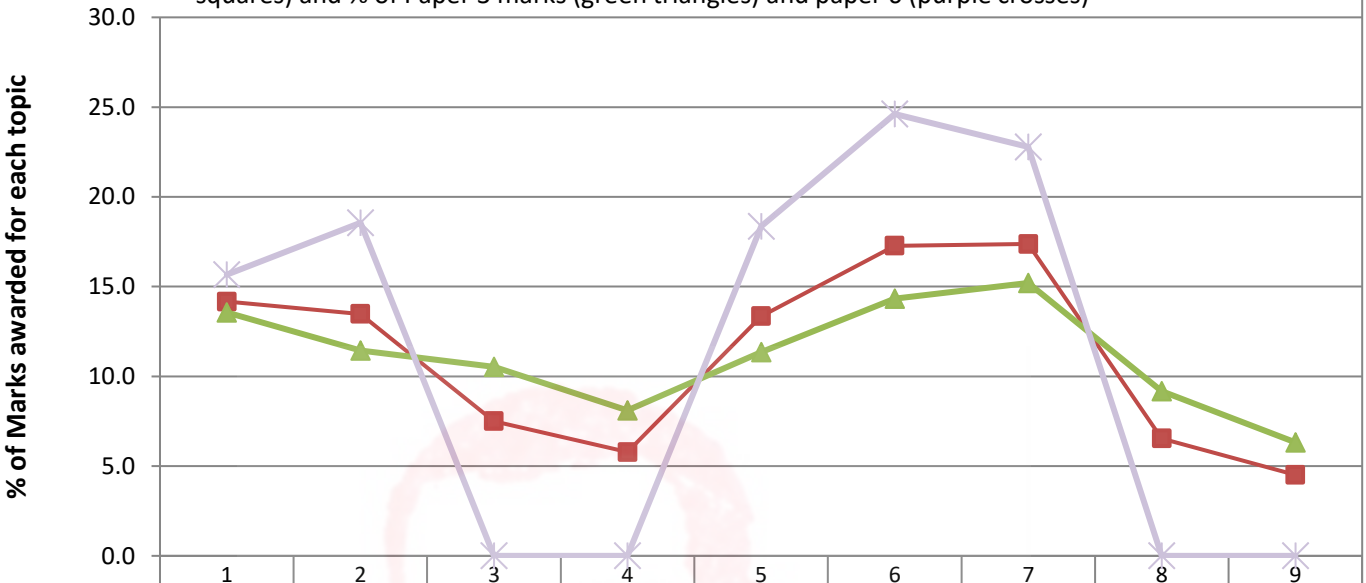
iG Phx 6 EQ 15w to 02s P6 4Students 256marks

For these stats only papers 3 (which after 2016 became paper 4) and paper 6 were used to investigate these topics.

iG Phx CIE 0625 PAPERS 3 and 6

Percentage of all WEIGHTED marks awarded for P3 & 6 each topic from s2002 to w2014 (red squares) and % of Paper 3 marks (green triangles) and paper 6 (purple crosses)

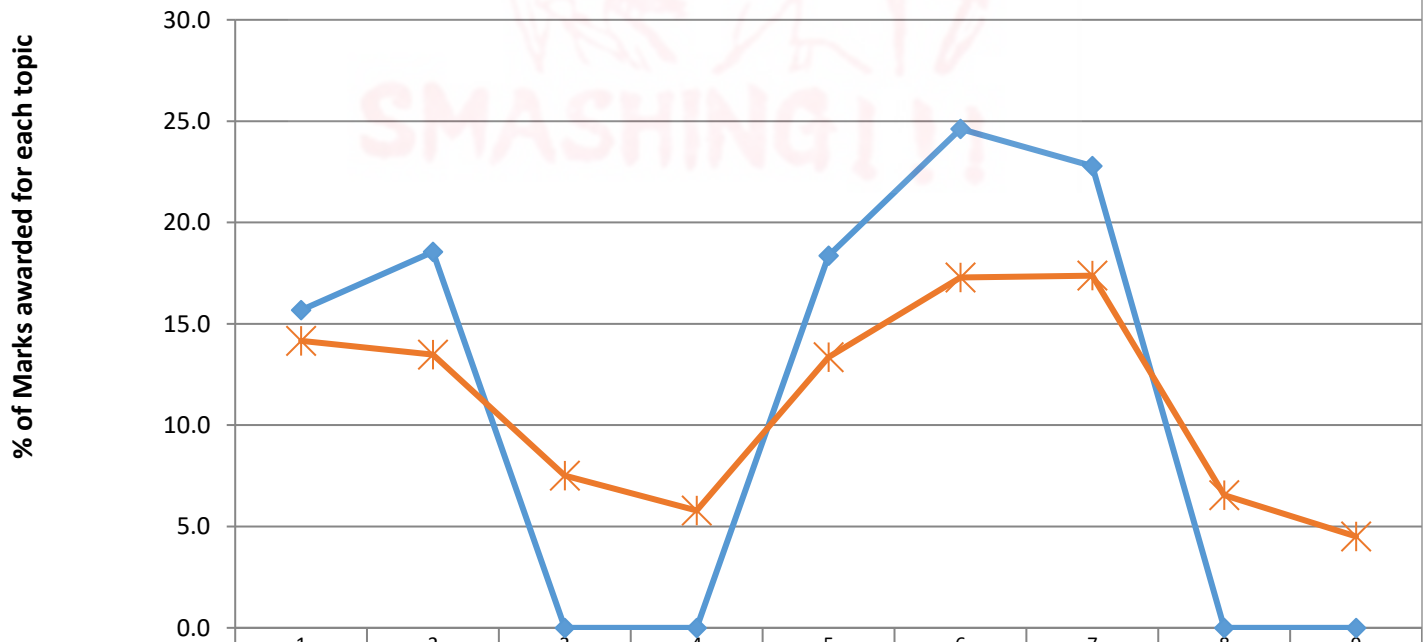


	1	2	3	4	5	6	7	8	9
PhxBoth P3&6	14.2	13.5	7.5	5.8	13.4	17.3	17.4	6.5	4.5
PhxP3	13.6	11.4	10.5	8.1	11.3	14.3	15.2	9.2	6.3
PhxP6	15.7	18.6	0.0	0.0	18.4	24.6	22.8	0.0	0.0

Papers 3 and 6 Topic Number

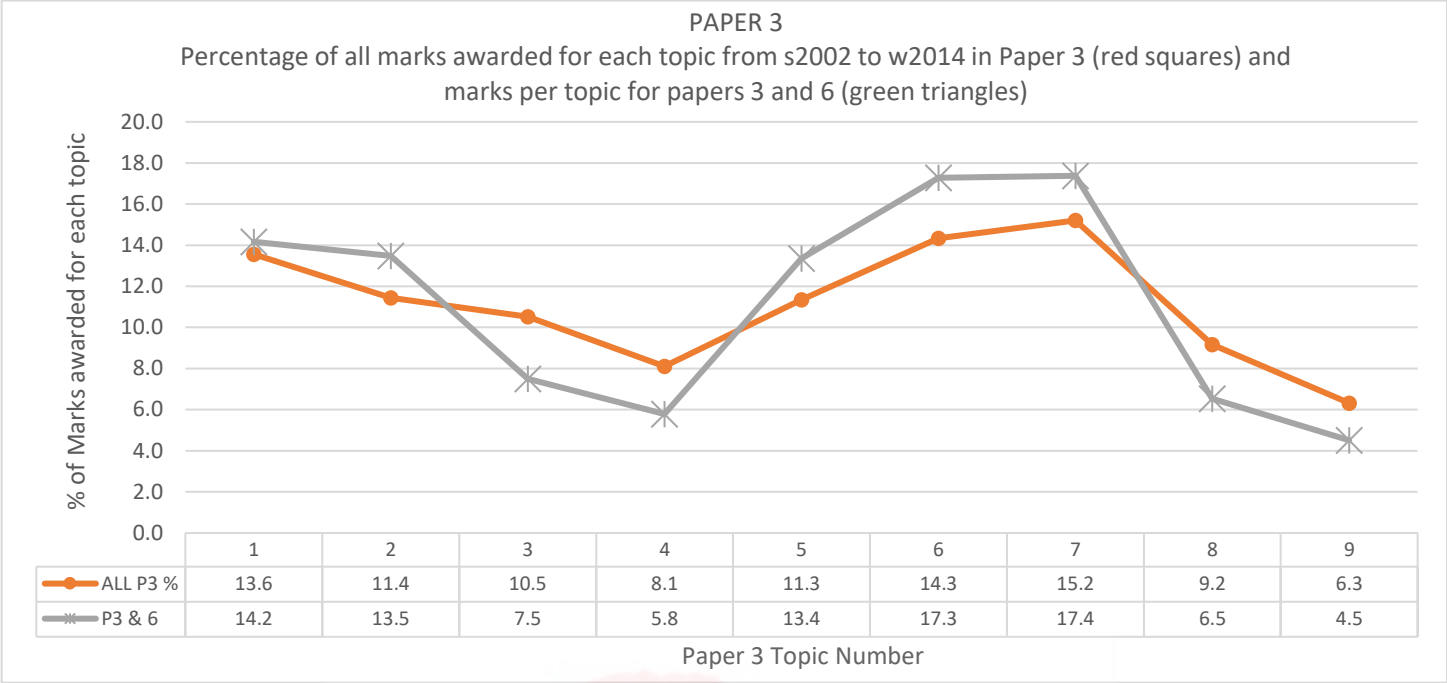
PAPER 6

Percentage of all marks awarded for each topic from s2002 to w2015 in Paper 6 (blue diamonds) and marks per topic for both papers 3/4 and 6 (red squares)



	1	2	3	4	5	6	7	8	9
PhxP6	15.7	18.6	0.0	0.0	18.4	24.6	22.8	0.0	0.0
PhxP3&6 weighted	14.2	13.5	7.5	5.8	13.4	17.3	17.4	6.5	4.5

Paper 6 Topic Number



Papers covered in this sample:

	1st Paper	Last Paper	Marks/ paper	Theor. All Papers	Actual All Marks	Difference	Difference %	Weight per paper	Weight per mark
Paper 3	2002w	2014w	80	2000	2072	72	3.6	50	0.63
Paper 6	2002s	2015w	40	1120	1040	-80	-7.1	20	0.50

There are a few missing: Got all Paper 31s (except 2014w Paper 31), and got 2014w 33. So papers in time zones 2 and 3 are not covered.

All topics ranked by frequency of marks in exams (P3 and 6 only):

Topic	PhxBoth P3&6	PhxP3	PhxP6
7	17.4	15.2	22.8
6	17.3	14.3	24.6
1	14.2	13.6	15.7
2	13.5	11.4	18.6
5	13.4	11.3	18.4
3	7.5	10.5	0.0
8	6.5	9.2	0.0
4	5.8	8.1	0.0
9	4.5	6.3	0.0

Other statistics that might be of interest:

	Topics:	1	2	3	4	5	6	7	8	9
P3/4 marks	2072	281	237	218	168	235	297	315	190	131
P3/4 %		13.6	11.4	10.5	8.1	11.3	14.3	15.2	9.2	6.3
P6	1040	163	193	0	0	191	256	237	0	0
P6 %		15.7	18.6	0.0	0.0	18.4	24.6	22.8	0.0	0.0
Total Marks (WIEGHTED)	1815	257	245	136	105	242	314	315	119	82
% of Marks (Weighted)	1815	14.2	13.5	7.5	5.8	13.4	17.3	17.4	6.5	4.5
# of Questions		63	64	35	16	63	74	70	26	20
Average marks per Q		**4.1**	**3.8**	**3.9**	**6.6**	**3.8**	**4.2**	**4.5**	**4.6**	**4.1**

Final note:

My iG and IB chemistry papers were broken down more carefully than these were, so there may be a mark or two in the wrong topic especially in topics 3 to 5, but if you learnt or taught these topics in sequence than you shouldn't have a problem with seeing material from an earlier topic.

Defining the Topics: Why not use the units given in the syllabus?

Artificial topics have been created for the physics syllabus by me so that each topic is roughly the same size. Topics go in syllabus order. I have decided to use the number of marks allocated in previous exams to each syllabus point to determine how many go into each topic.

1. General physics

Topic 1

1.1 Length and time
1.2 Motion
1.3 Mass and weight
1.4 Density

Topic 2

1.5 Forces
1.6 Momentum (Extended candidates only)

Topic 3

1.7 Energy, work and power
1.8 Pressure

2. Thermal physics

Topic 4

2.1 Simple kinetic molecular model of matter

Topic 5

2.2 Thermal properties and temperature
2.3 Thermal processes

3. Properties of waves, including light and sound

Topic 6

3.1 General wave properties
3.2 Light
3.3 Electromagnetic spectrum
3.4 Sound

4. Electricity and magnetism

Topic 7

4.1 Simple phenomena of magnetism
4.2 Electrical quantities
4.3 Electric circuits
4.4 Digital electronics (Extended candidates only)
4.5 Dangers of electricity

Topic 8

4.6 Electromagnetic effects

5. Atomic physics

Topic 9

5.1 The nuclear atom
5.2 Radioactivity

4 The class is investigating the refraction of light passing through a transparent block.

Fig. 4.1 shows a student's ray-trace sheet.

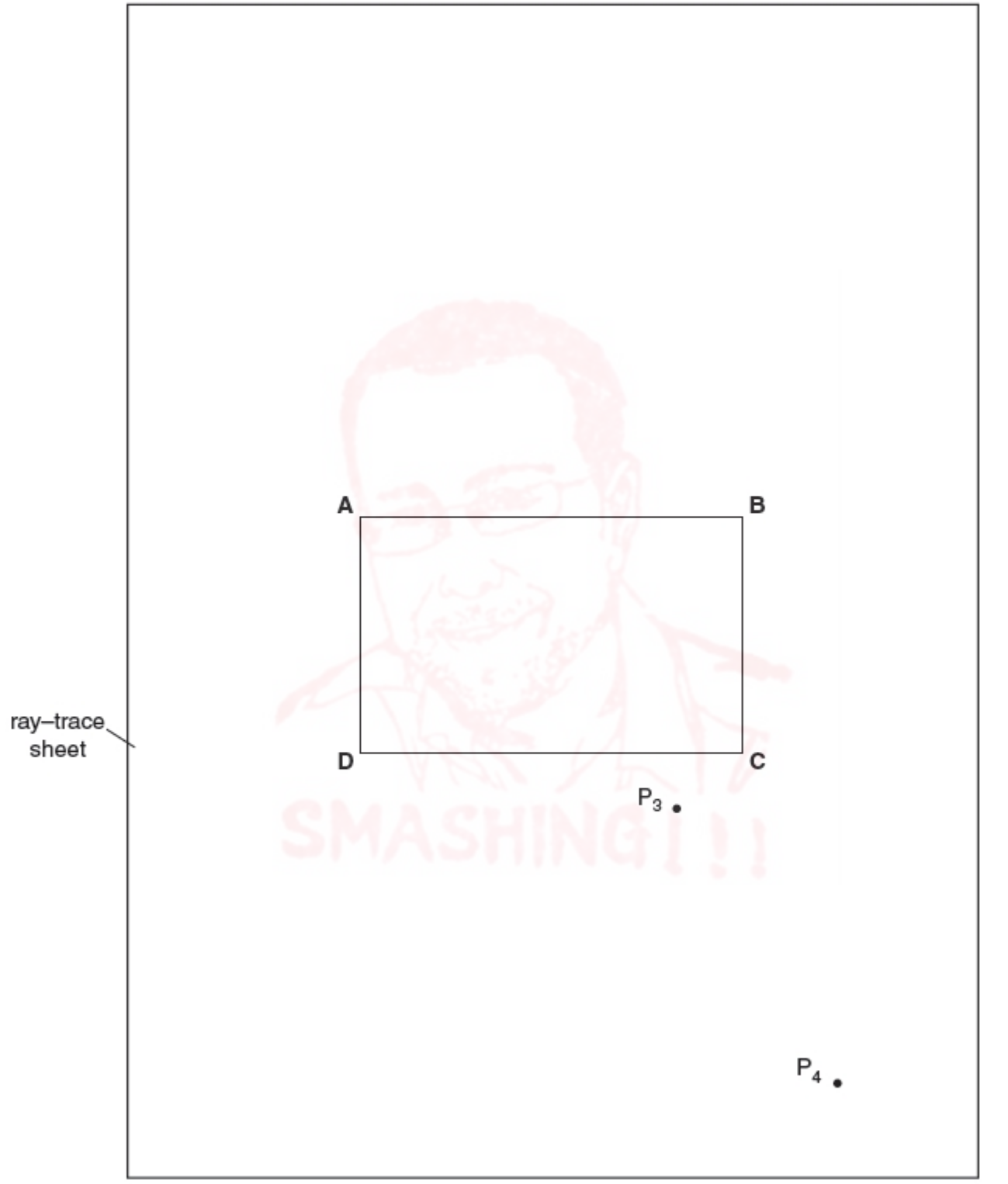


Fig. 4.1

A student draws the outline **ABCD** of a transparent block.

(a) **(i)** Draw 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**.

(ii) Draw a line **GH**, parallel to **AB** and 6.0 cm above **AB**. Label the point **J** where the normal crosses **GH**.

(iii) Draw a line, starting at **E**, to the left of the normal and at an angle of incidence $i = 30°$ to the normal. Label the point **F** where the line meets **GH**.

[3]

(b) The student places two pins P_1 and P_2 on the line **FE**.

On Fig. 4.1, label suitable positions for pins P_1 and P_2. [1]

(c) 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.

She places two pins P_3 and P_4 between her 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 shown on Fig. 4.1.

(i) Draw a line joining the positions of P_3 and P_4. Continue the line until it meets **CD** and label this point **K**.

(ii) Draw the line **KE**.

[1]

(d) **(i)** Measure and record the length *a* between points **F** and **J**.

a = ...

(ii) Measure and record the length *b* between points **F** and **E**.

b = ...

(iii) Measure and record the length *c* between points **E** and **K**.

c = ...

(iv) Measure and record the length *d* between points **M** and **K**.

d = ...

[1]

(v) Calculate *n*, the refractive index of the material of the block, using the equation $n = \frac{ac}{bd}$.

n = ...[1]

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

.....

.....

.....[1]

(f) Fig. 4.2 shows a ray box.

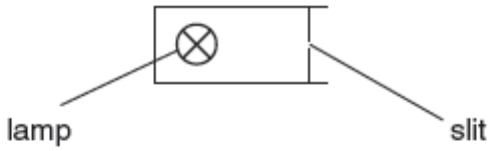


Fig. 4.2

This experiment can be carried out using a ray box instead of the pins.

On Fig. 4.1, draw a ray box in a suitable position for this experiment. [1]

[Total: 9]

1 The IGCSE class is investigating the reflection of light by a plane mirror. Fig. 1.1 shows a student's ray-trace sheet.

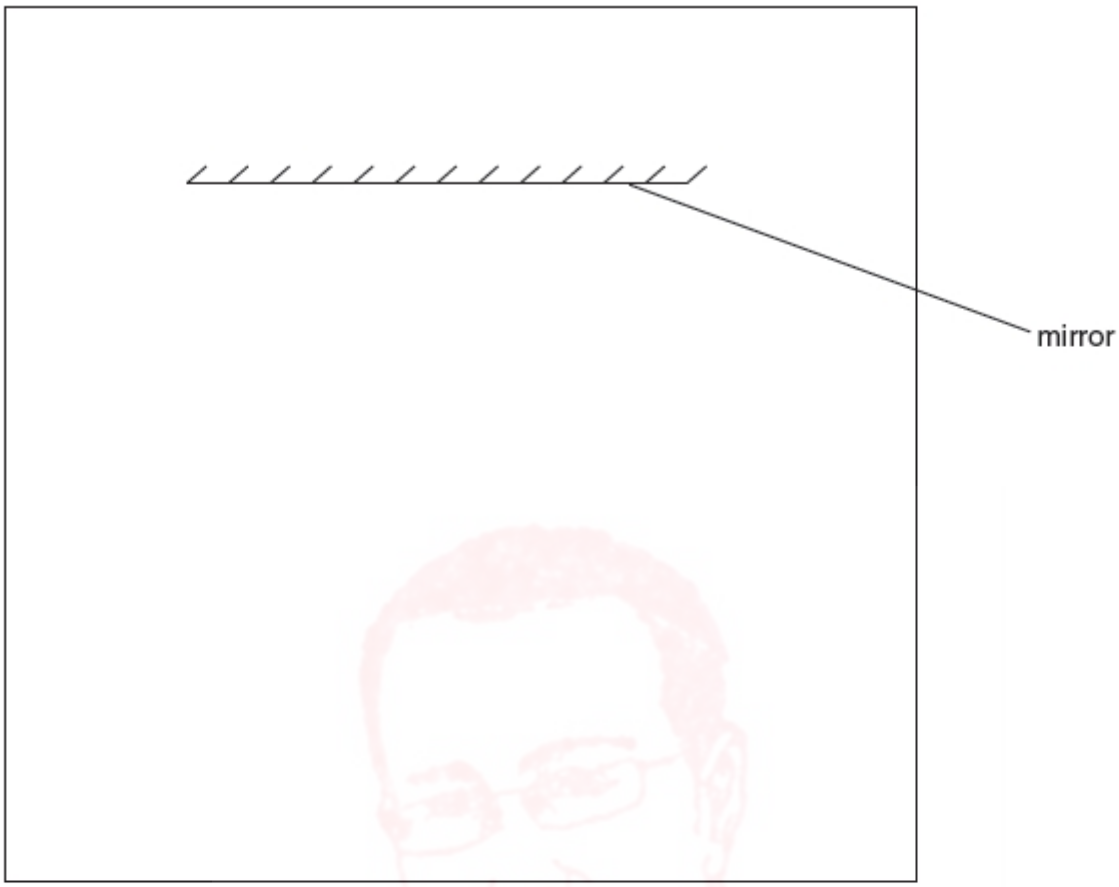


Fig. 1.1

(a) On Fig. 1.1, draw a normal to the centre of the mirror. [1]

(b) On Fig. 1.1, draw an incident ray at 30° to the normal and to the left of the normal. [1]

(c) Fig. 1.2 shows a diagram of a ray box.

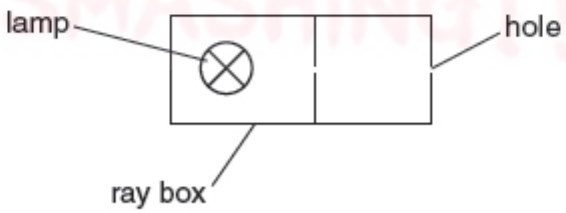


Fig. 1.2

On Fig. 1.1, draw the ray box in a suitable position to produce the incident ray that you have drawn. [1]

(d) On Fig. 1.1, draw a reflected ray in the position you would expect it to be using the incident ray that you have drawn. [1]

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

1. .....

.....

2. .....

.....

[2]

[Total: 6]

4 The IGCSE class is determining the magnification of an image produced by a lens.

The apparatus is shown in Fig. 4.1.

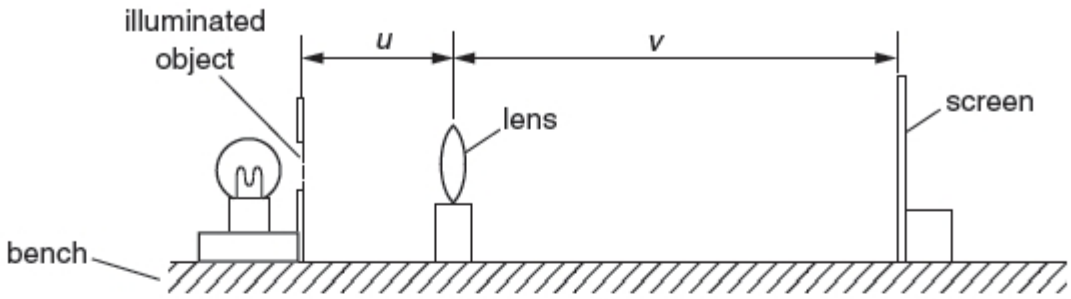


Fig. 4.1

(a) (i) On Fig. 4.1, measure and record in mm the distance *u* from the illuminated object to the centre of the lens.

u = ... mm

(ii) On Fig. 4.1, measure and record in mm the distance *v* from the centre of the lens to the screen.

v = ... mm
[1]

(b) Calculate the ratio $\frac{v}{u}$.

$\frac{v}{u}$ = ... [1]

(c) The diagram is drawn one tenth of actual size.

(i) Calculate the actual distance *U* from the illuminated object to the centre of the lens.

U = ... mm

(ii) Calculate the actual distance *V* from the centre of the lens to the screen.

V = ... mm
[1]

(d) The student measures the height *h* from the top to the bottom of the image on the screen.

h = 4.5 cm

(i) On Fig. 4.2, measure the height x of the illuminated object.

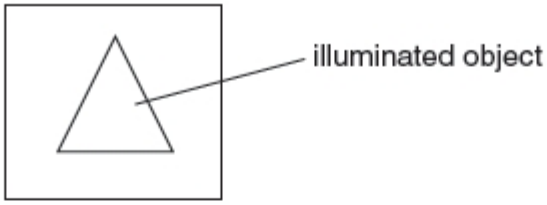


Fig. 4.2 (full size)

x = ...

(ii) Calculate $\frac{h}{x}$.

$\frac{h}{x}$ = ...
[1]

(e) The magnification m of the image is given by the equation $m = \frac{h}{x}$. The student suggests that the ratio $\frac{V}{U}$ also gives the magnification m. State whether the results support this suggestion and justify your answer by reference to the results.

statement .....

justification .....

.....
[2]

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

1. .....

.....

2. .....

.....
[2]

(g) The image on the screen in this experiment is magnified and dimmer than the object.

State one other difference that you would expect to see between the image and the illuminated object.

.....[1]

(h) Suggest one precaution that you would take in this experiment in order to focus the image as clearly as possible.

.....

.....[1]

[Total: 10]

5 The IGCSE class is investigating reflection using a plane mirror.

Fig. 5.1 shows a student's ray-trace sheet with a line **MR** drawn on it. In the experiment the reflecting face of a mirror is placed vertically on the line **MR**. The additional dashed line shows a second mirror position.

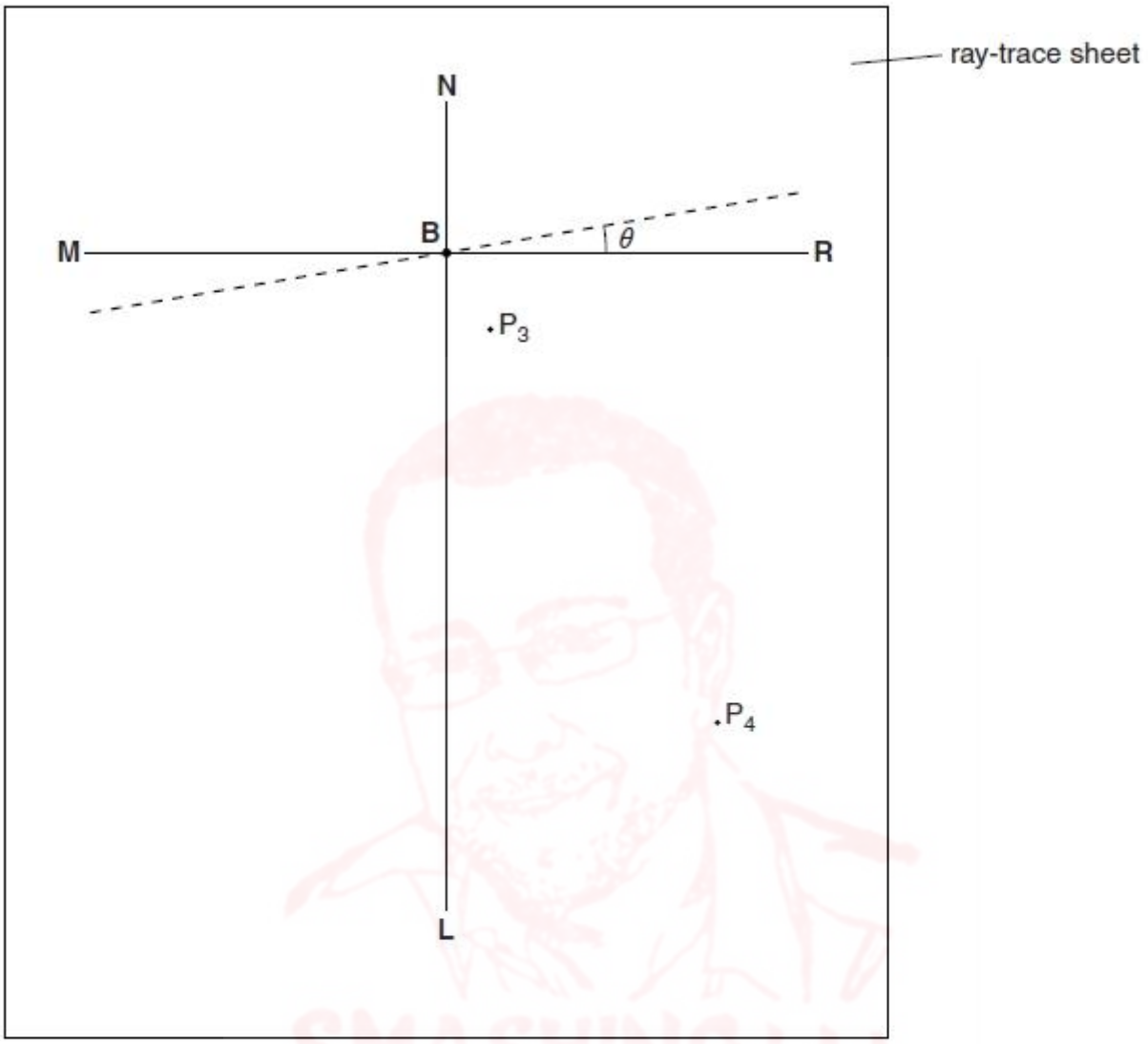


Fig. 5.1

(a) **NL** is a normal to line **MR**. Draw a line 8.0 cm long from **B** at an angle of incidence $i = 30°$ to the normal, below **MR** and to the left of the normal. Label the end of this line **A**. [1]

(b) The student places two pins, P_1 and P_2, on line **AB** a suitable distance apart for this ray tracing experiment. He views the images of pins P_1 and P_2 in the mirror and 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 shown in Fig. 5.1.

(i) Draw the line joining the positions of P_3 and P_4. Extend the line until it meets **NL**.

(ii) Measure the angle α_0 between **NL** and the line joining the positions of P_3 and P_4. At this stage the angle θ between the mirror and line **MR** is 0°.

α_0 = ...

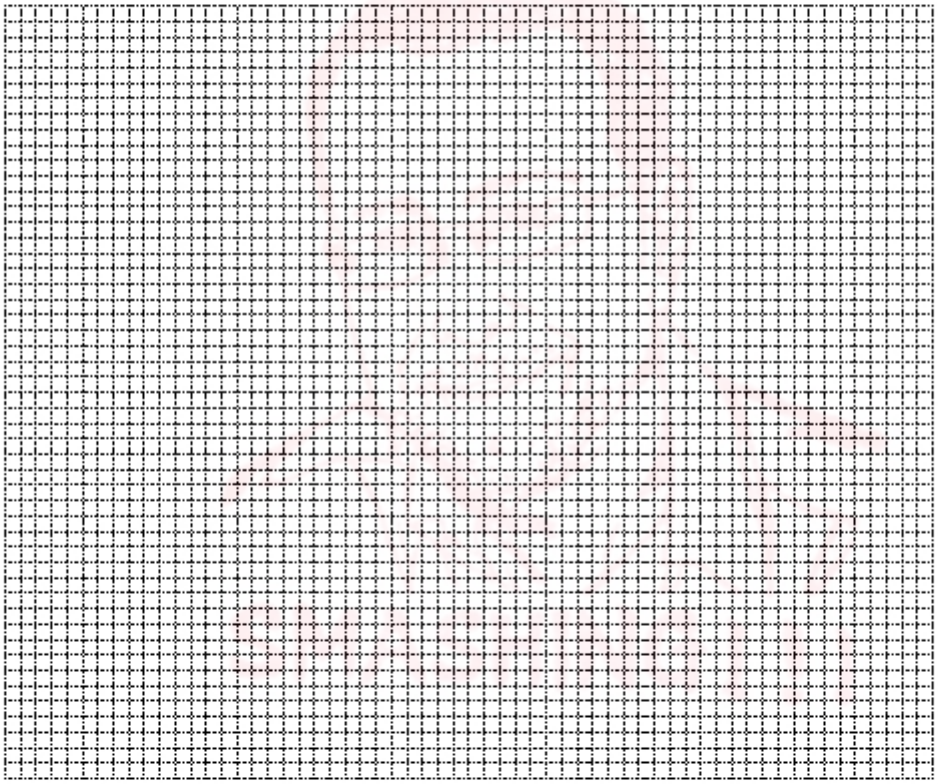
[2]

(c) The student draws lines at angles $\theta = 10°$, 20°, 30°, and 40° to **MR**. The first line, at 10° to **MR**, is shown in Fig. 5.1. He repeats the procedure described in part **(b)**, placing the mirror on each of the new lines in turn. The readings are shown in Table 5.1.

Table 5.1

θ/°	α/°
10	51
20	69
30	90
40	111
50	130

Plot a graph of α/° (y-axis) against θ/° (x-axis).



[5]

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

G = ... [2]

(e) In this experiment, when the mirror is moved though an angle θ, the reflected ray moves through an angle $(\alpha - \alpha_0)$.

Table 5.2

θ/°	α/°	$(\alpha - \alpha_0)$/°
10	51	
20	69	
30	90	
40	111	
50	130	

(i) Complete Table 5.2.

(ii) Suggest the relationship between $(\alpha - \alpha_0)$ and θ. You may express the relationship in words or as an equation.

.....

.....

[1]

(f) State **one** precaution, to improve accuracy, which you would take in this experiment.

.....

.....[1]

[Total: 12]

4 The IGCSE class is determining the focal length of a converging lens.

Fig. 4.1 shows the apparatus used to produce an image on the screen.

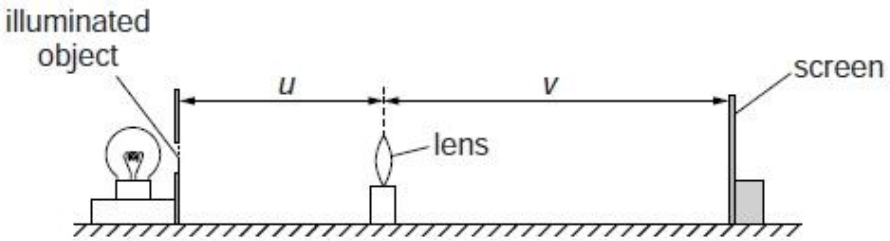


Fig. 4.1

(a) (i) On Fig. 4.1, measure the distance *u* between the illuminated object and the centre of the lens.

u = ...

(ii) On Fig. 4.1, measure the distance *v* between the centre of the lens and the screen.

v = ...
[2]

(b) (i) Calculate *uv*.

uv = ...

(ii) Calculate *u* + *v*.

u + *v* = ...
[1]

(iii) Calculate *x* using the equation $x = \frac{uv}{(u + v)}$.

x = ... [1]

(c) Fig. 4.1 is drawn 1/10th of actual size. The focal length *f* of the lens is given by the equation *f* = 10*x*.

Calculate a value for the focal length *f* of the lens, giving your answer to a suitable number of significant figures for this experiment.

f = ... [2]

(d) A student carrying out this experiment changes the position of the lens and then moves the screen to produce a well-focused image.

She records the distance v between the centre of the lens and the screen as $v = 18.2\,\text{cm}$. She finds it difficult to decide the exact point at which the image is sharpest.

Suggest a range of v values for which the image may appear well-focused.

range of v values = ... to ..... [1]

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

1. .....

.....

2. .....

.....

[2]

[Total: 9]

4 The IGCSE class is investigating the position of the image in a plane mirror.

A student's ray-trace sheet is shown in Fig. 4.1.

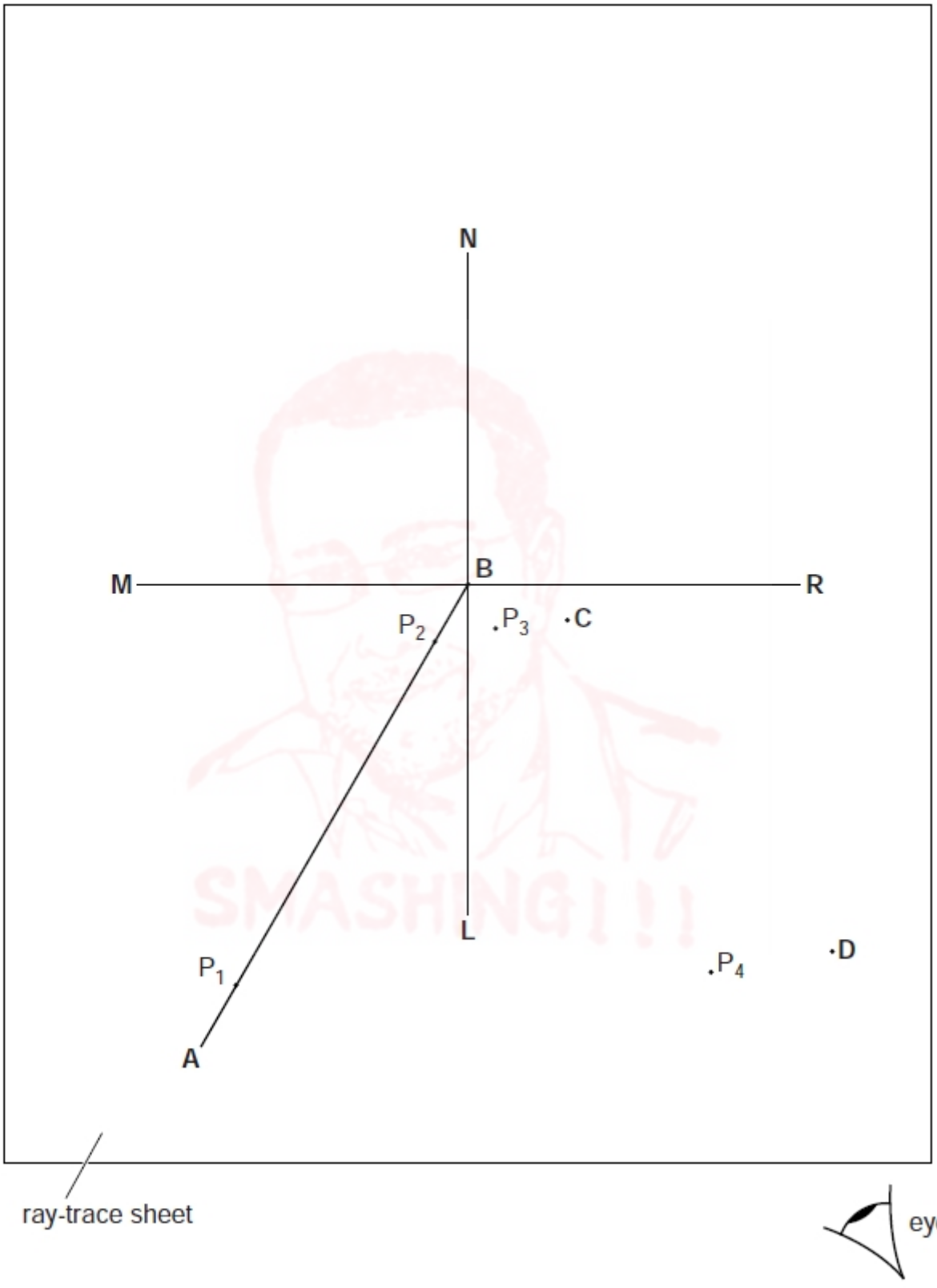


Fig. 4.1

The line **MR** shows the position of a plane mirror. **NL** is the normal at the centre of the mirror.

AB marks the position of an incident ray.

The student pushes two pins, P_1 and P_2 into this line. She views the images of pins P_1 and P_2 from the direction indicated by the eye in Fig. 4.1.

She places two pins P_3 and P_4 some distance apart so that pins P_4 and P_3, and the images of P_2 and of P_1, all appear exactly one behind the other. The positions of P_3 and P_4 are labelled.

(a) Draw in the line joining the positions of P_3 and P_4. Continue the line until it crosses **MR** and extends at least 8.0 cm beyond **MR**. [1]

(b) The student repeats the procedure without moving pin P_1 but using a different angle of incidence. On Fig. 4.1, the new positions of pins P_3 and P_4 are marked **C** and **D**.

(i) Draw in the line joining the positions **C** and **D**. Continue the line until it extends at least 8.0 cm beyond **MR**.

(ii) Label with a **Y** the point where the two lines beyond **MR** cross. [1]

(c) **(i)** Draw a line from P_1 to **MR** that meets **MR** at a right angle. Measure and record the length *a* of this line.

a = ...

(ii) Draw a line from the point labelled **Y** to **MR** that meets **MR** at a right angle. Measure and record the length *b* of this line.

b = ...
[2]

(d) A student suggests that the length of *a* should equal the length of *b*.

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

statement .....

justification .....

.....

.....
[2]

(e) Suggest a precaution that you would take, when placing the pins, in order to obtain reliable results.

.....

..... [1]

[Total: 7]

5 **(a)** The IGCSE class has a range of apparatus available. Here is a list of some of the apparatus.

ammeter

barometer

beaker

electronic balance

manometer

measuring cylinder

metre rule

newtonmeter (spring balance)

stopwatch

tape measure

thermometer

voltmeter

Complete Table 5.1 by inserting the name of one piece of apparatus from the list that is the most suitable for measuring each quantity described.

Table 5.1

quantity to be measured	most suitable apparatus
volume of water	
a distance of about 50 m	
the force required to lift a laboratory stool	
the mass of a coin	
the pressure of the laboratory gas supply	

[5]

(b) The IGCSE class is carrying out a lens experiment. This involves using an illuminated object, a screen and a lens.

Firstly, the distance between the illuminated object and the lens is measured with a metre rule. Next, a clearly focused image is obtained on the screen.

(i) Explain briefly how you would avoid a parallax (line-of-sight) error when using the metre rule.

.....

.....

..... [1]

(ii) State a precaution that you would take to ensure that the image is well focused.

.....

.....

..... [1]

[Total: 7]

4 The IGCSE class is investigating the refraction of light passing through a transparent block.

The apparatus and ray-trace sheet are shown in Fig. 4.1.

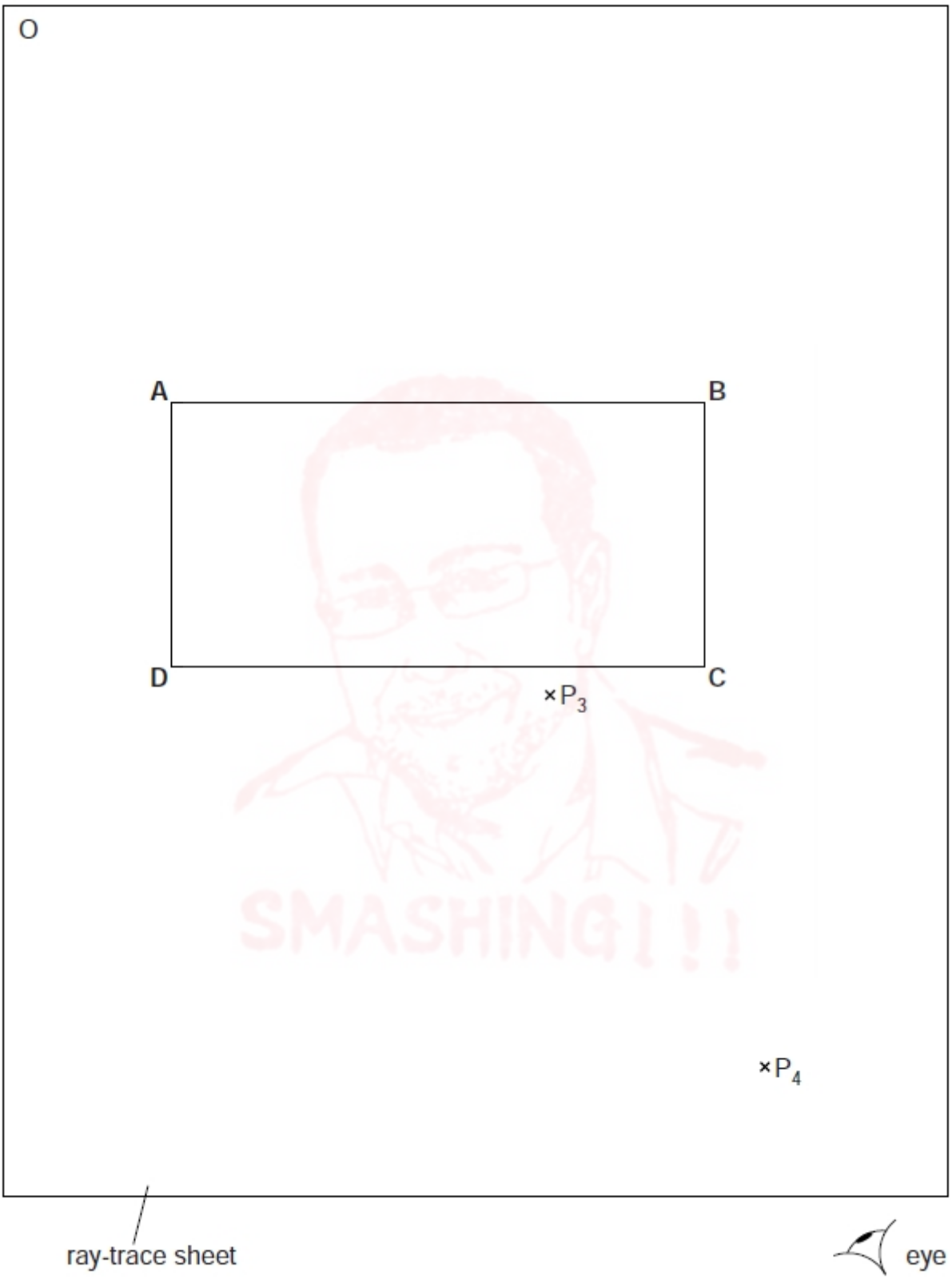


Fig. 4.1

(a) A student places the transparent block, largest face down, on the ray-trace sheet. She draws the outline of the block **ABCD**.

(i) On Fig. 4.1, draw a normal at the centre of side **AB**. Label the point **E** where the normal crosses **AB**.

(ii) Draw a line **FE** to the left of the normal and at an angle of incidence $i = 30°$ to the normal. [2]

(b) The student places two pins P_1 and P_2 on the line **FE**, placing one pin close to **E**. She 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. She places two pins P_3 and P_4 between her 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.

(i) On Fig. 4.1, mark suitable positions for the pins P_1 and P_2. [1]

(ii) Draw a line joining the positions of P_3 and P_4. Continue the line until it meets **CD** and label this point **G**.

(iii) Draw the line **GE**. [1]

(c) **(i)** Measure and record the angle of refraction r between the line **GE** and the normal.

$r =$ ..... [1]

(ii) Calculate the ratio $\frac{i}{r}$.

$\frac{i}{r} =$ ..... [1]

(d) The student repeats the procedure but with the angle of incidence $i = 40°$. The angle of refraction $r = 26°$.

(i) Calculate the ratio $\frac{i}{r}$.

$\frac{i}{r} =$ ..... [1]

(ii) A student suggests that the ratio $\frac{i}{r}$ should be a constant.

State and explain briefly whether your results support this suggestion.

.....

.....

..... [1]

[Total: 8]

4 The IGCSE class is determining the focal length of a lens.

The apparatus is shown in Fig. 4.1.

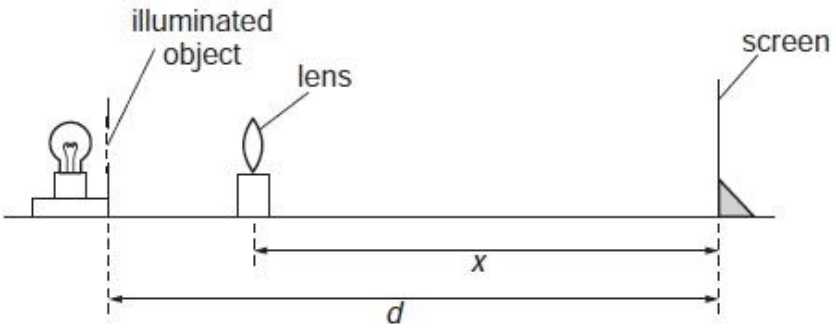


Fig. 4.1

(a) A student places the lens between the object and the screen and close to the object. She moves the lens towards the screen until a clearly focused, **enlarged** image is formed on the screen.

(i) On Fig. 4.1, measure and record the distance *d* between the object and the screen.

d = ...

(ii) On Fig. 4.1, measure and record the distance *x* between the centre of the lens and the screen.

x = ...
[2]

(iii) Fig. 4.1 is drawn one tenth actual size.

1. Calculate the actual distance *D* between the object and the screen.

D = ...

2. Calculate the actual distance *X* between the centre of the lens and the screen.

X = ...
[1]

(b) Without moving the illuminated object or the screen, the student moves the lens towards the screen until a clearly focused, **diminished** image is formed on the screen. She measures the distance *Y* between the centre of the lens and the screen: *Y* = 19.0 cm.

Calculate the focal length *f* of the lens using the equation $f = \frac{XY}{D}$.

f = ... [2]

(c) The student turns the lens through an angle of 180° and repeats the procedure obtaining a value for the focal length $f = 14.7\,\text{cm}$.

Theory suggests that the two values of the focal length f should be the same. State whether the results support this theory and justify your answer by reference to the results.

statement .....

justification .....

.....

[2]

(d) Briefly describe a precaution that you would take in this experiment in order to obtain a reliable result.

.....

.....

..... [1]

[Total: 8]

Q# 10/ iG Phx/2011/w/Paper 61/ www.SmashingScience.org :o)

5 The IGCSE class is carrying out an experiment to determine the speed of sound in air.

Fig. 5.1 indicates the method used. The experiment is conducted outside the school building.

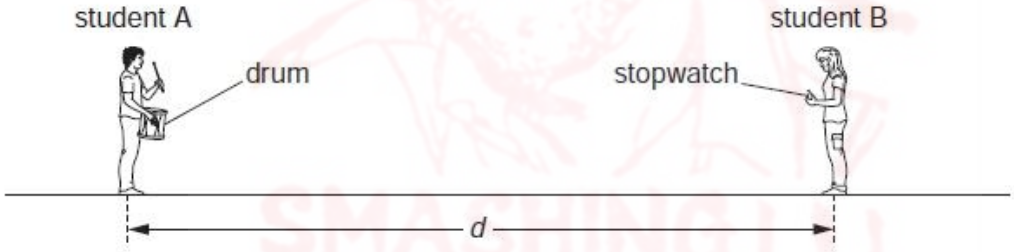


Fig. 5.1 (not to scale)

Student A strikes a drum once as loudly as possible. Student B stands some distance away from student A and starts a stopwatch when she sees the drum being hit. She stops the stopwatch when she hears the sound. She records the time interval t in Table 5.1. The experiment is repeated several times. She calculates the speed of sound v and enters the values in the table.

Table 5.1

t/s	v/(m/s)
0.87	344.83
0.92	326.09
0.84	357.14
0.83	361.45
0.86	338.84

(a) Suggest a suitable distance d for students to use when carrying out this experiment.

d = ... [1]

(b) Suggest a suitable instrument for measuring the distance d.

.....[1]

(c) Calculate the average value v_{av} for the speed of sound from the results in the table. Show your working.

v_{av} = ... [2]

(d) The student has recorded the values for the speed of sound v to five significant figures. State whether this is a suitable number of significant figures for the speed of sound in air in this experiment. Give a reason for your answer.

statement .....

reason .....

.....[1]

[Total: 5]

4 An IGCSE student is investigating reflection of light in a plane mirror.

Fig. 4.1 shows the student's ray trace sheet.

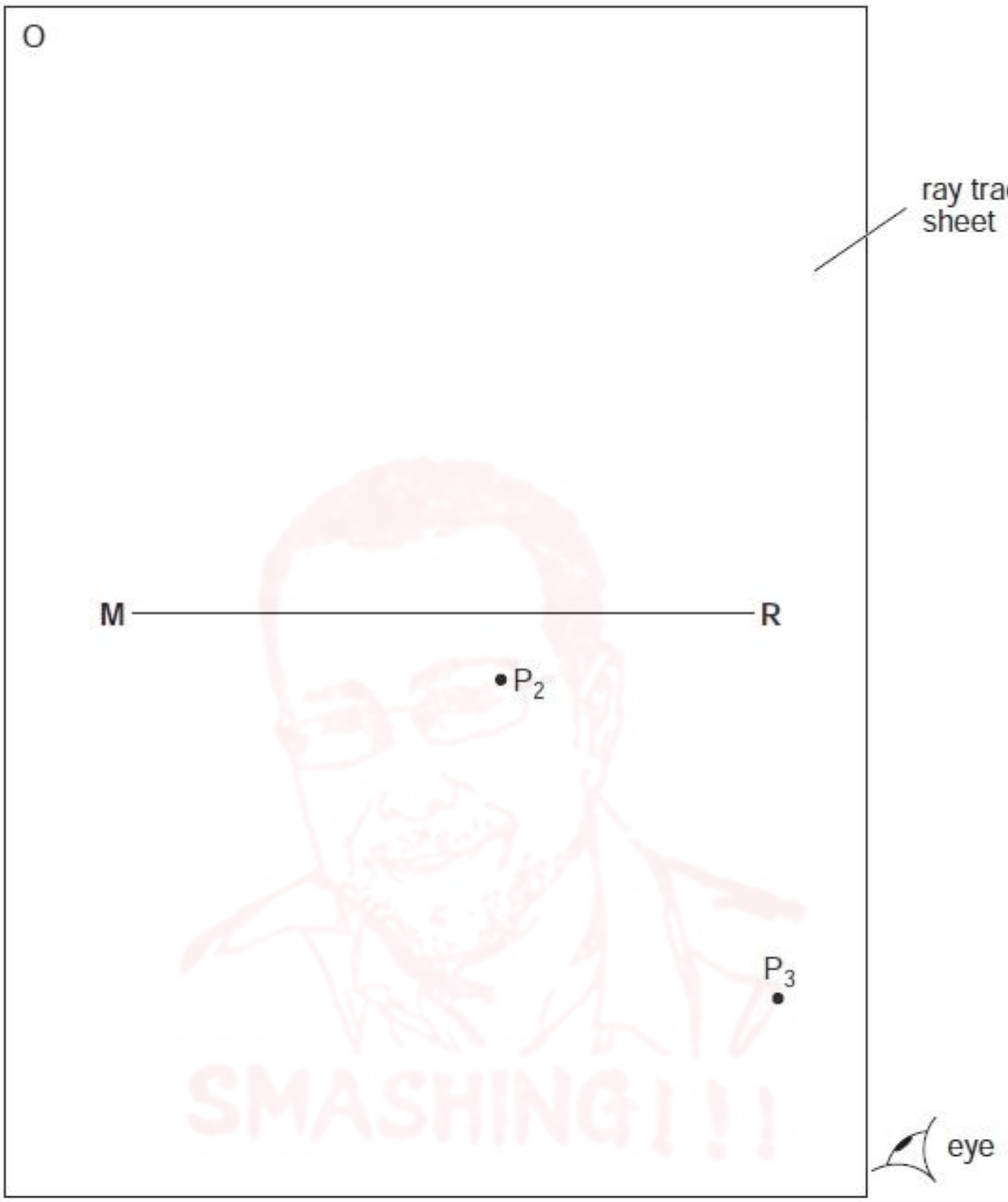


Fig. 4.1

(a) The line **MR** shows the position of a mirror.

(i) 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]

(ii) Draw a line 8 cm long from **B** at an angle of incidence $i = 40°$ to the normal below **MR** and to the left of the normal. Label the end of this line **A**. Record the angle of incidence i in the first row of Table 4.1.

Table 4.1

i / °	r / °
34	33

[2]

(b) Fig. 4.2 shows the mirror which is made of polished metal and has a vertical line drawn on it.

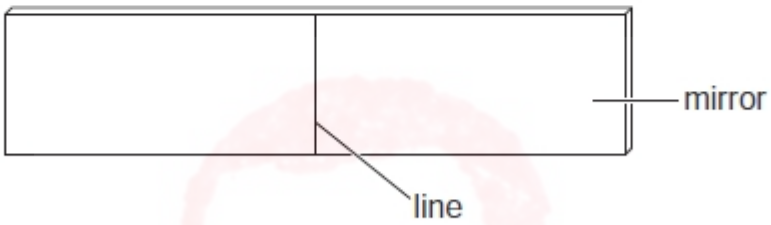


Fig. 4.2

The student places the mirror, with its reflecting face vertical, on **MR**. The lower end of the line on the mirror is at point **B**. He places a pin P_1 at **A**. He views the line on the mirror and the image of pin P_1 from the direction indicated by the eye in Fig. 4.1. He places two pins P_2 and P_3 some distance apart so that pins P_3, P_2, the image of P_1, and the line on the mirror all appear exactly one behind the other. The positions of P_2 and P_3 are shown.

(i) Draw the line joining the positions of P_2 and P_3. Continue the line until it meets the normal.

(ii) Measure, and record in the first row of Table 4.1, the angle of reflection r between the normal and the line passing through P_2 and P_3.

[2]

(c) The student draws a line parallel to **MR** and 2 cm above it. He places the mirror on this line and repeats the procedure without changing the position of pin P_1. His readings for i and r are shown in the table.

In spite of carrying out this experiment with reasonable care, it is possible that the values of the angle of reflection r will not be exactly the same as the values obtained from theory. Suggest two possible causes of this inaccuracy.

1. .....

.....

2. .....

.....[2]

(d) The student was asked to list precautions that should be taken with this experiment in order to obtain readings that are as accurate as possible. Table 4.2 shows the suggestions.

Place a tick (✓) in the second column of the table next to each correctly suggested precaution.

Table 4.2

suggested precaution	
avoid parallax (line of sight) errors when taking readings with the protractor	
carry out the experiment in a darkened room	
draw the lines so that they are as thin as possible	
keep room temperature constant	
place pins P_2 and P_3 as far apart as possible	
use only two or three significant figures for the final answers	

[3]

[Total: 10]

4 An IGCSE student is investigating reflection from a plane mirror.

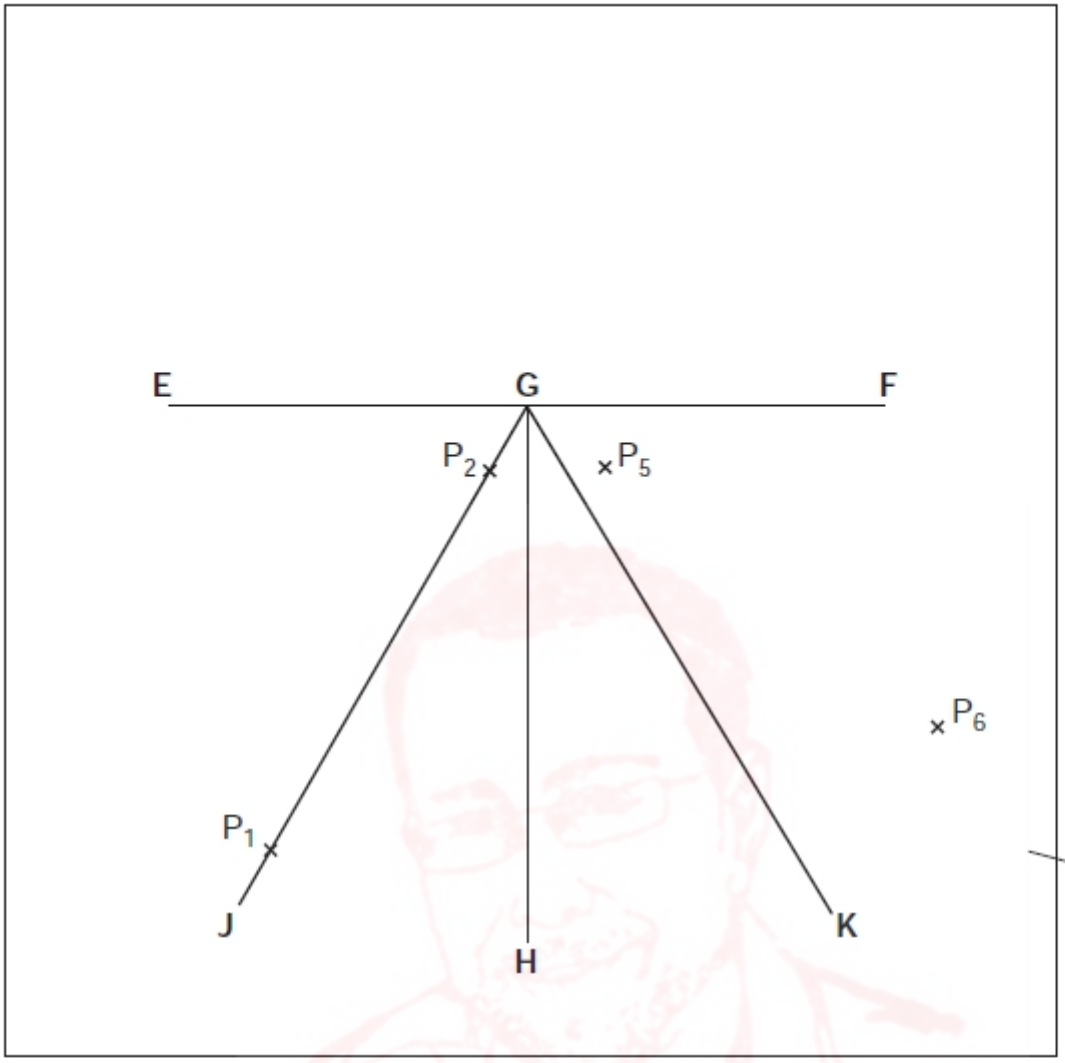


Fig. 4.1

The student is using a sheet of plain paper on a pin board. Fig. 4.1 shows the sheet of paper. The straight line **EF** shows the position of the reflecting surface of a plane mirror standing vertically on the sheet of paper. Line **GH** is a normal to line **EF**. Line **JG** marks an incident ray and line **GK** is the corresponding reflected ray. The student marks the position of the incident ray with two pins (P_1 and P_2) and uses two more pins (P_3 and P_4) to find the direction of the reflected ray.

(a) (i) On Fig. 4.1 mark with two neat crosses, labelled P_3 and P_4, suitable positions for the pins to find the direction of the reflected ray.

(ii) On Fig. 4.1 measure the angle of incidence *i*.

i = ...

(iii) On Fig. 4.1 measure the angle of reflection r_1.

r_1 = ...

[3]

(b) (i) On Fig. 4.1 draw a line **E'GF'** such that the angle θ between this line and the line **EGF** is 10°. Start with **E'** below the line **EGF**. The straight line **E'F'** shows a new position of the reflecting surface of the plane mirror standing vertically on the sheet of paper.
The points labelled P_5 and P_6 mark the positions of two pins placed so that P_5, P_6 and the images of P_1 and P_2 appear in line with each other. P_1 and P_2 have not been moved since the original set-up.

(ii) Using a ruler, draw a line joining the points labelled P_5 and P_6, and continue this line to meet the line **E'F'**.

(iii) Measure the angle of reflection r_2 between line **GH** and the line joining the points labelled P_5 and P_6.

r_2 = ...

(iv) Calculate the angle α through which the reflected ray has moved.

α = ...

(v) Calculate the difference between 2θ and α.
θ is the angle between the two positions of the mirror.

difference between 2θ and α = ...
[3]

(c) Theory suggests that if the mirror is moved through an angle θ then the reflected ray will move through an angle of 2θ.
State whether your result supports the theory and justify your answer by reference to the result.

Statement .....

Justification .....

.....[2]

4 The IGCSE class is investigating reflection of light using a plane mirror.

A student has set up a ray trace sheet and this is shown in Fig. 4.1. The line **MR** shows the position of a plane mirror.

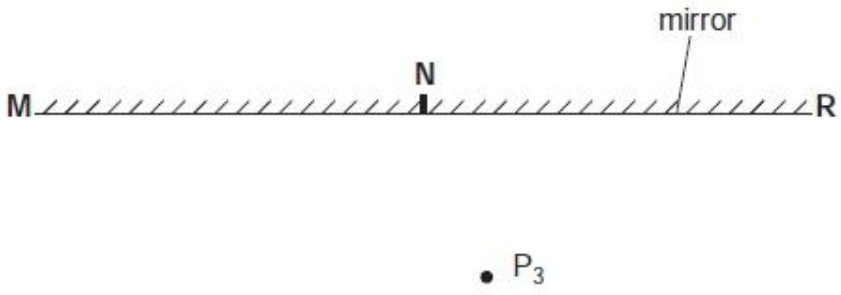


Fig. 4.1

(a) (i) Draw a normal to line **MR** at **N**.

(ii) Draw a line 10 cm long that is parallel to line **MR** and 12 cm below it. The ends of this line must be at the same distance from the edges of the page as the ends of line **MR**. Label this line **CD** with **C** directly below **M**. [3]

(b) The student places a pin P_1 so that it stands vertically at **C**. He places another pin P_2 as close as possible to the point **N**.

(i) Draw a line from **C** to **N**.

(ii) Measure and record the angle of incidence *i* between the line **CN** and the normal.

i = ...[2]

(c) The student views the image in the mirror of the pin P_1 from the direction indicated by the eye in Fig. 4.1. He places two pins P_3 and P_4 some distance apart so that pins P_4, P_3, P_2 and the image of P_1 all appear exactly one behind the other. The positions of P_3 and P_4 are shown on Fig. 4.1.

(i) Draw in the line joining the positions of P_3 and P_4. Continue the line until it meets the normal.

(ii) Measure and record the angle of reflection r between the normal and line P_3P_4.

r = ...[2]

(d) Several students found that, in spite of carrying out this experiment with reasonable care, the measured value of the angle of reflection r was not exactly the same as the value obtained from theory.

Suggest two possible causes of this inaccuracy.

1. .....

.....

2. .....

.....[2]

[Total: 9]

4 The IGCSE class is investigating the reflection of light by a mirror as seen through a transparent block.

Fig. 4.1 shows a student's ray-trace sheet.

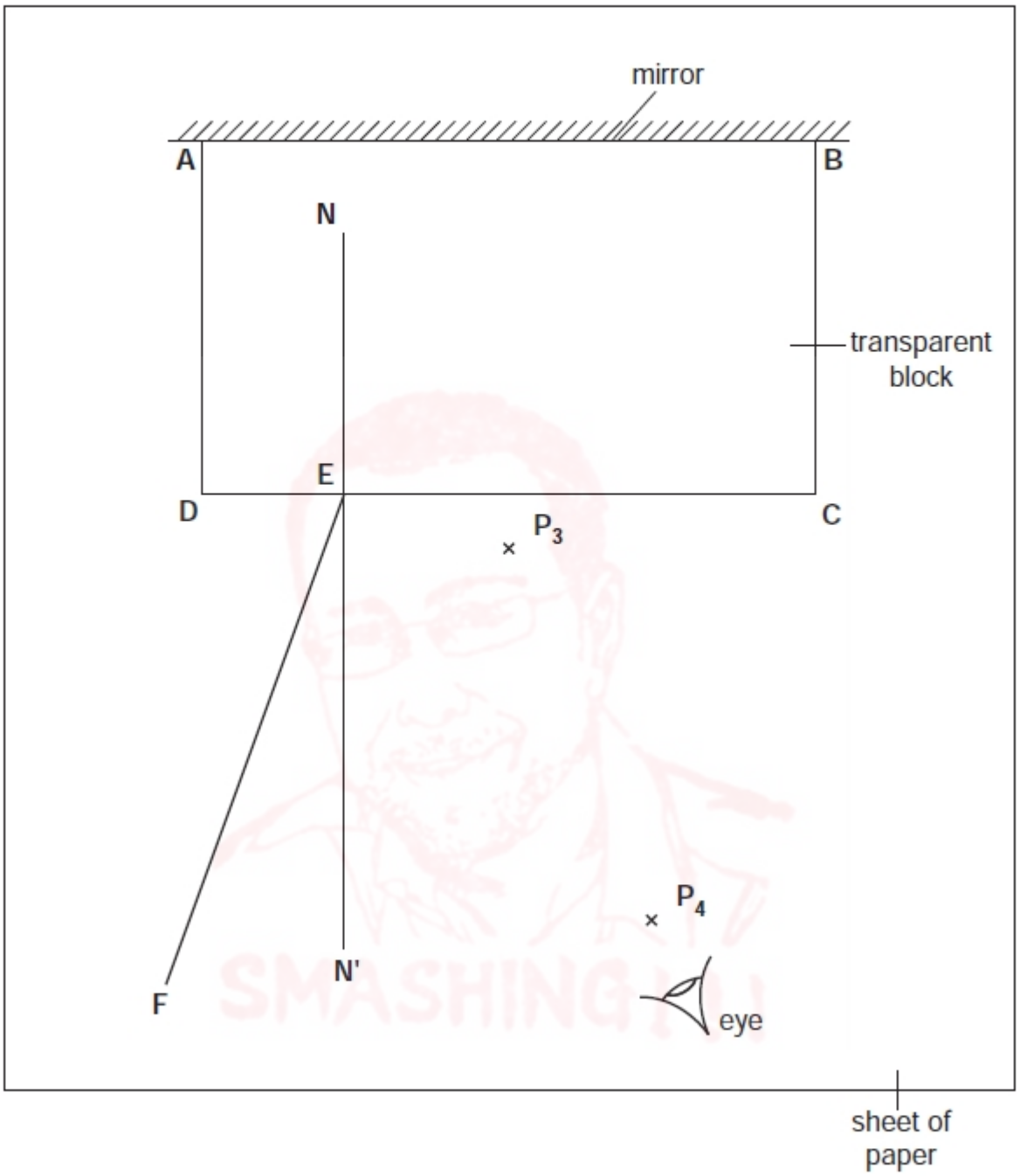


Fig. 4.1

(a) A student draws the outline of the transparent block **ABCD** on the ray-trace sheet. He draws the normal **NN'** to side **CD**. He draws the incident ray **EF** at an angle of incidence $i = 20°$. He pushes two pins $\mathbf{P_1}$ and $\mathbf{P_2}$ into line **EF** and places the block on the sheet of paper. He then observes the images of $\mathbf{P_1}$ and $\mathbf{P_2}$ through side **CD** of the block from the direction indicated by the eye in Fig. 4.1 so that the images of $\mathbf{P_1}$ and $\mathbf{P_2}$ appear one behind the other. He pushes two pins $\mathbf{P_3}$ and $\mathbf{P_4}$ into the surface, between his eye and the block, so that $\mathbf{P_3}$, $\mathbf{P_4}$ and the images of $\mathbf{P_1}$ and $\mathbf{P_2}$, seen through the block, appear in line. (The plane mirror along side **AB** of the block reflects the light.)

The positions of $\mathbf{P_3}$ and $\mathbf{P_4}$ are marked on Fig. 4.1.

(i) On line **EF**, mark with neat crosses (x) suitable positions for the pins $\mathbf{P_1}$ and $\mathbf{P_2}$.

(ii) Continue the line **EF** so that it crosses **CD** and extends as far as side **AB**.

(iii) Draw a line joining the positions of $\mathbf{P_4}$ and $\mathbf{P_3}$. Continue the line so that it crosses **CD** and extends as far as side **AB**. Label the point **G** where this line crosses the line from $\mathbf{P_1}$ and $\mathbf{P_2}$. [4]

(iv) Measure the acute angle θ between the lines meeting at **G**.

$\theta =$ .....

(v) Calculate the difference $(\theta - 2i)$.

$(\theta - 2i) =$ ..... [2]

(b) The student repeats the procedure using an angle of incidence $i = 30°$ and records the value of θ as 62°.

(i) Calculate the difference $(\theta - 2i)$.

$(\theta - 2i) =$ .....

(ii) Theory suggests that $\theta = 2i$. State whether the results support the theory and justify your answer by reference to the results.

statement .....

justification .....

..... [3]

(c) To place the pins as accurately as possible, the student views the bases of the pins. Explain briefly why viewing the bases of the pins, rather than the tops of the pins, improves the accuracy of the experiment.

.....

.....

..... [1]

[Total: 10]

4 An IGCSE student is determining the focal length of a lens by two different methods.

The set-up for Method 1 is shown in Fig. 4.1.

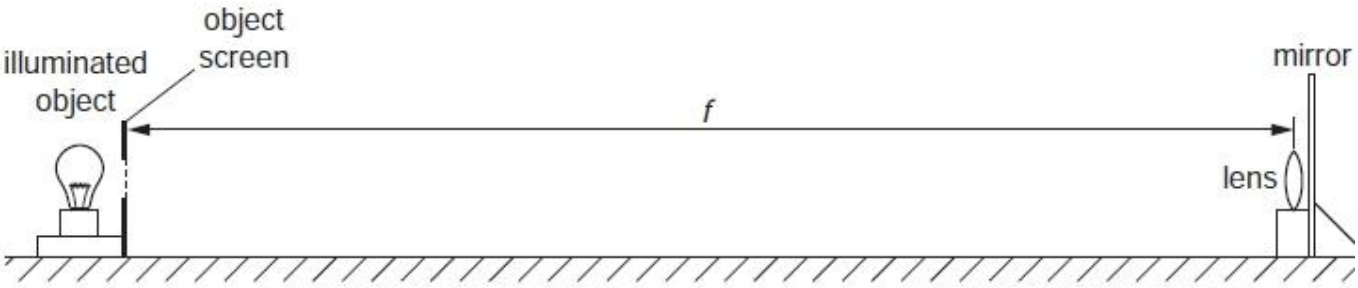


Fig. 4.1

The student moves the lens and the mirror slowly towards the object screen until a sharply focused image is obtained on the object screen as shown in Fig. 4.2.

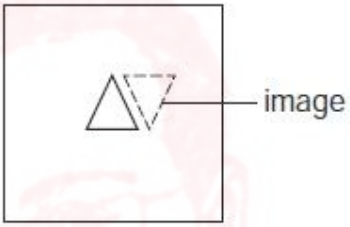


Fig. 4.2

(a) On Fig. 4.1, use your rule to measure the distance *f* between the lens and the object screen. This is the focal length of the lens.

f = ... [2]

(b) For Method 2, the student takes measurements of the diameter *d* and maximum thickness *t* of the lens. Use your rule to take measurements on Fig. 4.3.

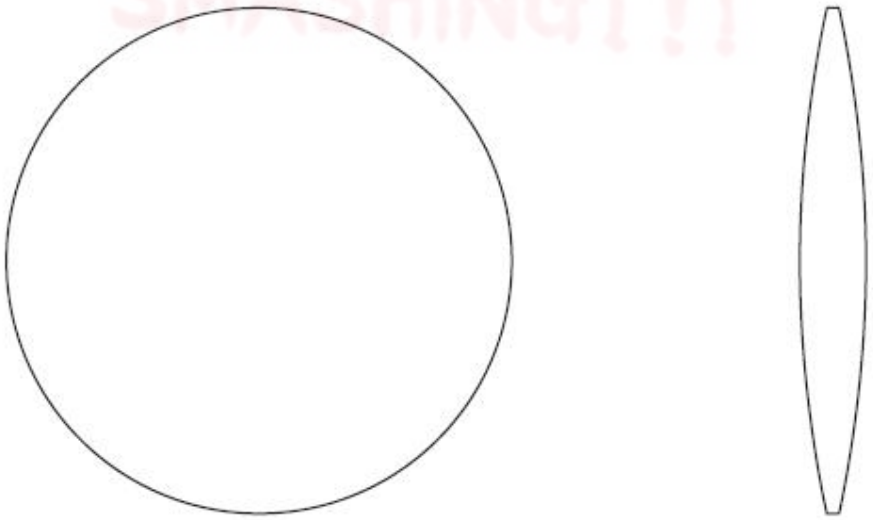


Fig. 4.3

(i) Determine an average value for the diameter d of the lens. Record your readings in the space below.

d = ...

(ii) Measure the maximum thickness t of the lens.

t = ...

(iii) Draw a diagram to show how, in the laboratory you would use two rectangular blocks of wood and a metre rule to measure the thickness of the lens as accurately as possible.

(iv) Theory shows that, for a perfectly formed lens, the focal length is given by the formula

$$f = \frac{d^2}{kt} \qquad \text{where } k = 4.16.$$

Calculate the focal length f of the lens using this formula.

f = ...

[7]

(c) Explain whether your results from Methods 1 and 2 support the theory in part **(b)(iv)**.

.....

.....

..... [1]

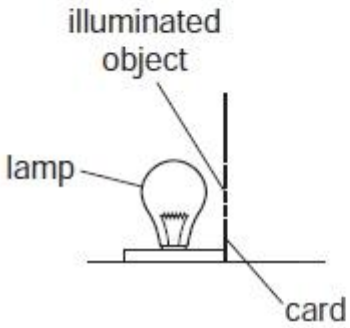
[Total: 10]

Q# 16/ iG Phx/2009/w/Paper 61/ www.SmashingScience.org :o)

5 An IGCSE student is carrying out an optics experiment.

The experiment involves using a lens to focus the image of an illuminated object onto a screen.

(a) Complete the diagram below to show the apparatus you would use. Include a metre rule to measure the distances between the object and the lens and between the lens and the screen. The illuminated object is drawn for you.



[3]

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

1. .....

.....

2. .....

..... [2]

[Total: 5]

4 An IGCSE student is determining the focal length of a lens.

Fig. 4.1 shows the experimental set-up. The student positions the illuminated object and the lens and then moves the screen away from the lens until a sharply focused image of the object is formed on the screen.

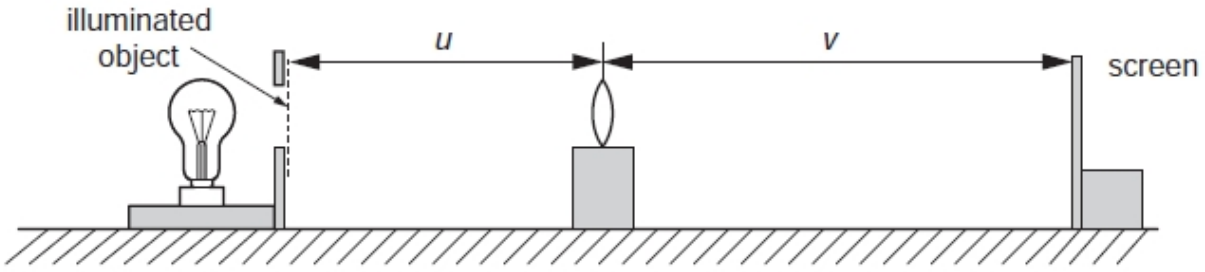


Fig. 4.1

(a) Using your rule, measure on Fig. 4.1 the distance *u*, in cm, from the centre of the lens to the illuminated object and the distance *v* from the centre of the lens to the screen.

u = ...

v =..... [2]

(b) **(i)** Fig. 4.1 is drawn one fifth actual size. Calculate the actual distance *x* from the illuminated object to the centre of the lens and the actual distance *y* from the centre of the lens to the screen.

Record these values in Table 4.1. The first pair of readings obtained by the student has already been entered in the table.

Table 4.1

x/cm	*y*/cm	*f*/cm
57.0	15.0	

[3]

(ii) Calculate for both pairs of readings the focal length *f* of the lens using the equation

$$f = \frac{xy}{(x+y)}.$$

Record the values of *f* in Table 4.1.

(c) Calculate the average value of the focal length.

average value for the focal length = ... [2]

(d) State two precautions you would take in the laboratory in order to obtain reliable measurements.

1. .....

2. ..... [2]

[Total: 9]

2 The IGCSE class is investigating the potential difference across, and the current in, wires.

The apparatus is shown in Fig. 2.1.

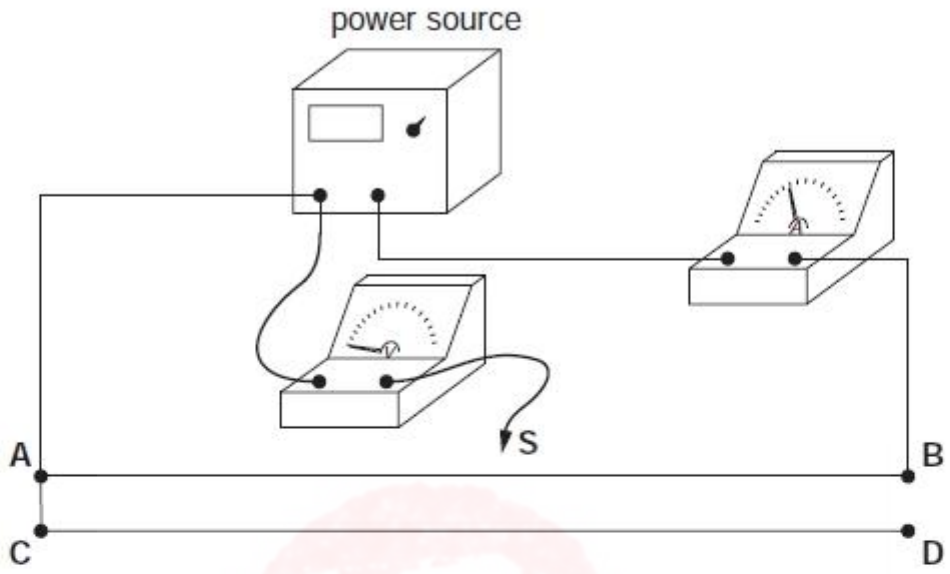


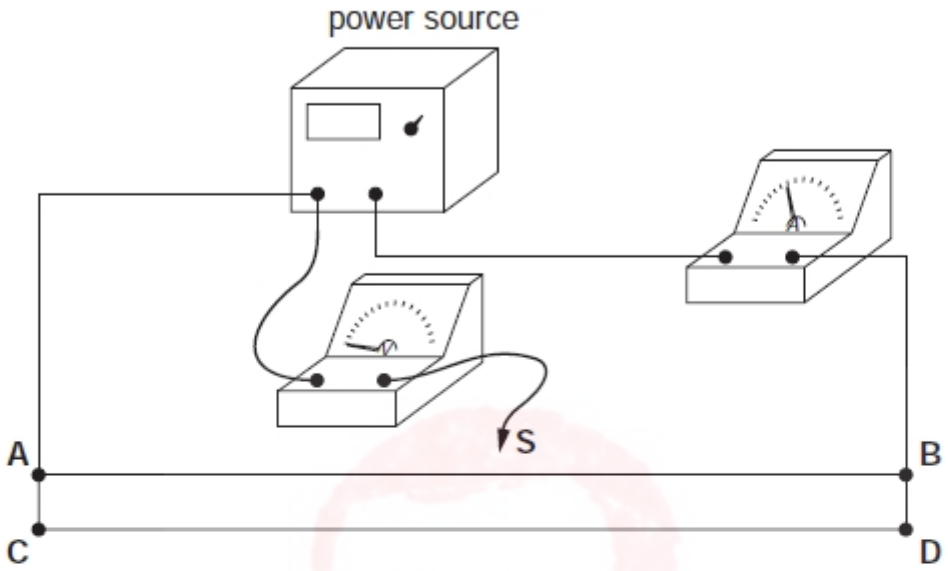
Fig. 2.1

(a) Draw a circuit diagram of the apparatus. Use standard circuit symbols.
(The circuit includes two identical resistance wires **AB** and **CD**. Use the standard symbol for a resistance to represent each of these wires.)
This circuit is called circuit 1.

[3]

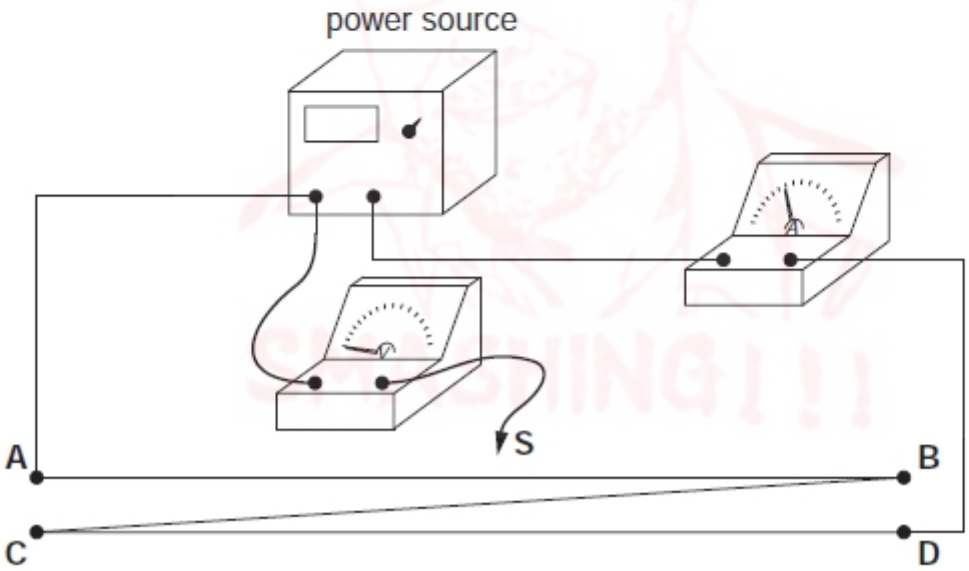
For circuit 1, the student places the contact **S** on the resistance wire **AB** at a distance of 0.500 m from **A**. He measures the p.d. V across the wire between **A** and **S** and the current I in the circuit.

The student then records the measurements for circuits 2 and 3, shown in Fig. 2.2 and Fig. 2.3.



circuit 2

Fig. 2.2



circuit 3

Fig. 2.3

The voltage V and current I for all three circuits are shown in Table 2.1.

Table 2.1

Circuit	V/	I/
1	0.83	0.53
2	0.75	0.95
3	0.41	0.28

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

(c) Theory suggests that,

1. in circuits 1 and 2, the values of potential difference V will be equal,
2. the value of potential difference V in circuit 3 will be half that in circuit 1 or circuit 2.

(i) State whether, within the limits of experimental accuracy, the results support these predictions.

Justify your statement by reference to the results.

Prediction 1 .....

.....

Prediction 2 .....

.....[2]

(ii) Suggest one reason, other than a change in temperature of the wires, why the results may not support the theory.

.....

.....[1]

[Total: 7]

4 An IGCSE student is determining the focal length of a converging lens.
The apparatus is shown in Fig. 4.1.

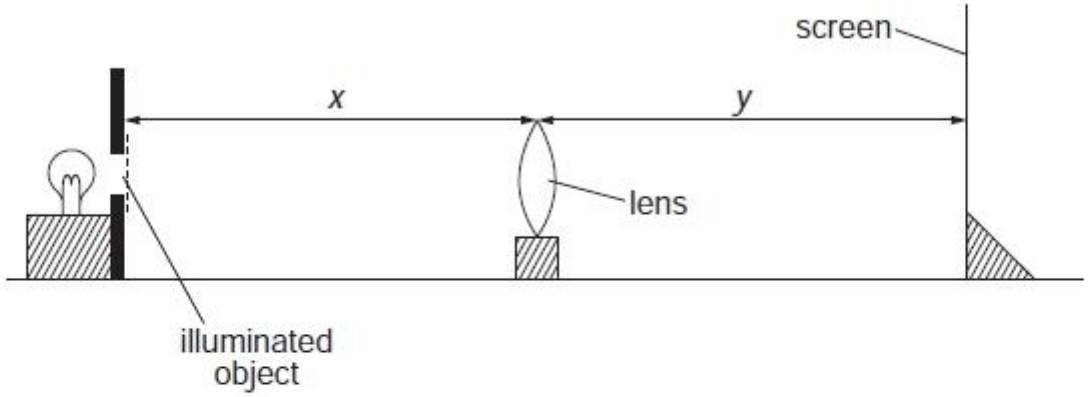


Fig. 4.1

(a) The student places the lens at a distance x = 25.0 cm from the illuminated object. She places the screen close to the lens and then moves it away from the lens until a sharply focused image is formed on the screen. She measures and records the distance y between the lens and the screen.

y = 37.1 cm

Calculate the focal length f of the lens using the equation

$$f = \frac{xy}{(x + y)}.$$

f = ... [2]

(b) She then repeats the procedure with the lens at a distance x = 30.0 cm from the illuminated object.

Fig. 4.1 shows this position of the apparatus. It is a scale diagram.

(i) On Fig. 4.1, measure the distance x_s between the lens and the illuminated object. Also on Fig. 4.1, measure the distance y_s between the lens and the screen.

x_s = ...

y_s = ...

(ii) Calculate the actual distance *y* between the lens and the screen.

y = ...

(iii) Calculate the focal length *f* using the new values of *x* and *y*.

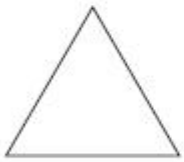
f = ...

(iv) Calculate the average value of *f*. Show your working.

average value of *f* = ...

[7]

(c) The illuminated object has the shape shown below.



Draw a diagram to show the appearance of the focused image in **(b)** on the screen.

[1]

[Total: 10]

4 A student is determining a quantity called the refractive index of the material of a transparent block.

Fig. 4.1 shows the ray-tracing sheet that the student is producing. **ABCD** is the outline of the transparent block, drawn on the ray-tracing sheet.

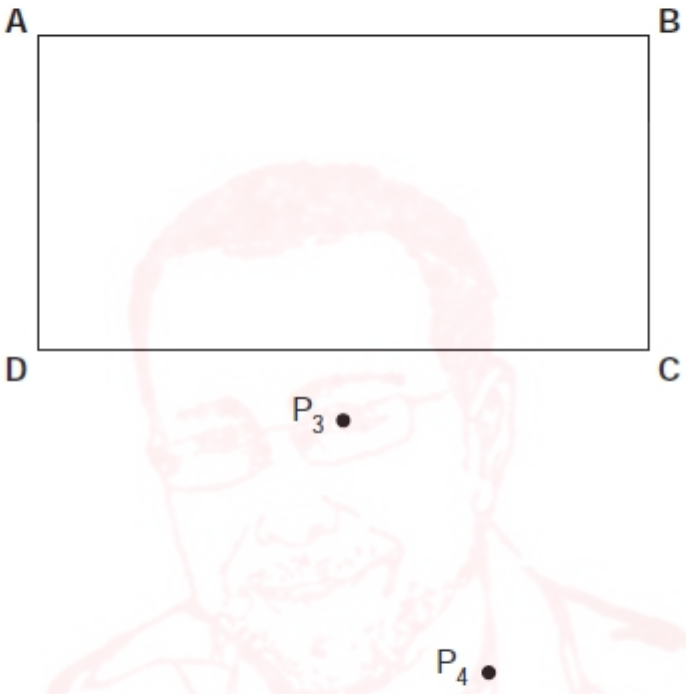


Fig. 4.1

(a) (i) Draw the normal **NN'** to side **AB**, extended to cross side **DC**, so that the normal is 2.0 cm from **A**. Label the point **F** where **NN'** crosses **AB**. Label the point **G** where **NN'** crosses **DC**.

(ii) Draw the line **EF** at an angle of 30° to the normal and to the left of the normal **NN'**. **E** is a point outside the block and above **AB** on the ray-tracing sheet.

[3]

(b) Read the following passage, taken from the student's notebook and then answer the questions that follow.

> I placed two pins P_1 and P_2 on line **EF**.
> I observed the images of P_1 and P_2 through side **CD** of the block so that the images of P_1 and P_2 appeared one behind the other. I placed two more pins P_3 and P_4 between my eye and the block so that P_3, P_4 and the images of P_1 and P_2, seen through the block, appeared one behind the other. I marked the positions of P_1, P_2, P_3 and P_4.

(i) Draw a line joining the positions of P_3 and P_4. Continue the line until it meets **CD**. Label this point **H**.

(ii) Measure and record the length *a* of the line **GH**.

a = ...

(iii) Draw the line **HF**.

(iv) Measure and record the length *b* of the line **HF**.

b = ...[3]

(c) Extend the straight line **EF** through the outline of the block to a point **J**. The point **J** must be at least 5 cm from the block. The line **EJ** crosses the line **CD**. Label this point **K**.

(i) Measure and record the length *c* of the line **GK**.

c = ...

(ii) Measure and record the length *d* of the line **FK**.

d = ...

(iii) Calculate the refractive index *n* of the material of the block using the equation

$$n = \frac{cb}{ad}.$$

n = ...[3]

[Total: 9]

4 The IGCSE class is investigating the refraction of light through a transparent block.

Fig. 4.1 shows the apparatus used.

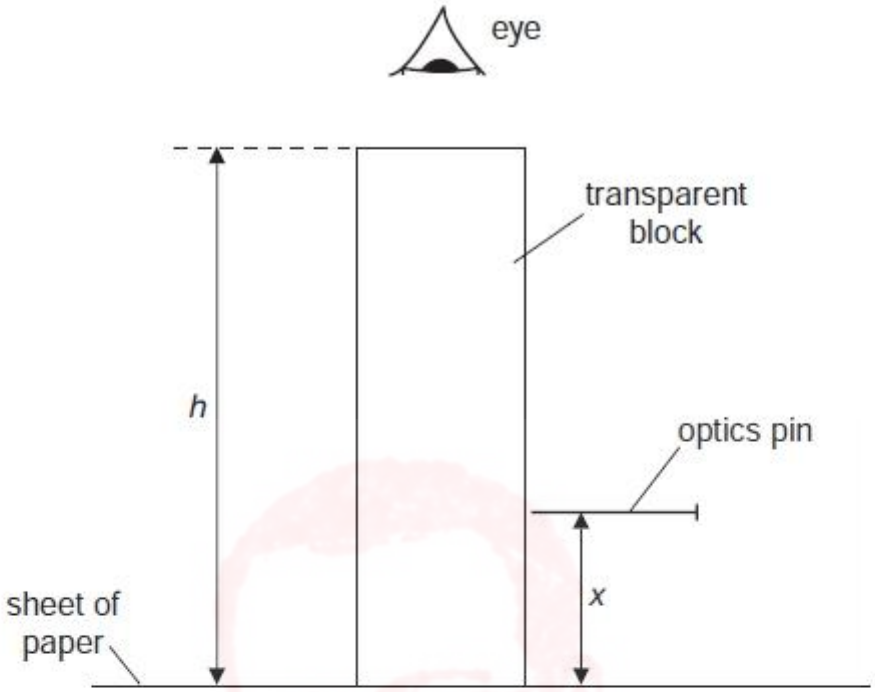


Fig. 4.1

(a) A student looks down through the transparent block at the image of a line drawn on the sheet of paper. She carefully places the point of the optics pin exactly in line with the image.

(i) On Fig. 4.1, measure the vertical distance *x* between the paper and the pin.

x = ...

(ii) On Fig. 4.1, measure the height *h* of the transparent block.

h = ...

(iii) Calculate the refractive index *n* of the material of the block using the equation

$$n = \frac{h}{h - x}.$$

n = ... [5]

(b) To obtain a reliable value for the vertical distance x between the paper and the pin, it is important that the pin is horizontal. Explain briefly with the aid of a diagram how you would check that the pin is horizontal.

.....

..... [1]

Q# 22/ iG Phx/2007/s/Paper 61/ www.SmashingScience.org :o)

4 The IGCSE class is investigating the formation of images by a lens.

Fig. 4.1 shows the apparatus that is being used.

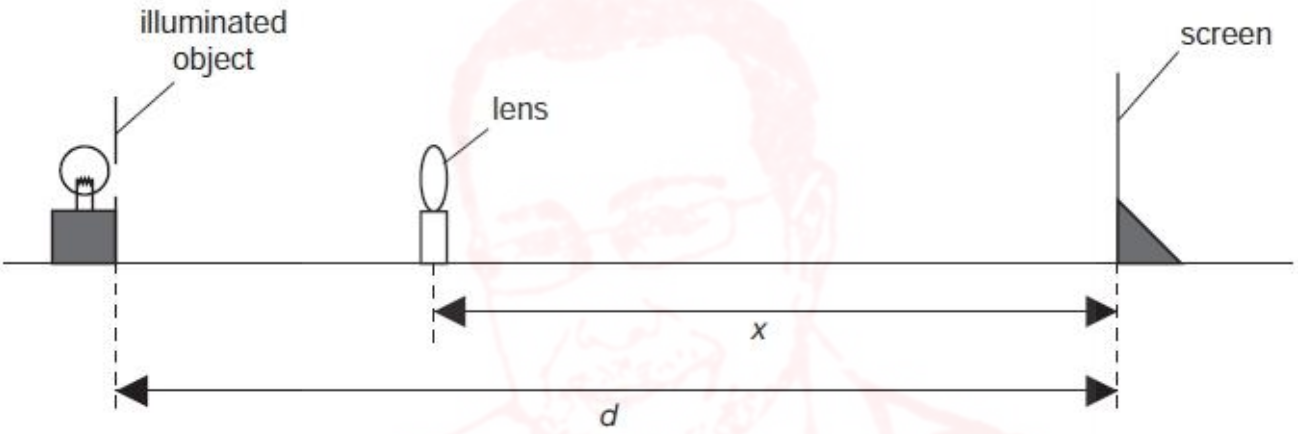


Fig. 4.1

(a) A student places the screen at a distance $d = 0.800\,\text{m}$ from the illuminated object. She adjusts the position of the lens until a clearly focused magnified image is formed on the screen. She measures the distance x between the centre of the lens and the screen. Without moving the illuminated object or the screen, she moves the lens towards the screen until a second clearly focused (but diminished) image is formed on the screen. She measures the distance y between the centre of the lens and the screen. She repeats the experiment with the distance d increased to 0.900 m. The readings are shown in the table.

x/m	y/m	d/m	f/m
0.205	0.600	0.800	
0.180	0.720	0.900	

(i) For each set of readings calculate the focal length f of the lens using the equation

$$f = \frac{xy}{d}.$$

(ii) Calculate the average value of the focal length *f*.

average value of the focal length *f* = ... [4]

(b) Suggest two precautions that can be taken in this experiment in order to obtain an accurate result.

1. .....

.....

2. .....

..... [2]

(c) The illuminated object is triangular in shape, as shown in Fig. 4.2.

Fig. 4.2

In the space below, sketch the appearance of one of the images on the screen.

[1]

[Total: 7]

3 The IGCSE class is investigating reflection in a plane mirror. Fig. 3.1 shows a ray diagram that a student is constructing.

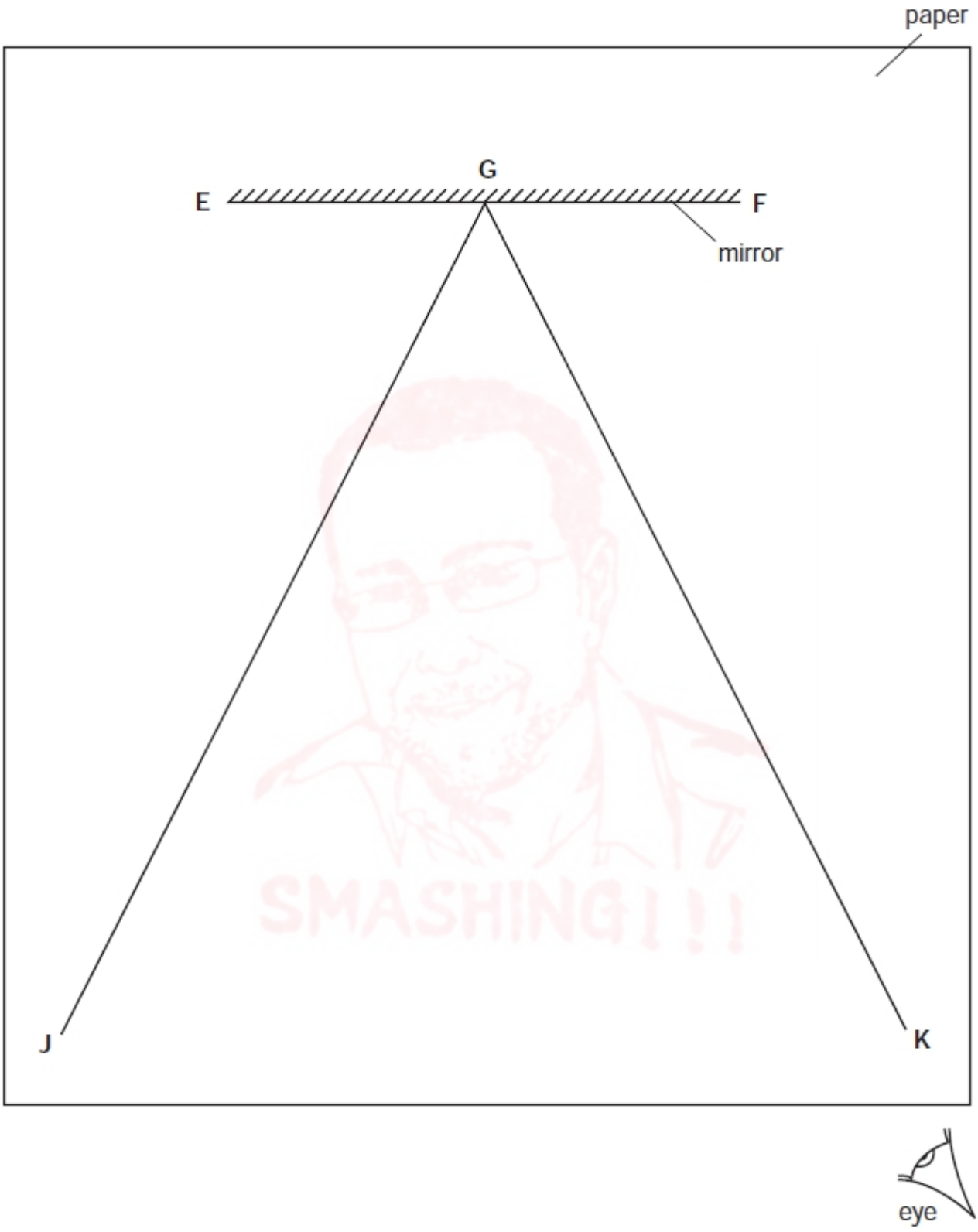


Fig. 3.1

(a) **(i)** Draw a normal GH to line EF.

(ii) Mark a point A on line GJ so that the distance AG is 11.5 cm.

(iii) Measure the angle of incidence *i* between line GJ and the normal.

i = ... [3]

(b) The student pushes two pins into the paper on line GJ, one at point A, and the other at a point B nearer to the mirror. He views the images of the pins from the direction indicated in Fig. 3.1. He then pushes in two pins on line GK between his eye and the mirror so that these two pins and the images of the pins on line GJ appear exactly one behind the other.

(i) On Fig. 3.1, mark suitable positions for the pins on lines GJ and GK. Label the marks with letters B, C and D.

(ii) To obtain an accurate result for this experiment, would you view the tops, bases or central parts of the pins when lining them up? Give a reason for your answer.

I would view .....

reason .....

.....

..... [3]

3 The IGCSE class is determining the refractive index of the material of a transparent block. Fig. 3.1. shows the drawing that a student makes.

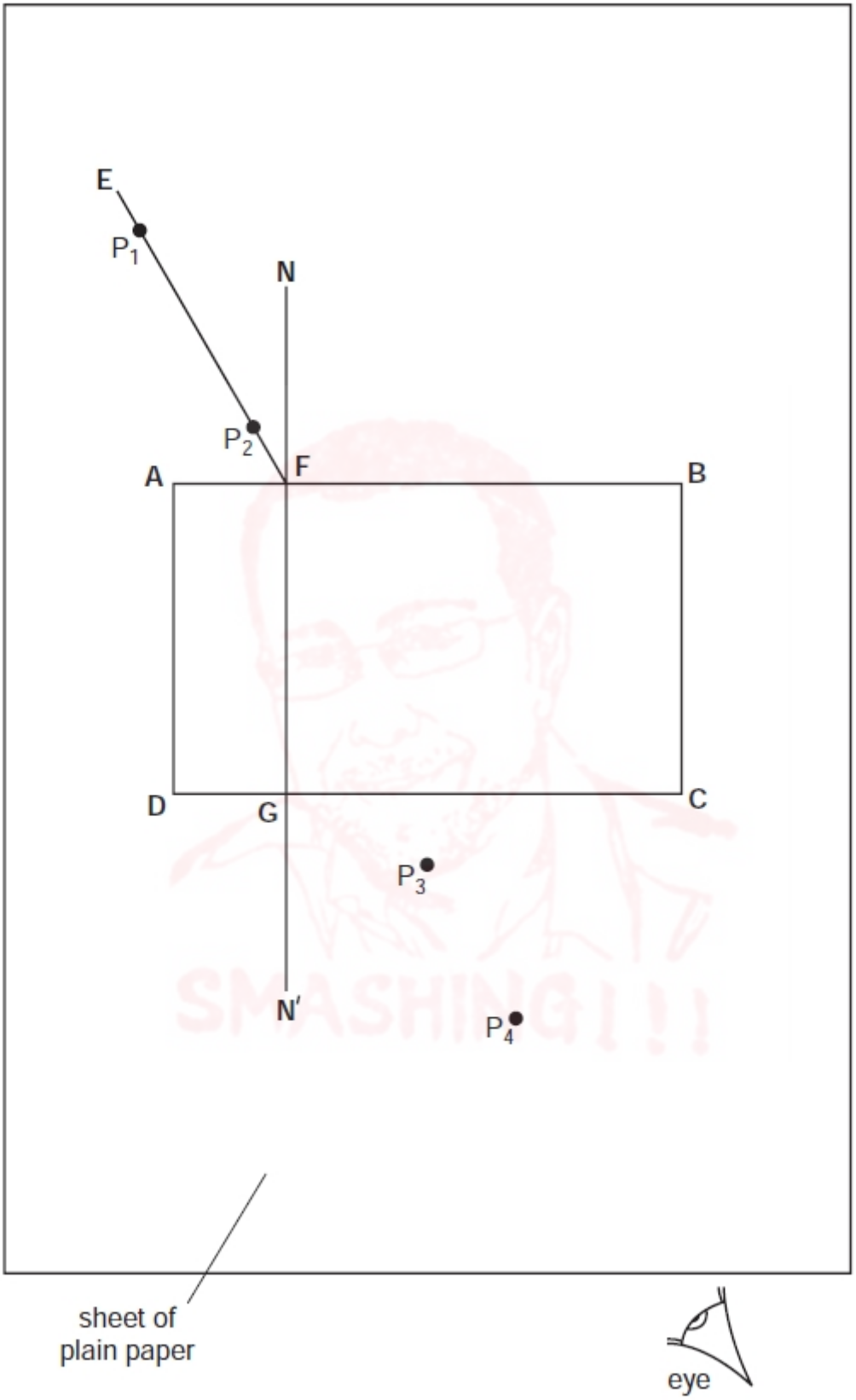


Fig. 3.1

The student places two pins P_1 and P_2 on line **EF** to mark an incident ray. Then she places the block on the paper and 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. She places two pins P_3 and P_4 between her 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.

(a) **(i)** Draw a line joining the positions of P_3 and P_4. Continue the line until it meets **CD**. Label this point **H**.

(ii) Measure the distance *a* between **G** and **H**.

a = ... [1]

(iii) Draw the line **HF**.

(iv) Measure the length *b* of the line **HF**.

b = ... [1]

(v) Extend the straight line **EF** within the outline of the block to a point **I**. The distance **FI** must be exactly equal to *b*.

(vi) From **I** draw a line that meets **NN′** at a right angle. Label this position **J**.

(vii) Measure the length *c* of the line **JI**.

c = ... [3]

(viii) Calculate the refractive index *n* of the material of the block using the equation

$$n = \frac{c}{a}.$$

n = ... [2]

(b) Suggest two improvements you would make to this experiment to ensure an accurate result for the refractive index *n*.

1 .....

.....

2 .....

..... [2]

4 An IGCSE student is investigating the reflection of light by a plane mirror.

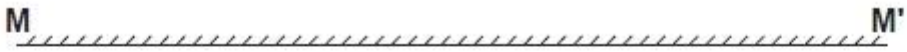


Fig. 4.1

On Fig. 4.1, the line **MM'** shows the position of the mirror that is standing on a sheet of paper. The reflecting surface of the mirror is vertical. **AB** is a card that is standing vertically and is parallel to the reflecting surface of the mirror.

(a) Draw a normal to the mirror such that the edge **B** of the card lies on the normal. [1]

(b) Measure the distance *x* along the normal between the line **MM'** and the edge **B** of the card.

x = ... [1]

(c) Draw a line from the edge **A** of the card to the point where the normal meets the line **MM'**. This represents an incident ray from the edge of the card. [1]

(d) Measure the angle *i* between the incident ray and the normal.

i = ... [1]

(e) Calculate the ratio $\frac{x}{y}$ where $y = 5.0$ cm, the length of the card.

$\frac{x}{y}$ = ... [2]

(f) The angle of reflection is to be determined as accurately as possible. On Fig. 4.1, mark with the letters **X**, **Y** and **Z** the points where the student would place three pins in order to plot the reflected ray. [4]

Q# 26/ iG Phx/2005/s/Paper 61/ www.SmashingScience.org :o)

5 A student investigates the refraction of light through a transparent block.

He places the transparent block on a sheet of plain paper, largest face down, and draws a line round the block. He draws a line to represent an incident ray and places two pins **W** and **X** in the line. Fig. 5.1 shows the outline of the block and the incident ray.

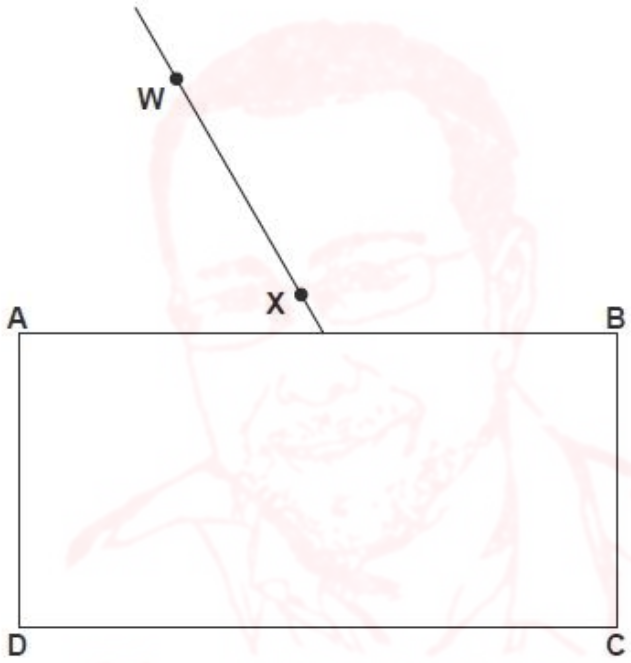


Fig. 5.1

(a) On Fig. 5.1, draw a normal to line **AB** at the point where the incident ray meets the block. The incident ray is drawn on the diagram. The positions of the two pins **W** and **X** that mark the incident ray are shown. [1]

(b) Measure the angle of incidence *i*.

i = ... [1]

(c) Draw in the refracted ray with an angle of refraction of 20°. Continue this line until it meets the line **CD**. [2]

(d) The ray emerges from the block in a direction that is parallel to the incident ray. Draw in this emergent ray. [2]

(e) Two pins **Y** and **Z** are placed so that the pins **W** and **X**, viewed through the block, and the pins **Y** and **Z** all appear exactly in line with each other. Mark on the diagram, with the letters **Y** and **Z**, where you would place these two pins. [2]

Q# 27/ iG Phx/2004/w/Paper 61/ www.SmashingScience.org :o)

4 A student is investigating the passage of light through a transparent block, as shown in Fig. 4.1.

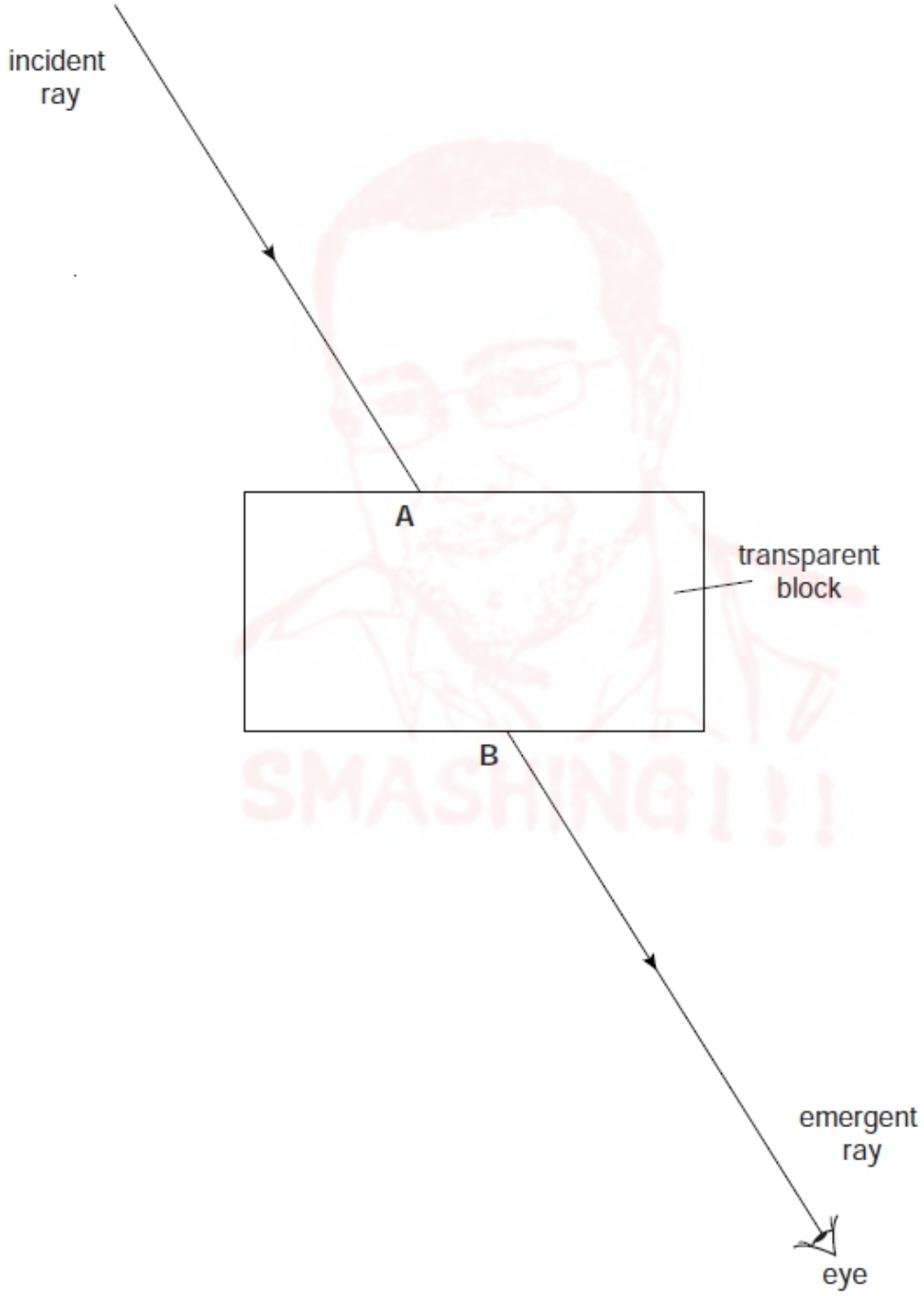


Fig. 4.1

The student looks through the block. He places pins so that two pins marking the incident ray and two pins marking the emergent ray all appear to be exactly one behind the other.

(a) On Fig. 4.1, mark suitable positions for the four pins, two on the incident ray and two on the emergent ray. [1]

(b) **(i)** On Fig. 4.1, draw the normal at point **A**.

(ii) On Fig. 4.1, draw in the line **AB**. Measure and record the angle of refraction *r* between the line **AB** and the normal.

r = ...

(iii) Measure and record the angle of incidence *i* between the incident ray and the normal.

i = ...

[4]

Q# 28/ iG Phx/2004/s/Paper 61/ www.SmashingScience.org :o)

4 The IGCSE class carries out an experiment using a convex lens, an illuminated object and a screen. Fig. 4.1 shows the apparatus. A sharp image is obtained on the screen.

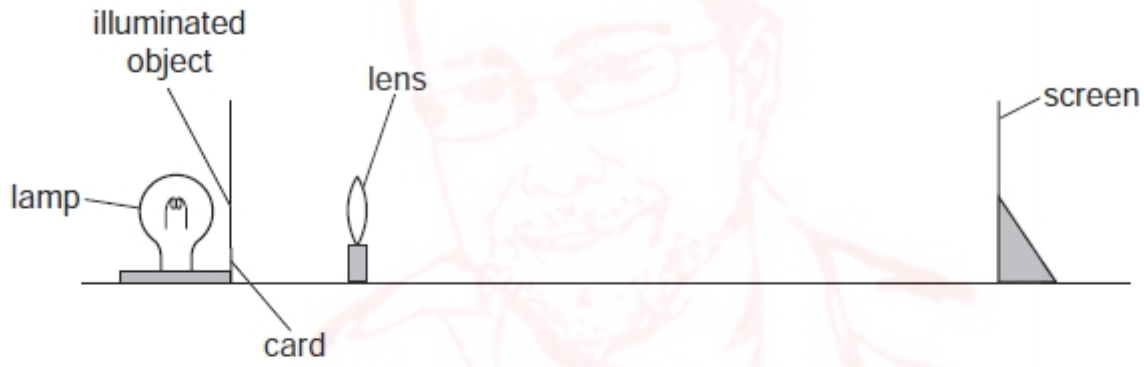


Fig. 4.1

(a) **(i)** Use your rule to measure, on Fig. 4.1, the distance *x* from the illuminated object to the centre of the lens.

x = ...

(ii) Use your rule to measure, on Fig. 4.1, the distance *y* from the centre of the lens to the screen.

y = ...

(iii) Fig. 4.1 shows the apparatus drawn to 1/5th of actual size. Calculate the actual distance *u* between the object and the lens, and the actual distance *v* between the lens and the screen.

u = ...

v = ...

(iv) Calculate the magnification m using the equation $m = \frac{v}{u}$.

m = ...

[5]

(b) The illuminated object is triangular in shape, as shown in Fig. 4.2.

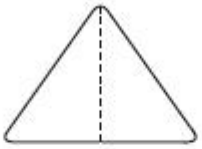


Fig. 4.2

Draw a diagram of the image as it would appear on the screen.

[1]

(c) State two precautions that the IGCSE class should take to obtain experimental readings that are as accurate as possible.

1. .....

.....

2. .....

..... [2]

1 The IGCSE class is investigating the conduction of electric current through copper sulphate solution. The circuit used is shown in Fig. 1.1.

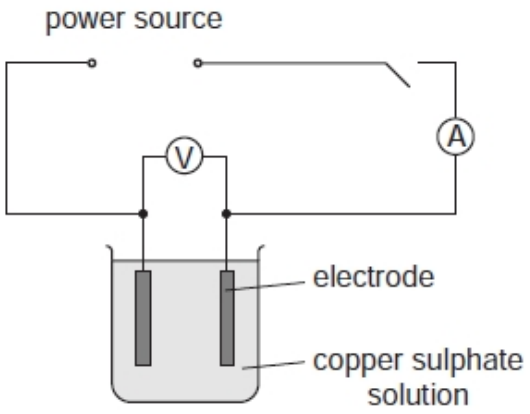


Fig. 1.1

During the experimental work, the students measure the volume of water, the mass of copper sulphate that is dissolved in the water, the current in the solution, the potential difference across the electrodes and the gap between the electrodes.

One set of readings is shown in Figs. 1.2 – 1.6.

(a) Write down the readings shown. Include appropriate units.

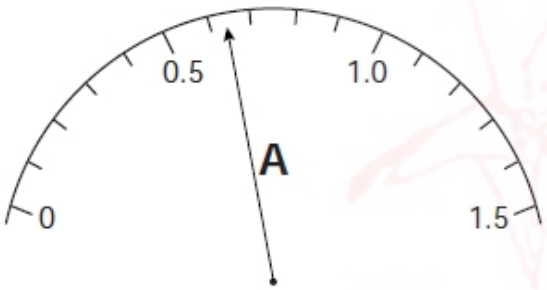


Fig. 1.2

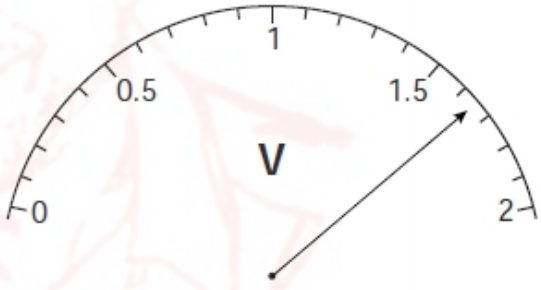


Fig. 1.3

current = ... potential difference = ...

Fig. 1.4

mass of copper sulphate = ...

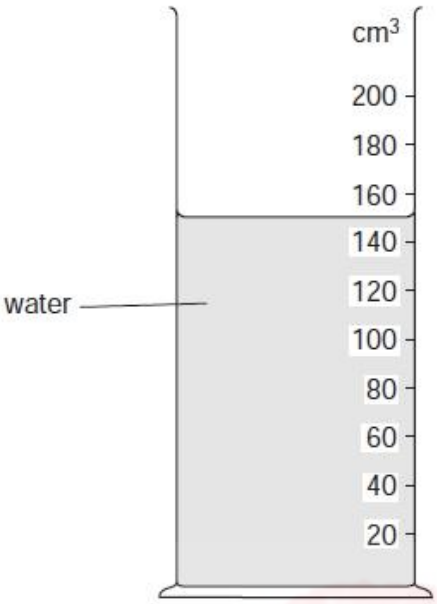


Fig. 1.5

volume of water = ...

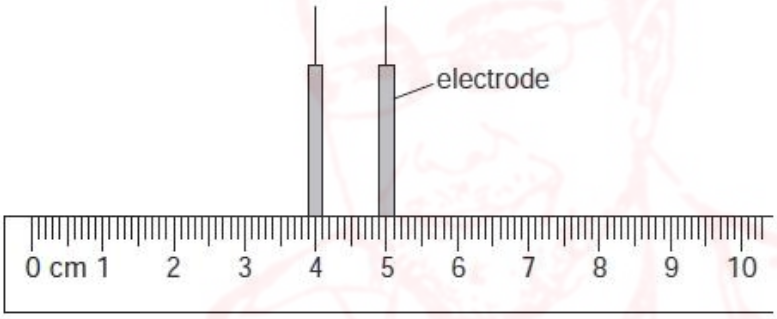


Fig. 1.6

gap between electrodes = ...
[6]

(b) It is not possible to put the rule inside the beaker to measure the gap between the electrodes. Explain how you would overcome this problem.

.....

.....

.....

..... [2]

(c) Suggest a variable, which is not measured in Figs. 1.2 – 1.6, that might affect the value of the current.

..... [1]

2 Fig. 2.1 shows a ray tracing sheet obtained by a student carrying out a reflection of light experiment using pins and a plane mirror.

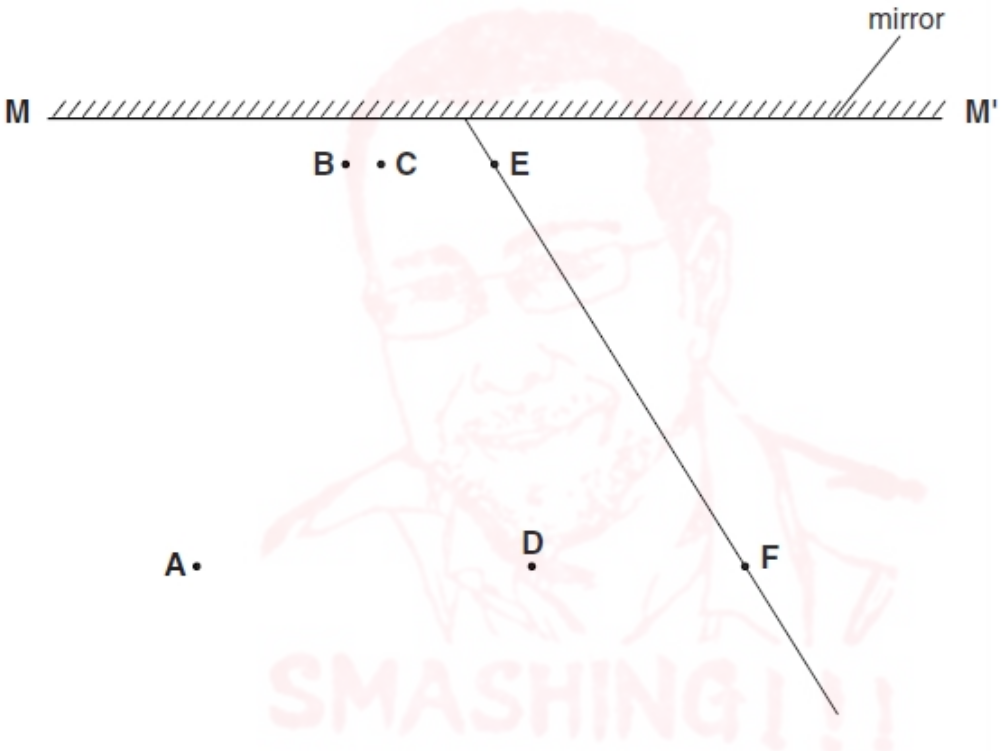


Fig. 2.1

The student looks into the mirror **MM'** and views the images of pins **A** and **B**. He then places pins **C** and **D** so that pins **C** and **D** and the images of pins **A** and **B** appear to be in line.

(a) On Fig. 2.1,

(i) draw the incident ray in this experiment,

(ii) draw the reflected ray,

(iii) draw a normal at the point where the incident ray meets the mirror,

(iv) measure the angle of incidence *i*.

i = ...

[3]

(b) The student moves pin **B** and then repeats the experiment, obtaining the reflected ray **EF**.

(i) On Fig. 2.1, continue the lines **CD** and **EF** behind the mirror to find the point where they meet. Label this point **X**.

(ii) Draw the line **AX**. Label with the letter **Y** the point where line **AX** crosses the mirror **MM'**.

(iii) Use your rule to measure the distances **AY** and **YX**.

AY = ...

YX = ...

[2]

(c) According to theory, **AY** = **YX**. Suggest why, in spite of very careful work, the student's values may have been slightly different.

.....

..... [1]

2 An IGCSE student was investigating the passage of red light through a prism. Fig. 2.1 shows the outline of the prism and an incident ray.

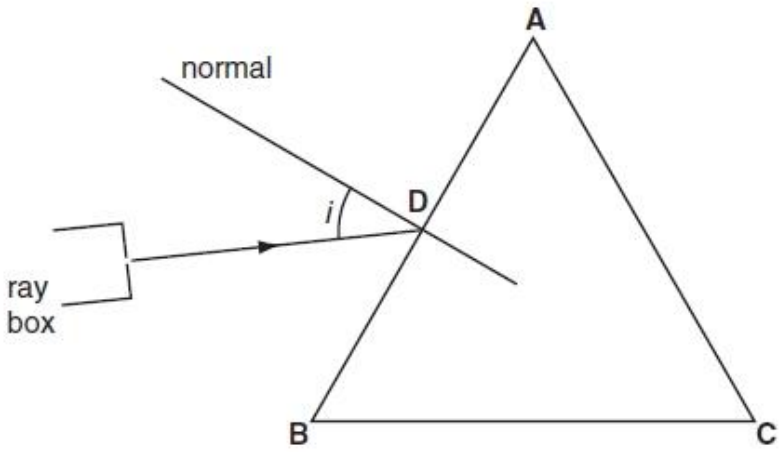


Fig. 2.1

(a) Measure the angle of incidence *i* shown in Fig. 2.1.

i = ...[1]

(b) The angle of refraction as the ray entered side **AB** of the prism was 22°.

(i) On Fig. 2.1, draw in the refracted ray from point **D** as accurately as possible.

(ii) Mark the point **E**, where the ray meets side **AC**. Draw the normal at point **E**.

[4]

(c) At point **E** the ray came out of the prism with an angle of refraction of 75°. On Fig. 2.1, draw as accurately as possible the ray coming out of the prism. [1]

(d) Another student used four optics pins to trace the passage of a ray through a prism. Fig. 2.2 shows the prism, the position of the student's eye and the directions of the ray.

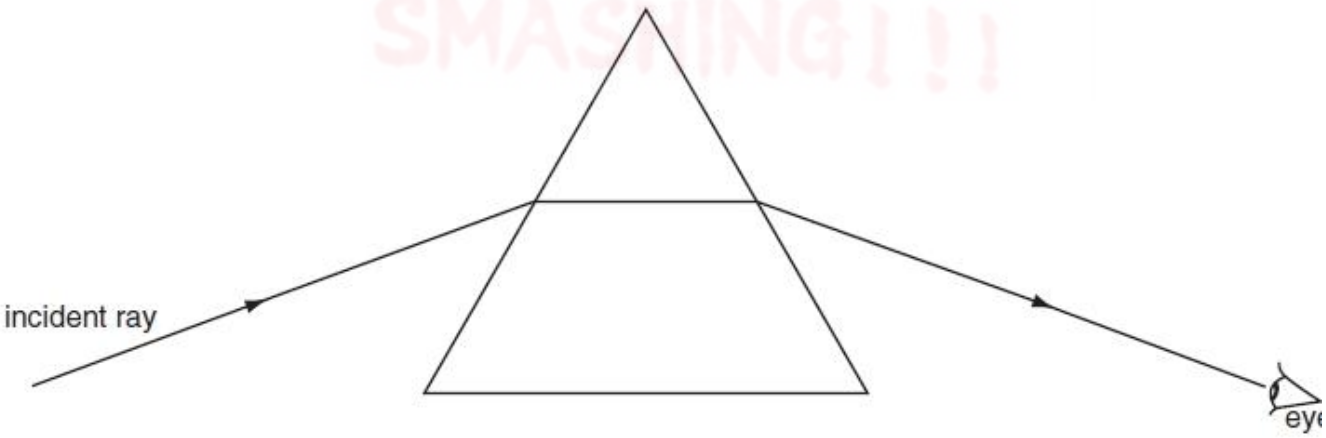


Fig. 2.2

On Fig. 2.2, show positions of the four optics pins, placed to obtain as accurate a result as possible. Mark each position clearly with a cross (X). [2]

5 A student carried out a lens experiment to investigate the magnification of an image. The apparatus is shown in Fig. 5.1.

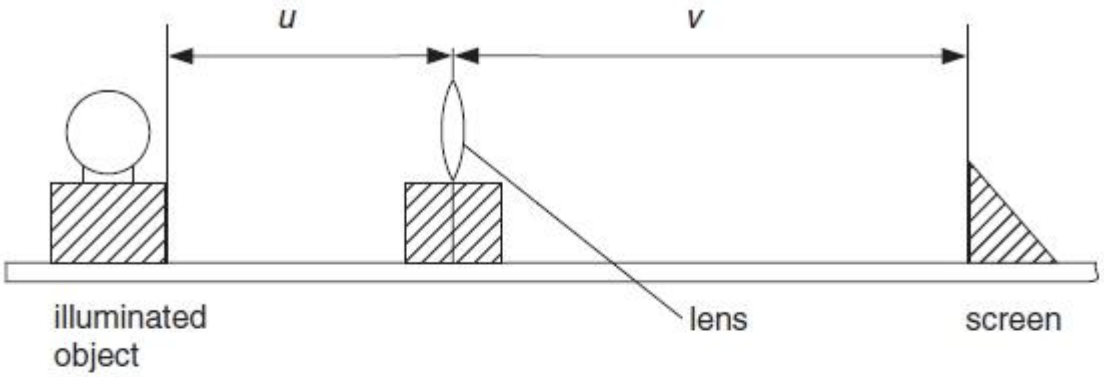


Fig. 5.1

The object is a triangular hole in a screen. Fig. 5.2 shows this, actual size.

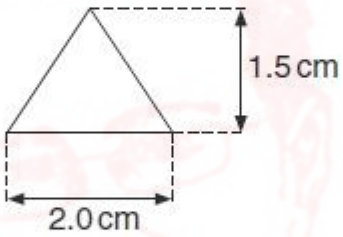


Fig. 5.2

The student set the distance *u* at 35.0 cm and moved the screen to obtain a sharply focused image. The image distance *v* was 72.3 cm.

(a) (i) Calculate *m*, the magnification, using the equation

$$m = v/u.$$

m = ...

(ii) Draw a diagram of the image, actual size, for a magnification $m = 2.0$.

[5]

(b) The image distance v is the distance from the screen to the **centre** of the lens.
Explain briefly how you would position a metre rule to obtain an accurate value for v.
You may draw a diagram.

.....

.....

.....[1]

Q# 1/ iG Phx/2015/s/Paper 61/ www.SmashingScience.org :o)

4 (a) (i) normal at centre of AB and through block [1]

(ii) GH parallel to AB AND 6 cm ± 2 mm above AB [1]

(iii) $i = 30° \pm 2°$ to left of normal [1]

(b) P_1P_2 distance ≥ 5.0 cm [1]

(c) line KE correct, single and straight, emergent ray through P_3 and P_4 [1]

(d) $a = 3.3 – 3.7$ (cm); $b = 6.8 – 7.2$ (cm); $c = 4.0 – 4.4$ (cm); $d = 1.4 – 1.8$ (cm) [1]

n in range 1.2–1.5, no unit, 2 or 3 significant figures [1]

(e) any one from:
- large pin separation
- ensure pins are vertical
- view bases of pins
- drawing thin lines / use a sharp pencil
- use thin pins [1]

(f) ray box near start of incident ray or anywhere on incident ray; pointing in correct direction [1]

[Total: 9]

Q# 2/ iG Phx/2014/w/Paper 61/ www.SmashingScience.org :o)

1 (a) normal at 90°, straight, at centre [1]

(b) incident ray at 30° on left of normal, straight [1]

(c) ray box near beginning of incident ray and pointing along it [1]

(d) reflected ray at angle of reflection approximately 30° [1]

(e) any two from:
darkened room / brighter ray box owtte
mark rays at centre / edge of beam
use sharp pencil
thin ray / small slit in ray box
perpendicular viewing of protractor [2]

[Total: 6]

4 (a) $u = 20\,\text{mm}$ AND $v = 58\,\text{mm}$ [1]

(b) $v/u = 2.9$ e.c.f. from (a) no unit [1]

(c) $U = 200$, $V = 580$ e.c.f. from (a) [1]

(d) 1.5 cm OR 15 mm [1]

(e) statement to match results (expect yes) [1]

justified by reference to results, communicating idea of within (beyond, ecf) limits of experimental accuracy [1]

(f) any two from:
use of darkened room / brighter lamp
mark position of centre of lens on holder
place metre rule on bench (or clamp in position)
ensure object and (centre of) lens are same height (from the bench)
repeats and average
moving lens / object / screen back and forth (to find sharpest image) owtte
screen and lens and object all perpendicular to bench [2]

(g) image inverted [1]

(h) any one from:
darkened room / brighter lamp
moving lens / object / screen back and forth owtte
use object with fine detail e.g. cross-wires
measure at middle of range where image is sharp [1]

[Total: 10]

5 (a) angle of incidence 30° and **AB** 8.0 cm single, continuous, straight line [1]

(b) P_3P_4 line correct and neat [1]

$\alpha_o = 30 \pm 1°$ [1]

(c) **graph:**
axes correctly labelled and correct way round [1]

suitable scales, i.e. *y*-axis 2 cm = 20°, *x*-axis 2 cm = 10° [1]

all plots correct to ½ small square [1]

good line judgement [1]

single, thin, continuous line, neat points [1]

(d) triangle method seen on graph with triangle using at least half of line [1]

G between 1.9 and 2.1, ecf for axes wrong way round [1]

(e) $(\alpha - \alpha_o) = 2\theta$ or words to that effect, no ecf [1]

(f) any one from:
large(r) pin separation
view bases of pins (or ensure pins vertical)
repeat and average
thin(ner) pins
thin(ner) lines / sharp(er) pencil [max 1]

[Total: 12]

Q# 5/ iG Phx/2013/w/Paper 61/ www.SmashingScience.org :o)

4 (a) (i)(ii) $u = 26$ (mm) or 2.6 (cm) [1]
$v = 44$ (mm) or 4.4 (cm) [1]

(b) (i)(ii) 1144 mm^2 and 70 mm
OR 11.44 cm^2 and 7.0 (or 7) cm [1]
e.c.f. from (a)

(iii) $x = 16$ or 16.3 or 16.34 (1.6 or 1.63 or 1.634)
e.c.f. from (b)(i) and (ii) [1]

(c) $f = 16$ or 16.3 or 16.34 cm (160 or 163 or 163.4 mm) [1]
f given to 2 or 3 significant figures [1]

(d) up to 0.5 cm either side of 18.2 cm [1]

(e) any two from:
use of darkened room / brighter lamp / no other light interfering
mark position of centre of lens on holder
place metre rule on bench (or clamp in position)
ensure object and lens are same height from the bench
lens / object / screen perpendicular to bench
repeats
avoidance of parallax with action and reason [2]

[Total: 9]

Q# 6/ iG Phx/2013/s/Paper 61/ www.SmashingScience.org :o)

4 on ray trace:
one line drawn accurately through P_3P_4 or CD [1]
both lines in correct place, neat, thin and intersecting [1]
normals Y to MR and P_1 to MR correct [1]
b = 55 – 65 (mm) [1]

(d) statement matches results (expect Yes) [1]
idea of within (or beyond) experimental accuracy [1]

(e) any one from:
large spaces between pins
make sure pins are vertical
observe bases of pins [1]

[Total: 7]

Q# 7/ iG Phx/2012/w/Paper 61/ www.SmashingScience.org :o)

5 **(a)** Measuring cylinder
Tape measure
Newtonmeter (spring balance)
Electronic balance
Manometer

1 mark each [5]

(b) **(i)** Viewing scale perpendicularly (owtte) [1]

(ii) Any one from:
Moving lens back and forth
Dark area (owtte)
Object and lens at same height from bench
Object lens and screen at right angles to bench [1]

[Total: 7]

Q# 8/ iG Phx/2012/w/Paper 61/ www.SmashingScience.org :o)

4 (a) Trace:
Normal at 90° in correct position [1]
Angle of incidence = 30° (± 2°) [1]

(b) P_1P_2 distance ⩾ 5.0 cm [1]
P_3P_4 line and line **GE** correctly and neatly drawn [1]

(c) (i) r = 18 or 19 or 20 [1]

(ii) i/r value correct [1]

(d) (i) i/r value 1.54 and both i/r values with no unit and to 2 or 3 significant figures [1]

(ii) Idea of within (or beyond) limits of experimental accuracy [1]

[Total: 8]

Q# 9/ iG Phx/2012/s/Paper 61/ www.SmashingScience.org :o)

4 (a) d in range 79 to 80 (mm), 7.9 to 8.0 (cm) [1]
x = 61 (mm) and consistent correct unit for both (mm or cm) [1]
D = 80 (cm), X = 61 (cm) ecf from (i) and (ii) [1]

(b) f = 14.5(cm) allow ecf from (a) [1]
2 or 3 significant figures and correct unit [1]

(c) Correct statement for results (expect Yes or wtte) [1]
Idea of within (or beyond) experimental accuracy or wtte [1]
Can only score if previous mark is scored

(d) Any one from:
Use of darkened room
How to avoid parallax when taking readings
Movement of lens back and forth to obtain clearest image
Mark lens holder to show position of centre of lens
Metre rule clamped or on bench
Object, lens and screen all perpendicular to bench
Object and lens same height above bench [1]

[Total: 8]

Q# 10/ iG Phx/2011/w/Paper 61/ www.SmashingScience.org :o)

5 (a) 200 m or more with unit [1]

(b) tape measure, trundle wheel or gps device [1]

(c) correct working seen [1]
345.67 (accept 345.66, 345, 346, 350) [1]

(d) (No), readings (time or distance) too inaccurate [1]

[Total: 5]

Q# 11/ iG Phx/2011/w/Paper 61/ www.SmashingScience.org :o)

4 (a) (i) normal at 90°, at centre of **MR** and crossing **MR** [1]

(ii) **AB** is a continuous line from **B**, 8 cm long [1]
AB is at 40° to normal [1]

(b) (i) continuous, thin line that reaches normal and at least touches P_2 and P_3 dots [1]

(ii) $r = 40 - 43(^{\circ})$ (no ecf) [1]

(c) any two from:
thickness of lines
thickness of protractor o.w.t.t.e. / accuracy of reading protractor
thickness of pins / pin holes [2]
accept thickness of mirror / glass in front of mirror

(d) ticks in boxes 1, 3, 5 (1 mark each)
(if more than 3 ticks, –1 for each tick in a wrong box to minimum of 0) [3]

[Total: 10]

Q# 12/ iG Phx/2011/s/Paper 61/ www.SmashingScience.org :o)

4 (a) (i) pins at least 5 cm apart [1]

(ii) $i = 30$ [1]

(iii) $r_1 = 31$ [1]

(b) (i) & (ii) both lines correct area [1]

(iii)–(v) r_2 correct to $\pm$ 1° with unit [1]
difference = 1 or –1 (c.a.o.) [1]

(c) statement matches result (expect YES) (ecf NO) [1]
justification matches statement and by reference to result
(expect within limits of experimental accuracy, wtte) (too different, wtte) [1]

[Total: 8]

Q# 13/ iG Phx/2011/s/Paper 61/ www.SmashingScience.org :o)

4. (a) Normal in centre at 90° to **MR** [1]
CD drawn correctly [1]
Both neat and thin [1]

(b) (i) **CN** drawn correctly [1]

(ii) $i = 23(^{\circ}) \pm 1(^{\circ})$ (ecf allowed) [1]

(c) (i) Line through P_3 and P_4 correct [1]
$r = 21(^{\circ}) \pm 1(^{\circ})$ [1]

(d) Any two:
Thickness of lines
Thickness of mirror
Protractor can only be read to $\pm$ 1° OR protractors are not that precise (owtte)
Thickness of pins [2]

[Total: 9]

Q# 14/ iG Phx/2010/w/Paper 61/ www.SmashingScience.org :o)

4 (a) (i) – (iii)
EF extended correctly and neat [1]
P_3P_4 line drawn correctly and neat [1]
G labelled [1]
P_1 and P_2 at least 5cm apart [1]

(iv) and **(v)** 40 – 42 (ecf) [1]
$(\theta - 2i)$ correct (ecf) [1]

(b) (i) 2 and unit (°) present at least once [1]

(ii) yes (or No, ecf) [1]
reference to 'within limits of experimental accuracy'
(or close enough or wtte) [1]

(c) no concern about pins being vertical (or wtte) [1]

[Total: 10]

Q# 15/ iG Phx/2009/w/Paper 61/ www.SmashingScience.org :o)

4 (a) f 14.95 ± 0.05 (cm) [1]
unit to match number [1]

(b) more than one value shown [1]
d 6.5 ± 0.1 [1]

(c) t 0.85 ± 0.05 (cm) [1]
d and t both with correct unit [1]

(d) diagram showing blocks correctly placed [1]
rule shown correctly touching both blocks [1]

(e) f 10.9 – 13.1 (cm) (or 109 – 131 (mm)) [1]
no, too far out to be explained by experimental inaccuracy (wtte) [1]

[Total: 10]

Q# 16/ iG Phx/2009/w/Paper 61/ www.SmashingScience.org :o)

5 (a) lens between object and screen (not mirror) [1]
lens at least 2 cm from object and screen [1]
metre rule on bench or clamped [1]

(b) any two from:
use of darkened room/brighter object
slowly moving lens back and forth to obtain good image
avoid parallax, action given
lining up object and lens
object and lens at same height from bench/object on principal axis
repeats
screen/lens perpendicular to bench
mark centre of lens position on block [2]

[Total: 5]

Q# 17/ iG Phx/2009/s/Paper 61/ www.SmashingScience.org :o)

4 (a) 4.0 (cm) [1]
6.0 (cm) [1]

(b) 20, 30 ecf allowed [1]
f values 11.88 (11.9), 12.00 (12.0) [1]
f consistent 3 or more significant figures [1]

(c) average f 11.9, 11.94, 11.95, 12.0, 12 (cm) ecf allowed [1]
2/3 significant figures [1]

(h) Any two from
use of darkened room
slowly moving lens back and forth to get good image
clamp rule or place on bench
avoid parallax action given
object/lens/screen perpendicular to bench
object and lens same height from bench
repeats [2]

[Total: 9]

Q# 18/ iG Phx/2008/w/Paper 61/ www.SmashingScience.org :o)

2 Diagram: correct symbols for ammeter and voltmeter [1]
correct symbols for resistor [1]
correct circuit arrangement [1]

Table: units V, A (symbol/word) [1]

(c) Prediction 1 Yes – close enough (or words to that effect)
OR No – not close enough (or words to that effect) [1]
Prediction 2 Yes – approximately half (or words to that effect) [1]

Resistance at connections
Internal resistance of source/other sensible suggestion [1]

[Total: 7]

Q# 19/ iG Phx/2008/w/Paper 61/ www.SmashingScience.org :o)

4 (a) f = 14.9(4), or 15 [1]
correct unit for f [1]

(b) (i) x_s = 5.0(cm) and y_s = 5.2(cm) [1]

(ii) factor of ×6 [1]
y = 31.2(cm) (ecf) [1]

(iii) 15.29, 15.3, 15 (ecf) [1]

(iv) correct method [1]
2 or 3 significant figures and correct unit [1]
average f 15.1 (correct answer only) [1]

(c) inverted image [1]

[Total: 10]

Q# 20/ iG Phx/2008/s/Paper 61/ www.SmashingScience.org :o)

4 Trace:

(a) all lines present, thin, neat and in correct area [1]
normal at 90° (by eye)
and EF at 30° to normal (by eye) [1]
line KJ to at least beyond P_4 [1]

(b) **(i)** a = 12–13 (mm) no ecf [1]

(ii) b = 40 (mm) no ecf [1]
a and b both with appropriate unit [1]

(c) **(i)** & **(ii)** c recorded and d = 44 (mm) [1]

(iii) correct calculation of n, value 1.43 (ecf) [1]
2/3 significant figures with no unit [1]

[Total: 9]

Q# 21/ iG Phx/2007/w/Paper 61/ www.SmashingScience.org :o)

4 **(a)** **(i)** x = 2.1, 2.2 [1]

(ii) h = 6.5, 6.6 [1]
x and h with same unit [1]

(iii) correct arithmetic for n1.47 – 1.51 (ecf) [1]
2/3 sf and no unit [1]

(b) two equal heights from bench (or other valid method) [1]

[Total: 6]

Q# 22/ iG Phx/2007/s/Paper 61/ www.SmashingScience.org :o)

4 **(a)** correct arithmetic for f, 0.154, 0.144 (any sf) [1]
correct average f (0.149, ecf) [1]
average f to 2/3 sf [1]
correct unit for average f (m) [1]

(b) precautions:
any two from:
use darkened area (wtte)
metre rule on bench or clamped
object and lens same height from bench
mark on lens holder to show position of lens centre
take more readings
choosing mid point between acceptable positions
parallax, action and reason
lens/screen perpendicular to bench [2]

(c) inverted [1]

[Total: 7]

Q# 23/ iG Phx/2006/w/Paper 61/ www.SmashingScience.org :o)

3	(a)	(i)	normal correct (by eye) (single, thin line)	[1]
		(ii)	AG = 11.5 cm (± 0.1)	[1]
		(iii)	i = 26°/27°/28° (ignore unit)	[1]
	(b)	(i)	CD pin separation ≥ 5 cm	[1]
		(ii)	bases pins may not be vertical	[1] [1]

[Total: 6]

Q# 24/ iG Phx/2006/s/Paper 61/ www.SmashingScience.org :o)

3	**(a)**		All lines present and neat, a = 1.5 cm	**[1]**
		(iv)	b = 4.3 cm	**[1]**
		(iv)	FI = 4.3 cm (or cand's a value)	**[1]**
		(v)	IJ meets NN' at right angle (by eye)	**[1]**
		(vi)	c correct to ± 1 mm, 2.1 cm	**[1]**
		(vii)	n calculation correct 2/3 sf and no unit (1.4)	**[1]** **[1]**
	(b)		repeats and averages greater pin spacing	**[1]** **[1]**

TOTAL 9

Q# 25/ iG Phx/2005/w/Paper 61/ www.SmashingScience.org :o)

4	**(a)**	normal in correct position and at 90° (by eye)	1
	(b)	9.9 – 10.2 cm	1
(c)		incident ray drawn in correctly	1
(d)		27° (± 2°)	1
(e)		2.0 (or correct from candidates x value) 2 or 3 sf and no unit	1 1
(f)		X on incident ray close to mirror Y and Z on reflected ray Y – Z distance at least 5 cm i = r (by eye)	1 1 1 1

TOTAL 10

Q# 26/ iG Phx/2005/s/Paper 61/ www.SmashingScience.org :o)

5	(a)	normal in correct position and at 90° (by eye)	[1]
	(b)	i = 29 - 31	[1]
	(c)	refracted ray correct side of normal and at angle < i	[1]
		r = 18 - 22	[1]
	(d)	ray displaced and parallel to incident ray (by eye)	[1]
		all correct lines drawn neatly, not too thick, and forming continuous path	[1]
	(e)	two pins on emerging ray, labelled Y and Z	[1]
		pins at least 3 cm apart	[1]
			[total: 8]

Q# 27/ iG Phx/2004/w/Paper 61/ www.SmashingScience.org :o)

4	(a)	4 pins at least one separation, separation ≥ 5 cm	1
		normal at 90° (by eye)	1
		r = 19 – 21	1
		i = 31 – 33	1
		unit given for both	1
			TOTAL 5

Q# 28/ iG Phx/2004/s/Paper 61/ www.SmashingScience.org :o)

4	(a)	(i)	x = 14 – 16mm	1
		(ii)	y = 76.5 – 78.5 mm	1
		(iii)	u = 75mm (ecf) and v = 390mm (ecf)	1
			x,y,u and v all correct and with no unit	1
		(iv)	m = 5.2 (ecf) 2/3 sf and with no unit	1
	(b)		Upside down	1
			Precaution 1	1
			Precaution 2	1
			(e.g. repeats, use mark on block supporting lens to show centre of lens, place metre rule on bench to take readings or clamp rule in position, use a dark area, explanation of how to avoid parallax error, vertical screen/lens/both, centres of lens and object in line)	
			TOTAL	8

Q# 29/ iG Phx/2004/s/Paper 61/ www.SmashingScience.org :o)

1	(a)	0.63 – 0.65 (A) (strictly)	1
		1.64 – 1.66 (V) (strictly)	1
		3.32 (g)	1
		150 (cm^3)	1
		8 (mm) or 0.8 (cm)	1
		All units correct	1

(b)	Remove electrodes from beaker		1
	A method to ensure gap remains the same (or other suitable suggestion e.g. measurement arrangement that the beaker sits on)		1
(c)	New variable (e.g. temperature, surface area / vol / size of electrodes, power source setting, depth of immersion)		1
		TOTAL	**9**

Q# 30/ iG Phx/2003/w/Paper 61/ www.SmashingScience.org :o)

2	(a) (i)(ii)	2 neat continuous rays (thickness up to as EF)	1
	(iii)	normal where incident ray meets mirror (90° by eye)	1
	(iv)	i = 20° ± 1° (allow e.c.f. if mark for normal not scored)	1
	(b) (i)(ii)	lines complete and neat with AX correctly intersecting	1
	(iii)	AY = 5.9 – 6.1 cm AND YX = 5.5 + 0.3 cm	1
	(c)	any one from: thickness of mirror thickness of lines thickness of pins judgement of where lines cross	1
			TOTAL 6

Q# 31/ iG Phx/2003/s/Paper 61/ www.SmashingScience.org :o)

2	(a)	36° (±1°)	1
	(b)	Refracted ray drawn	1
		22° (±1°)	1
		normal correct (by eye)	1
		neat, thin, correct lines	1
	(c)	Correct refracted ray (by eye) with arrow	1
	(d)	Separation (LHS) at least 5cm	1
		Separation (RHS) at least 5cm	1
		TOTAL	**8**

Q# 32/ iG Phx/2002/w/Paper 61/ www.SmashingScience.org :o)

5. (a) (i)	2.07	1
	2/3 sf	1
	no unit	1
(ii)	upside down	1
	3 cm high	1
(b)	metre rule on bench or clamped above lens	1
		TOTAL 6