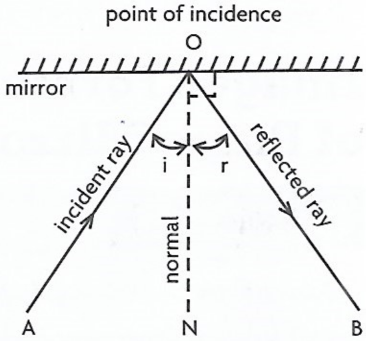
# CHAPTER 14 Light

Can you recall the important facts you have learnt about light until now?

## Exercise 1

The figure here shows what happens to a ray of light as it strikes a plane mirror. Which statement is **not** true about this figure?




i. ∠AON = ∠BON

ii. AO is the incident ray.

iii. O is the only point from where the light ray can be reflected.

iv. If BO is the incident ray, then OA will be the reflected ray.

## Exercise 2

Raja shows you an inverted, diminished image of a doll in a concave mirror. Where has he placed the doll?

i. between F and C

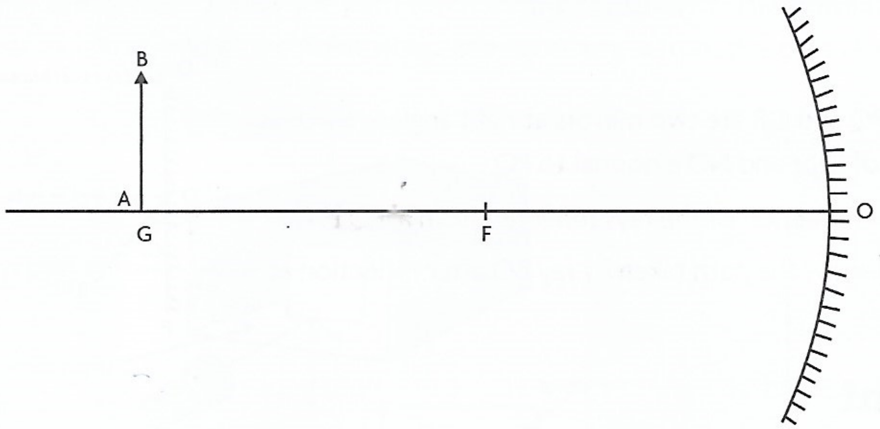
ii. at C

iii. beyond C

iv. within the focal length

## Exercise 3

Copy this figure into your notebook and complete it. Describe the image.



### Exercise 4

The items below refer to the image formed by a concave mirror whose radius of curvature is 20 cm. Match the items in column I with those in column II.

| Column I | Column II |
|---|---|
| **i.** object at 30 cm | **a.** image is magnified and upright |
| **ii.** object at 20 cm | **b.** image is diminished and inverted |
| **iii.** object at 7 cm | **c.** image is magnified and inverted |
| **iv.** object at 15 cm | **d.** image is same size and inverted |

## Images Formed by Combinations of Plane Mirrors

### Activity 1

You will need: two rectangular plane mirrors, a ball

Place two mirrors perpendicular to each other. The mirrors must be standing vertically. Place a small object like a ball in between them. Look carefully in the mirrors. How many images of the object can you see in the mirror?

Now decrease the angle between the mirrors to 60°. How many images of the ball can you see now?

Make your two mirrors parallel to each other. Look into them and notice how many images of the ball you can see. Have you ever stood between two parallel mirrors? If you stand in front of two plane mirrors kept facing each other, you will see an infinite number of images.

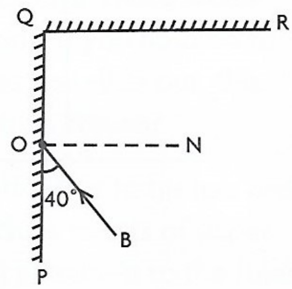
You will observe that as the angle between the mirrors __________ (decreases/increases), the number of images which can be seen __________ (increases/decreases).

### Exercise 5

In the figure shown here, PQ and QR are two mirrors at right angles to each other. BO is a ray of light and NO a normal to PQ.

**i.** What are the angles of reflection of the rays reflected from a. PQ b. QR?

**ii.** Copy the diagram and show the path taken by ray BO after reflection at both mirrors.




## Speed of Light

Light travels at an enormous speed of 300,000 km/s. This means in just one second, it covers 300,000 km! If you could travel around the earth with the speed of light, you would finish seven orbits in only one second!

## Exercise 6

The speed of sound is 330 m/s. Can you say why, during a storm, lightning is seen much before we hear the sound of thunder?

## Exercise 7

Light is not only reflected by some materials, it goes through some of them. What are such materials called?

## Activity 2 What happens to light as it goes through glass?

You will need: a large cardboard carton painted black on the inside or lined with black paper, a rectangular glass slab, a torch with new cells, black paper, scissors, a sheet of white paper, pencil, ruler, protractor

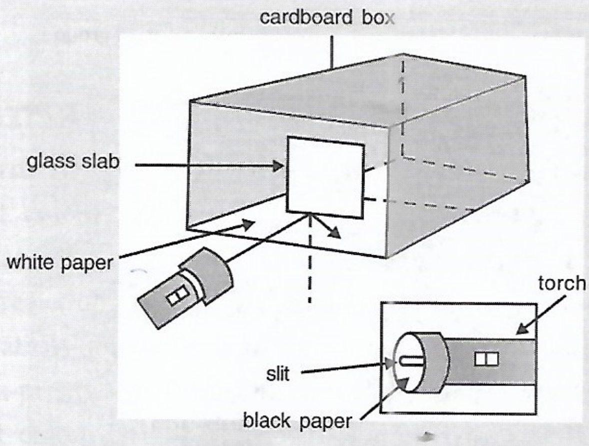
Work in a small group of two to four people. First cover the front of the torch with black paper and cut a thin slit in it. When the torch is switched on, you should get a thin beam of light.

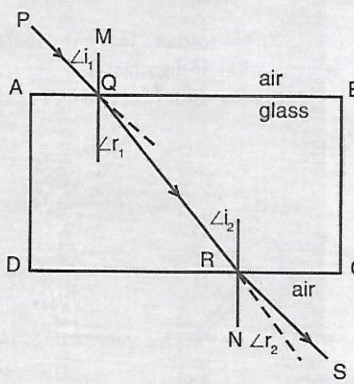
Place the glass slab ABCD on a sheet of white paper and draw its outline. Draw a normal MQ, as shown in the figure. Draw a line PQ making an angle of about 45° with MQ. This line PQ is the **incident ray**. Fix the white paper firmly on the base of the cardboard box. Place the glass slab on its outline. Now hold the torch so that the ray of light shines along PQ on the base of the carton.

Can you see the beam of light inside the glass slab? Does it go straight through? Can you also see a ray of light coming out from the other side of the glass slab? This is the **emergent ray**. Using a sharp pencil, mark two points on this emergent ray, RS. Look at the figure below. Remove the glass slab and join the two points. Extend the ray backwards to meet the outline of the glass slab at R. Join QR.

As PQ enters the glass slab it changes direction or bends towards the normal. **This change in the direction of light as it passes from one medium to another is known as refraction**. Again when the ray of light leaves the glass slab, it is refracted, this time away from the normal.

In the diagram, PQRS shows the path taken by the ray of light. The **normal** has been drawn at the point of incidence and at the point where the ray emerges from the glass block. The normal is always



perpendicular to the boundary between the two media. The angle which the incident ray makes with the normal is the **angle of incidence**. Similarly, the angle which the **refracted ray** makes with the normal is the **angle of refraction**.

Label your own drawing to match the one given above. Notice that refraction has taken place twice — at first when the ray of light went from air to glass (at AB) and again when it went from glass to air (at DC).

**i.** Look at your drawing and complete the following sentences:
At AB, the incident ray is ______, the refracted ray is ______. The angle of incidence is ______, the angle of refraction is ______.
At DC, the incident ray is ______, the refracted ray is ______. The angle of incidence is ______ and the angle of refraction is ______.

**ii.** From your drawing, find the relationship between these pair of angles $\angle i_1$ and $\angle r_1$; $\angle i_2$ and $\angle r_2$; $\angle r_1$ and, $\angle i_2$; $\angle i_1$ and $\angle r_2$.

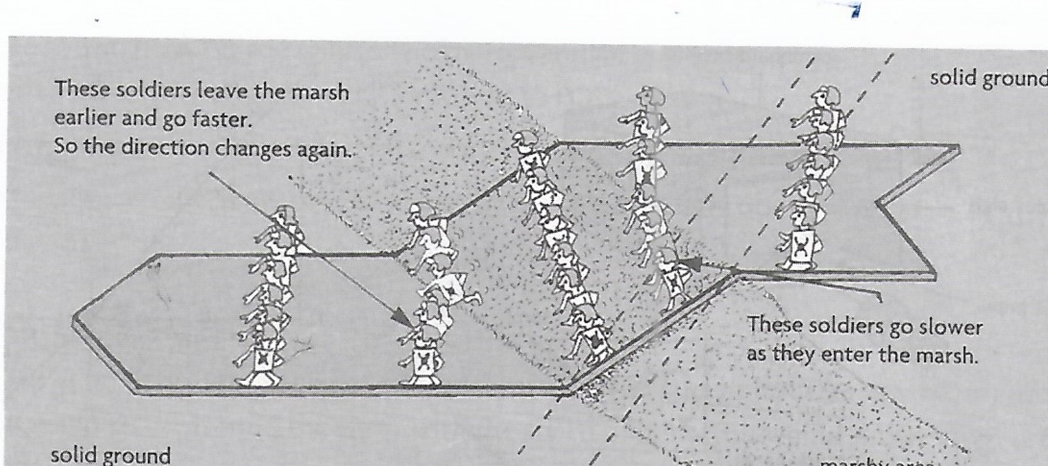
**iii.** When ray PQ enters the glass slab, is it turned towards or away from the normal?

**iv.** When ray RS emerges out of the glass slab, does it turn towards or away from the normal?

Refraction occurs because of the change in the speed of light as it goes from one transparent medium to another. Light travels at about 300,000 km/s in air. As it enters a **denser** medium like glass or water, it slows down, which makes it change direction. **Light is refracted towards the normal when it goes from air (a rarer medium) into glass (a denser medium). When a ray of light goes from glass (a denser medium) to air (a rarer medium), it is refracted away from the normal.**

## Why does refraction take place?

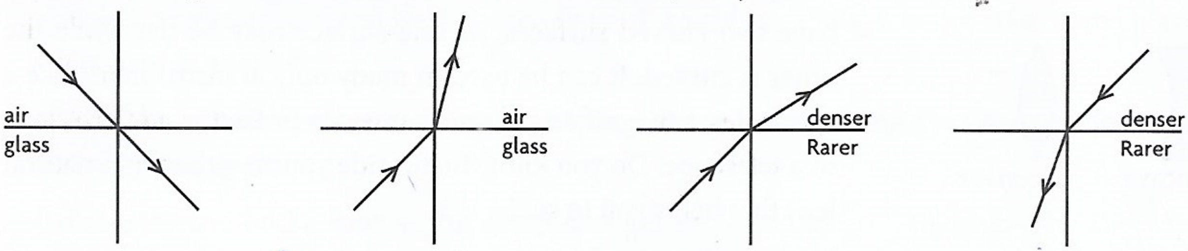
Imagine a column of soldiers marching, at first on solid ground, then entering a marshy area where the ground is soft and then coming out again. Their speed of marching changes depending on whether they are on solid ground or in the marsh.



As the first line enters the marsh, the soldiers at one end slow down before the rest of the line catches up. This changes the direction of the whole group. When the soldiers leave the marshy ground, their direction will change in the opposite way. This is similar to what happens to a ray of light when it goes from one transparent medium to another.

## Exercise 8

Look at the diagrams drawn here and find out mistakes, if any.

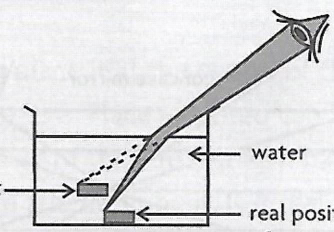



## Activity 3

You will need: a glass tumbler, some water, a pen, a small metal bowl, a coin

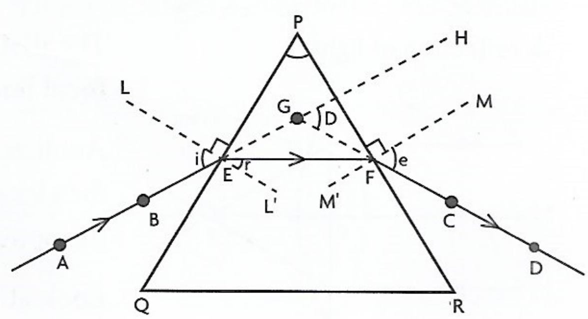
i. Pour some water into a glass tumbler. Put a pen in the glass at a slant and not straight. When you look at the pen, it looks broken. Is this a trick?
You see the pen in the first place because light bounces off it to your eyes. Light from the end of the pen underwater bends as it leaves the water and enters the air. Because of this bending, the pen looks broken.

ii. Place a metal bowl on a table. Now, place a coin in it. Keep moving away from the table till you can no longer see the coin. Ask your friend to pour some water into the bowl. You will be able to see the coin now. The coin seems to have risen!




# Prisms

You learnt last year that sunlight is made up of seven different colours which make up the **spectrum**. The triangular piece of glass shown here is called a **prism**. A prism breaks up white light into a spectrum. How does it do that? When a beam of light passes from air into the glass prism, it is refracted. Since it is made of seven different colours, the rays of each colour travel with a




AE – incident ray
EF – refracted ray
FD – emergent ray
∠P – angle of prism
∠i – angle of incidence
∠r – angle of refraction
∠e – angle of emergence
∠D – angle of deviation

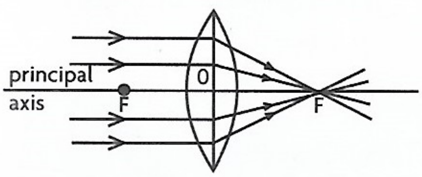
different speed and they are refracted by different amounts. When they emerge from the prism, each colour is seen separately. This separation of white light into the colours of which it is made up is called **dispersion**.

## Lenses

A lens is a transparent disc, usually made of glass or plastic. It may have two curved surfaces; or one surface may be flat while the other is curved. It can be used in many optical instruments like a spectacles, a magnifying glass, a camera, a projector, a microscope or a telescope. Do you know that inside your eye there is a natural lens that helps you to see?

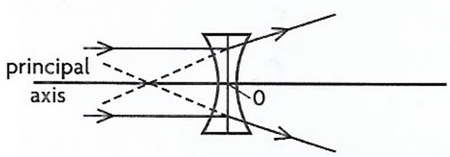
▲ concave ▲ convex

Lenses come in a variety of shapes and sizes but there are two basic shapes—**concave** and **convex**. A concave lens curves inward and is thicker at the edges than in the middle. A convex lens curves outwards and is thicker in the middle than at the edges.



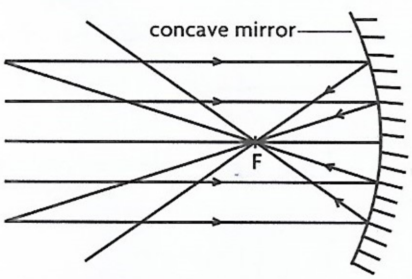

▲ converging lens

Light rays change direction as they pass through a lens. Look at the adjacent diagram. O is the **optical centre** of the lens. The horizontal line passing through the optical centre of the lens is called the **principal axis**.




▲ diverging lens

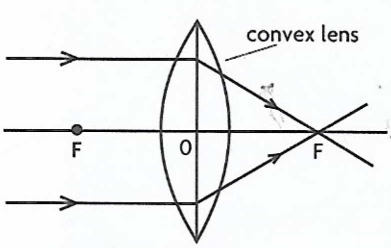
In a convex lens, the rays of light parallel to the principal axis **converge** or meet at a point after refraction. This point is called the **focus**, **F**, of the lens. A convex lens is also called a **converging lens** because it brings the rays of light together after refraction.




▲ reflection of light

In a concave lens, the rays of light parallel to the principal axis **diverge** or go away from each other after refraction. A concave lens is, thus, also called a **diverging lens.** The refracted rays in a concave lens seem to come from a point behind the lens. This is the focus of the concave lens.

**The distance from the centre of a lens to its focus is called the focal length.**




▲ refraction of light

Another point, which we need to refer to when we draw ray diagrams for a lens, is located at a distance equal to twice the focal length from the optical centre. In the diagrams, you will find it labelled 2F.

Look at the two pictures here. One shows how a concave mirror turns a ray of light. The other shows how a convex lens bends light. Both of them bring the light rays together at the focus.

# Image Formation in a Convex Lens

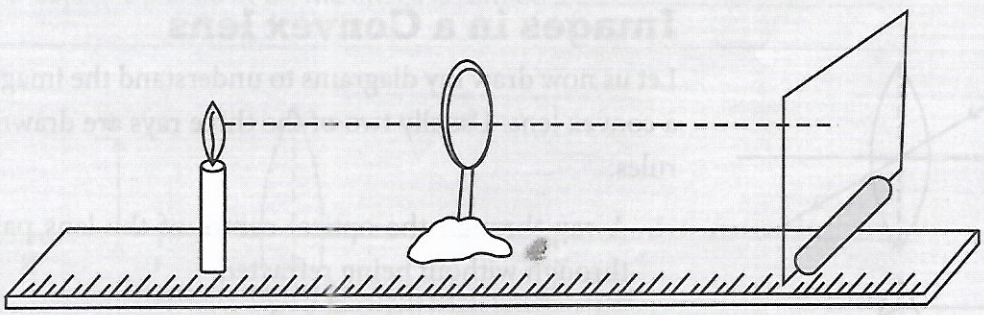
Last year you learnt how a concave mirror can form different images. Let us now study the images formed by a convex lens.

## Activity 4

You will need: a magnifying glass (a convex lens), a lighted candle, a metre stick, some plasticine, a white card as a screen

**NOTE: Never look at the sun directly with or without a magnifying glass because your eyes may be badly damaged**.

Go outside and find a spot in the direct sunlight. Hold the magnifying glass over the white card so that the sunlight passes through the magnifying glass and forms a bright spot that is very small and bright on the card. **Do not stare long at this bright spot as this can damage your eyes.** Use a ruler to measure the distance between the lens and the card. This is the focal length, f, of your lens.



Place the metre ruler on a table. Fix the lens in a block of plasticine and place it at the centre of the metre ruler. Mark the focus, F, and the point at, 2F, on either side of the lens. Place a lighted candle beyond 2F near one end of the ruler. Hold the white card on the other side of the lens. Move it back and forth till you get a sharp image of the candle on it. Study the image and describe it. Is it real or virtual? Is it upright or inverted? Is it larger than the candle flame, the same size, or smaller?

Next, place the candle at 2F. Try and obtain the image on the white card as earlier. What kind of image do you see now? Where is it formed?

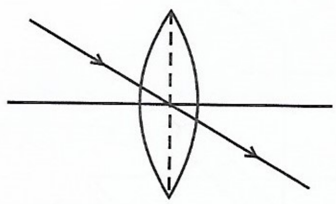
Now, move the candle closer to the lens so that it is between F and 2F. Describe the image. Where is it formed?

Finally move the candle so that it is between O, the optical centre of the lens, and F. What kind of image do you see in each case? (Hint: Look through the lens.)

In your notebook, make a table like the one below and record your observations:

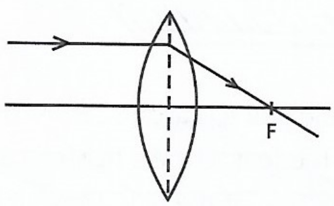
| Position of the Object | Position of the Image | Type of Image |
|---|---|---|
| **i.** object beyond 2F | | |
| **ii.** object at 2F | | |
| **iii.** object between F and 2F | | |
| **iv.** object within the focal length | | |

## Ray Diagrams to Show the Formation of Images in a Convex lens

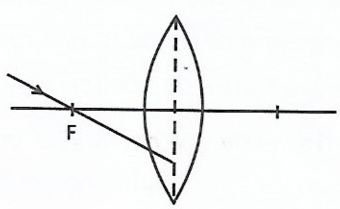


Let us now draw ray diagrams to understand the images formed in a convex lens. Usually two of the three rays are drawn using these rules:

**i.** A ray through the optical centre of the lens passes straight through without being refracted.




**ii.** When a ray of light parallel to the principal axis passes through a convex lens, it passes through the focus after refraction.

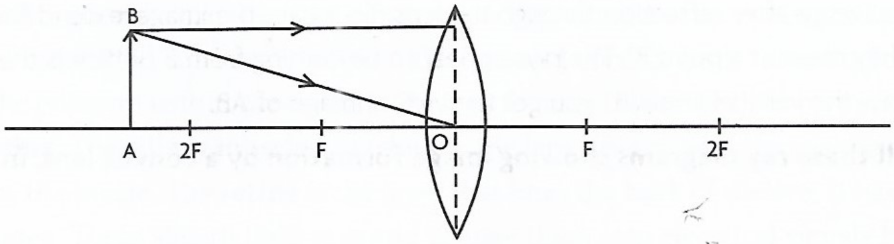



**iii.** The incident ray and the refracted ray are **interchangeable.** So if an incident ray from the focus passes through the convex lens, what will be its path after refraction? Complete the figure here.

### Exercise 9

Complete these ray diagrams showing how a convex lens forms images.

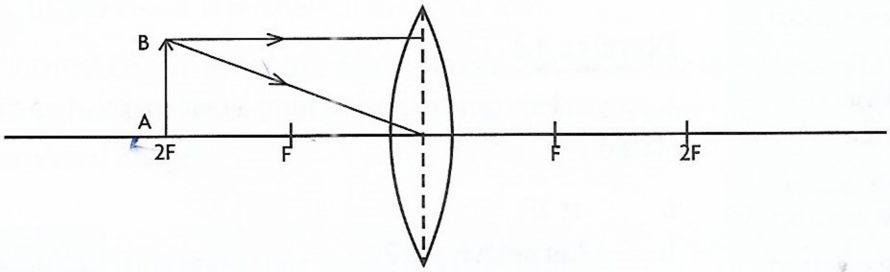
**i.** AB represents the object placed beyond 2F. Two incident rays have been drawn. Draw the refracted rays. The point A' where the two refracted rays meet will be the image of A. The image B', of B will lie on the axis. Hence the line A'B' drawn perpendicular to the axis represents the image of AB.




When the object is placed beyond 2F, the image is formed ______________________.

It is ______________________.

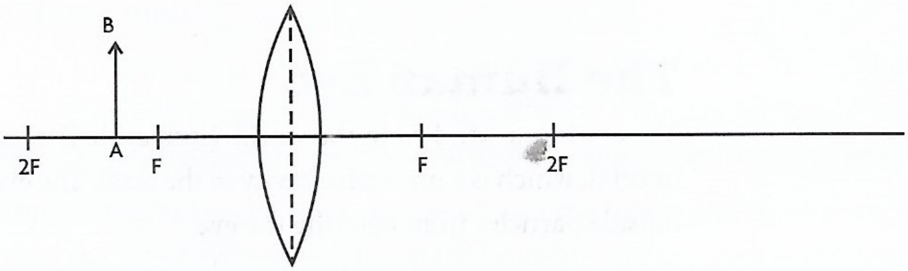
ii.




When the object is placed at 2F, the image is formed ______________________.

It is ______________________.

iii.

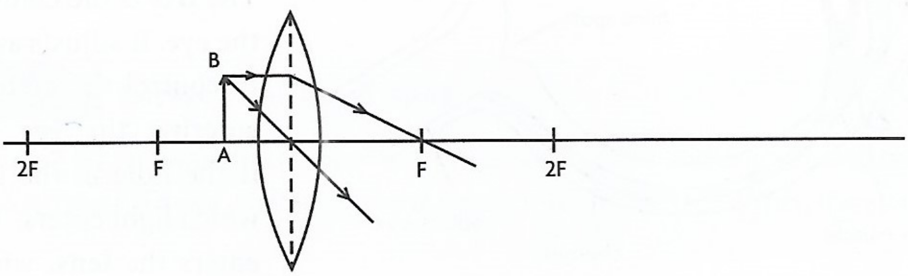



When the object is placed between F and 2F, the image is formed ______________________.

It is ______________________.

## Exercise 10

What happens when the object is within the focal length? A partially complete ray diagram is shown here. Complete the diagram and describe the image.



Notice that the rays diverge after refraction through the lens. To locate the image, extend the refracted rays backwards till they meet at a point B'. The rays appear to be coming from B', which is the virtual image of B. If you draw the vertical line A'B', you get the virtual image of AB.

**Practise drawing all these ray diagrams showing image formation by a convex lens, in your notebook.**

**Did you know?**

The eyes in human are set about 6.4 cm apart.

The human eyeball measures about 25 mm in diameter.

The colour of the eye is due to the pigment melanin in the iris.

The cornea has no blood vessels at all.

### Exercise 11

If the convex lens is used to see an enlarged image of the print on this page, where must you hold the lens?

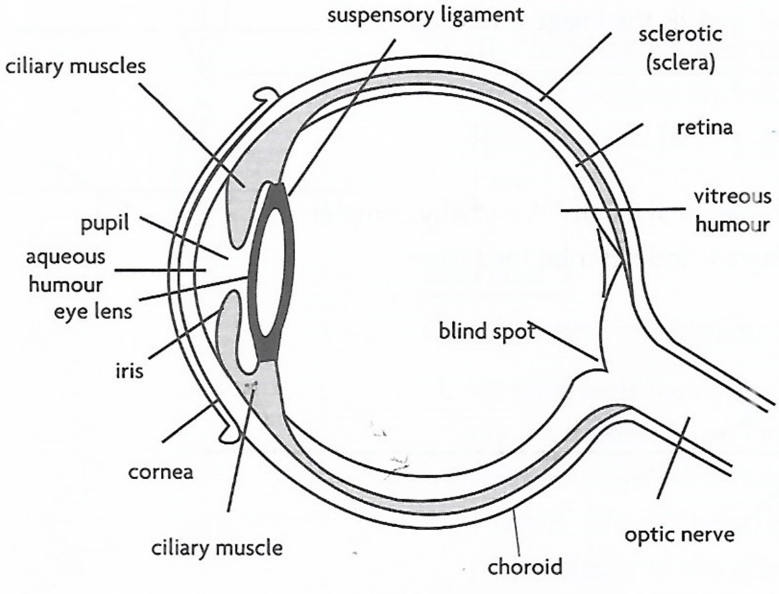
### Exercise 12

A convex lens can be used to form a real image when the object is placed

- **i.** at 2F.
- **ii.** between F and 2F.
- **iii.** beyond 2F.
- **iv.** at any of the above positions.

## The Human Eye

The eye is our window to the world. Each eyeball is set in a socket, or orbit, which is a protective cavity in the skull. The eyelids prevent outside particles from entering the eye.




▲ human eye

The **sclera** or **sclerotic** is the tough, outer covering of the eye. In the front of the eye it becomes the curved, transparent **cornea**. When a ray of light enters the cornea, most of the refraction occurs here. The **iris** is the coloured part of the eye. It adjusts automatically to control the amount of light entering the eye. The **pupil** is the hole in the iris through which light enters. Thereafter it enters the **lens**, which focuses it on the **retina**.

The **vitreous humour**, a clear, jelly-like substance, occupies most of the eye behind the lens. The **aqueous humour** is a more fluid substance between the lens and cornea. Both these liquids help maintain the shape and the pressure within the eyeball. The **lens** focuses incoming light rays onto the light-sensitive layer, the **retina**. The **ciliary muscles** attached to the lens, control and change the curvature of the lens to help focus the image. The **retina** is the layer that lines the back of the eye. It has sensory cells called **rods** and **cones**. These absorb light rays and change them into electrical signals for the brain to read. Rod cells allow the eye to see in dim light. The cones allow the eye to see in colour and in bright light. Nerve fibres attached to the rods and cones join to form the **optic nerve**. The point where the optic nerve enters the eye is called the **blind spot** as it contains no rods and cones and therefore cannot respond to light. No vision is possible at the blind spot.

The images formed on the retina are **upside down**, **reversed left to right**, and **flat**. Each side of the brain receives visual signals from both the eyes. The brain interprets such an image correctly to provide a three-dimensional image.

## Activity 5 Observe Your Reactions to Light

You will need: a torch with new cells

Work in pairs. First sit in a well-lit room. After a few moments, look at each other's pupils. Do you find them wide open or small?

Next, close all the curtains or shift to a semi-dark room. Allow about three minutes for your eyes to adjust to the darkness. Switch on the torch and shine it quickly for barely two seconds in your partner's eyes. Do his/her pupils look the same as they were earlier? What difference do you notice? Shine the torch in his/her eyes **from a distance** for a little longer and check once again. What do you see now? Why should you not shine a bright light directly into anyone's eyes?

Your partner can now try the experiment on you.

What have you learnt about the function of the iris?

### Exercise 13

A doctor shines a bright torch into a patient's eye. He notices that the pupil does not change. Does this patient have normal eyes? Why or why not?

## Activity 6 Locate Your Blind Spot

Hold this book 60 cm away from your face. Close the left eye and concentrate on the cross on the next page with the right eye. Slowly bring the book closer to the face. When the image of the dot falls on the blind spot, the dot will disappear. To find the blind spot in your left eye, hold your book upside down and at a distance of 60 cm. Close the right eye and concentrate on the cross with the left eye. Again when the image of the dot falls on the blind spot, it will disappear.

### Exercise 14

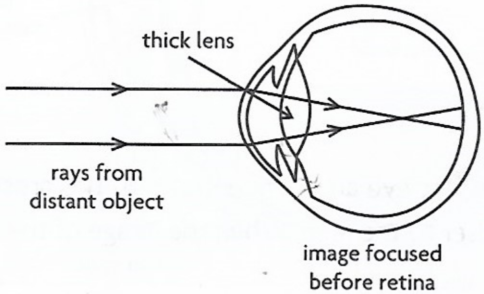
Match the items in column I to those in column II.

| Column I | Column II |
|---|---|
| **i.** cornea | **a.** region without any sensory cells |
| **ii.** iris | **b.** jelly-like fluid that occupies most of the eye |
| **iii.** sclera | **c.** transparent outer layer that refracts light |
| **iv.** retina | **d.** transparent, focuses light on retina |
| **v.** blind spot | **e.** fluid in between lens and cornea |
| **vi.** vitreous humour | **f.** opening in the iris |
| **vii.** ciliary muscles | **g.** part that gives colour to the eye |
| **viii.** lens | **h.** control the thickness of lens |
| **ix.** pupil | **i.** outermost tough lining |
| **x.** aqueous humour | **j.** light sensitive layer |

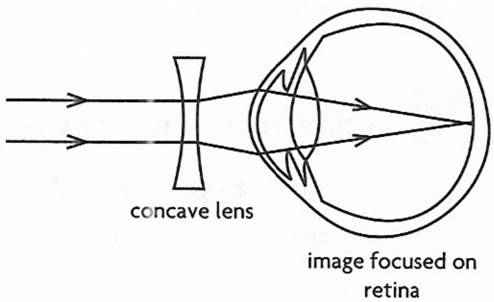
## Defects of Vision

Not everyone has perfect eyesight. **Short-sighted** people can see things which are close by clearly, but they cannot focus on objects which are far away. For example, they may read the print in a book easily, but are unable to read a distant road sign. This condition is known as **short-sight** or **myopia.**

In this case, the image is focussed in front of the retina. This defect can be corrected by using a **concave lens.** The concave lens in the spectacles make the rays diverge a little before they enter the eye.

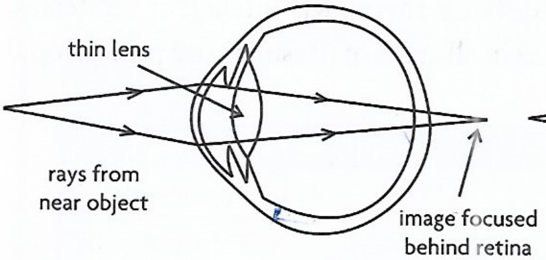



▲ short sight

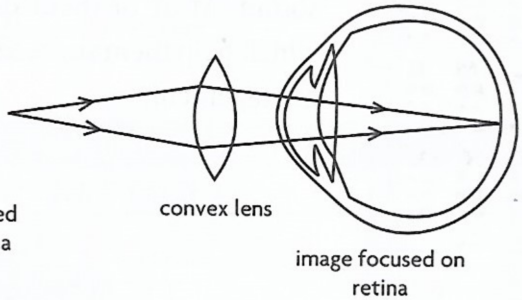



▲ short sight corrected

**Long-sighted** people can see distant things clearly, but cannot focus on things close to them. This is because the lens in the eye is weak. Old people tend to be long sighted. This condition is known as **hypermetropia**. In this case, the image is focussed behind the retina. This defect can be corrected by using a **convex lens**. Convex lenses in the spectacles make the rays converge more so that the image is formed on the retina.




▲ long sight




▲ long sight corrected

Some people have poor eyesight; they are **visually impaired**. Some of them can only see slightly or just sense some light. Others cannot see at all. Most visual impairment is caused by some disease or malnutrition. It is very important to have a balanced diet as one grows. **Vitamin A**, found in carrots and yellow or orange fruits, green leafy vegetables, fish and nuts is essential for good eye sight. Visual impairment may also be caused by **cataract** where the lens becomes cloudy and opaque. With advanced modern technology, many of these problems, especially cataracts can be cured. In some cases, spectacles, eye exercises and suitable medicines can help. Early detection of the problem is necessary. For this, a regular eye check-up is very important.

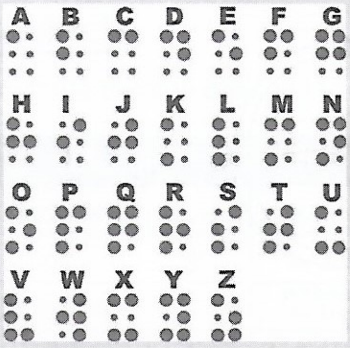
Have you ever wondered how people who cannot see are able to read? Many of them are educated to a high level. Some of them listen to books read out and recorded on tapes, just as people with sight do. In some universities, they use a 'reader' or 'writer' who helps them by reading out lessons, question papers and taking down the answers as they dictate them. The visually impaired can also read with their fingers using a special alphabet called **Braille**. It consists of raised dots on stiff paper and was, invented in 1922 by Louis Braille. Today there are many books published in Braille.

**Did you know?**

Visually impaired people can do almost everything that people with normal sight can do. There are a few things such as driving a car or flying an aeroplane that they cannot do yet. They are in many professions — as successful teachers, students, lawyers, computer engineers, musicians and writers. Have you heard of Helen Keller? She was deaf and visually impaired, and yet became a role model for millions of people. Read her story. There are many more such success stories. Find out about them.

## Did you know?

How does Braille work? Braille is written using a combination of six raised dots on stiff white paper. Look at the model below that shows the alphabets in Braille.



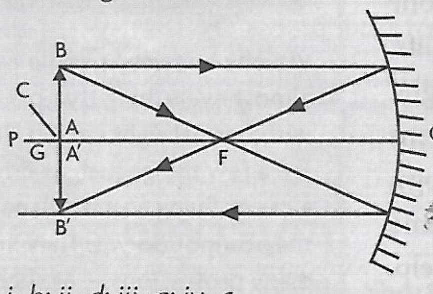

There are Braille typewriters and Braille printers so that the visually impaired can use computers to print out their work in Braille.

Visually impaired persons devise a number of techniques that allow them to complete their daily activities. Their other senses, like hearing, are usually much sharper than others. Thus, they can often tell who has entered a room, even before that person speaks. They can locate the direction from which they hear a sound. Most of them develop their own intelligent strategies, which help them succeed in all areas of personal and professional management.

## CHECK IT OUT

***1.*** *iii* ***2.*** *iii. When the object is placed beyond the centre of curvature of a concave mirror, the image formed is diminished and inverted. Thus, Raja must have placed the doll beyond C.*

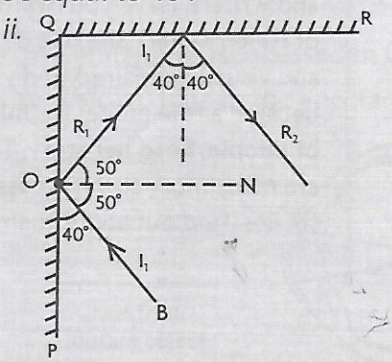
***3.*** *The image is real, inverted and the same size as the object.*




***4.*** *i.-b; ii.-d; iii.-a; iv.-c*

***5.*** *i. The angle of reflection will be equal to 50° on mirror PQ. The angle of reflection at QR will be equal to 40°.*

*ii.*



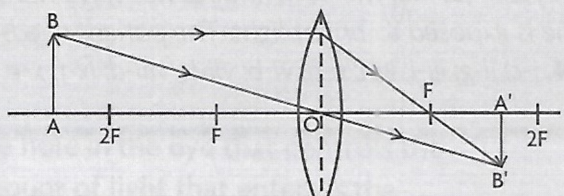

***6.*** *Light travels faster than sound. That is why we are able to see lightning much before we can hear thunder.* ***7. Transparent*** *substances allow all the light falling on them to pass through.*

**Translucent** substances, like ground glass or oiled paper, allow part of the light falling on them to pass through. **Activity 2:** i. At AB, the incident ray is **PQ**, the refracted ray is **QR**. The angle of incidence is $\angle i_1$, the angle of refraction is $\angle r_1$. At DC, the incident ray is **QR**, the refracted ray is **RS**. The angle of incidence is $\angle i_2$ and the angle of refraction is $\angle r_2$. ii. You must have observed $\angle i_1$ is greater than $\angle r_1$; $\angle i_2$ is less than $\angle r_2$; $\angle r_1 = \angle i_2$, $\angle i_1 = \angle r_2$. iii. When ray PQ enters the glass slab, it turns towards the normal. iv. When ray RS emerges out of the glass slab, it turns away from the normal. **8.** i. The refracted ray should move towards the normal. ii. The refracted ray should move away from the normal. iii. The refracted ray should move towards the normal. iv. The refracted ray should move away from the normal.

**Activity 4:**

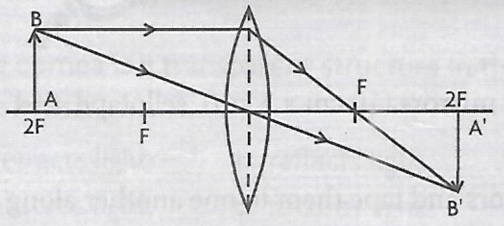
| Position of the Object | Position of the Image | Type of Image |
|---|---|---|
| **i.** object beyond 2F | between F and 2F | real, inverted, diminished |
| **ii.** object at 2F | at 2F | real, inverted, same size |
| **iii.** object between F and 2F | beyond 2F | real, inverted, enlarged |
| **iv.** object within the focal length | same side as the object | virtual, upright, magnified |

**9.** i.



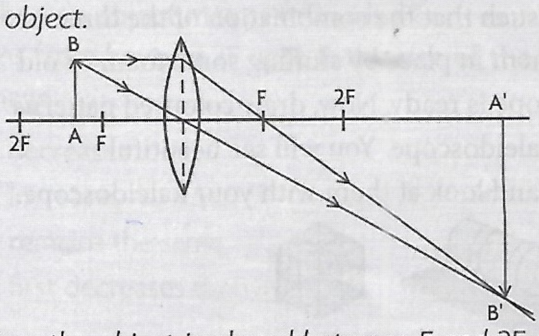

When the object is placed beyond 2F, the image is formed between F and 2F. It is real, inverted and diminished.

ii.



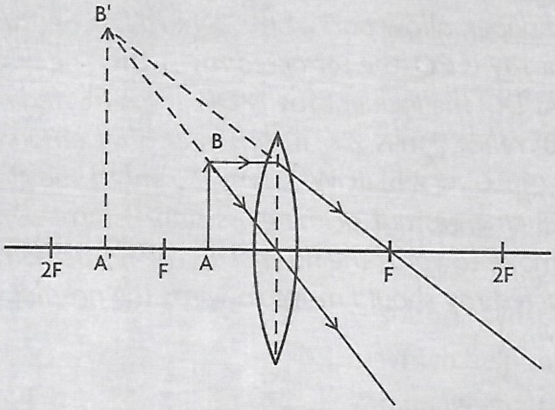

When the object is placed at 2F, the image is formed at 2F. It is real, inverted and the same size as the object.

iii.




When the object is placed between F and 2F, the image is formed beyond 2F. It is real, inverted and magnified.

*10.*




*When the object is placed within the focal length of the lens, the image is on the same side as the object. It is virtual, erect and magnified.* ***11.*** *The lens must be held fairly close to the page so that the page lies within the focal length of the lens. You will then see an enlarged, upright image of the print on this page. That is why a convex lens is used as a magnifying glass.* ***12.*** *iv.* ***Activity 5:*** *In semi-darkness, the pupils open wider to let in more light. When you shine a light into the eyes, the pupils contract and let in less light. Shining a bright light directly into a person's eyes may damage his/her eyes. Did you notice how the iris changes the size of the pupil to adjust to the amount of light entering the eye?* ***13.*** *No, the patient does not have normal eyes. The pupil must become smaller when one is exposed to bright light. The patient needs to be tested further to diagnose his problem.* ***14.*** *i-c; ii-g; iii-i; iv-j; v-a; vi-b; vii-h; viii-d; ix-f; x-e.*

## BECOME A YOUNG SCIENTIST

**Make a Simple Kaleidoscope**

**You will need:** three equal-sized rectangular mirrors (10 cm x 5 cm), sellotape, and thick black chart paper.

**What to do:** Take the three rectangular mirrors and tape them to one another along their length with the shiny reflecting surface on the inside. Roll and tape a piece of thick chart paper into a cylindrical tube such that the combination of the three mirrors fits inside the tube. You can keep them in place by stuffing some foam or old cloth pieces inside the tube. Your kaleidoscope is ready. Now, draw coloured patterns on a white paper. Look at it through your kaleidoscope. You will see beautiful symmetrical patterns. Make more patterns and look at them with your kaleidoscope.