1 In a light experiment, a plane mirror is placed upright at the corner of a piece of graph paper, as shown in Fig. 1.1. A small lamp acts as a bright object. The lamp is placed over a point L on the edge of the graph paper that is adjacent to the mirror. Note that

1. the mirror has a line drawn on its face,

2. there is a card with a vertical viewing slot.

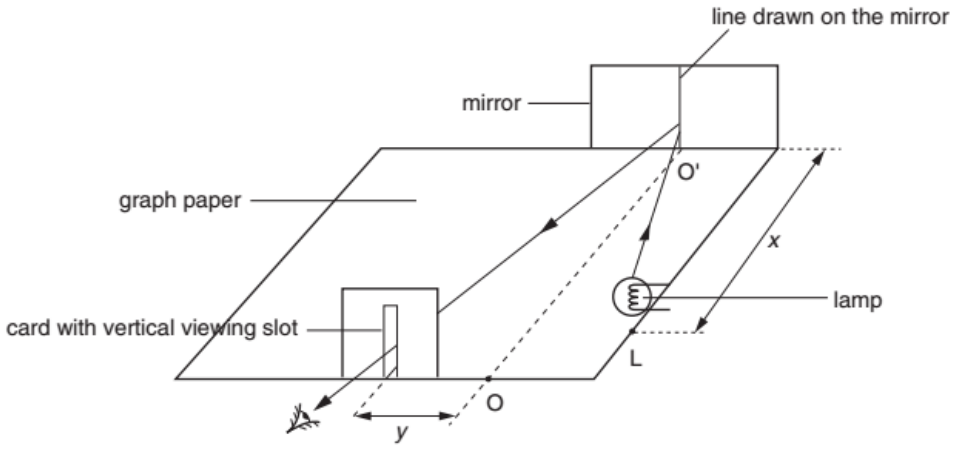


Fig. 1.1

Some of the light rays coming from the lamp are reflected from the line that is drawn on the mirror. These rays are located by looking through the slot in the card. When the card is in the correct position, the slot in the card, the line on the mirror and the lamp appear to be in one straight line.

The distances shown as *y* and *x* are measured.

In all, the experiment was performed with the lamp in four positions. These are shown in Fig. 1.2 on page 3 and are labelled L_1, L_2, L_3 and L_4. The values for *x* are 180 mm, 150 mm, 100 mm and 50 mm.

The corresponding positions for the slot are labelled S_1, S_2, S_3 and S_4.

(a) Fig. 1.2 shows the graph paper and the positions of the lamp labelled L and the slot labelled S. Four incident rays and one reflected ray are shown.

(i) Complete the diagram by drawing the three remaining reflected rays.

(ii) For each reflected ray you have drawn, measure and record the value for *y*.

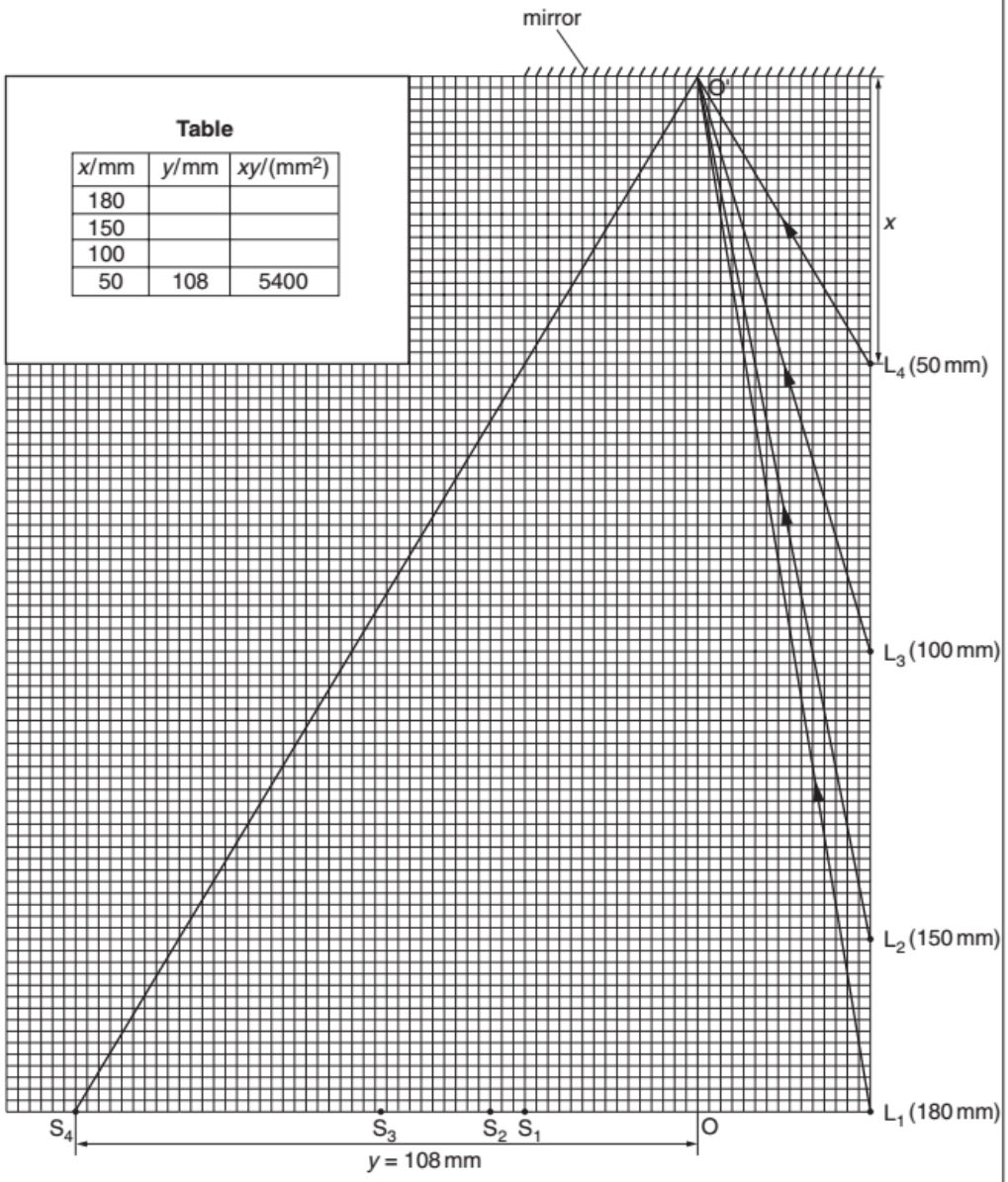
(iii) Complete the table in Fig. 1.2 by calculating the three missing values of *xy*.

[3]

(b) Explain how the viewing slot enables the student to locate the reflected ray.

.....

.....[1]



Table

x/mm	y/mm	xy/(mm^2)
180		
150		
100		
50	108	5400

Fig. 1.2

(c) (i) Determine the average value of the product xy.

average value = ...[1]

(ii) Comment on your values of xy.

.....

.....[1]

For Examiner's Use

2 When a ray of light is incident on a rectangular transparent block at an angle of incidence *i*, the ray of light is refracted. The emergent ray is displaced sideways by a distance *t*.

A student is investigating how *t* depends on the angle of incidence *i*. The apparatus is shown in Fig. 1.1.

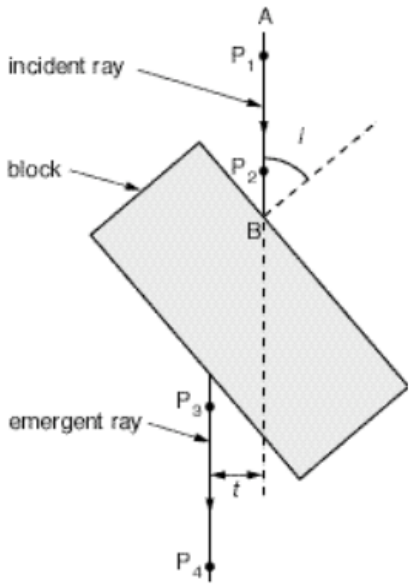


Fig. 1.1

The line AB represents the direction of an incident ray at an angle of incidence of 50°. Two pins P_1 and P_2 are inserted to show the direction of the incident ray. The direction of the emergent ray is found by aligning P_1 and P_2, as seen through the block, with two more pins P_3 and P_4.

The displacement of the ray is measured and both *i* and *t* are recorded in a table. The experiment is repeated with different values for *i*.

(a) Why is it important that the pins P_1, P_2, P_3 and P_4 are standing perpendicular to the piece of the paper?

.....

.....

..... [2]

For Examiner's Use

(b) In the space below, draw a table in which you could record the results of the experiment. Do not write any numerical values in the table.

[1]

(c) Fig. 1.2 shows a sketch graph of the results obtained for a glass block.

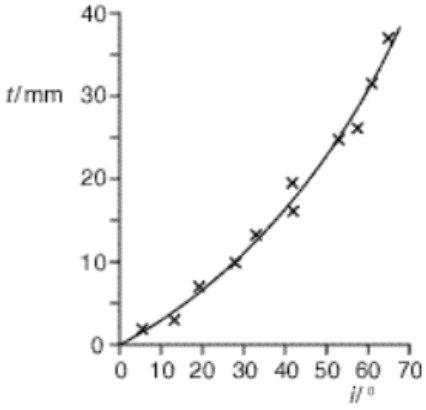


Fig. 1.2

(i) Using the graph, obtain an estimate for the value for t when $i = 10°$.

t = ...

(ii) Suggest two reasons why some of the points do **not** lie on the curve.

1 .....

.....

.....

2 .....

.....

.....

[3]

[Turn over

For Examiner's Use

3 Light from an extended source **XY** is allowed to pass through a circular hole in a piece of card and to illuminate part of a screen. The apparatus is shown in Fig. 1.1.

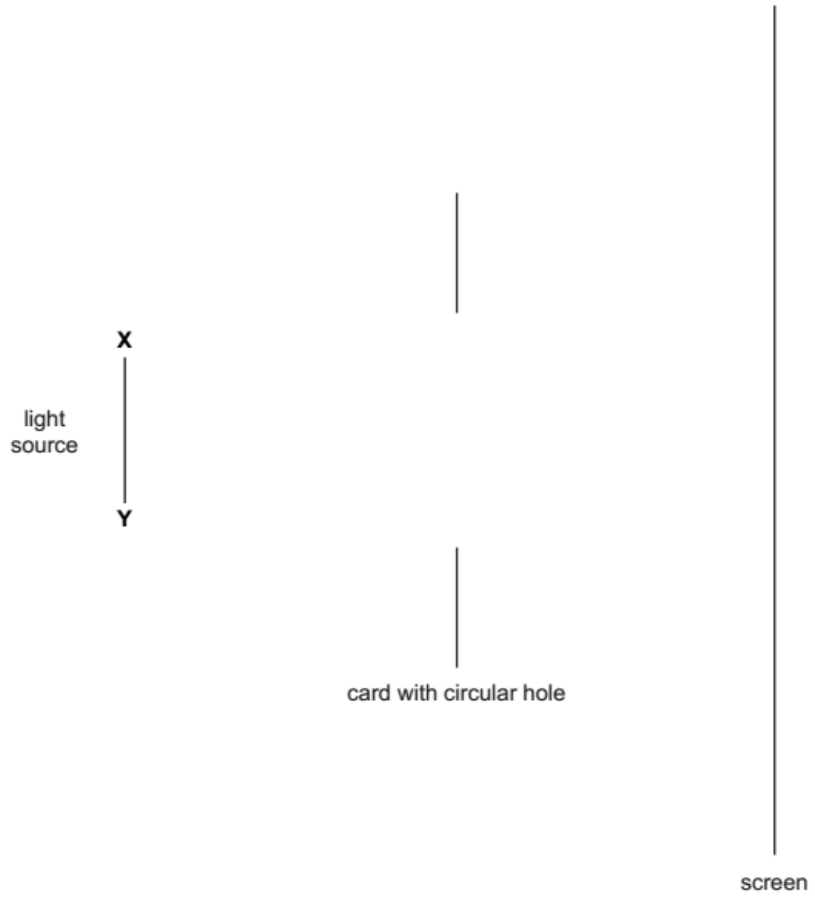


Fig. 1.1

(a) **(i)** Carefully draw the paths of the rays to show the part of the screen illuminated by point **X**. Use the labels $\mathbf{X_1}$ and $\mathbf{X_2}$ to show this part of the screen.

(ii) Carefully draw the paths of the rays to show the part of the screen illuminated by point **Y**. Use the labels $\mathbf{Y_1}$ and $\mathbf{Y_2}$ to show this part of the screen.

[4]

(b) Measure and record the diameter of the area of that part of the screen illuminated by all of the source **XY**.

diameter = ...[1]

For Examiner's Use

4 A converging lens is to be used to produce a focused image on a screen.

A student sets up the apparatus as shown in Fig. 5.1.

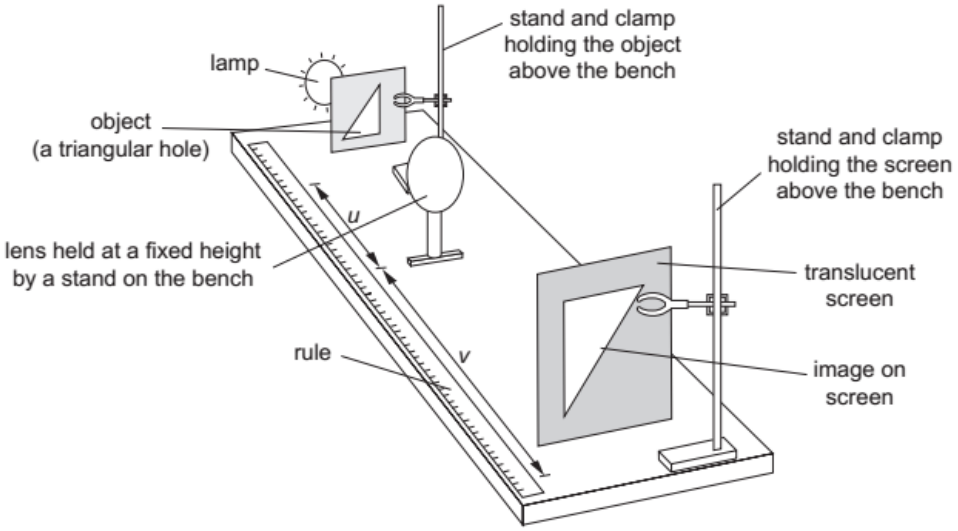


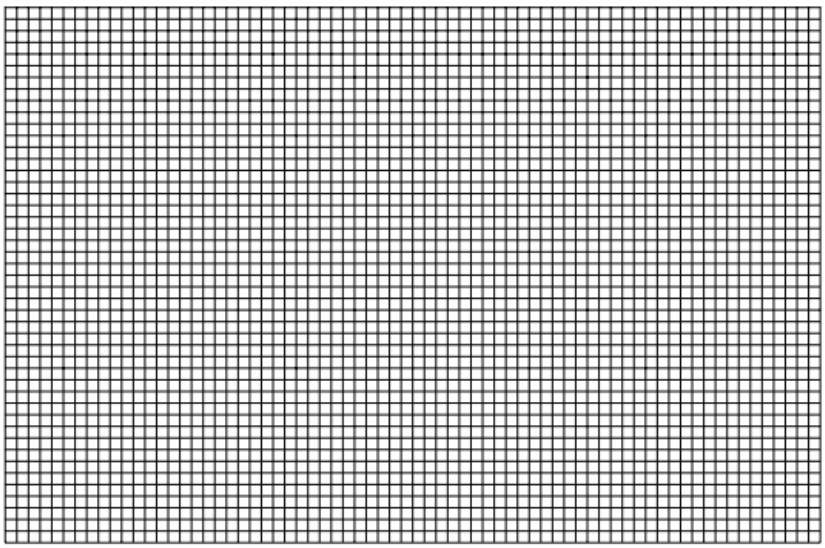
Fig. 5.1

The image is located for different object distances. In each case the distances labelled *u* and *v* are measured. The values obtained are given in Fig. 5.2.

u/mm	169	180	200	222	235	280
v/mm	299	280	234	210	200	175

Fig. 5.2

(a) Using the grid on page 9, plot the graph of *v*/mm (*y*-axis) against *u*/mm (*x*-axis). Start the axes from the point where *u*/mm = 150 and *v*/mm = 150. Draw the best curve through the graph plots. [4]



(b) Another student attempts the experiment. This student does **not** obtain a full image of the object on the screen. In this attempt, only a clear focussed image of the top of the object is formed at the top of the screen.

(i) Draw a diagram to illustrate an arrangement of the apparatus that would cause only this part of the image to appear on the screen. On your diagram, draw a line to show the path of a ray from the top of the object to the corresponding point on the image.

(ii) How would you adjust the apparatus so that a full image appears in the centre of the screen?

.....

.....

[3]

For Examiner's Use

5 In a light experiment, a ray of light is incident on one face of a triangular glass prism.
The path of the incident ray and the path of the emergent ray are marked with small dots P_1, P_2, P_3 and P_4, as shown in Fig. 4.1.

(a) On Fig. 4.1, draw neat lines to represent the incident and emergent rays. Make the two lines long enough so that they cross. Measure the angle between the incident ray and the emergent ray.

angle = ... [3]

(b) The ray of light passes through the glass. On Fig. 4.1, draw the path of the refracted ray inside the glass. [1]

(c) In order to view an object, the normal eye needs to be at least 25 cm away from the object. On Fig. 4.1 the object is labelled O. Fig. 4.1 is a full-size diagram.

On Fig. 4.1, mark with the letter **E** the position where you would place your eye in order to see the object O through the prism. [1]

(d) On Fig. 4.1, draw the angle of incidence at the surface of the prism nearest to the object O. Label the angle *i*. [1]

For Examiner's Use

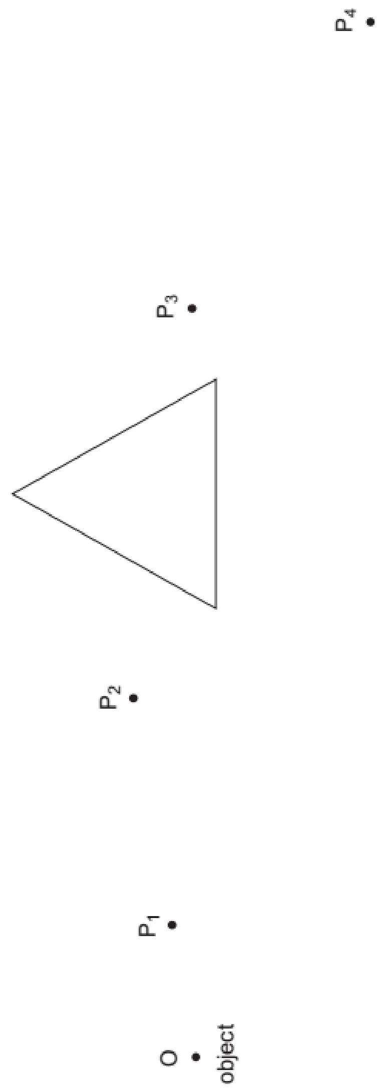


Fig. 4.1

6 A converging lens is used as a magnifying glass. A well-lit scale on a rule is observed through the lens, as shown in Fig. 5.1.

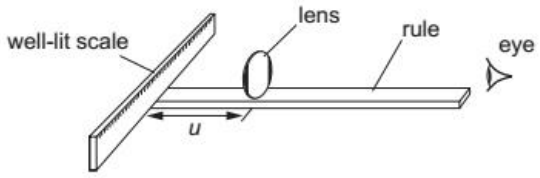


Fig. 5.1

Two labels stuck to the sides of the lens restrict the field of view through the lens. A magnified image of a small part of the scale is observed, as shown in Fig. 5.2. The length *w* of the scale seen through the lens is recorded. The object distance *u* is also recorded.

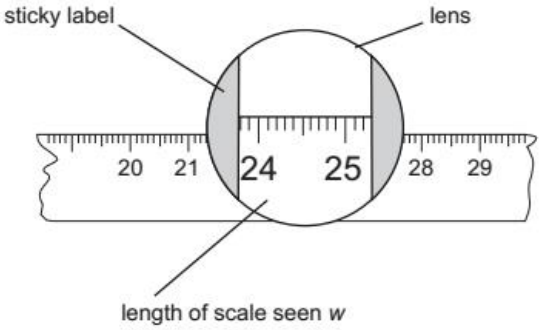


Fig. 5.2

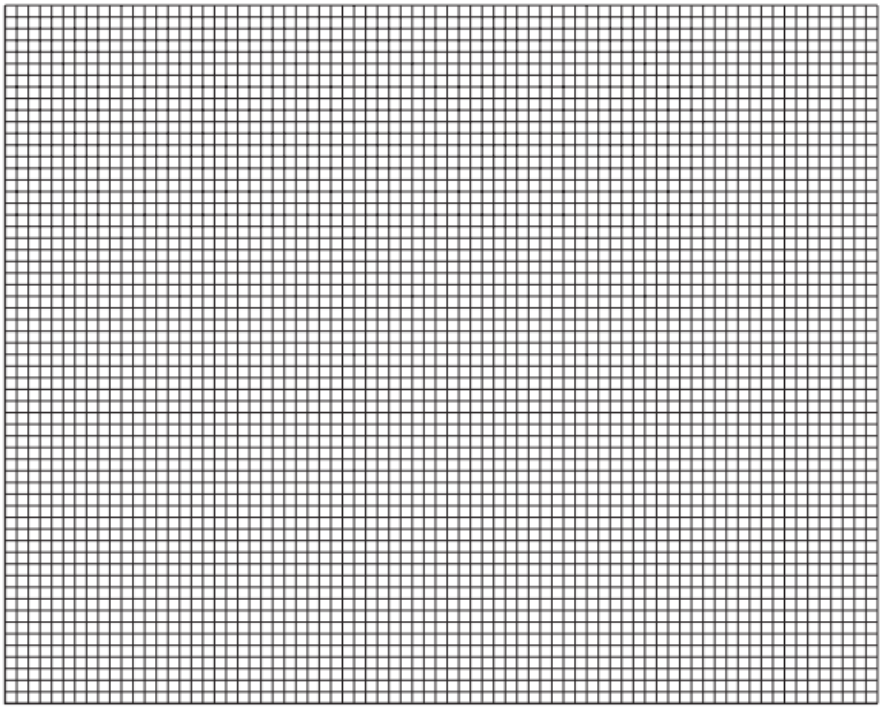
The procedure is repeated for different values of *u* and the values obtained are given in Fig. 5.3.

object distance *u*/mm	19	39	78	82	108	148
length of scale seen *w*/mm	42	37	30	29	26	21

Fig. 5.3

For Examiner's Use

(a) Plot the graph of w/mm (y-axis) against u/mm (x-axis). Draw the best smooth curve through the graph plots. [4]



(b) State how the readings show that the magnification of the scale is greatest for the last set of values, [148, 21]. You may draw a diagram if you wish.

.....

.....

.....[1]

(c) Describe how the magnification of the image of the scale changes as the value of u is increased.

.....

.....[1]

7 A student is asked to measure the focal length *f* of a convex lens. A quick method is used first to obtain a rough estimate for *f*. This is followed by a more accurate experiment.

(a) For the quick estimate, the student forms a focused image of the Sun on a piece of card.

(i) In the space below, sketch a labelled diagram to show how *f* can be measured.

[1]

(ii) The student repeats the experiment in **(a)** using a window 4 m away instead of the Sun. State how this will affect the measurement obtained for *f*.

..... [1]

(b) For the more accurate experiment, the student uses the small illuminated object shown in Fig. 3.1. This object and a plane mirror are set up as shown in Fig. 3.2.

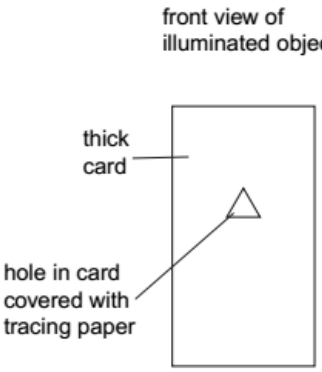


Fig. 3.1

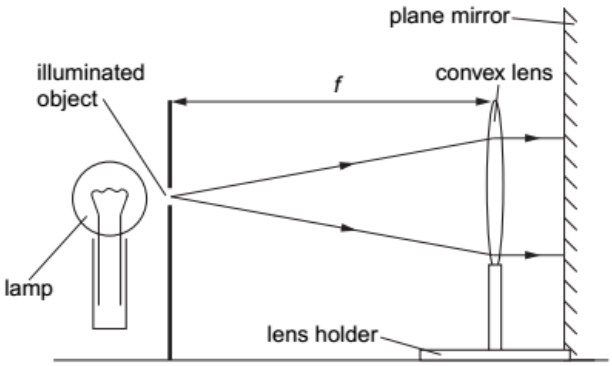


Fig. 3.2

(i) Two rays from the illuminated object to the mirror are shown on Fig. 3.2. Explain why a clear focused image of the illuminated object is seen beside the object on the card.

.....

..... [1]

For Examiner's Use

(ii) State the effect on the image of

1. moving the mirror further away from the lens,

..... [1]

2. moving the lens towards the object.

..... [1]

For Examiner's Use

8 A student measures the volume V of the glass prism shown in Fig. 1.1. A displacement method is used five times.

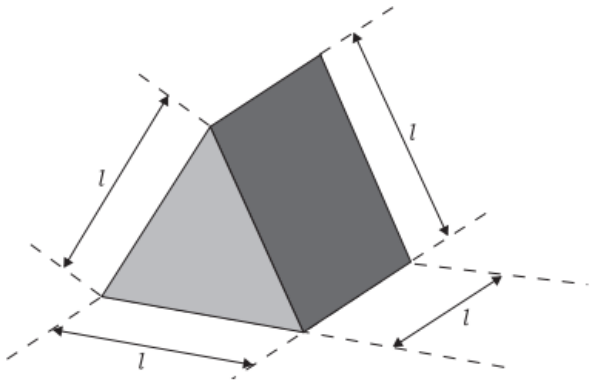


Fig. 1.1

The volumes measured were

$24.8\,cm^3$ $27.8\,cm^3$ $24.5\,cm^3$ $24.3\,cm^3$ $25.0\,cm^3$.

(a) **(i)** Circle the measurement that is **not** consistent with the others. [1]

(ii) Suggest a possible reason for the error in this measurement.

..... [1]

(iii) Calculate the average value for V, ignoring the inconsistent measurement.

V = ... [2]

(b) The volume of the prism is given by

$$V = 0.433l^3$$

where l is the length of the side of the prism.

Use your average value for V to obtain a value for l. Give your answer to a suitable number of significant figures.

l = ... [2]

For Examiner's Use

9 Fig. 3.1 on page 7 shows a rectangular glass block used in a light experiment.

The path of a ray of light incident on one face of the glass block is marked with pins P_1 and P_2. The path of the emergent ray after passing through the block is marked by pins P_3 and P_4.

(a) (i) On Fig. 3.1, draw a straight line of length 20 cm that passes through P_1 and P_2. Label the ends of the line X and Y. [1]

(ii) On Fig. 3.1, draw lines to show the emergent ray and the path of the ray inside the glass block. [1]

(iii) On Fig. 3.1, mark the distance *d* between the line XY and the emergent ray. [1]

(iv) Measure *d*.

d = ... [1]

(b) Use Fig. 3.1 to measure the thickness *t* of the glass block.

t = ... [1]

(c) The refractive index *n* of the glass is given by the equation

$$n \approx \frac{t}{t-2d}.$$

Calculate the refractive index of the glass.

$n \approx$ ..... [1]

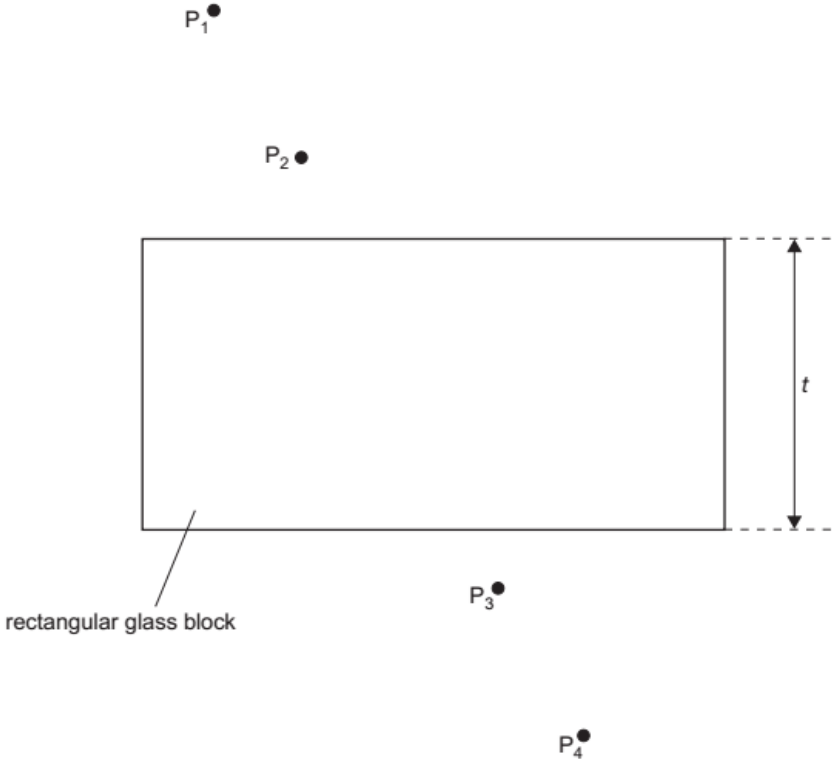


Fig. 3.1

For Examiner's Use

10 A student performs an experiment to find the position of the image of an object in a plane mirror. The student forgets to draw the line of the mirror on the paper he uses.
The paper with the positions of object O and the pins is shown in Fig. 2.1.

The student places two pins P_1 and P_2 on an incident ray from O to the mirror. He places two pins P_3 and P_4 on the reflected ray.

This is repeated with pins Q_1 and Q_2 on a different incident ray and Q_3 and Q_4 on the reflected ray.

(a) On Fig. 2.1,

(i) draw the incident ray from the object through pins P_1 and P_2,

(ii) draw the reflected ray through pins P_3 and P_4,

(iii) continue these two rays and find where they meet. [3]

(b) Repeat **(a)** using pins Q_1, Q_2, Q_3 and Q_4. [1]

(c) On Fig. 2.1, draw a line to show the position of the mirror. Label this line M. [1]

(d) On Fig. 2.1, use the reflected rays to find the position of the image in the plane mirror. Label the image position I. [1]

(e) Measure the distance between O and I.

distance = ... [1]

(f) Explain why the student should observe the bottom of the pins when performing the experiment.

.....

..... [1]

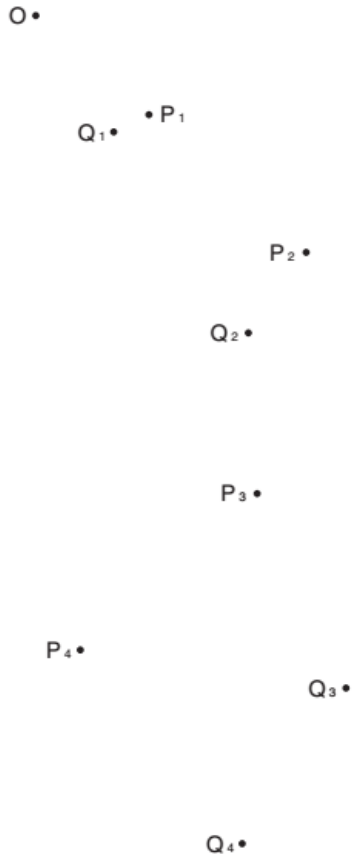


Fig. 2.1

[Turn over

11 A student takes three lenses from a drawer labelled 'convex lenses: $f = 15\,\text{cm}$'.

(a) Describe, with the aid of a labelled diagram, how the student quickly checks that the lenses have the correct focal length.

.....

.....

.....

..... [3]

(b) The student places two of the lenses touching each other, as shown in Fig. 3.1, and then measures the focal length of the two lenses together.

Fig. 3.1

Fig. 3.2

The focal length of two lenses together is found to be 7.5 cm.

The student repeats the experiment with three lenses together, as shown in Fig. 3.2, and the focal length is now 5.0 cm.

State the relationship between the number of lenses and the focal length.

.....

.....

..... [2]

12 A student performs an experiment using optical pins to find the effect of a circular block, made of transparent plastic, on parallel rays of light.

Fig. 4.1 shows the circular plastic block on a sheet of white paper.

The student draws round the block with a sharp pencil. The student also draws three parallel lines up to the block before starting the experiment.

(a) Explain why the student draws round the block.

.....

..... [1]

(b) The student places pins P_1 and P_2 on line 1, representing an incident ray of light.

Describe how the student places pins P_3 and P_4 to locate the emergent ray.

.....

.....

..... [1]

(c) On Fig. 4.1,

(i) complete the path of the ray along line 1 through the block, [1]

(ii) draw the normal at the point where the ray along line 1 enters the block, [1]

(iii) measure the angle of incidence *i* where the ray along line 1 enters the block.

i = ... [1]

(d) Explain why a ray along line 2 passes through the block without changing direction.

.....

..... [1]

(e) On Fig. 4.1, complete the path of a ray along line 3 through the block. [1]

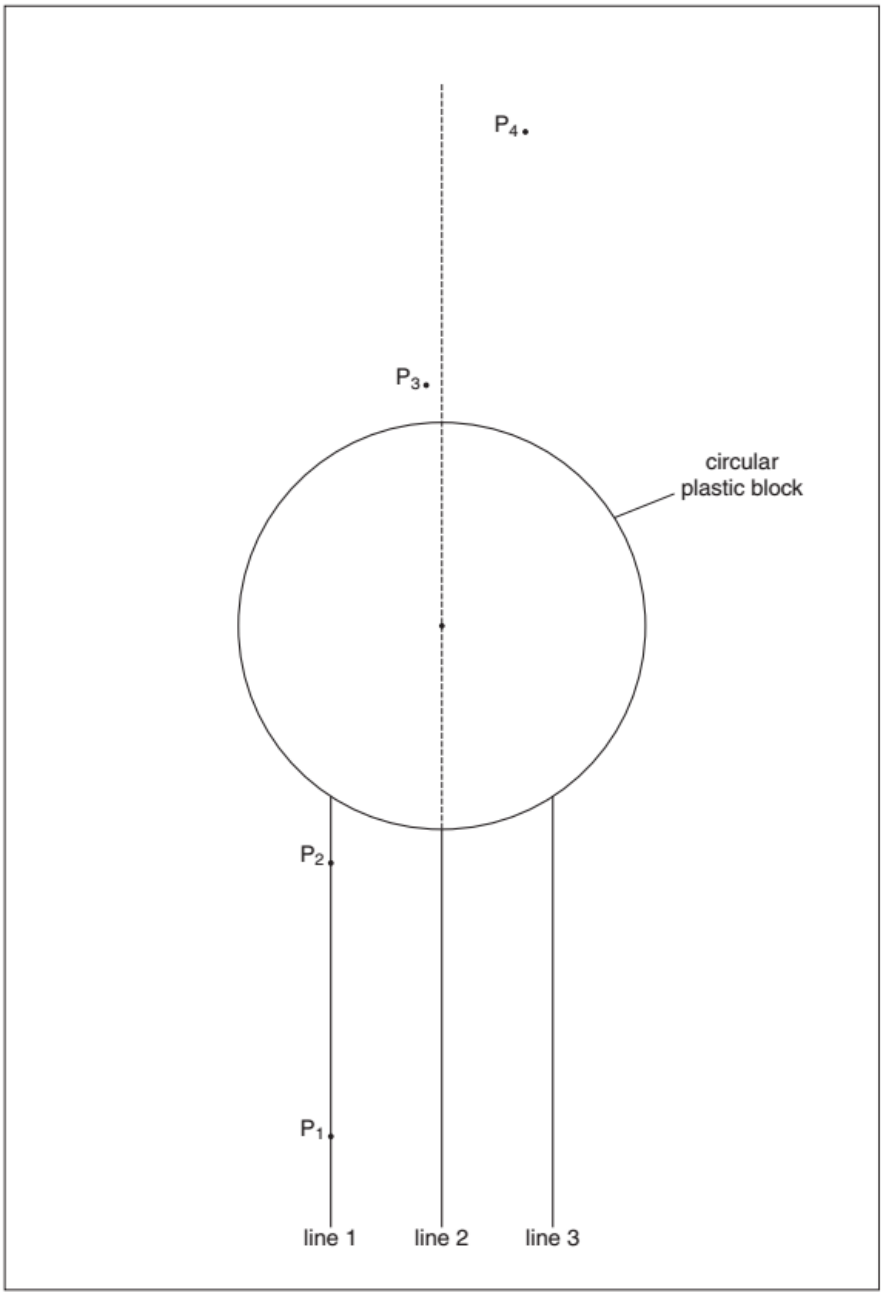


Fig. 4.1

13 A student investigates the effect of a converging lens on light from the Sun.

The student uses a converging lens to produce a clear image of the Sun on a piece of white card, as shown in Fig. 2.1.

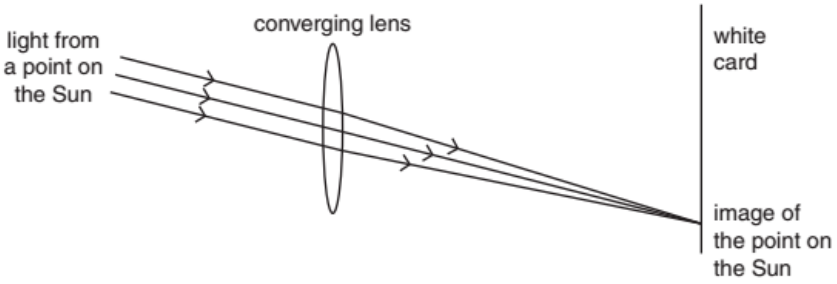


Fig. 2.1 (not to scale)

The student measures the perpendicular distance from the centre of the lens to the white card.

(a) (i) On Fig. 2.1, mark this distance and label it *s*. [1]

(ii) State the name given to this distance.

.....[1]

(b) Describe in detail the experimental techniques used to obtain an accurate value for this distance.

.....

.....

.....

.....

.....

.....[3]

14 A student measures the focal length of a converging lens.

The student sets up the apparatus as shown in Fig. 1.1.

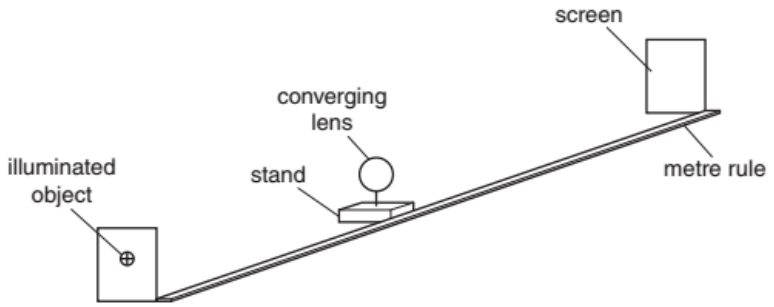


Fig. 1.1

(a) The distance *D* between the illuminated object and the screen is fixed initially at 1.00 m.

(i) The image on the screen is blurred. Describe the adjustment that the student makes to obtain a sharply focused image, without changing *D*.

.....

.....[1]

(ii) The focused image is at the top of the screen. Describe one adjustment that the student makes to move the focused image to the centre of the screen.

.....

.....[1]

(iii) The lens is in a holder on a stand. The position of the centre of the lens is to be marked accurately on the stand. Describe how the student does this.

.....

.....[1]

(b) The student finds that, for the same value of D, there are two positions of the lens that produce a focused image on the screen. These positions are at distances u_1 and u_2 from the illuminated object, as shown in Fig. 1.2.

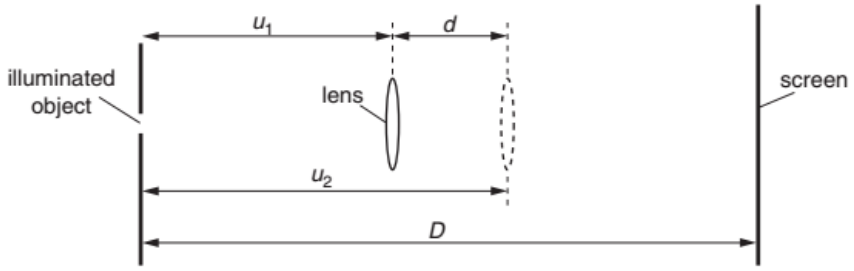


Fig. 1.2

The two distances u_1 and u_2 are measured for $D = 1.00\,\text{m}$.
The values obtained are $u_1 = 0.42\,\text{m}$ and $u_2 = 0.56\,\text{m}$.

(i) Calculate the distance d between the two lens positions.

$d =$ .....[1]

(ii) Theory shows that the focal length f of the lens is given by the relationship

$$f = \frac{(D^2 - d^2)}{4D}.$$

Calculate f.

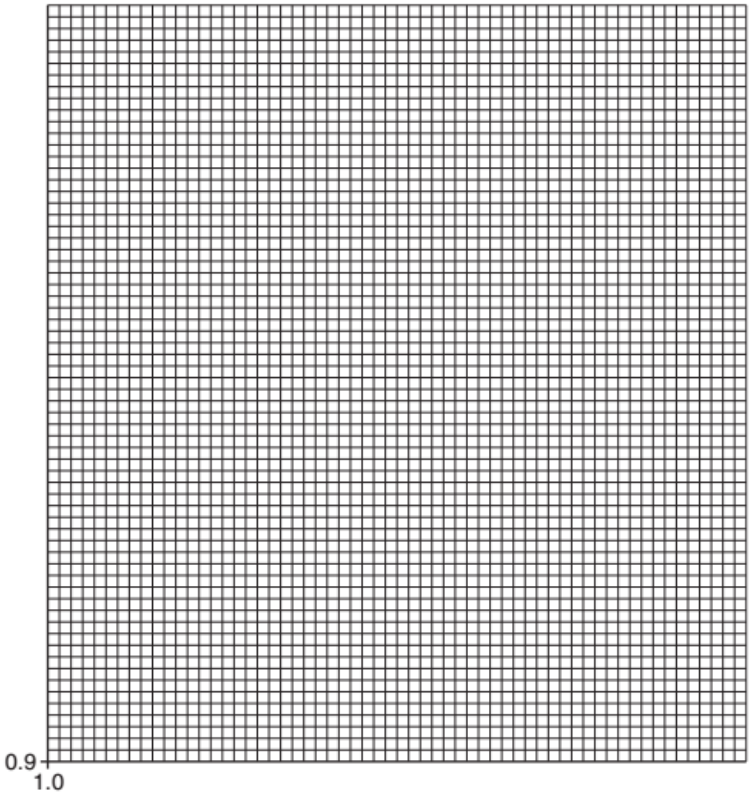
$f =$ .....[1]

(c) The student repeats the experiment for different values of D and calculates values of $(D^2 - d^2)$ each time.
Fig. 1.3 shows the student's results.

D/m	$(D^2 - d^2)$/m^2
1.10	1.08
1.20	1.18
1.30	1.29
1.40	1.38
1.50	1.47

Fig. 1.3

(i) On Fig. 1.4, plot the graph of $(D^2 - d^2)/\text{m}^2$ on the y-axis against D/m on the x-axis.
Start your graph from $(D^2 - d^2) = 0.90\,\text{m}^2$ and $D = 1.00\,\text{m}$.
Draw the straight line of best fit.



[4]

Fig. 1.4

(ii) Determine the gradient of the line of best fit. Show your working clearly.

gradient = ...[2]

(iii) Calculate f using the relationship

$$f = \frac{\text{gradient}}{4}.$$

f = ...[1]

(d) Explain why it is better to determine f using the method in **(c)** rather than the method in **(b)**.

.....

.....[1]

15 A student investigates the deviation of a ray of light by a prism.

For Examiner's Use

A ray of red light passes through the prism. The student places pins P_1 and P_2 on the incident ray and pins P_3 and P_4 on the emergent ray.

Fig. 4.1 on page 11 shows the positions of the pins and the prism.

(a) (i) On Fig. 4.1, draw a straight line through P_1 and P_2.
Continue this line through the prism. [1]

(ii) On Fig. 4.1, draw a straight line through P_3 and P_4.
Continue this line to cross the line drawn in **(i)**. [1]

(iii) Measure the smaller angle between the line drawn in **(i)** and the line drawn in **(ii)**.

angle = ... [1]

(iv) On Fig. 4.1, draw a line to represent the actual path of the ray through the prism. [1]

(b) Suggest why the student uses red light and not white light in this experiment.

.....

..... [1]

Question 4 continues on page 12.

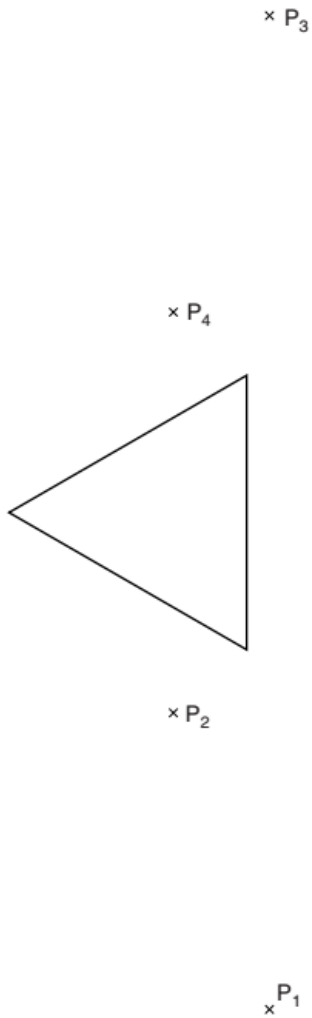


Fig. 4.1

For Examiner's Use

(c) In a different experiment, the student is asked to draw the normal at the point where an incident ray strikes a prism.

For Examiner's Use

The student draws a line, as shown in Fig. 4.2.

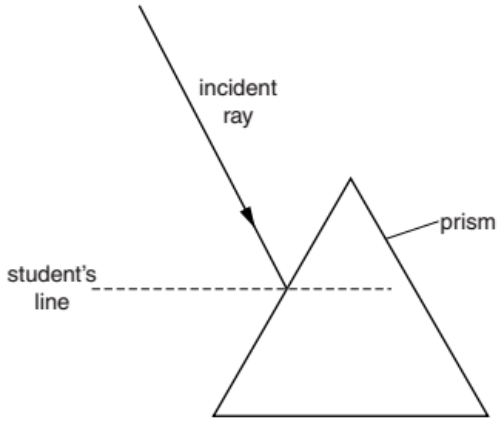


Fig. 4.2

(i) Explain why the student's line is not the normal.

.....

..... [1]

(ii) On Fig. 4.2, draw the correct normal. Measure the angle of incidence *i*.

i = ... [1]

16 A student determines the focal length of a lens.

For Examiner's Use

The apparatus is set up as shown in Fig. 1.1.

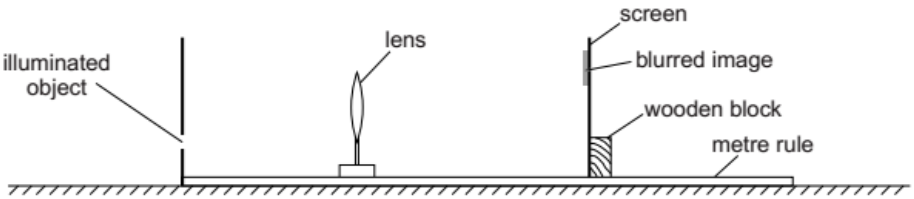


Fig. 1.1 (not to scale)

The illuminated object is fixed at the 0 cm mark on the metre rule.
The perpendicular distance u of the object from the lens is fixed at 15.0 cm.

(a) On Fig. 1.1, mark u and label it 15.0 cm. [1]

(b) The image on the screen is not clear and the centre of the image is above the centre of the lens.
Explain how the apparatus is adjusted

(i) to produce a focussed image on the screen,

.....

..... [1]

(ii) so that the centre of the image is level with the centre of the lens.

.....

..... [1]

(c) The image on the screen is in focus.
The student measures the distance from the object to the screen.
Fig. 1.2 shows an enlarged view of part of the screen and the metre rule.

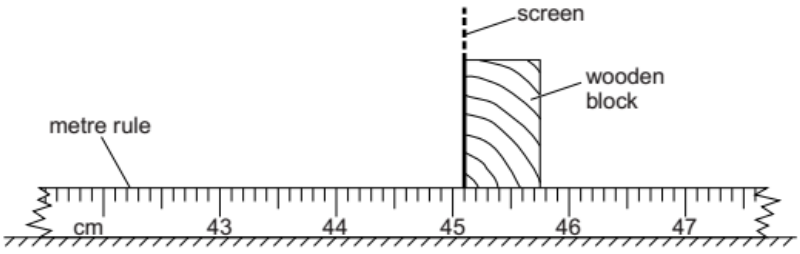


Fig. 1.2

(i) State the reading on the metre rule at the position of the screen.

reading = ... [1]

(ii) Use your answer to **(c)(i)** to calculate the distance v of the image from the lens.

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v = ... [1]

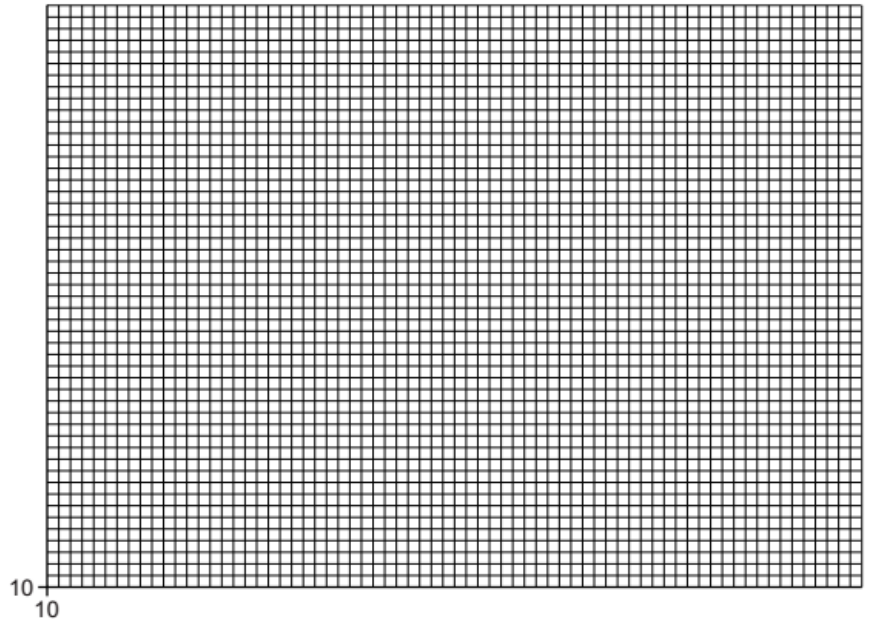
(d) The student repeats the experiment for increasing values of u. The results are recorded in Fig. 1.3.

u/cm	v/cm
20.0	19.8
25.0	16.5
30.0	15.1
35.0	14.2
40.0	13.3

Fig. 1.3

(i) In the spaces in Fig. 1.3, write your value of v from **(c)(ii)** and the corresponding value of u. [1]

(ii) On Fig. 1.4, plot the graph of v/cm on the y-axis against u/cm on the x-axis.
Start your graph from v = 10 cm and u = 10 cm.
Draw a curved line of best fit.



[4]

Fig. 1.4

(e) Suggest two practical techniques that the student uses to make the readings for v as accurate as possible.

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1. .....

.....

2. .....

.....

[2]

(f) When $u = v$, theory shows that the focal length f of the lens is given by $f = u/2$.

Use your graph to determine a value for f.

f = ... [1]

17 A student investigates the reflection of light.

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The student has available:

- a pin board,
- a sheet of plain paper,
- a plane mirror,
- optical pins,
- a pencil, ruler and protractor.

(a) Describe how the student uses the apparatus to verify that the angles of incidence and reflection are equal.
Include a clear labelled diagram in your answer.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) The student carries out the experiment carefully.
Describe one practical technique that improves the accuracy of the experiment.

.....

.....

..... [1]

3 An experiment is carried out to investigate refraction of light through a glass block.

Fig. 3.1 shows a rectangular glass block. A ray of light is incident at P at an angle of incidence of 40°. The angle of refraction in the block is 24°.

(a) On Fig. 3.1, draw lines to represent

(i) the normal at P, [1]

(ii) the refracted ray. [1]

(b) The lower face of the block is labelled XY.

(i) On Fig. 3.1, continue the normal to meet XY. Label this point A.

(ii) On Fig. 3.1, continue the line of the refracted ray to meet XY. Label this point B.

(iii) Measure AB and PB.

AB = ...

PB = ...
[1]

(iv) On Fig. 3.1, continue the line of the incident ray to meet XY. Label this point C.

(v) Measure AC and PC.

AC = ...

PC = ...
[1]

(vi) Theory suggests that the refractive index of the glass is given by the ratio

$$\frac{AC \times PB}{AB \times PC}.$$

Calculate this ratio.
Give your answer to a suitable number of significant figures.

ratio = ...[1]

(c) On Fig. 3.1, draw a line to represent the ray of light that emerges from the block.

Label this line L. [1]

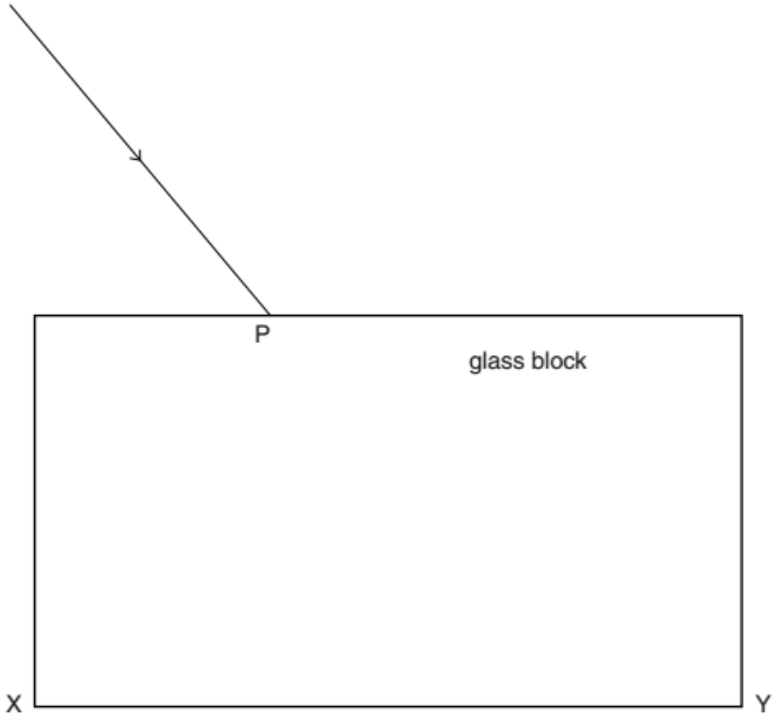

Fig. 3.1

19 A student performs an experiment to obtain an accurate value for the focal length of a converging lens.

His school has lenses with focal lengths 10 cm and 15 cm.
The student is given a lens from a packet labelled 'focal length 10 cm'.

(a) Describe a simple method the student can use in order to check that the lens has a focal length of 10 cm. You may use a diagram in your answer.

.....

.....

..... [1]

(b) The student then uses the apparatus in Fig. 1.1 to obtain an accurate value for the focal length *f* of the lens.

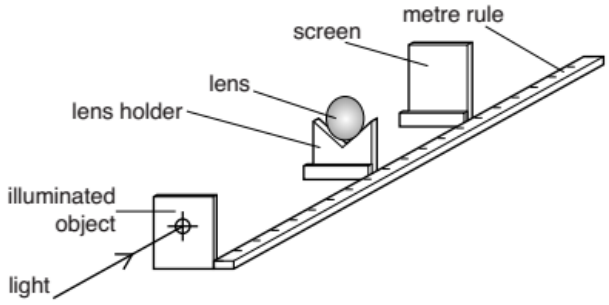

Fig. 1.1 (not to scale)

The student places the lens a measured distance *u* from the illuminated object. He then adjusts the position of the screen until a clear focused image is seen on the screen. He measures the distance *D* from the object to the focused image on the screen.

(i) On Fig. 1.1, mark and label the lengths *u* and *D*. [2]

(ii) The distance *u* is set at 85.0 cm and the student measures the distance *D*. He repeats the experiment and obtains the following values, in cm, for *D*.

96.5 96.3 96.2 96.1 96.2

Calculate D_{av}, the average value of *D*.
Give your answer to three significant figures.

D_{av} = ... [1]

(iii) State one way in which the student can ensure that each measurement of *D* is accurate.

..... [1]

(c) The student repeats the experiment for a range of values of u and obtains a value for D_{av} each time. The results are recorded in Fig. 1.2.

u/cm	D_{av}/cm
85.0	
70.0	81.0
50.0	62.3
25.0	41.6
18.0	40.5
15.0	45.1
12.0	69.5

Fig. 1.2

(i) On Fig. 1.2, add your value of D_{av} for $u = 85.0$ cm from **(b)(ii)**.

(ii) On Fig. 1.3, plot the graph of D_{av}/cm on the *y*-axis against *u*/cm on the *x*-axis. Start your axes from (0, 30).

The graph shows that D_{av} has a minimum value.
Draw the smooth curve of best fit.

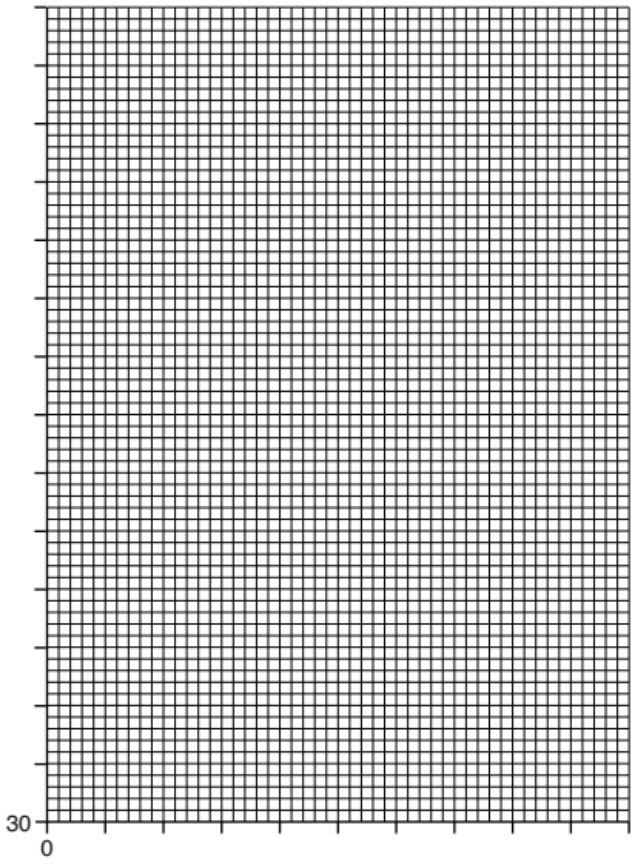

Fig. 1.3

[4]

(iii) Use your graph to find

1. the minimum value of D_{av},

minimum value of D_{av} = ... [1]

2. u_m, the value of *u* when D_{av} is minimum.

u_m = ... [1]

(iv) Theory shows that the minimum value for D_{av} is when $D_{av} = 4f$ and when $u_m = 2f$.

Calculate $\frac{D_{av}}{4}$ and $\frac{u_m}{2}$ from the values you have given in **(c)(iii)**. Comment on your answers.

.....

..... [1]

20 A student investigates the path of a ray of light through a triangular prism.

Fig. 2.1 on page 7 shows the triangular prism placed in the centre of a sheet of white paper.

(a) On Fig. 2.1,

(i) mark and label P, the mid-point of the side AB of the prism, [1]

(ii) draw the normal to the prism at P, [1]

(iii) draw a line to represent a ray of light incident at P with an angle of incidence of 40°. [1]

(b) Fig. 2.2 shows a ray box that produces a narrow ray of light.

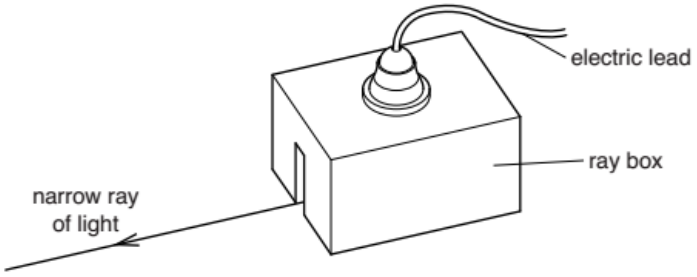

Fig. 2.2

Describe how the student can use the narrow ray of light to find the path of the ray through the prism.

.....

.....

.....

.....

.....

.....

.....

.....[4]

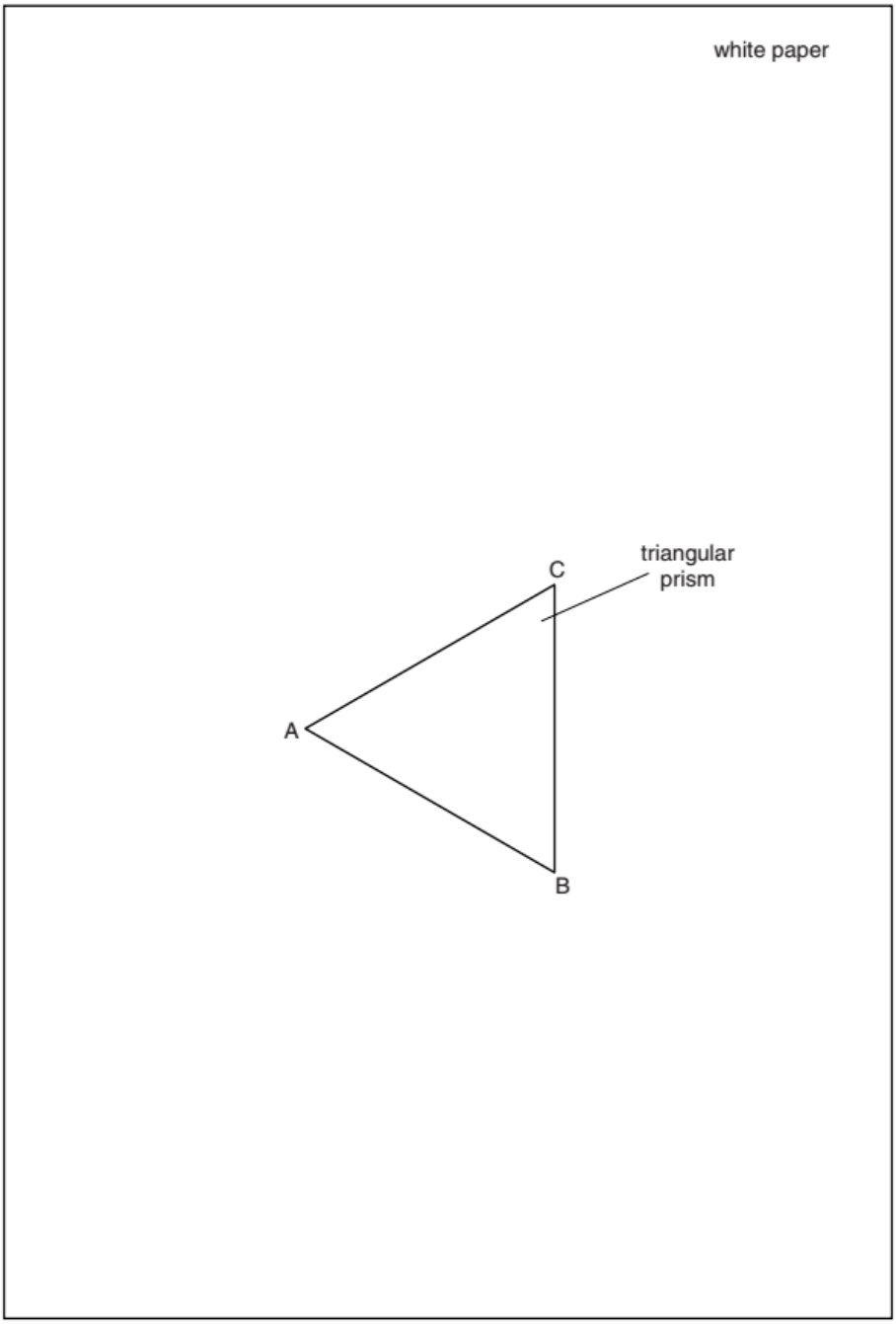

Fig. 2.1

21 An object is moved between a lamp and a screen. A student investigates how the height of th shadow cast by the object on the screen changes.

The apparatus is shown in Fig. 4.1.

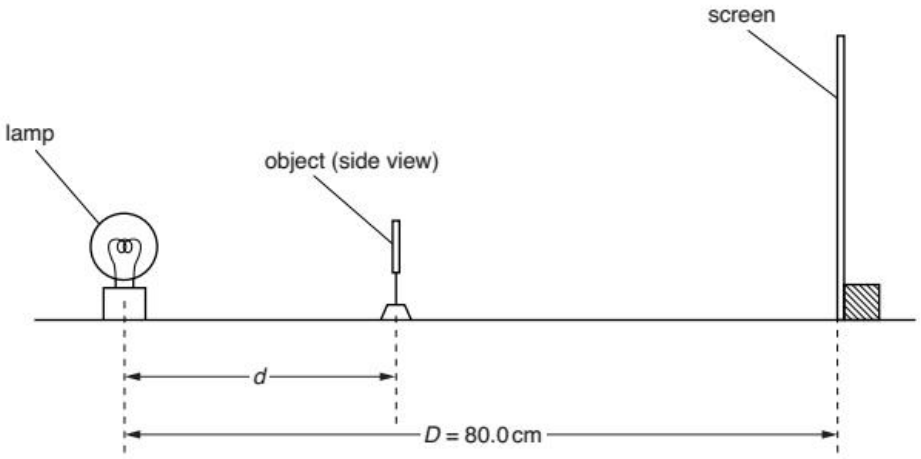

Fig. 4.1 (not to scale)

The object is a square sheet of white card. The length of each side is *H*. The object is attached to a pin and supported by a cork, as shown in Fig. 4.2.

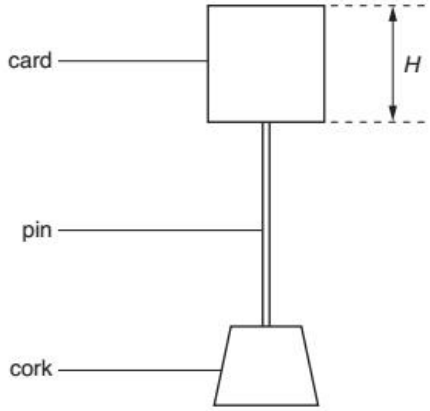

Fig. 4.2 (full size)

(a) Measure and record the length *H* as shown in Fig. 4.2.

H = ... cm [1]

(b) The screen is placed at a distance $D = 80.0\,\text{cm}$ from the centre of the lamp.

She places the object at a distance $d = 70.0\,\text{cm}$ from the centre of the lamp and observes the shadow made by the object on the screen. The shadow is shown in Fig. 4.3.

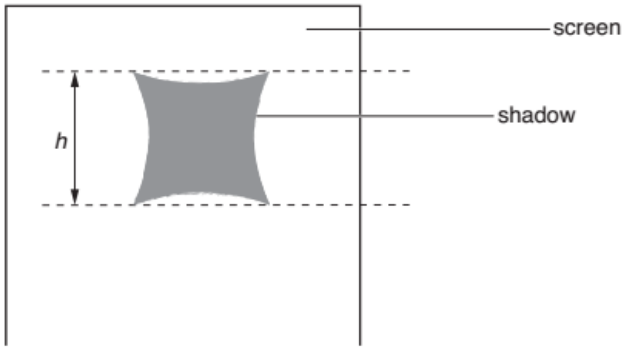

Fig. 4.3 (full size)

(i) Measure and record the length h of the shadow shown in Fig. 4.3.

h = ... cm [1]

(ii) Suggest why it would be difficult to measure accurately the length of the shadow.

.....

.....[1]

(c) She repeats the procedure for values of d of 60.0 cm, 55.0 cm, 45.0 cm, 30.0 cm and 25.0 cm. Her results are recorded in the table of Fig. 4.4.

d/cm	h/cm
70.0	
60.0	2.7
55.0	2.9
45.0	3.6
30.0	5.3
25.0	6.4

Fig. 4.4

(i) Add your value of h from **(b)(i)** to the table in Fig. 4.4.

(ii) On Fig. 4.5, plot a graph of h/cm on the y-axis against d/cm on the x-axis. Start both axes from the origin. Draw the smooth curve of best fit.

Question 4 continues on page 12.

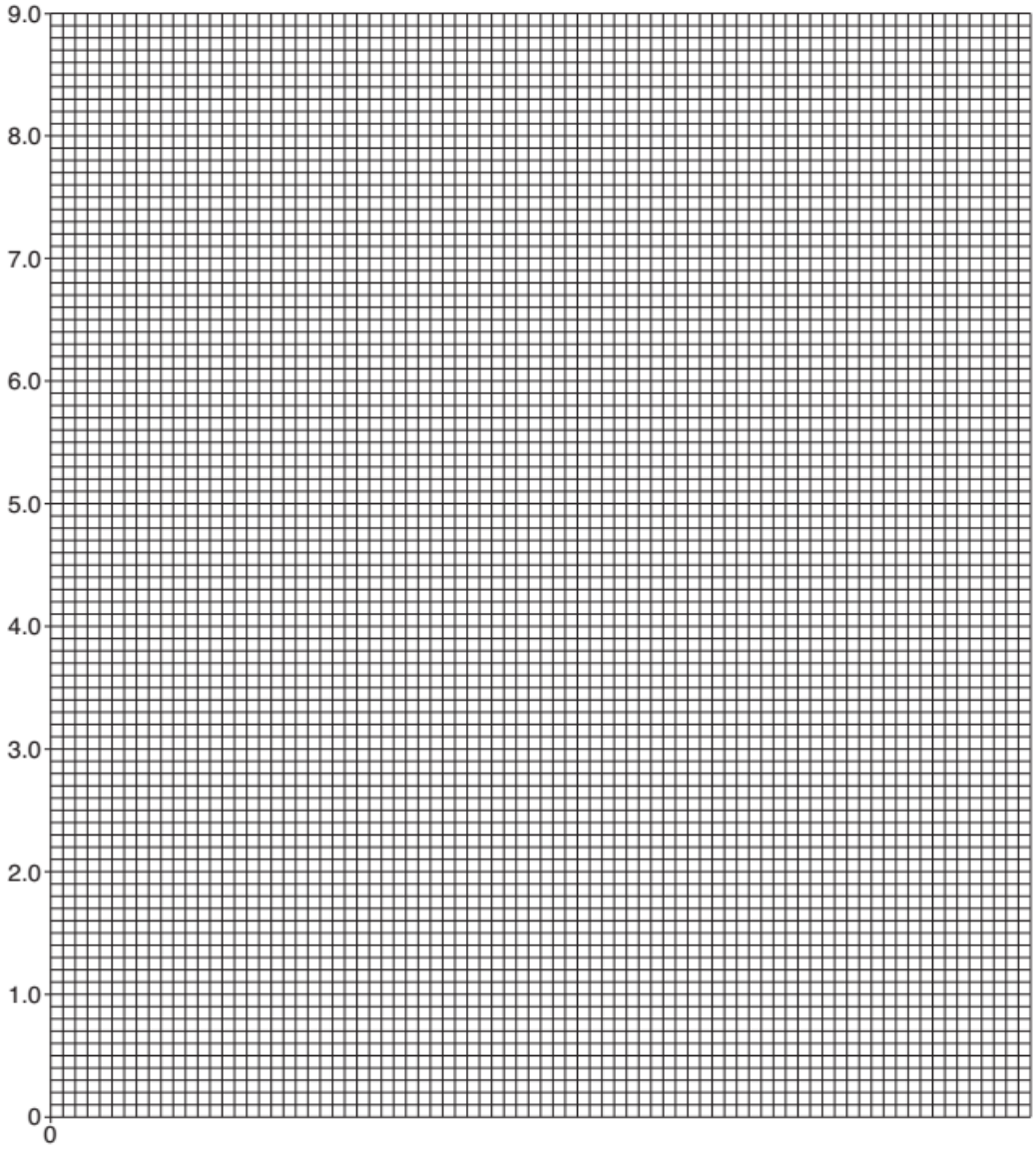

Fig. 4.5

[4]

(d) **(i)** Use your graph to find h_{40}, the value of h when the object is 40.0 cm from the centre of the lamp.

h_{40} = ... cm [1]

(ii) The student suggests that the value of h_{40}, is related to the length H of the object by the equation

$$h_{40} = 2H.$$

Calculate the length H of the object using this equation.

H = ... cm [1]

(iii) Compare the value for H calculated in **(d)(ii)** with the value that you measured in **(a)**.

State whether your results support the student's suggestion and justify your answer by reference to the results.

statement .....

justification .....

.....

[1]

(e) **(i)** Extend your graph to predict the length h_{20} of the shadow when d = 20.0 cm.

h_{20} = ... cm [1]

(ii) The student suggests that the distance d should not be less than 10.0 cm. Give **one** reason why this is a sensible suggestion.

.....

.....[1]

(f) D was kept constant throughout the investigation. Suggest why.

.....

.....[1]

22 A student measures the refractive index of the material of a transparent block ABCD by tracing the path of a ray of light through it.

The experiment is set up as shown in Fig. 3.1.

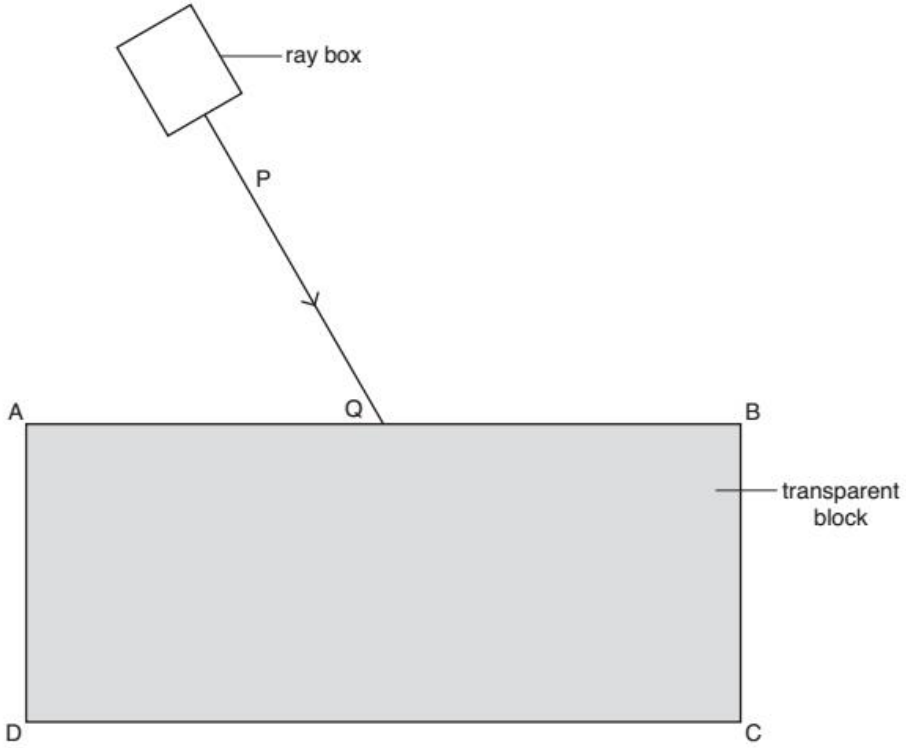

Fig. 3.1

(a) She directs a ray of light PQ from the ray box on to side AB of the block.

(i) On Fig. 3.1, draw a normal to side AB at point Q. Extend the normal so that it crosses side CD. Label the point at which the normal crosses CD with the letter R. [1]

(ii) Measure the angle of incidence α of the ray PQ on side AB.

α = ...[1]

(b) She marks, with crosses, two points on the emergent ray from CD, as shown on Fig. 3.1.

- On Fig. 3.1 draw a line joining the two crosses and continue this line until it meets QR.
- Label the point where the line crosses CD with the letter S and the point where it crosses QR with the letter T.
- Draw a straight line from Q to S.

(i) Measure the length x of QS.

x = ...

(ii) Measure the length y of ST.

y = ...
[2]

(c) The refractive index n of the material of the block is given by the equation

$$n = \frac{x}{y}.$$

Calculate n.

n = ...[1]