °C [1]

(b) The student pours 50 cm^3 of hot water into a beaker.

He measures the temperature θ_H of the hot water.

θ_H = ...86 °C...............

He adds 50 cm^3 of cold water to the beaker. He stirs the water briefly.

He measures the new temperature θ_M of the water in the beaker.

θ_M = ...52 °C...............

Calculate the temperature fall θ_F using the equation $\theta_F = (\theta_H - \theta_M)$.

θ_F = ...
[1]

(c) He repeats the procedure in **(b)** using 100 cm^3 of hot water and 100 cm^3 of cold water.

θ_H = ...84 °C...............

θ_M = ...54 °C...............

Calculate the temperature fall θ_F using the equation $\theta_F = (\theta_H - \theta_M)$.

θ_F = ...[1]

(d) Suggest **one** reason for stirring the water before reading θ_M.

....

....[1]

(e) A student states that the temperature fall θ_F should be the same each time because the proportions of hot and cold water are the same.

Suggest **one** reason why θ_F could be significantly different in **(b)** and **(c)**.

....

....

....[1]

(f) Suggest an improvement to the apparatus to make it more likely that θ_F would be the same each time.

....

....

....[1]

(g) Suggest a condition, not included in your answer to **(f)**, that you would control to make it more likely that θ_F would be the same each time.

....

....

....[1]

(h) The student uses a measuring cylinder to measure the volume of water he uses. Draw a measuring cylinder about half-full of water. Show clearly on your diagram the line-of-sight required for obtaining a correct reading for the volume of water.

[3]

[Total: 10]

3 A student is determining the focal length *f* of a lens.

Fig. 3.1 shows the apparatus used.

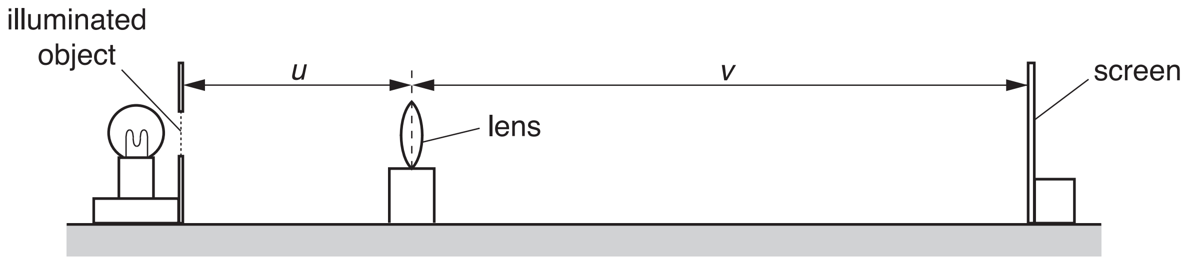


Fig. 3.1

(a)
- The student places the screen about 100 cm from the illuminated object.
- She places the lens between the object and the screen so that the centre of the lens is at a distance u = 20.0 cm from the object.
- She adjusts the position of the screen until a clearly focused image is formed on the screen.
- She measures the distance v between the centre of the lens and the screen.
- She repeats the procedure using values for u of 22.0 cm, 25.0 cm, 30.0 cm and 35.0 cm.
- The readings are shown in Table 3.1.

Table 3.1

u / cm	v / cm
20.0	60.0
22.0	47.1
25.0	37.5
30.0	29.8
35.0	26.3

Plot a graph of v/cm (y-axis) against u/cm (x-axis). You do not need to start your axes at the origin (0, 0). Draw the best-fit curve.

[4]

(b) **(i)**
- Mark, with a cross, the point on the graph grid where u = 25.0 cm and v = 25.0 cm.
- Mark with a cross, the point on the graph grid where u = 35.0 cm and v = 35.0 cm.
- Join these two points with a straight line. [1]

(ii)
- Record u_1, the value of u at the point where the straight line crosses your graph line.

u_1 = ...cm

- Record v_1, the value of v at the point where the straight line crosses your graph line.

v_1 = ...cm
[1]

(iii) Calculate the focal length f of the lens using the equation $f = \frac{(u_1 + v_1)}{4}$.

f = ...cm
[2]

(c) Suggest **two** differences that you would expect to see between the appearance of the illuminated object and the image on the screen.

1. ....

2. ....
[2]

(d) Suggest **two** precautions that you would take in order to obtain reliable readings in this experiment.

1. ....

2. ....
[2]

[Total: 12]

4 A student has a selection of rubber bands of different widths. He is investigating the extension produced by adding loads. Fig. 4.1 shows the set-up used.

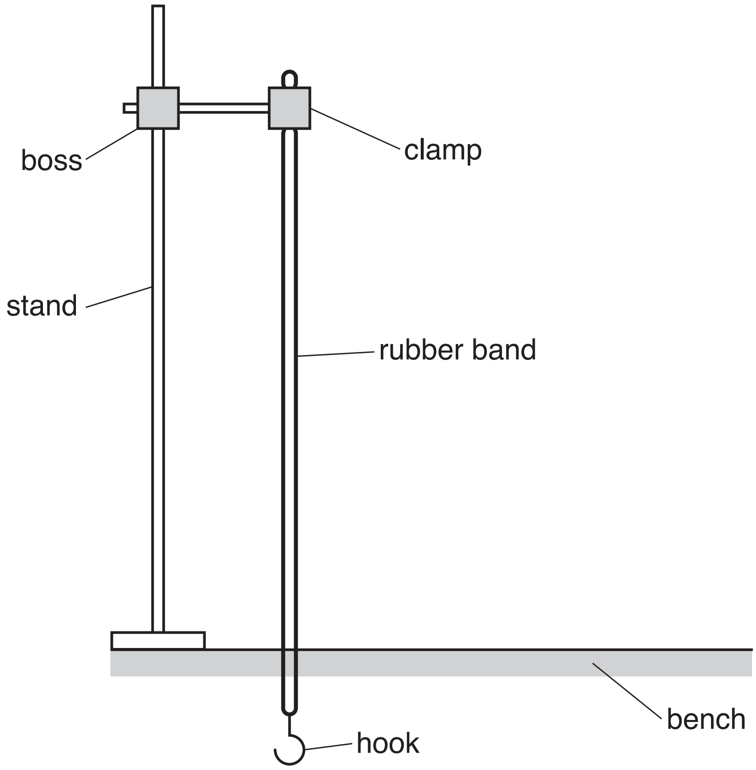


Fig. 4.1

In addition to the apparatus shown in Fig. 4.1, the following apparatus is available to the student:

A metre rule
A selection of different rubber bands
A selection of loads.

Plan an experiment to investigate how strips of rubber of different widths stretch when loaded.

You should

- explain briefly how you would carry out the investigation
- state the key variables that you would control
- draw a table, or tables, with column headings to show how you would display your readings (You are **not** required to enter any readings in the table.)
- explain briefly how you would use your readings to reach a conclusion.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....[7]

[Total: 7]

1 A student determines the density of a block of wood.

(a) Fig. 1.1 shows one face of the block of wood that the student uses.

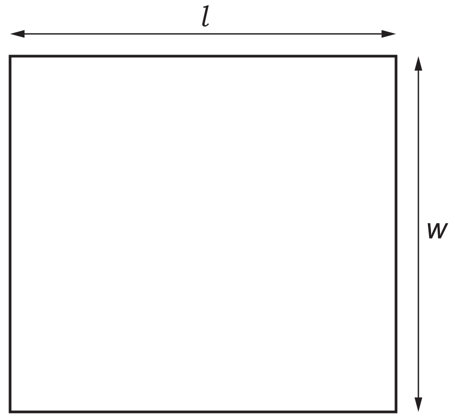


Fig. 1.1

(i) Measure the length l and width w of the block of wood. Fig. 1.1 is drawn actual size.

l = ... cm

w = ... cm [1]

(ii) The student measures the height h of the block of wood.

h = ...4.0.......................... cm

Calculate the volume V of the block of wood using the equation $V = l \times w \times h$.

V = ... cm^3 [1]

(iii) The student measures the mass m of the block of wood on a balance.

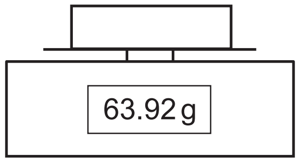


Fig. 1.2

Write down the mass m of the block as shown in Fig. 1.2. Give your answer to the nearest gram.

m = ... g [1]

(iv) Calculate the density ρ of the wood using the equation $\rho = \frac{m}{V}$. Give your answer to a suitable number of significant figures for this experiment and include the unit.

ρ = ... [2]

(b) The student places the block of wood carefully in water in a glass dish. The wood floats as shown in Fig. 1.3.

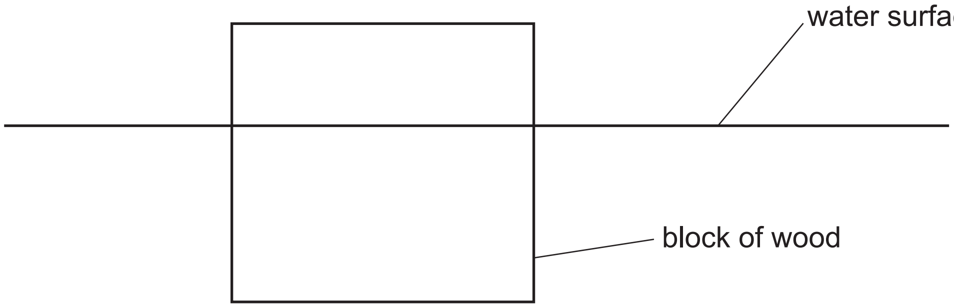


Fig. 1.3

(i) Using Fig. 1.3, estimate, without taking a measurement, the volume V_1 of wood that is below the water surface.

V_1 = ... cm^3 [1]

(ii) Calculate m_W, the mass of water with volume V_1, using the equation $m_W = \rho_W \times V_1$, where ρ_W = 1.00 in the same units as ρ in part **(a)(iv)**.

m_W = ... [1]

(c) A student suggests that the mass m of the block of wood should be equal to the mass m_W of the water with volume V_1.

(i) Calculate the difference d between your values of m and m_W.

d = ... [1]

(ii) Discuss whether the difference d is small enough to conclude that $m = m_W$.

....

....

.... [1]

(d) Another student wants to obtain a more accurate value for V_1. He uses the method of floating the block of wood in water as described in **(b)**.

Suggest how the student could obtain a more accurate value by taking a measurement.

....

....

.... [2]

[Total: 11]

2 A student investigates the resistances of a resistor and a lamp.

Fig. 2.1 shows the first circuit arrangement.

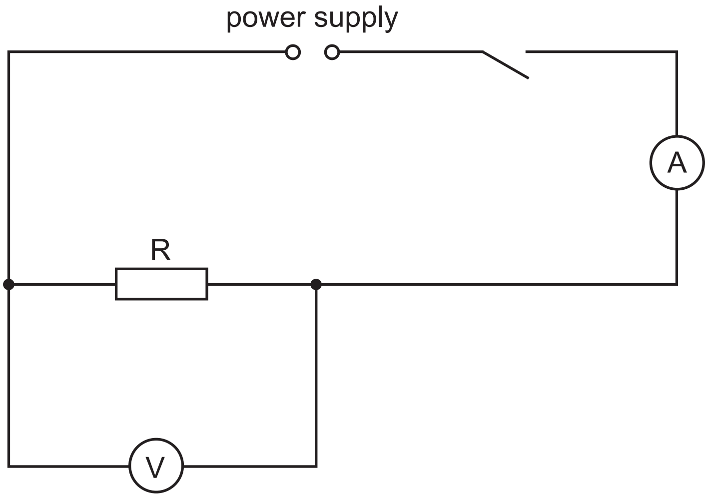


Fig. 2.1

(a) She records V_S, the potential difference (p.d.) across the resistor R, and the current I_S in the circuit. The meters are shown in Fig. 2.2 and Fig. 2.3.

(i) Write down the readings. Include the units for potential difference, current or resistance where appropriate in all parts of the question.

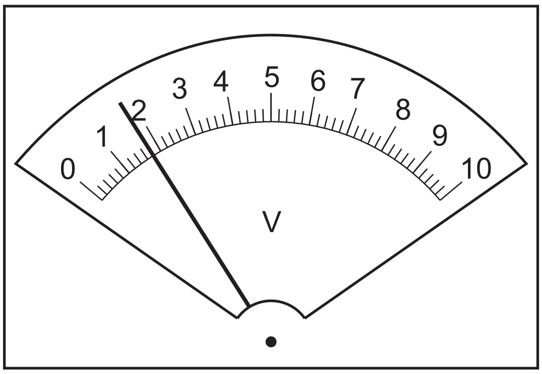


Fig. 2.2

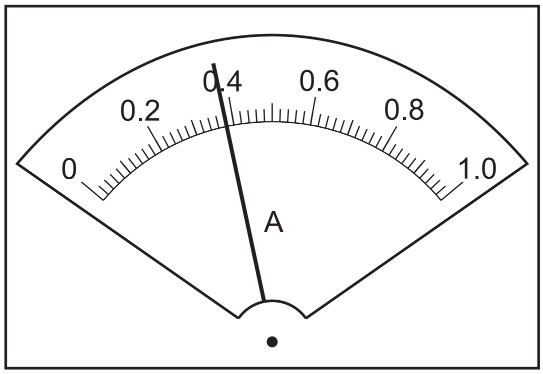


Fig. 2.3

V_S = ...

I_S = ...
[2]

(ii) Calculate R_S, the resistance of resistor R, using the equation $R_S = \frac{V_S}{I_S}$.

R_S = ... [2]

(b) The student replaces the resistor with the lamp. She records V_L the potential difference across the lamp and the current I_L in the circuit.

V_L = ...1.7........................

I_L = ...0.35........................

Calculate R_L, the resistance of the lamp, using the equation $R_L = \frac{V_L}{I_L}$.

R_L = ... [2]

(c) The student connects the resistor R in series with the lamp. She connects the voltmeter to record V_C, the potential difference across the series combination of the resistor and the lamp. Draw the circuit diagram for this arrangement.

[2]

(d) The student records V_C the potential difference across the resistor and the lamp in series and the current I_C in the circuit.

V_C = ...1.7........................

I_C = ...0.21........................

Calculate R_C, the combined resistance of the resistor and the lamp connected in series, using the equation $R_C = \frac{V_C}{I_C}$.

R_C = ... [1]

(e) State and explain briefly whether the results show that $R_S + R_L = R_C$ within the limits of experimental accuracy.

statement ....

explanation ....

.... [2]

[Total: 11]

3 A student investigates the image produced by a lens.

Fig. 3.1 shows the apparatus.

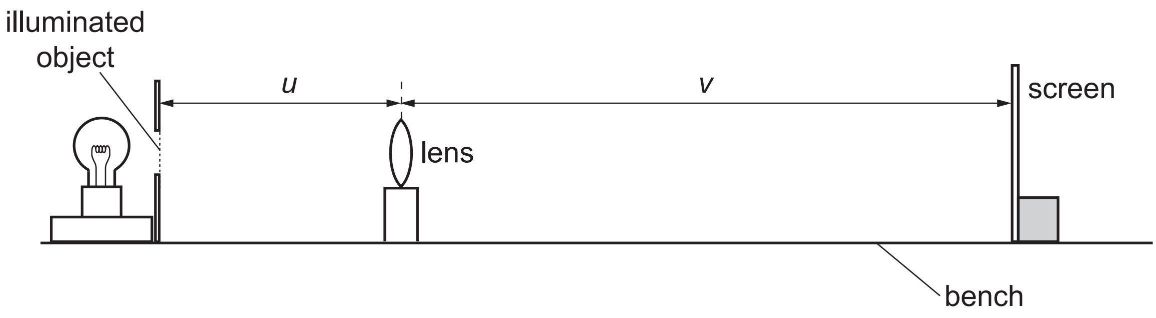


Fig. 3.1

(a)
- The student places the lens a distance u = 20.0 cm from the illuminated object.
- He moves the screen until a clearly focused image is formed on the screen.
- He measures the distance v between the centre of the lens and the screen.
- Calculate, and record in the first row of Table 3.1, $\frac{u}{v}$.
- He repeats the procedure for u = 25.0 cm, u = 30.0 cm, u = 35.0 cm and u = 40.0 cm. The readings and results are shown in Table 3.1.

Table 3.1

u / cm	v / cm	$\frac{u}{v}$
20.0	79.5	
25.0	44.5	0.56
30.0	35.0	0.86
35.0	30.0	1.17
40.0	27.0	1.48

[1]

(b) Plot a graph of u/cm (y-axis) against $\frac{u}{v}$ (x-axis). Start the y-axis at u = 15.0 cm.

[4]

(c) Use your graph to find u_1, the value of u when $\frac{u}{v}$ = 1.0. Show clearly on the graph how you obtained the necessary information.

u_1 = ... [2]

(d) Calculate the focal length f of the lens using the equation $f = \frac{u_1}{2}$. Give your answer to a suitable number of significant figures for this experiment.

f = ... cm [2]

(e) Suggest **one** practical difficulty with this experiment. Explain briefly how you would try to overcome this difficulty in order to obtain accurate results.

suggestion ....

....

explanation ....

....

....

[2]

[Total: 11]

4 A student investigates the strengths of wires made from different metals by measuring the force required to break the wires.

The apparatus is shown in Fig. 4.1. A wire is held by a clamp at one end and a load is suspended from the other end. The load is increased until the wire breaks. The student takes all the necessary safety precautions.

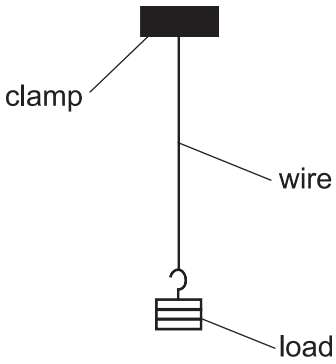


Fig. 4.1

Plan an experiment to investigate the force required to break wires made from different metals.

The following apparatus is available:

clamps and stands
a selection of masses with a suitable hanger
metre rule
a selection of wires made from different metals.

You can also use other apparatus and materials that are usually available in a school laboratory.

In your plan, you should:

- write a list of suitable metals for the wires you would investigate
- explain briefly how you would do the investigation
- state the key variables that you would keep constant
- draw a table, or tables, with column headings, to show how you would display your readings (you are **not** required to enter any readings in the table)
- explain how you would use the results to reach a conclusion.

You may add to the diagram if it helps your explanation.

You are **not** required to write about the safety precautions that the student should take.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

.... [7]

1 A student investigates temperature changes when mixing hot and cold water.

Fig. 1.1 shows the set-up.

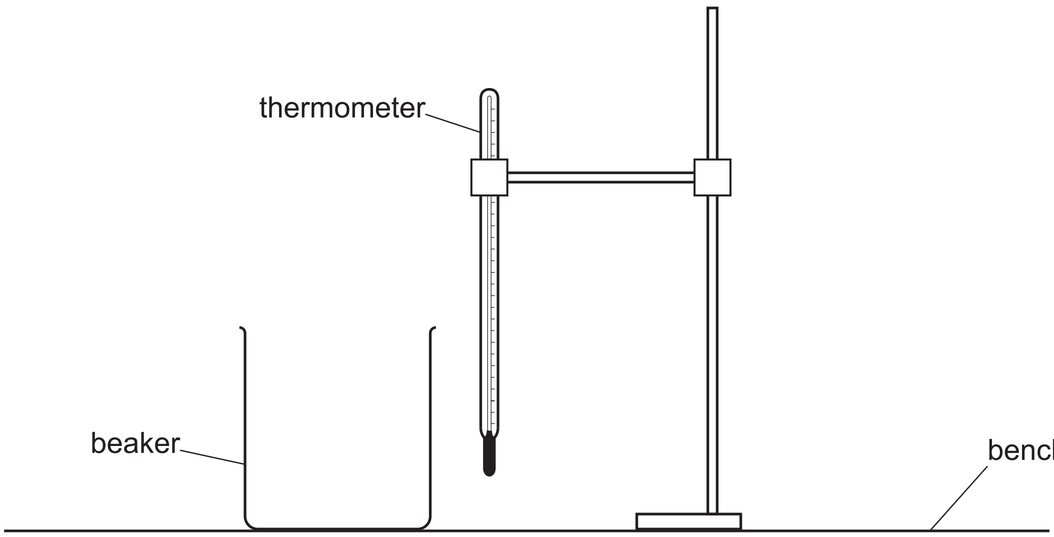


Fig. 1.1

(a) The thermometer in Fig. 1.2 shows room temperature θ_R at the beginning of the experiment. Record θ_R.

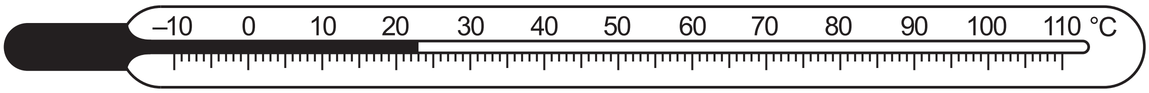


Fig. 1.2

θ_R = ... °C [1]

(b) The student records the temperature θ_C of a supply of cold water.

θ_C = ...19.......................... °C

She records the temperature θ_H of a supply of hot water.

θ_H = ...88.......................... °C

She immediately pours 100 cm^3 of the hot water into a beaker containing 100 cm^3 of the cold water. She records the highest temperature θ_M of the mixture.

θ_M = ...46.......................... °C

(i) Suggest **two** precautions that you would take to obtain an accurate value for the highest temperature θ_M of the mixture.

1. ....

....

2. ....

....
[2]

(ii) Calculate the decrease in temperature $\Delta\theta_1$ of the hot water using the equation $\Delta\theta_1 = (\theta_H - \theta_M)$. Include the unit.

$\Delta\theta_1$ = ...

Calculate the increase in temperature $\Delta\theta_2$ of the cold water using the equation $\Delta\theta_2 = (\theta_M - \theta_C)$. Include the unit.

$\Delta\theta_2$ = ...
[2]

(c) Calculate the average θ_A of the temperatures θ_H and θ_C. Show your working. Include the unit.

θ_A = ... [2]

(d) State whether θ_A and θ_M can be considered to be equal within the limits of experimental accuracy. Justify your answer by reference to the results.

statement ....

....

justification ....

....
[2]

(e) State **two** requirements when reading the volume of water in a measuring cylinder to obtain an accurate result.

1. ....

2. ....
[2]

[Total: 11]

2 A student investigates the position of the image in a plane mirror.

Fig. 2.1 shows the ray-trace sheet.

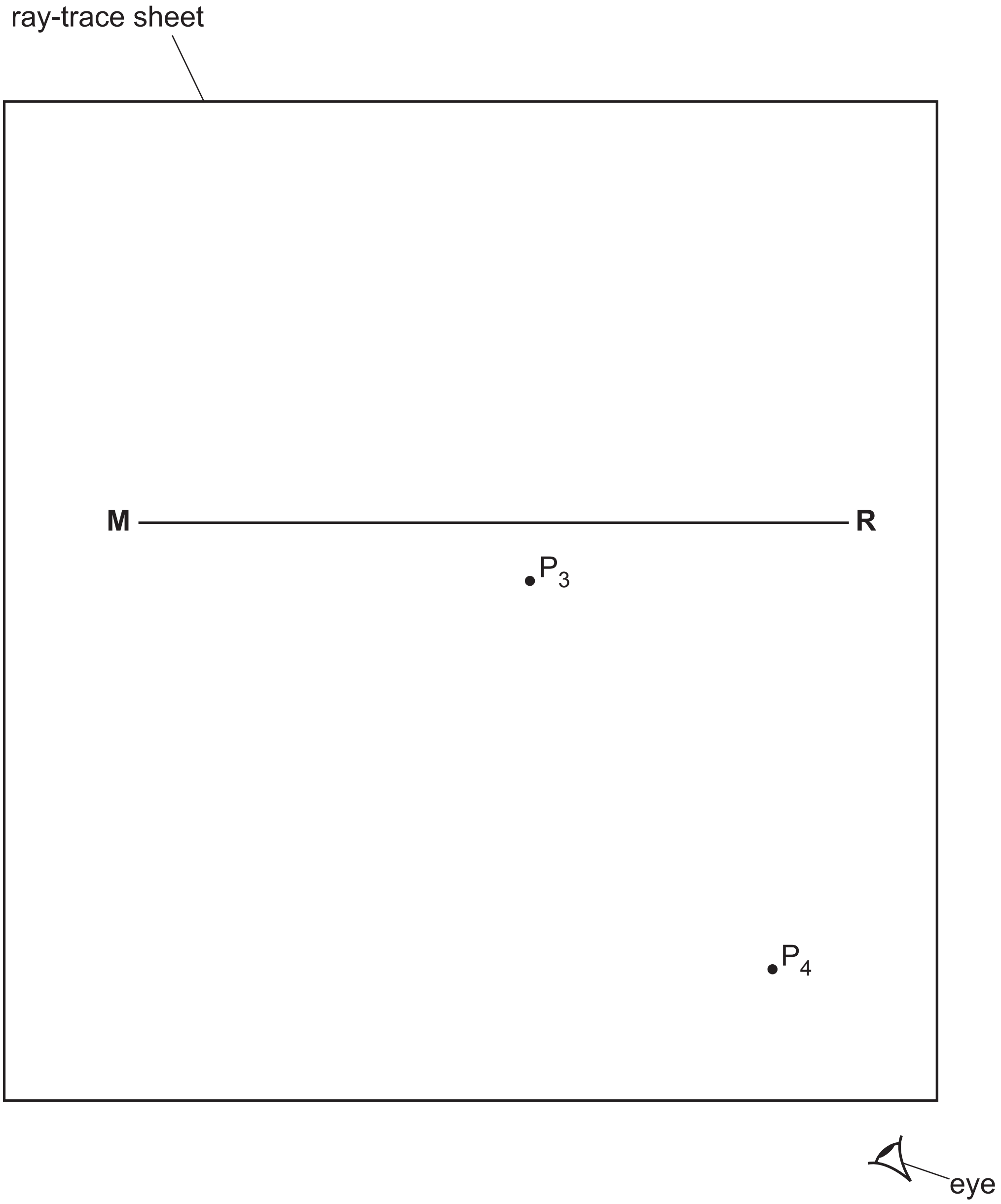


Fig. 2.1

(a) Line **MR** shows the position of the plane mirror. Draw a normal to this line that passes through its centre. Label the normal **NL**. Label the point at which **NL** crosses **MR** with the letter **B**. [1]

(b) Draw a line 7.0 cm long from **B** at an angle of incidence α = 30° to the normal below **MR** and to the left of the normal. Label the end of this line **A**. [1]

(c)
- The student places the reflecting face of the mirror vertically on the line **MR**.
- He places two pins, P_1 and P_2, on line **AB** at a suitable distance apart for this type of ray-trace experiment.

(i) Suggest a suitable distance apart for pins P_1 and P_2 for this type of ray-trace experiment.

distance = ... [1]

(ii) State the reason for your suggested distance.

....

.... [1]

(d)
- The student views the images of pins P_1 and P_2 from the direction indicated by the eye in Fig. 2.1.
- He places two pins, P_3 and P_4, so that pins P_3 and P_4 and the images of P_2 and P_1 all appear exactly one behind the other. The positions of P_3 and P_4 are marked on Fig. 2.1.

Draw a line through the positions of P_3 and P_4. Continue the line until it meets **MR**.

(i) Measure, and record in Table 2.1, the acute angle β between the line through the positions of P_3 and P_4 and the line **MR**. [1]

(ii) Add units to the column headings in Table 2.1.

Table 2.1

α/	β/	$(\alpha + \beta)$/
30		
45	46	

[1]

(e) The student places the reflecting face of the mirror vertically on the line **MR** with the centre of the mirror at **B**.

He repeats the procedure using an angle of incidence α = 45°. The values of α and β are recorded in Table 2.1.

Calculate, and record in Table 2.1, the values of ($\alpha + \beta$). [1]

(f) Suggest a relationship, if any, between the two values of ($\alpha + \beta$) in Table 2.1.

.... [1]

(g) In order to investigate further a possible relationship between values of ($\alpha + \beta$), more values are required.

Suggest values of the angle of incidence α that the student could use.

....

.... [2]

(h) The student does this experiment with care.

Suggest a practical reason why the results may not be exactly those that the theory of reflection predicts.

....

.... [1]

[Total: 11]

3 A student investigates the balancing of a metre rule.

Fig. 3.1 shows the set-up.

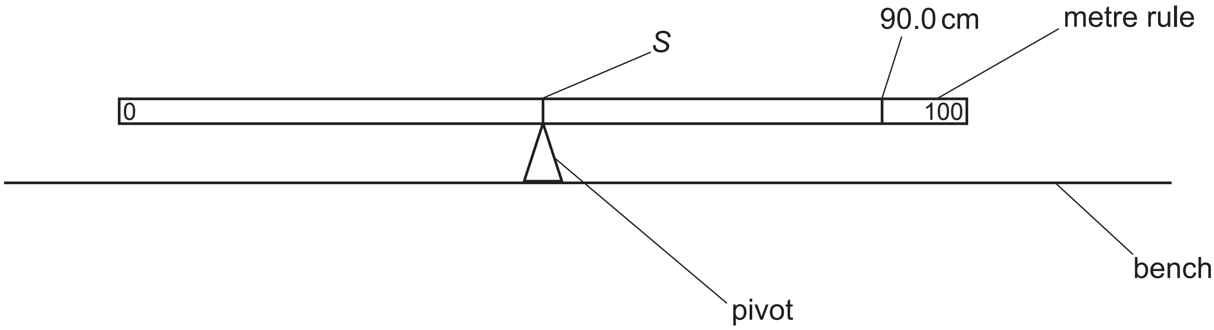


Fig. 3.1

(a) The student places the metre rule on the pivot so that the metre rule is as near as possible to being balanced. Fig. 3.2 shows the position of the pivot.

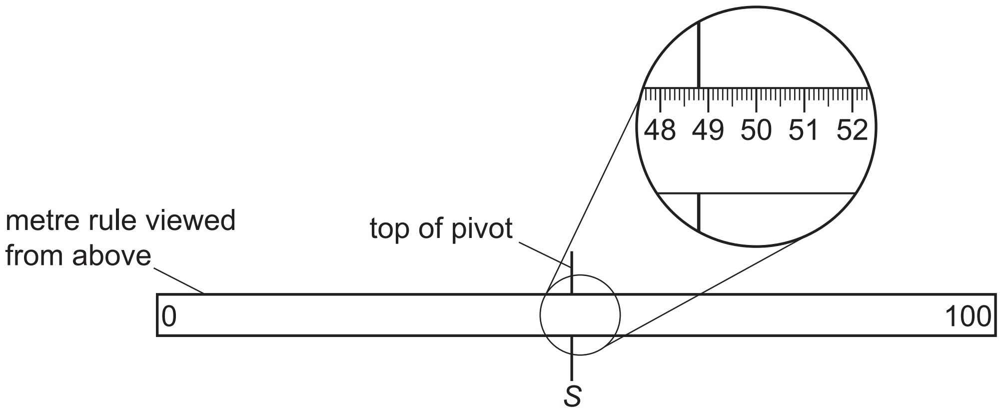


Fig. 3.2

Record the scale reading *S* on the metre rule at the point where the rule balances on the pivot.

S = ... cm [1]

(b) The metre rule is 4 mm thick. The pivot is under the metre rule. The scale is on the top of the metre rule. Suggest how you would obtain an accurate value of the scale reading *S*.

....

.... [1]

(c) • The student places an object Q with its centre on the metre rule at the 90.0 cm mark. The position of Q is not changed during the experiment.

• He places a load P of weight P = 1.0 N on the metre rule.

• He adjusts the position of load P so that the metre rule is as near as possible to being balanced with the pivot directly below the scale reading S.

• He records, in Table 3.1, the distance a from the centre of load P to the centre of load Q.

• He repeats the procedure using loads of weight P = 2.0 N, 3.0 N, 4.0 N and 5.0 N.

• He records all the values of a in Table 3.1.

Complete the column headings in Table 3.1 by inserting the unit in the $\frac{1}{P}$ column.

Table 3.1

P / N	a / cm	$\frac{1}{P}$ /
1.0	80.0	1.00
2.0	59.5	0.50
3.0	54.5	0.33
4.0	50.4	0.25
5.0	47.8	0.20

[1]

(d) Plot a graph of a / cm (y-axis) against $\frac{1}{P}$ (x-axis). Start the y-axis at a / cm = 30.

[4]

(e) Determine the gradient G of the graph. Show clearly on the graph how you obtained the necessary information.

G = ... [3]

(f) The gradient G is numerically equal to the distance d between the pivot and the centre of load Q. Record the value of d to a suitable number of significant figures for this experiment.

d = ... cm [1]

[Total: 11]

4 A student investigates the effect on the resistance of a wire when the tension in the wire is increased. The apparatus is shown in Fig. 4.1. The tension in the wire is increased by adding loads to the hook attached to the wire. The student measures the current I in the wire and the potential difference (p.d.) V across the wire. She determines the resistance R of the wire using the equation $R = \frac{V}{I}$.

The student takes all the necessary safety precautions. You are **not** required to write about safety precautions.

The following apparatus is available:

- resistance wire
- power source, connecting wires and crocodile clips
- ammeter
- voltmeter
- selection of loads and a hanger.

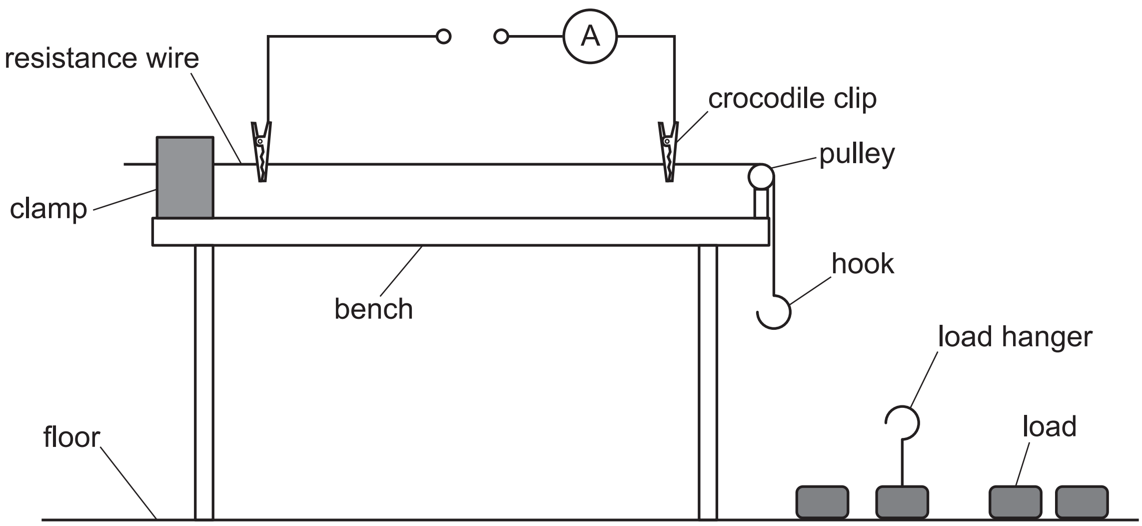


Fig. 4.1

Plan an experiment to investigate the effect on the resistance of a wire when the tension in the wire is increased.

You should:

- complete the circuit diagram in Fig. 4.1 to show a voltmeter connected to measure the potential difference across the resistance wire
- explain briefly how you would carry out the investigation
- state the key variables that you would keep constant
- draw a table, or tables, with column headings, to show how you would display your readings (you are **not** required to enter any readings in the table)
- explain how you would use your readings to reach a conclusion.

....

....

....

....

....

....

....

....

....

....

.... [7]