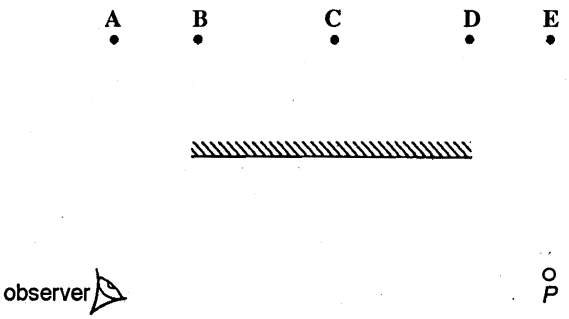
TOPIC 13 Light

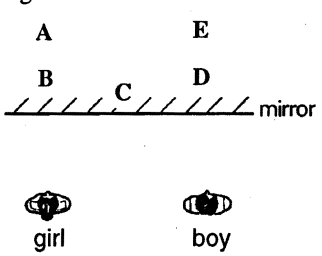
13.1 Reflection of light

1 A pin *P* is placed in front of and to the right of a plane mirror as shown in the diagram.



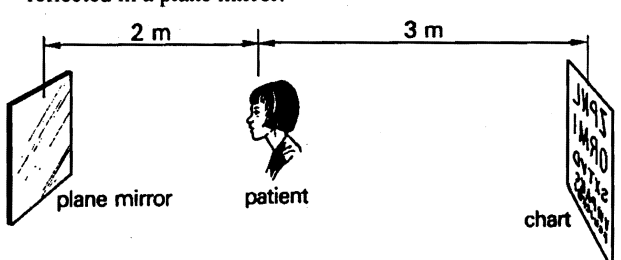
At which point is the image of the pin seen? J91/I/21

2 A boy stands at the side of a girl in front of a large plane mirror. They are both the same distance from the mirror, as shown in the diagram.



Where does the boy see the girl's image? N92/I/20

3 The diagram shows a patient having her eyes tested. A chart with letters on is placed behind her and she sees it reflected in a plane mirror.



How far away from the patient will the chart seem to be?

A 7m **B** 6m **C** 5m **D** 4m **E** 2m

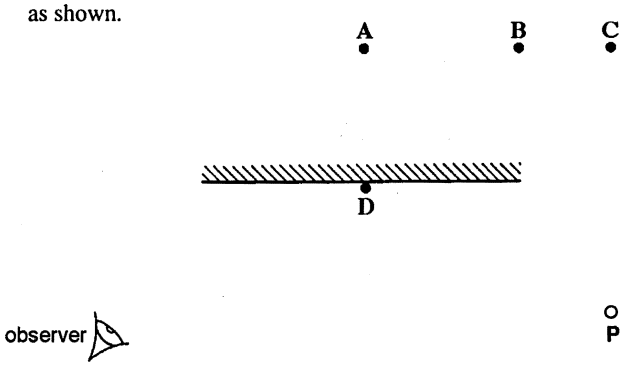
J93/I/19

4 Which of the following describes the image formed in a plane mirror when compared to the object?

	image type	*image size*
A	virtual	smaller
B	virtual	same
C	virtual	larger
D	real	smaller
E	real	same

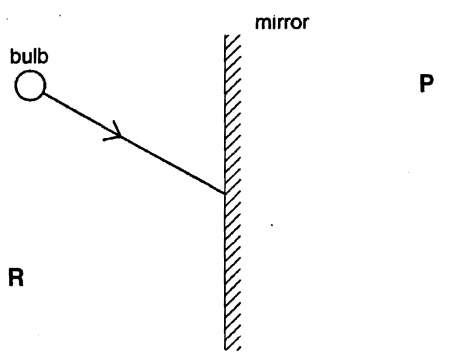
N93/I/20

5 A pin **P** is placed in front of and to the right of a plane mirror as shown.



Where is the image of the pin? N95/I/21

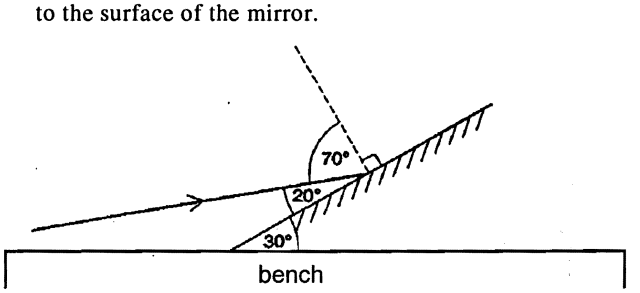
6 The diagram shows a ray of light from a small lamp striking a plane mirror.



The image of the lamp formed by the mirror is

A at **P** and is real.
B at **P** and is virtual.
C at **R** and is real.
D at **R** and is virtual. J96/I/22 ; N2000/I/18

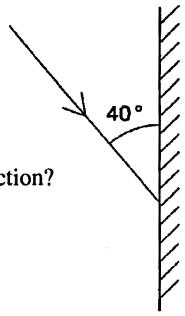
7 A mirror is tilted at an angle of 30° to the bench. A ray of light is directed so that it hits the mirror at an angle of 20° to the surface of the mirror.



What is the angle of reflection?

A 20°
B 30°
C 50°
D 70° J97/I/19

8 The diagram shows a single ray of light being directed at a plane mirror

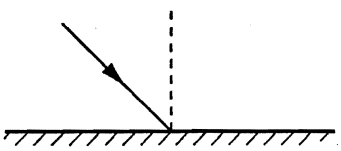


What are the angles of incidence and reflection?

	angle of incidence	*angle of reflection*
A	40°	40°
B	40°	50°
C	50°	40°
D	50°	50°

N97/I/21

9 The diagram shows a ray of light striking a plane mirror.

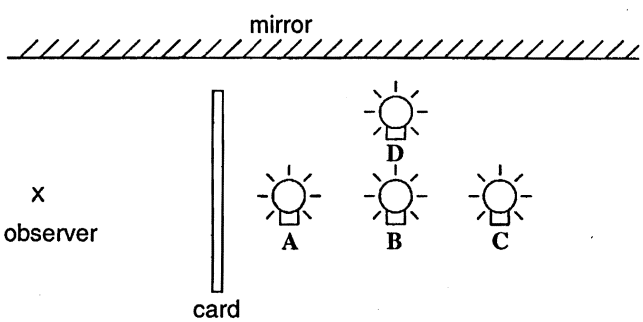


What must the angle of incidence be if the total angle between the incident and reflected rays is 80°?

A 40° **C** 80°
B 50° **D** 100° J98/I/19

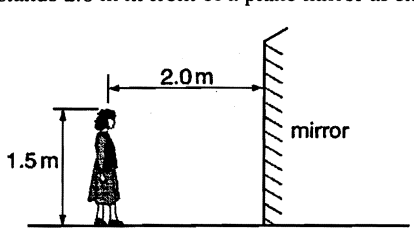
10 The diagram shows four lamps in front of a plane mirror. The card prevents the observer at X from seeing the lamps directly, although the image of one lamp can be seen in the mirror.

Which lamp's image can be seen?



N98/I/20

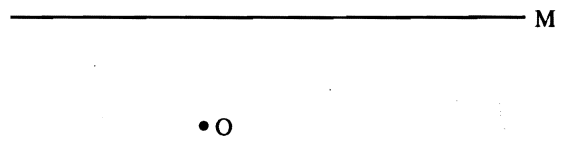
11 A person stands 2.0 m in front of a plane mirror as shown.



How far from the person is her image?

A 2.0 m **C** 3.5 m
B 3.0 m **D** 4.0 m J2000/I/18

12

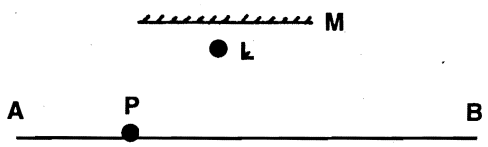


The straight line M in the diagram represents the reflecting surface of a plane mirror.

Show the position of I, the image formed by the mirror of the object O. Draw the paths of two rays of light from the object to a marked position of an eye, to show how the eye can see this image.

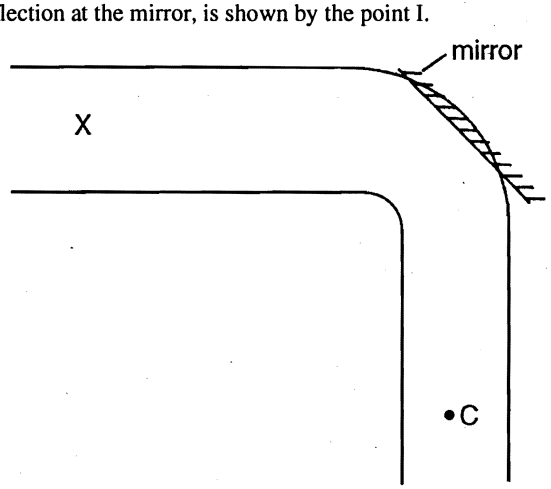
If the mirror is made of glass and silvered on the back surface, more that one image can be seen, the eye being in the same position as before. Why is this? J79/I/6

13 A small lamp L hangs above a sheet of white paper, AB, as shown in the diagram. With the aid of rays drawn on the diagram, explain briefly why the paper around P appears brighter when a plane mirror M is placed above the lamp in the position shown.



Why does the appearance of the paper around A remain unchanged when the mirror is introduced? N81/1/6

14 The diagram below is a scale drawing of a narrow road with a plane mirror mounted across the corner of a 90° bend. The point C represents a car. The image of the car, formed by reflection at the mirror, is shown by the point I.

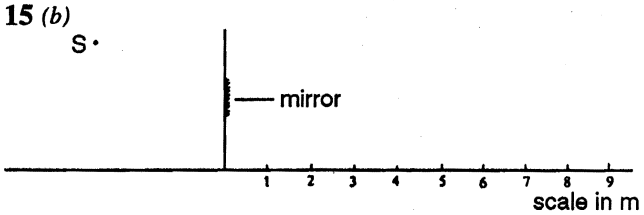


Draw the paths of **two** rays of light from C by which a man at X sees this image.

The car travels towards the bend, along the centre line of the road, a distance represented by 10 mm on the diagram. Mark I' the position of the image of the car when it has travelled to this position.

Draw an arrow on the diagram to show the direction in which the car appears to the man to be travelling. N82/1/8

15 *(b)*



The window is now covered with a plane mirror as shown above.

(i) Show how two rays from S are reflected by the mirror and use them to locate the image of S. Mark clearly the position of the *image* of S.

Write down the distance of this image from S.

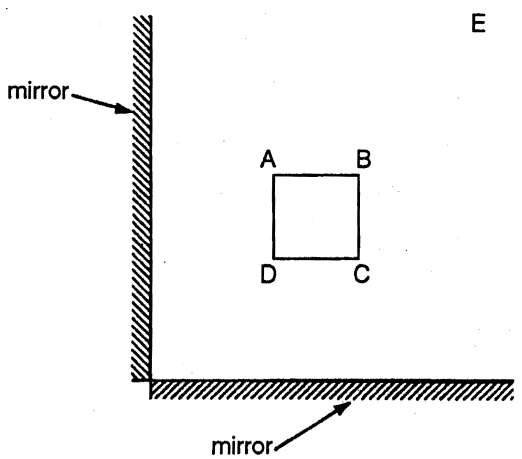
(ii) Write down **one** characteristic of this image

(iii) State the **two** laws of reflection that this example demonstrates. J82/II/3*(b)*

16 A square ABCD is placed, as shown, in the corner between two vertical plane mirrors set at right angles.

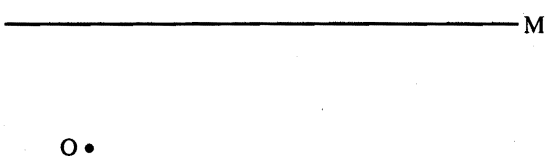
Draw rays to show how an eye at E can see both the midpoints of AD and CD by single renections.

By drawing an additional ray, locate the image of the midpoint of AD.



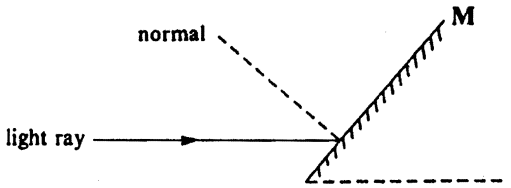
J83/I/5

17 In the diagram, M represents a polished reflecting surface. Draw the paths of two rays to show how an eye, to the right of an object O, is able to see an image of O in the mirror. Mark the position of this image.

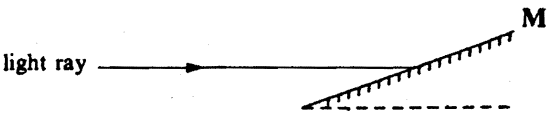


Account for the fact that, under some circumstances, two images of an object may be seen in a glass mirror. (You are not required to draw a diagram for this part of the question.) N83/I/9

18



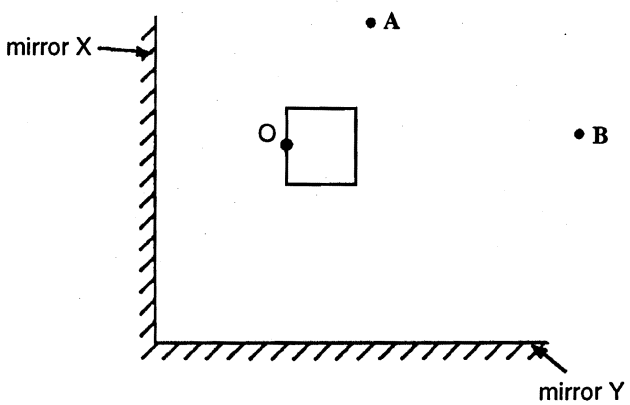
The diagram above shows a ray of light incident on a plane mirror M. Measure the angle of incidence and draw accurately the path of the light ray after reflection.



The mirror is now turned through 30°, as shown. Draw the new path of the reflected ray.

Determine the angle the reflected ray turned through when the mirror turned through 30°. J85/I/8

19 The diagram shows two mirrors X and Y, and a solid object with a coloured spot at O, the centre of its left hand face.

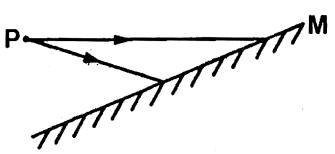


An eye at A sees an image of O resulting from the reflection at the mirror X. Mark I, the position of this image and draw a ray from O to the eye at A.

When the eye is moved to B, it sees an image of O resulting from reflections at *both mirrors*. Draw a ray of light from O which enables the eye at B to see this image.

N86/1/10

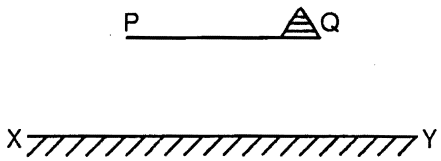
20 *(b)* The diagram shows two light rays, from an object P, incident on a plane mirror M.



Sketch the paths of the rays aher reflection from M.

Using the reflected rays, locate the image of P formed by the mirror. J87/1/6*(b)*

21



In the diagram, XY is the reflecting surface of a plane mirror and PQ is an object in front of the mirror. Show the position of the image of P formed by reflection at XY by a dot labelled P'. Draw the paths of two rays from P which are reflected by the mirror.

State **two** properties of the image of PQ produced by reflection at the morror. N87/1/8

22 *(a)* Fig. 1.1 shows the positions of the eye of a car driver, the wing mirror of the car and the front of a lorry.

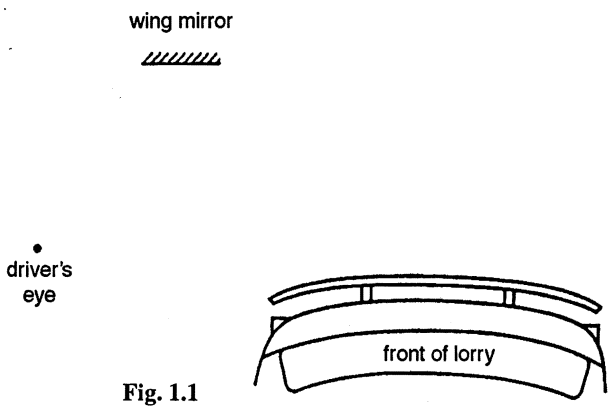


Fig. 1.1

(i) Draw rays to indicate the part of the front of the lorry which can be seen in the mirror by the car driver. [3]

(ii) The wing mirror of a car is often curved with a surface of the shape shown in Fig. 1.2.

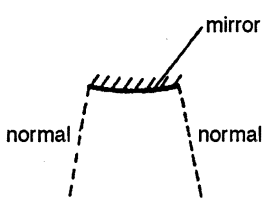


Fig. 1.2

Using the laws of reflection, explain how the curved mirror would enable more of the front of the lorry to be seen. [2] N89/II/3*(a)*

23 *(a)* Fig. 2 shows a point object **O** in front of a plane mirror.

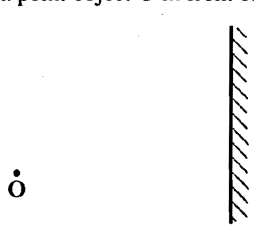


Fig. 2

On Fig. 2 mark with a cross the position of the image of **O**. Label the image "M". N91/II/5*(a)*

24 *(a)* Fig. 3.1 shows a point object **P** in front of a plane mirror.

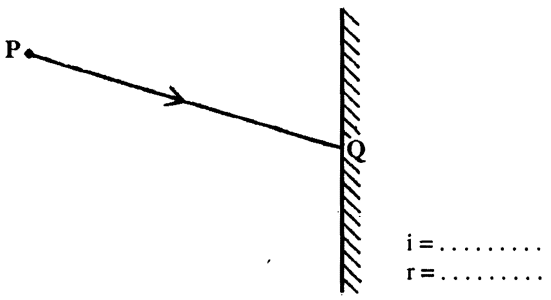


Fig. 3.1

(i) On Fig. 3.1 mark with a cross (x) the position of **I**, the image of **P**. Label your cross **I**.

(ii) On Fig. 3.1 draw the reflected ray from **Q**.

(iii) Measure the angle of incidence, *i*, and the angle of reflection, *r*, and write the values in the spaces provided on the diagram. [5]

(c) (i) Car J is following car K. The registration number of car J is LEF 9Z, as shown in Fig. 3.2.

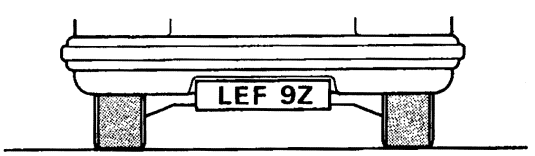


Fig. 3.2

On your answer sheets, write down the registration number of car J as seen by the driver of car K in a plane mirror.

(ii) There are 11 letters in the word EXAMINATION.

How many of these letters are not changed when the word is seen by reflection? [3] J92/II/9

25 *(a)* Figure 4 shows a large letter P placed in front of a plane mirror.

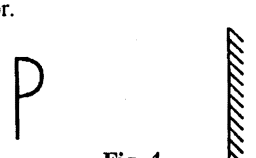


Fig. 4

Copy Fig. 4 and on your diagram draw

(i) the image of the object,

(ii) rays from the bottom of the large letter P to the top of the mirror and to the bottom of the mirror; also draw the two reflected rays. [5] J94/II/9

26 A student sits in front of a plane mirror. In Fig. 5, **E** is the position of one of the student's eyes and **M** and **N** are the ends of the mirror. **E** is directly opposite the centre of the mirror.

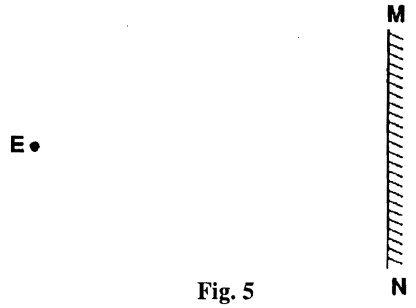


Fig. 5

(a) **On Fig. 5,**

(i) mark with a cross (X) the position of the image of **E** formed by the mirror,

(ii) draw rays of light from **M** to **E** and from **N** to **E**,

(iii) draw the rays of light incident at **M** and **N** which are reflected along **ME** and **NE**.

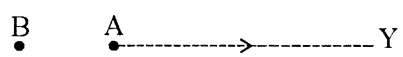
Show clearly any construction lines you have used. [5]

(b) (i) Measure the angle between the rays reflected along **ME** and **NE**.

(ii) Calculate a value for the angle of incidence at **M**. [2]

N94/II/2

27 A person standing at point A in Fig. 6 sees the reflection in a shop window of a person standing at point B.



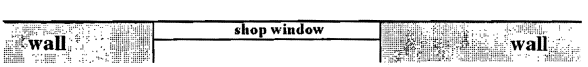


Fig. 6

(a) On Fig. 6, draw a ray of light to show how, by reflection, the person at A sees the person at B. [1]

(b) On Fig. 6, mark, with a letter I, the position of the image of B formed by reflection in the shop window. [2]

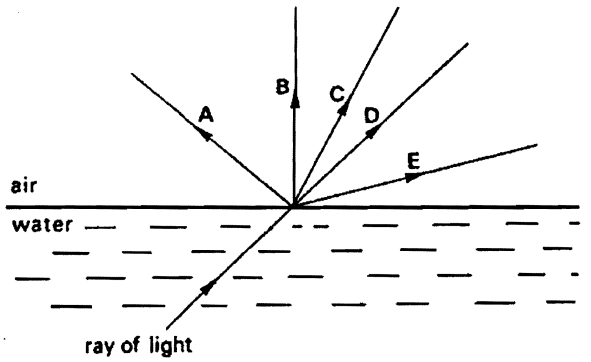
(c) (i) The person at A moves further away from B towards Y in the direction of the arrow shown in Fig. 6. Mark with a letter X the furthest position along AY to which the person can move so that the two people will still be able to see each other by reflection in the shop window.

(ii) Explain how you decided on the position of X. [2]

J99/II/2

13.2 Refraction of light

1 A ray of light passes from water to air.

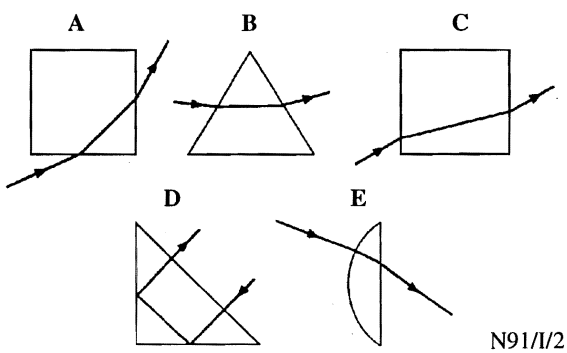


Which labelled arrow shows the direction of the ray in air?

N90/I/21

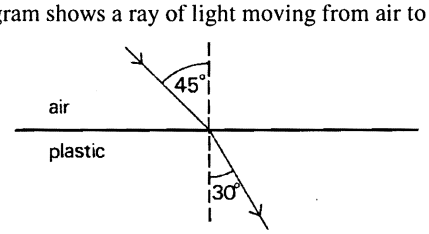
2 The diagrams show rays of light passing from air through five pieces of glass.

Which diagram shows a path which is **not** possible?



N91/I/21

3 The diagram shows a ray of light moving from air to plastic.



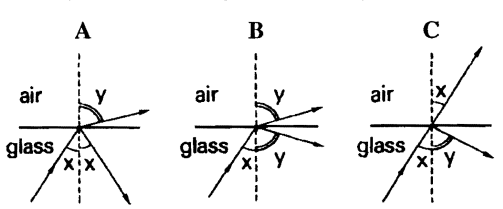
What is the refractive index of the plastic?

A 0.71 **B** 0.82 **C** 1.22 **D** 1.41 **E** 1.50

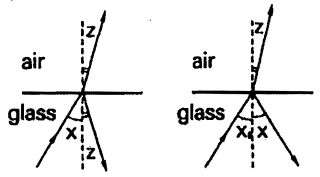
J92/I/20

4 A ray of red light travelling in glass strikes the glass-air boundary. Some light is reflected and some is refracted.

Which diagram shows the paths of the rays?



D E

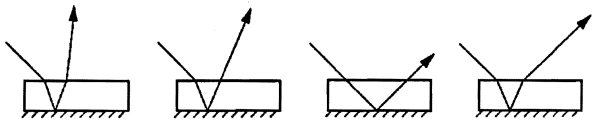


J93/I/20

5 The bottom surface of a glass block is silvered to act as a mirror.

Which diagram could represent the path of a light ray which enters this block through the top surface?

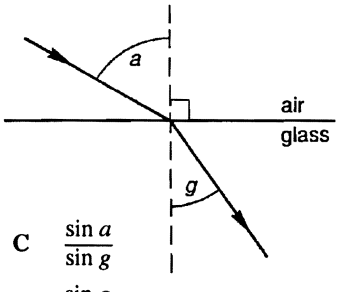
A B C D



J94/I/21

6 A ray of light is travelling from air to glass.

Which ratio is called the refractive index of glass?



A $\frac{a}{g}$

B $\frac{g}{a}$

C $\frac{\sin a}{\sin g}$

D $\frac{\sin g}{\sin a}$

N95/I/22

7 The table shows measurements taken during an experiment in which a ray of light is shone at one of the sides of a rectangular block of glass.

angle of incidence, i angle of refraction, r	26.0° 15.5°	39.0° 22.5°
$\sin i$ $\sin r$	0.438 0.267	0.629 0.383

What is the refractive index of the glass?

A 1.50 B 1.64 C 1.68 D 1.73

J96/I/21

8 A ray of light travels from air into glass. The refractive index of the glass is 1.5.

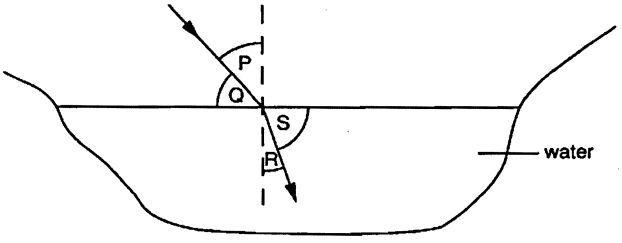
Which of the following pairs could be values of the angle of incidence and the angle of refraction?

	angle of incidence	*angle of refraction*
A	21.5°	20.0°
B	40.0°	60.0°
C	60.0°	35.3°
D	80.0°	53.3°

N96/I/19

9 The diagram shows the path of a ray of light travelling towards and into a pool of water.

Four angles are labelled.



Which two angles would be correctly used in the equation $\frac{\sin i}{\sin r}$ = constant?

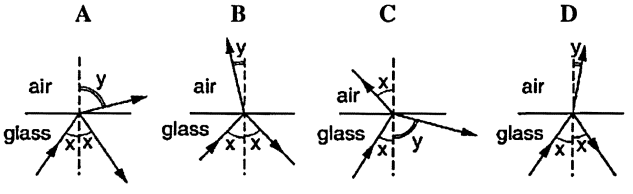
A P and R
B P and S
C Q and R
D Q and S

N98/I/21

10 Red light travelling in glass strikes a glass-air boundary. Some light is reflected and some is refracted.

Which diagram correctly shows the reflection and refraction?

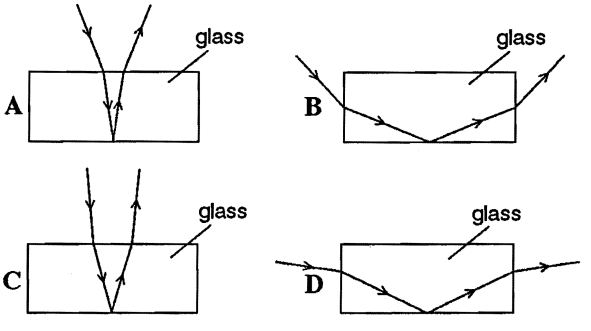
A B C D



J99/I/9

11 A ray of light passes through a rectangular glass block. It is refracted and totally internally reflected.

Which diagram shows a possible path of this ray?



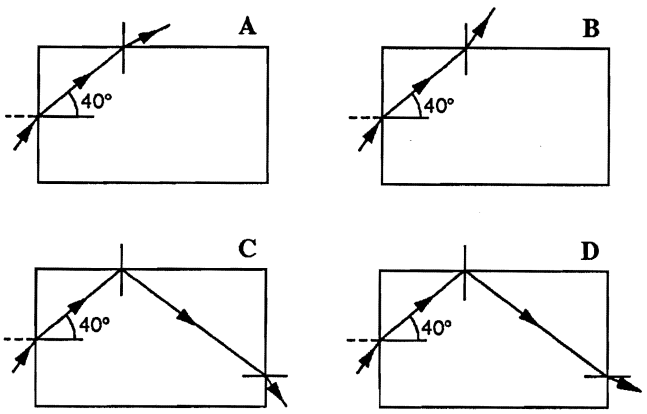
J2000/I/19

12 What happens to light as it passes from glass into air?

A Its frequency decreases because its speed decreases.
B Its frequency increases because its speed increases.
C Its wavelength decreases because its speed decreases.
D Its wavelength increases because its speed increases.

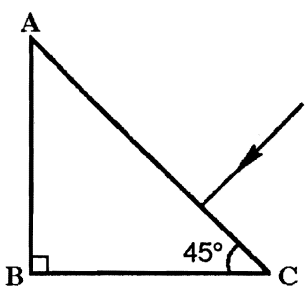
N2000/I/16

13 A ray of light is incident on one side of a rectangular glass block, so that the angle of refraction is 40° in the glass.



Which diagram correctly shows a possible path of this ray? [The critical angle for glass is 42°.] N2000/I/19

14 A ray of light is incident, as shown above, at right angles to the face AC of a glass prism. The critical angle of the glass is 41°. On the diagram, complete the path of the ray until it emerges into the air.



Give brief reasons to justify your answer. N79/I/6

15 The ray of light shown in Fig. 7 is incident on the face AB of the prism at a small angle to the normal and emerges through the face AC. The incident angle is slowly reduced until the position shown in Fig. 4 is reached where the ray strikes AB normally and this is the first position in which no light emerges through AC.

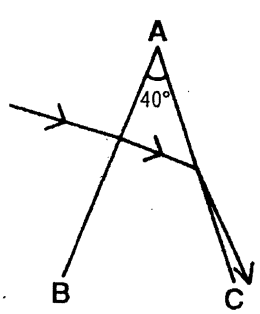


Fig. 7

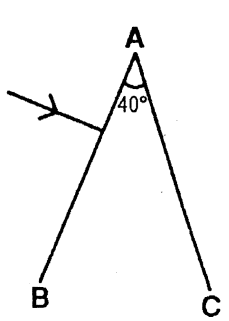
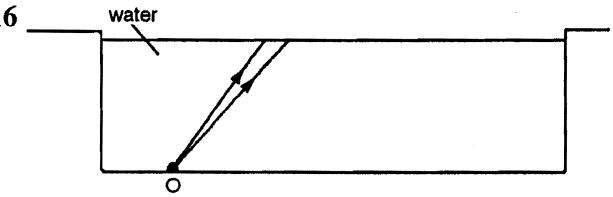


Fig. 8

Explain this and indicate the path of this ray on Fig. 8.

The angle BAC of the prism is 40°. Calculate a value for the refractive index of the material of the prism. J82/I/9

16



The diagram shows the paths of two rays of light from a bright object O on the bottom of a swimming pool to the surface.

(a) (i) Sketch the paths of the rays as they emerge from the water and travel towards the eye of an observer standing on the right-hand side of the pool.

(ii) Indicate on the diagram, using any necessary construction lines, where the observer sees the image of the object.

(b) Draw on the diagram the paths of two other rays of light from the object, one of which strikes the water surface at an angle of incidence equal to the critical angle and the other at an angle of incidence greater than the critical angle.

(c) Given that the refractive index of water is 1.33, calculate a value for the critical angle of water.

(d) A glass beaker contains water. Outline how you would measure the apparent depth of the water. N82/II/4

17 *(a)* What is meant by the *refraction* of a ray of light at a boundary between two media.

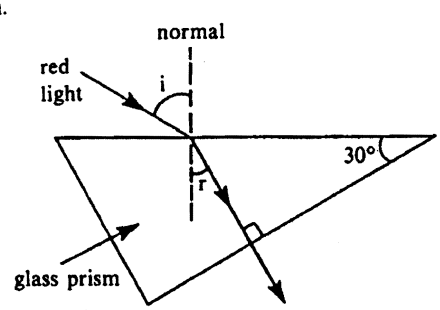
Why does it occur?

A ray of light in air strikes a liquid surface at an angle of incidence of 35°. Calculate the angle of refraction, given that the refractive index of the liquid is 1.25.

With the aid of a labelled diagram, explain what is meant by the *critical angle* of a liquid. Calculate the critical angle of the liquid described above.

N84/II/10*(a)*

18 A ray of monochromatic red light is incident on a glass prism in such a way that the refracted ray inside the prism strikes the second surface at right angles, as shown in the diagram.



Write down the value of the angle of refraction, r.

r = ...

Given that the refractive index of the glass for red light is 1.5, calculate the angle of incidence, i, of the light on the prism.

A ray of monochromatic blue light incident on the prism at the same angle does not follow the same path. Why is this?

J86/II/7

19 A ray of light is incident at an angle of 60° at the midpoint O of the plane face AB of a semicircular glass block, as shown in Fig. (i).

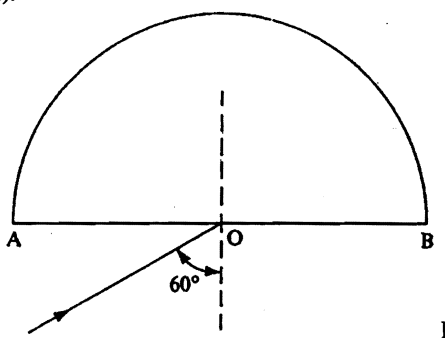


Fig. (i)

(a) Calculate the angle of refraction of this ray at O, given that the refractive index of the glass is 1.5.

Draw the path of this ray from O on Fig. (i) and continue its path until it has emerged into the air.

(b) Calculate the critical angle for the glass-air boundary.

On Fig. (ii) draw the path of a ray which travels through the glass to O in such a way that it strikes the surface AB at an angle of incidence equal to the critical angle. Label the critical angle and continue the path of this ray after it has struck the surface AB at O.

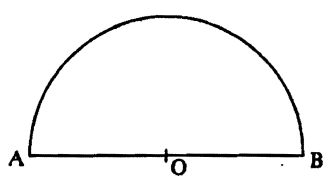


Fig. (ii)

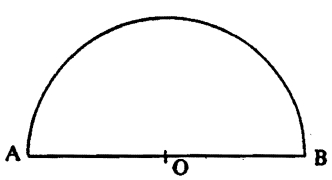


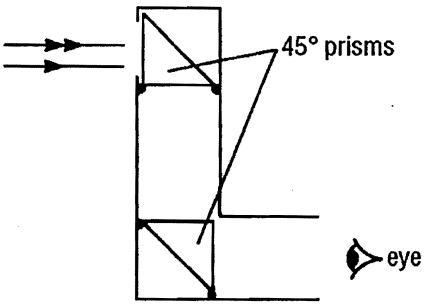
Fig. (iii)

On Fig. (iii) draw the complete path of a ray directed towards O which undergoes total internal reflection at the surface AB.

N86/II/1

20 The diagram shows the structure of a simple periscope used at sporting events to see over the heads of the crowd.

(a) When the periscope is in use, total internal reflection occurs at one surface of each prism Indicate this surface for one of the prisms by a letter "S" on the diagram. [1]



(b) Complete the paths of the two rays through the periscope to the eye. [2]

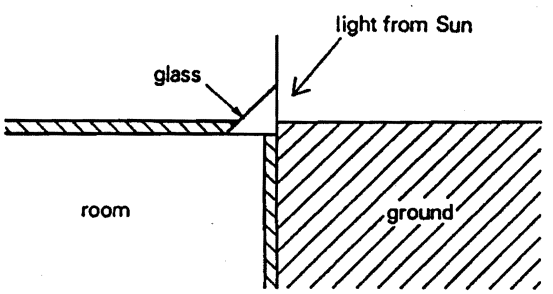
(c) Indicate why these paths are not affected by the colour of the light. [2]

(d) Is the image the right way up or upside down? Justify your answer. [2]

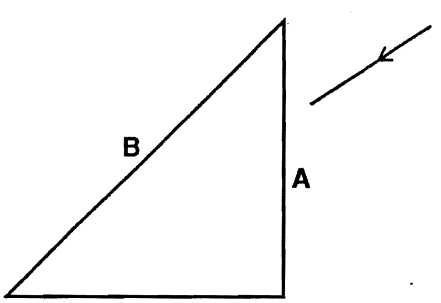
(e) In choosing a material for the prism, the critical angle of the material must be less than 45°. What is the smallest possible refractive index for the material of the prism? [3]

J88/II/3

21 The diagram shows how a triangular glass block may be used to allow light into a room which is below ground level.



(a) On the diagram of the glass block sketch a possible path of a ray of light from the Sun in order to make clear how it enters the room.

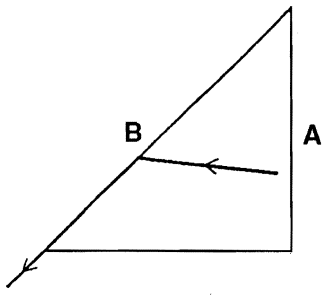


[4]

Name the processes taking place at face **A**, face **B**. [2]

Give one advantage of using a glass block rather than a mirror in this arrangement. [1]

(b) When a ray of light meets the prism at a certain angle, a ray inside the prism strikes the face **B** as shown in the diagram.



By measurement from the diagram, find the critical angle for the glass.

Hence calculate the refractive index of the glass. [3]
N88/II/4

22 Fig. 9 shows a ray of light refracted at one surface of a glass prism.

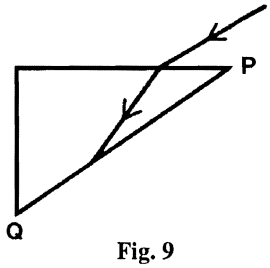


Fig. 9

(a) By measuring appropriate angles on the diagram, calculate a value for the refractive index of the glass. [3]

(b) Complete the diagram to show the path of the ray immediately after it strikes the surface **PQ**. [1]
J89/I/8

23 *(b)* Fig. 10 shows a ray of light meeting the glass of the window of a car at an angle of incidence of 40°.

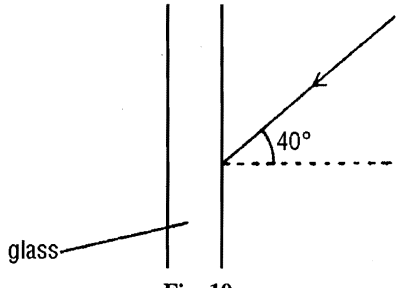


Fig. 10

(i) Assuming that the refractive index of glass is 1.5, calculate the angle of refraction for this ray in the glass.

(ii) Complete the diagram by sketching the path of the ray through the glass and out on the other side.

(iii) Use the diagram to explain the effect of the glass on what is seen by the driver. [5]
N89/II/3

24 *(a)* Explain what is meant by the *refraction of light* and state the conditions needed for refraction to take place. [4]

(b) Fig. 11 shows a ray of red light **KLMN** passing through a triangular glass prism **QRS**.

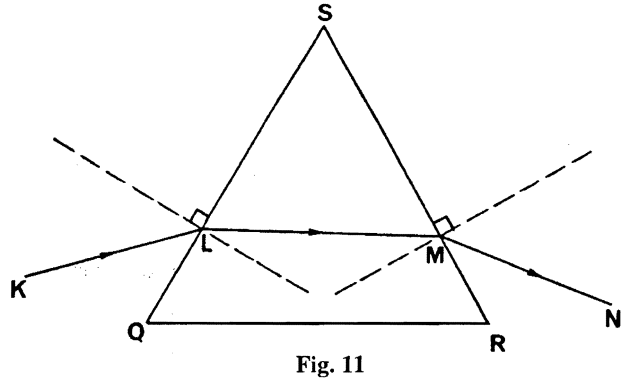


Fig. 11

(i) Using a protractor, measure and record the angle of incidence and the angle of refraction at the point **L**.

(ii) Measure and record the angle of incidence and the angle of refraction at the point **M**.

(iii) Using your answers to (i) and (ii), find two values of the refractive index of the glass and calculate the average. [6]
J90/II/10

25 Fig. 12 represents a ray of light passing from air to glass.

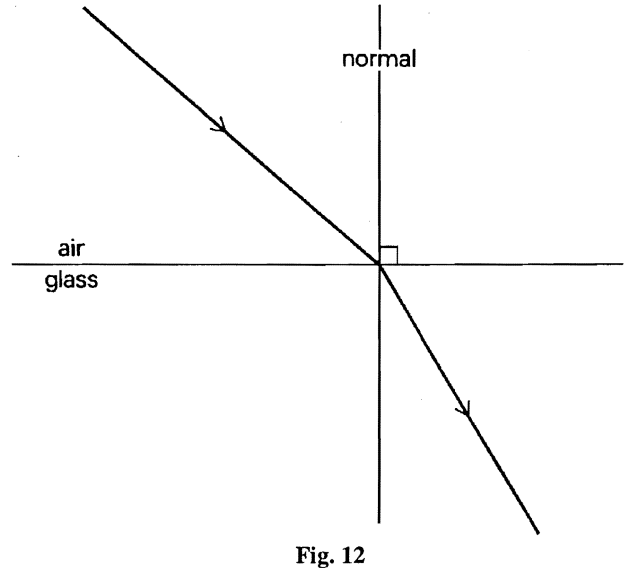


Fig. 12

(a) (i) Measure the angle of incidence and the angle of refraction.

(ii) Calculate the refractive index of the glass. [4]

(b) At what angle of incidence will the angle of refraction be zero? [1]
N92/II/3

26 *(a)* Figure 13.1 shows a rectangular glass block with a ray of light passing into the block.

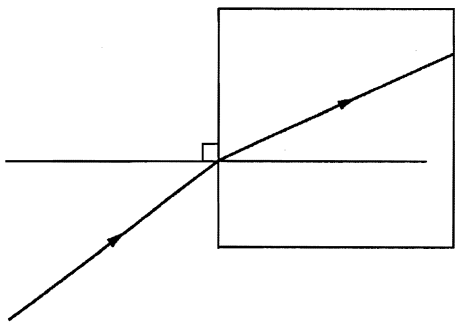


Fig. 13.1

(i) Using a protractor, measure the angle of incidence and the angle of refraction.

(ii) Draw on Fig. 13.1, as accurately as possible, the path of the emergent ray. [4]

(b) Figure 13.2 shows the path of another ray of light passing through the block.

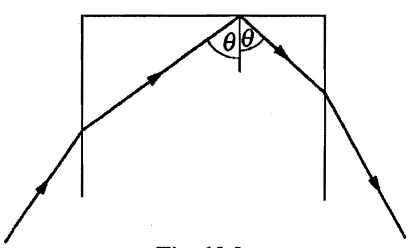


Fig. 13.2

(i) Name the special effect shown in Fig. 13.2.

(ii) Is the angle θ greater or smaller than the critical angle of the glass?

Give your reason for your answer. [2]

N93/II/3

27 *(c)* Figure 14 shows a cross-section through part of a *light pipe* and a ray of light entering one end.

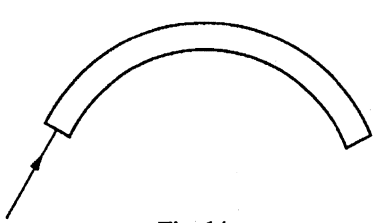


Fig. 14

Copy Fig. 14 and on your copy show the path of the ray along the pipe. [2]

J94/II/9*(c)*

28 Figure 15 shows the path of a ray of light **PQ** in a rectangular glass block. **Q** is on the surface of the block. The diagram also shows the normal at **Q** and what happens to the light when it reaches **Q**.

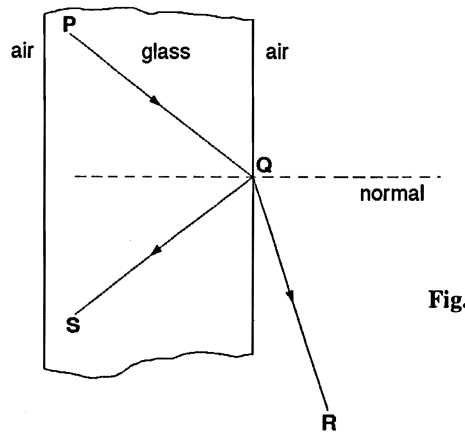


Fig. 15

(a) The ray **PQ** is called the *incident ray.*

Complete the following sentences.

(i) The ray **QR** is called .....

(ii) The ray **QS** is called. ..... [1]

(b) Measure the *angle of incidence* and the *angle of refraction* and use your values to determine the *refractive index* of the glass.

angle of incidence = ...

angle of refraction = ...

refractive index = ... [4]

J95/II/4

29 Fig. 16 shows a square block of glass **JKLM** with a ray of light incident on side **JK** at an angle of incidence of 60°. The refractive index of the glass is 1.50.

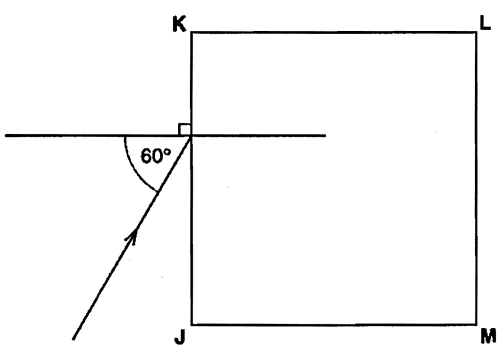


Fig. 16

(a) Calculate the angle of refraction of the ray. [2]

(b) Calculate the critical angle for a ray of light in this glass. [2]

(c) Explain why the ray shown in Fig. 16 cannot emerge from side **KL** but will emerge from side **LM**. [3]

N97/II/6

30 Fig. 17 shows the passage of a ray of white light into a semi-circular glass block. The ray meets the straight side of the block at O, the centre of the semi-circle. The angle *i* is less than the critical angle.

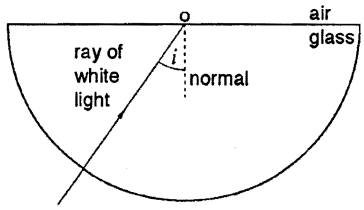


Fig. 17

(a) As the light meets the straight side of the block, part of the light is reflected and the rest of the light is refracted.

(i) On Fig. 17, draw rays which show the reflection and refraction of the light at O.

(ii) Explain why a spectrum may be seen in the light that is refracted.

(iii) Explain why the reflected light stays white. [5]

(b) The angle of incidence i at O is increased until total internal reflection occurs.

(i) State what is meant by *total internal reflection.*

(ii) Draw a diagram to show how a light pipe (optic fibre) makes use of total internal reflection. [2]

J98/II/5

31 A student performs an experiment to demonstrate the refraction of light by a rectangular glass block. Fig. 18.1 shows, to scale, the outline of the glass block and the paths of the incident and emergent rays that the student draws on a piece of paper.

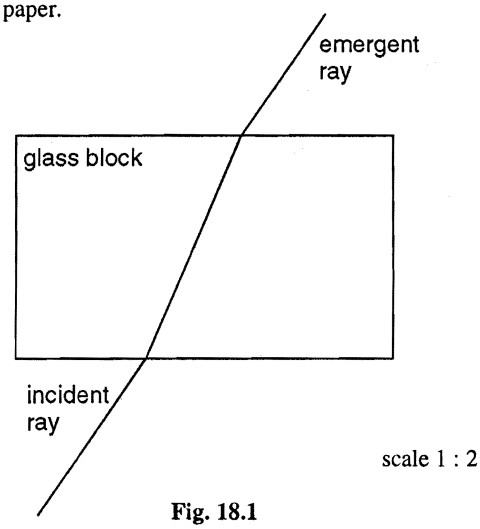


Fig. 18.1

(a) Describe the apparatus needed and also a method by which the paths of the incident and emergent rays may be drawn on a piece of paper. [3]

(b) Take measurements from Fig. 18.1 to find the refractive index of the glass block. Show clearly your working, state the equation that you use and give your answer to an appropriate number of significant figures. [3]

(c) The student repeats the experiment with the incident ray at different angles. The values obtained for the angles x and y shown in Fig. 18.2 are given in the table.

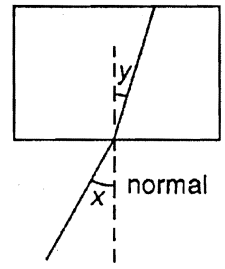


Fig. 18.2

x/°	0	10	20	30	40	50	60	70	80
y/°	0	7	13	20	26	31	36	39	42

Plot a graph of y/° (y-axis) against x/° (x-axis). Your axes should end at y/° = 50 and x/° = 90.

Draw the best curved line through your points. [4]

(d) (i) **Use your graph** to estimate the critical angle for glass and explain how you obtained your result.

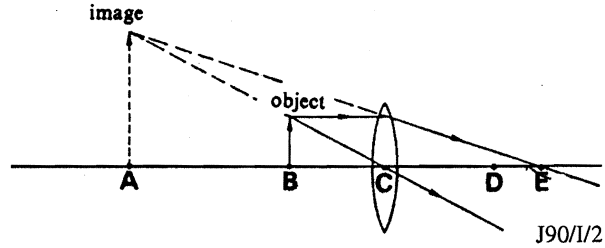
(ii) Explain why it is impossible to obtain a value of $y = 50°$ in this experiment. [3]

(e) The glass block used in the experiment is replaced by one having a larger refractive index. The experiment is repeated and a second graph is plotted. State one similarity and one difference between this second graph and the graph obtained in *(c).* [2] N99/II/9

13.3 Thin converging lenses

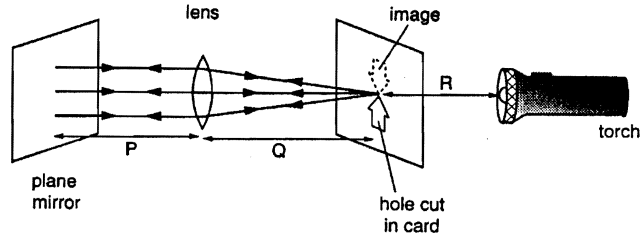
1 The diagram shows the action of a magnifying glass.

Which point is the principal focus of the lens?



J90/I/21

2 The diagram shows an experiment to measure the focal length of a lens.

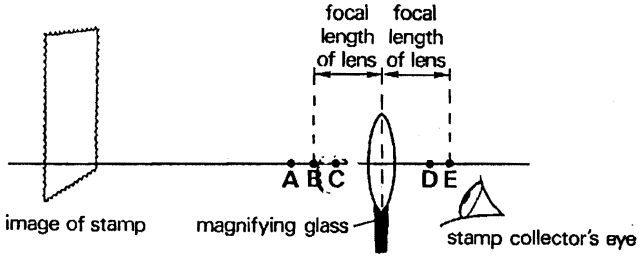


Which distance is the focal length of the lens?

A P
B Q
C R
D P + Q

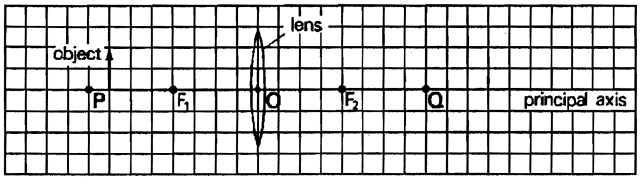
J91/I/22; N96/I/20

3 A stamp collector is using a magnifying glass to see a stamp more clearly.



Where is the stamp placed? J92/I/21

4 The diagram shows an object between **P** and F_1 on the principal axis of a converging (convex) lens. The principal foci of the lens are at F_1 and F_2.

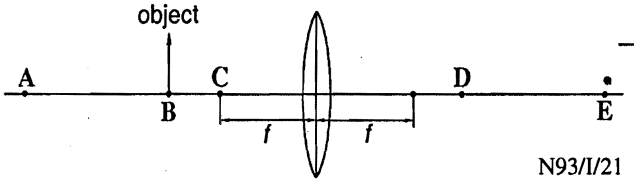


Where is the image formed by the lens?

A at infinity
B between **O** and F_1
C between **O** and F_2
D at **Q**
E beyond **Q** N92/I/21

5 The diagram shows an object placed in front of a converging lens of focal length *f*.

At which position will the image be formed?



N93/I/21

6 The image formed on the film of a simple camera is

A real, inverted and diminished.
B virtual, upright and diminished.
C virtual, upright and magnified.
D real, inverted and magnified. J94/I/22

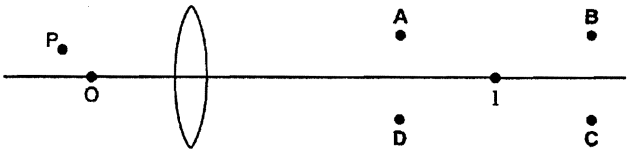
7 The human eye contains a converging lens system which produces an image at the back of the eye.

If the eye views a distant object, what type of image is produced?

A real, erect, diminished
B real, inverted, diminished
C virtual, erect, diminished
D virtual, inverted, diminished N94/I/22

8 A lens forms an image at **I** of an object at O.

Where does the lens form an image of an object at P?

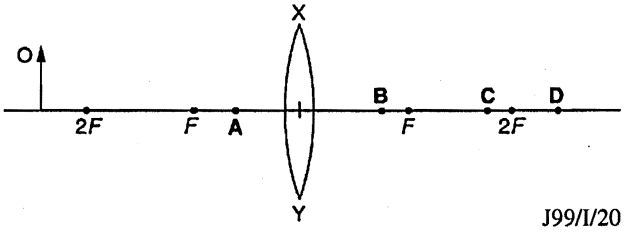


N97/I/22

9 In the diagram, *XY* is a converging (convex) lens.

Points labelled *F* are one focal length from the lens and points labelled *2F* are two focal lengths from the lens.

If an object is placed at O, at which point is the image of its base formed?



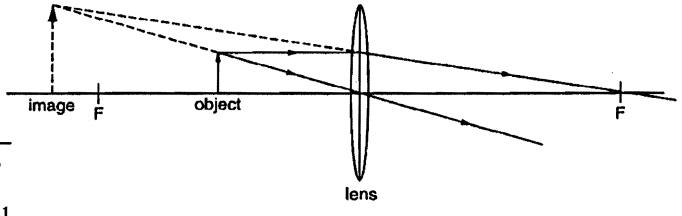
J99/I/20

10 The focal length of a thin converging lens is 10 cm.

What is the maximum distance from the lens that the object can be placed so that the lens acts as a magnifying glass?

A 5 cm **C** 15 cm
B 10 cm **D** 20 cm N99/I/20

11 The diagram shows a converging lens producing an upright, virtual image.

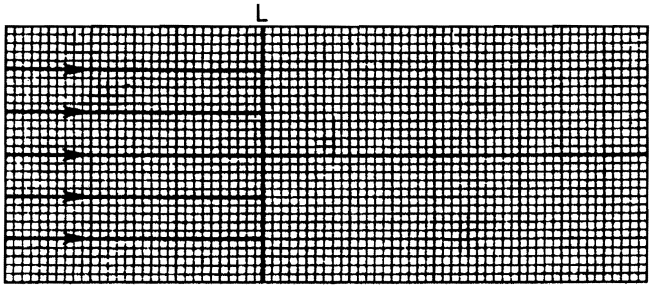


Which optical instrument uses this arrangement?

A a camera **C** a photographic enlarger
B a magnifying glass **D** a projector

J2000/I/18

12 *(a)* The straight line L in the diagram represents a converging lens of focal length 35 mm.



Complete the diagram accurately **full scale** to show the effect of the lens on the incident rays shown.

(b) An object of height 20 mm is placed perpendicular to the axis of the lens and 60 mm from the lens.

Determine (i) the distance of the resulting image from the lens, (ii) the size of the image.

(c) The object is now moved so that it is at a distance of 30 mm from the lens. In what respects will the image formed differ from that formed in *(b)*? A scale diagram or calculation is **not** required.

(d) Suggest a use for the lens in which the image produced is the type formed in *(c)*. J79/II/1

13 Draw separate diagrams showing a converging lens being used as

(a) a magnifying glass, to produce a magnified image,

(b) a camera lens to produce a diminished image.

A converging lens is used to projects an image of a slide on to a screen 1000 mm from the lens, which has a focal length of 200 mm. The size of the image is 250 mm square. By means of a scale drawing determine

(i) the distance of the slide from the lens,

(ii) the size of the slide. N79/II/9

14 *(a)* In Fig. 19 the position of a lens are indicated by straight lines; in Fig. 19 the lens is a converging lens.

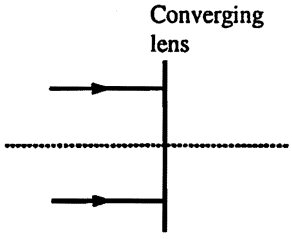


Fig. 19

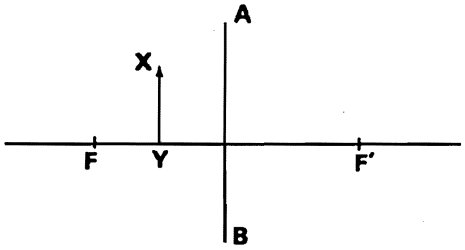
Complete the figure to show the effect of the lens on the incident rays shown. Mark the principal focus of the lens with the letter **F**.

(b) A converging lens can form an image of an object when the distance of the object from the lens is greater or less than the focal length of the lens. Use the table below to compare the images formed under the two conditions.

Description of image when the object distance is greater than the focal length	Description of image when the object distance is less than the focal length

(c) When the object distance is less than the focal length a converging lens may be used as a magnifying glass. Draw a labelled ray diagram to illustrate this use of the lens. J80/II/3

15 The line AB in the diagram represents a converging lens whose principal foci are at F and F'. XY is an object placed in front of the lens. All distances are drawn to actual size.



Draw a ray diagram to locate the position of the image of XY and determine its size.

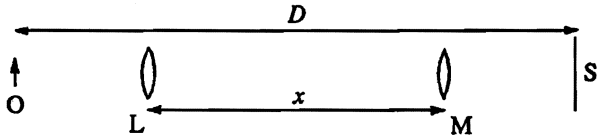
Distance of image from lens. _____

Length of image. _____ J81/I/8

16 An illuminated object O and a screen S are placed 800 mm apart. A converging lens is moved between them until a clearly focused image of the object is obtained on the screen.

The position of the lens is then altered until a second clearly focused image is obtained on the screen.

These two positions, represented by L and M in the diagram below, are a distance *x* apart.

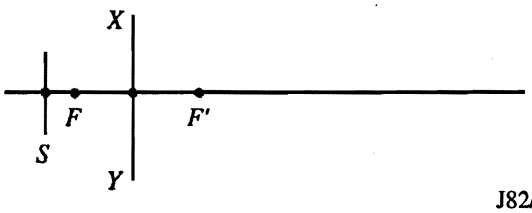


(i) Explain which of the lens positions will give the larger image.

(ii) Explain how you would attempt to measure the distance *x* between the two lens positions as accurately as possible.

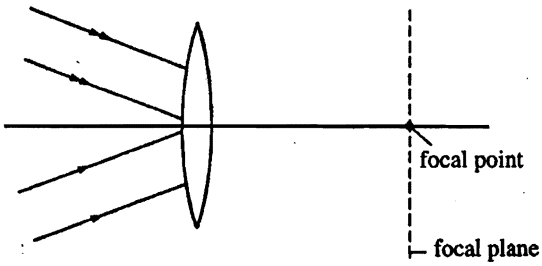
(iii) Suggest a suitable object that could be used for this experiment, giving a reason for your choice. J82/I/II/1

17 In the diagram above, XY represents a converging lens whose principal foci are F and F'. The lens is to be used to project an image of the slide S on to a screen. With the slide in the position shown, draw a ray diagram to locate the position of the screen. Determine the magnification obtained.



J82/I/7

18 Describe an experiment you could carry out to determine the focal length, f, of a converging lens: make clear how you would obtain the result from the readings.



The diagram (not drawn to scale) illustrates two parallel beams of light, from two different points on the Moon, falling on a thin converging lens. Draw a diagram to show the effect of the lens on the beams of light.

An object 20 mm high is placed 30 mm in front of a converging lens of focal length 50 mm. By means of a scale diagram, determine the position and size of the image formed by the lens.

By reference to your diagram, explain as clearly as you can why a magnifying glass enables a person to observe the details of a small object more clearly. N82/II/9

19 Draw a ray diagram to illustrate what is meant by the focal length of a converging lens.

An object 15 mm high is placed 70 mm in front of a converging lens of focal length 50 mm. Draw a ray diagram to a stated scale and use your diagram to deduce

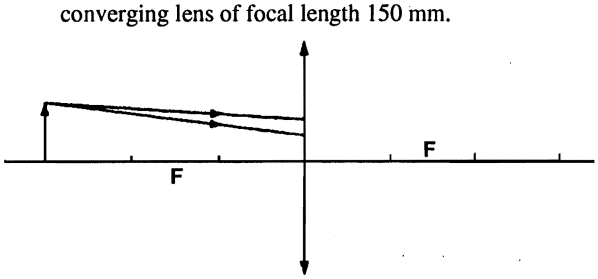
(a) the height of the image,

(b) the distance of the image from the lens,

(c) the nature of the image.

How is the image affected by moving the object to a distance 60 mm from the lens? N83/II/9

20 *(a)* The diagram shows an object placed 300 mm from a converging lens of focal length 150 mm.



(i) By drawing construction rays on the diagram, locate the position of the image.

(ii) Given that the object is 50 mm high, determine the size of the image.

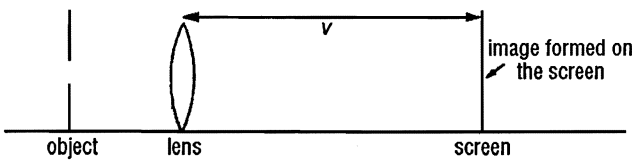
(iii) Complete the paths of the two rays given on the diagram to show their passage through the lens and to the image.

J84/II/3*(a)*

21 *(b)* Draw a labelled ray diagram to illustrate the action of a magnifying glass. Mark clearly a suitable eye position.

N84/II/10*(b)*

22 The diagram represents the apparatus used by a student to project a real image of an object on to a screen.



In an experiment, the height of the image was measured for different values of image distance v. The magnification, m, which is (the height of the image)/(the height of the object), was calculate for each value of v. The readings in the table below were obtained.

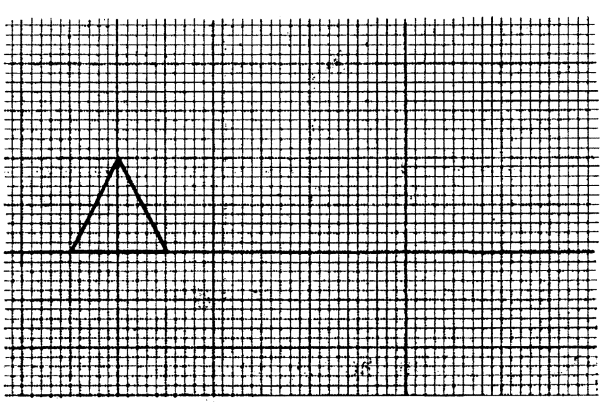
v/mm	200	240	275	300	350
m	0.8	1.2	1.5	1.7	2.2

(a) (i) On the graph paper, plot the graph m against v.

(ii) From the graph determine G, the gradient of the line, showing the essential working. Mark the graph in such a way as to show how the information required to determine the gradient was obtained.

(iii) The focal length of the lens, f, is given by the relation $C = 1/f$. Determine a value for f.

(b)

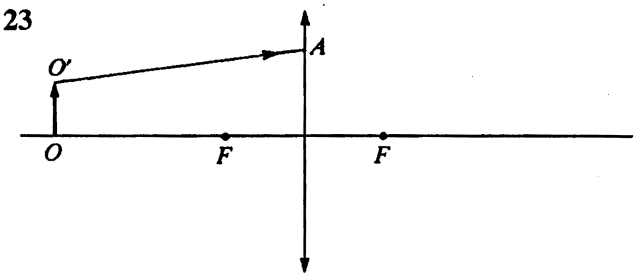


In this experiment the object was a small triangular hole. On the gad draw the outline of the image as seen on the screen and magnified such that $m = 2.0$.

(c) When the experiment was performed accurately and v = 200 mm the magnification was found to be m = 0.82 and not 0.8 as recorded in the table. By considering your graph and the grid in part *(b)* give two experimental errors which might have been made in the original measurement.

J85/I/5

23



The diagram shows, *half-scale*, a converging lens as used in a camera to form an image of the object *OO'*.

(a) Draw construction rays from *O'* to locate its image, *I'*.

(b) Complete the path of the ray *O'A* to the image.

(c) Mark *II'*, the image of *OO'* on the diagram. From measurements on the scale diagram find

(i) the actual length of the image

(ii) its distance from the lens

(d) Draw labelled diagrams to show the use of a converging lens as

(i) a magnifying glass,

(ii) a projector lens. J85/II/2

24 Draw a diagram to illustrate the effect that a converging lens has on a beam of light, parallel to, and extending on both sides of, the principal axis. Indicate clearly the position of the principal focus of the lens.

With the aid of a labelled diagram describe an experiment to find the focal length on a converging lens.

A converging lens of focal length 50 mm is to be used as a magnifying glass for inspecting stamps. A rectangular stamp, which is 20 mm × 40 mm, is placed 30 mm from the lens.

By means of a scale diagram, drawn to a stated scale, find the length of the image of the 20 mm side of the stamp, and hence find the area of the image. Record the distance of this image from the lens.

When the lens is moved so that it is 60 mm from the stamp an image can no longer be seen by an eye placed close to the lens, on looking into the lens. With the aid of a sketch, explain this observation.

N85/II/9

25 *(a)* Draw ray diagrams to show how a converging lens forms an image when the object distance is

(i) 0.7 times the focal length of the lens,

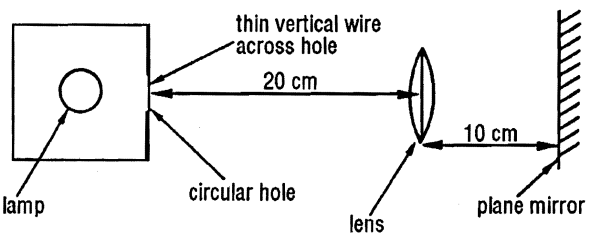
(ii) 5.0 times the focal length of the lens.

(b) In each case (i) write a description of the image, (ii) state a particular use of the lens arranged in this way, (iii) explain why the image described is suitable for the use stated.

N86/II/10

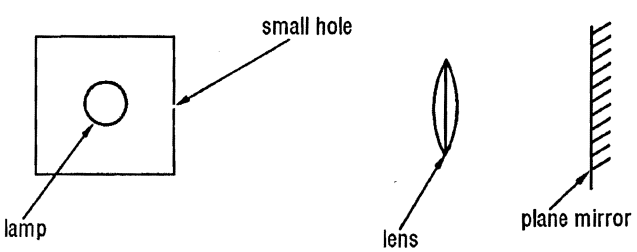
26 *(a)* An object 1.5 cm high is placed 18.0 cm from the centre of a converging lens of focal length 10.0 cm. One end of the object is on the principal axis of the lens. By means of a diagram drawn to a stated scale, determine the size of the resulting image and its distance from the lens. J87/II/9*(a)*

27 *(a)* A lamp is arranged in a box behind a circular hole with a thin vertical wire; the light from the hole falls on a converging lens and a plane mirror placed 10.0 cm behind the lens as indicated in the diagram. The box and vertical wire are then moved until an image of the vertical wire appears in sharp focus on a piece of paper placed alongside the vertical wire. The distance between the wire and lens is then measured and found to be 20.0 cm. What characteristic property of the lens does this length represent? [1]



Suggest how it would be possible to show that this image of the vertical wire is inverted. [1]

(b) The vertical wire is removed and a metal plate with a small hole at its centre placed across the hole in the box. On the diagram above, draw two rays emerging from the hole and show their paths as they pass through the lens and subsequently. [2]



(c) The plane mirror is replaced by a white screen. What would be observed on this screen? [2]

(d) The metal plate is now removed and the vertical wire replaced. The positions of lens and screen are adjusted to give a clearly focused image of the vertical wire on the screen, of size equal to that of the object.

What would be the distance

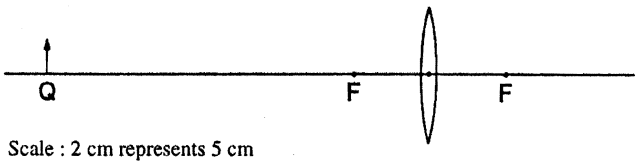
(i) between the vertical wire and the lens,

(ii) between the lens and the screen? [2]

(e) The screen is removed and the lens is moved until it is only 10 cm from the vertical wire. Explain how it would be possible with the lens in this position for you to see a clear image of the vertical wire. [2]

N87/II/2

28 An object Q is placed 25 cm in front of a lens of focal length 5 cm, as shown in the scale diagram below, Fig. 20.



Scale : 2 cm represents 5 cm

Fig. 20

Draw construction rays to locate the position of the image of Q.

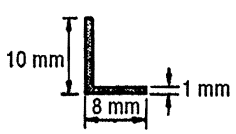
From measurements made on the diagram, determine the distance of the image from the lens. [4]

J88/I/7

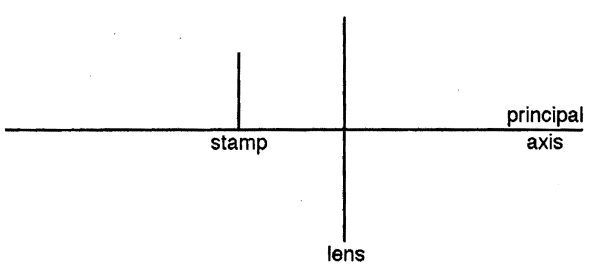
29 A collector views a postage stamp of height 2.0 cm through a hand lens placed 2.8 cm from the stamp. The image he sees appears to be magnified 3.0 times.

(a) State the type of lens used for the hand lens. [1]

(b) The collector views the letter *L* on the stamp, shown full size below. In the space to the right, draw full size the magnified image that will be seen using the hand lens. [2]



(c) In the diagram below, the horizontal line represents the principal axis of the hand lens: the stamp and the lens are represented by vertical lines, as shown.



Remembering that the image is upright and has a magnification of 3.0, calculate the height of the image and draw a line parallel to the principal axis to represent the height of the image.

Draw a line to represent a ray of light from the top of the stamp passing through the centre of the lens. Using a dotted line, extend the line you have just drawn backwards to locate the position of the image.

Measure the distance of the image from the lens.

Now draw a line parallel to the axis to represent a ray of light from the top of the stamp to meet the lens. By considering where this ray meets the lens and the position of the image, draw a line to locate the position of one of the focal points (principal foci) of the lens.

Measure the focal length of the lens. [6]

(d) Explain why it is unlikely that the observer could see this image clearly if his eye was almost touching the lens. [1] N88/II/3

30 *(a)* Fig. 21 shows an object 25 mm high placed 80 mm in front of the lens of a camera. The focal length of the lens is 20 mm and the diagram has been drawn full size.

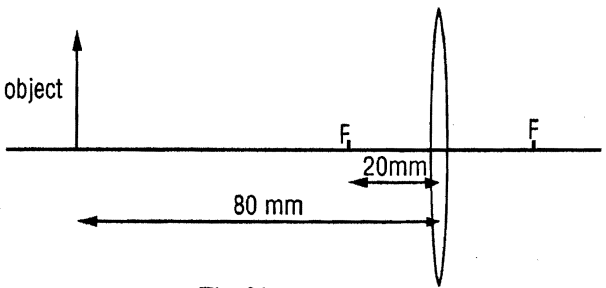


Fig. 21

(i) Draw an accurate ray diagram to locate the image.

(ii) Measure and record the size of the image and its distance from the lens.

(iii) Assuming that the distance you have measured in (ii) is the maximum distance between the lens and the film in the camera, explain why it is impossible to use this camera to take a clear photograph of an object less than 80 mm away from the camera. [7] J89/II/2*(a)*

31 Fig. 22 shows an object O in front of a converging lens. The points marked F are the focal points of the lens.

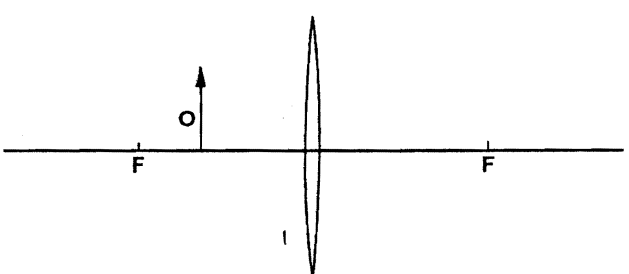


Fig. 22

(a) Draw two rays from the top of the object in order to locate the position of the image. [2]

(b) The image is upright. State two other characteristics of the image. [2]

N89/I/7

32

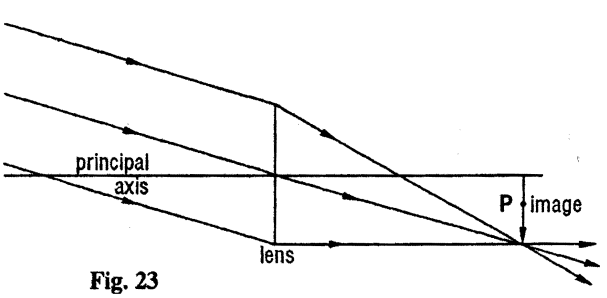


Fig. 23

Fig. 23 shows rays from the top of a distant object brought to a focus by a converging lens.

(a) How does the diagram show that the object is a long way from the lens? [1]

(b) Name one optical instrument which makes use of an image formed in this way. [1]

(c) On Fig. 23 draw the paths of three rays which help form the point **P** on the image. [2]

N90/II/5

33 Fig. 24 shows a thin converging lens forming a real image **I** of a point object **O**.

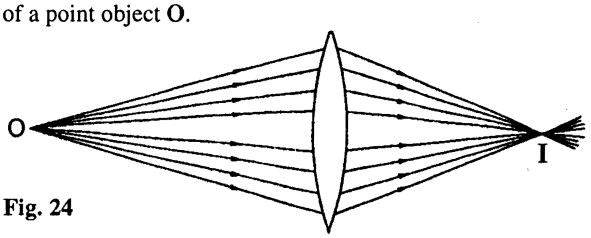


Fig. 24

(a) (i) State clearly what happens to the path of a ray of light as it passes through each surface of the lens.

(ii) Explain why the lens has a bigger effect on the paths of rays passing near the edge than it does on the paths of rays near the centre. [5]

(b) A thin converging lens has a focal length of about 4cm.

Draw a ray diagram to show the lens forming a virtual image of a point object situated above the axis of the lens. [5]

(c) (i) State how you would use a thin converging lens as a magnifying glass.

(ii) In what way(s) are the images formed by a camera and a projector similar and in what way(s) are they different?

(iii) A slide projector set up in a classroom gives a clear image which only half fills the screen. Explain clearly what you would do to obtain a clear image which completely fills the screen, using the same projector. [5]

N91/II/10

34 *(a)* **Figure 25** shows three rays of light passing from the top of an object to a thin converging lens. (The lens is represented by the thin vertical line.) The object is 1.2 cm tall and is 5.0 cm from the lens.

The image formed by the lens is also shown; it is 1.8 cm tall and is 7.5 cm from the lens.

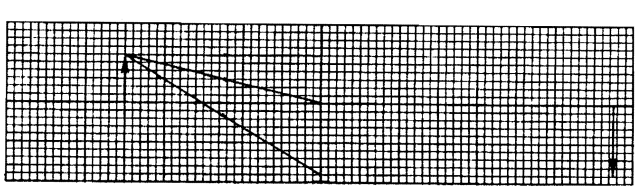


Fig. 25

(i) Copy **Fig. 25** onto a sheet of graph paper. **On your copy,** show the paths of the three rays of light after they have passed through the lens.

(ii) Use your diagram to determine the focal length of the lens. Give your value in cm.

(iii) Draw a separate diagram to determine the position and size of the image formed when the 1.2 cm object is placed 2.0 cm from the lens. Describe this new image. [8]

(b) (ii) State the speed of electromagnetic waves through a vacuum.

(iii) List the main regions of the electromagnetic spectrum, starting from the low frequency end. [7]

J93/II/9

35 Figure 26 shows a small object **KL** to the left of a thin converging lens. The principal axis and the principal focus **F** are also shown.

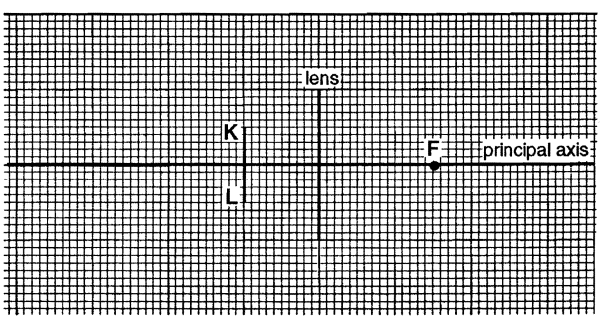


Fig. 26

On Fig. 26, draw rays which will enable you to find the positions of the images of points **K** and **L**. Label these images **K'** and **L'** respectively. [5]

N95/II/4

36 Fig. 27.1 shows a vertical object, the image of that object as formed by a converging lens and two rays from the top of the object.

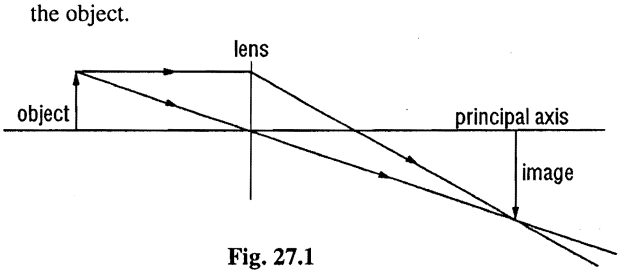


Fig. 27.1

(a) Describe the image.

(b) Using Fig. 27.1,

(i) determine the focal length of the lens,

(ii) determine the image magnification. [5]

(c) Fig. 27.2 shows the same object placed nearer the same lens.

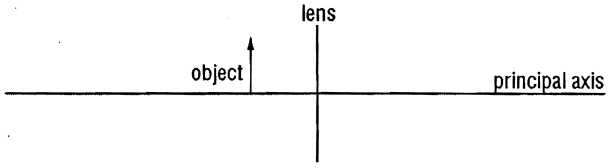


Fig. 27.2

On Fig. 27.2, draw ray paths to enable you to determine the position and size of the new image. Measure the distance of this image from the lens and the size of the image. [3]

J96/II/5

37 In a slide projector, light from a lamp is converged on to a slide AB and a lens is used to form an image of the slide on a screen. Fig. 28 shows the slide, lens and screen. The lamp which illuminates the slide is not shown in Fig. 28.

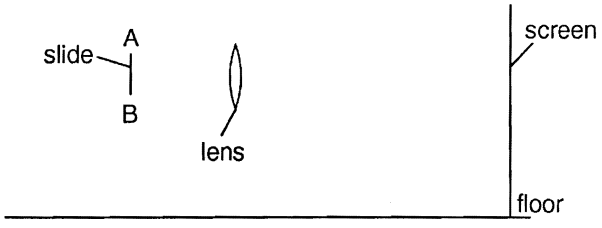


Fig. 28

(a) On Fig. 28, draw two rays from A and two rays from B to show how a focused image of the slide is formed on the screen. [3]

(b) Describe the image formed on the screen. [1]

(c) When a projector is first turned on, the image formed is often not in focus. Describe how the operator can focus the image on the screen. [1]

(d) The slide should be put **upside down** in the projector. Use Fig. 28 to explain why this is necessary. [1]

N98/II/2

38 Fig. 29 shows an object AB near a thin converging lens. The principal foci of the lens are at F and F'.

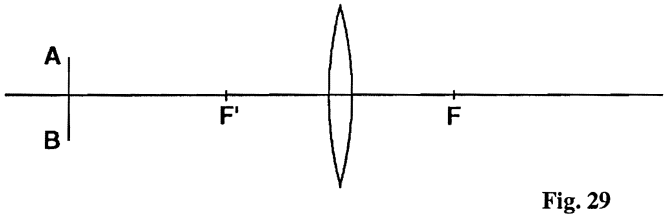


Fig. 29

(a) On Fig. 29, draw rays to find the positions of the images of the points A and B. [3]

(b) The image of the object AB is real. State two other characteristics of the image. [2]

(c) State the name of an optical device that uses a lens to form a real image of an object. [1]

N2000/II/4

ANSWERS

13.1 Reflection of light

1. **E** 2. **A** 3. **A** 4. **B** 5. **C**
6. **B** 7. **D** 8. **D** 9. **A** 10. **B**
11. **D**
24. *(a)* $i = 16°$, $r = 16°$
(c) (i) LEF 9Z (ii) 8
26. *(b)* (i) 38° (ii) 19°

13.2 Refraction of light

1. **E** 2. **B** 3. **D** 4. **A** 5. **D**
6. **C** 7. **B** 8. **C** 9. **A** 10. **A**
11. **B** 12. **D** 13. **C**
15. 1.56
16. *(c)* 48.75°
17. 27° 18' ; 53° 8'
18. $r = 30°$; $i = 48.6°$
19. *(a)* 35.3° *(b)* 41.8°
21. *(b)* 40° ; 1.56
23. *(b)* (i) 25° 22'
24. *(b)* (i) 45° ; 29° (ii) 30° ; 52°
(iii) 1.459 ; 1.576 ; average = 1.518
25. *(a)* (i) 49° ; 30° (ii) 1.51
(b) 0°
26. *(a)* (i) 37° ; 25°
28. *(a)* (i) Refracted Ray (ii) Reflected Ray
(b) ∠ of incidence = 38°
∠ of refraction = 72°
refractive index = 1.54
29. *(a)* 35.3° *(b)* 41.8°

13.3 Thin converging lenses

1. **E** 2. **B** 3. **C** 4. **E** 5. **E**
6. **A** 7. **B** 8. **D** 9. **C** 10. **A**
11. **B**
12. *(b)* 84 mm; 28 mm
13. *(b)* (i) 250 mm; (ii) 60 mm
18. 75 mm from lens; 50 mm
19. *(a)* 37.5 mm *(b)* 175 mm
24. 50 mm; 5000 mm^2 ; 75 mm
30. *(a)* (ii) 8 mm; 29 mm
34. *(a)* (ii) 3 cm; *(b)* (ii) 3×10^8 m/s