4 Light

'On a windless day, the smooth surface of a lake reflects light and produces stunning images of the surrounding landscape and sky. The light falling on the flat, smooth, surface of lake undergoes regular reflection.'

1. Introduction

Much of our experience of the world comes through light and sound. Without light, life would be impossible. We need light to see objects around us. Plants use light energy to manufacture food. In fact, light from the Sun is the source of nearly all of our energy and warmth.

The phenomenon of light, the explanation of what it is, and of why objects are visible, has taken a long time to be understood.

We see things only when objects send out light. Every object which we see around us would be invisible unless light comes from it, enters our eyes, and causes messages to be sent from our eyes to our brain.

SPOT LIGHT

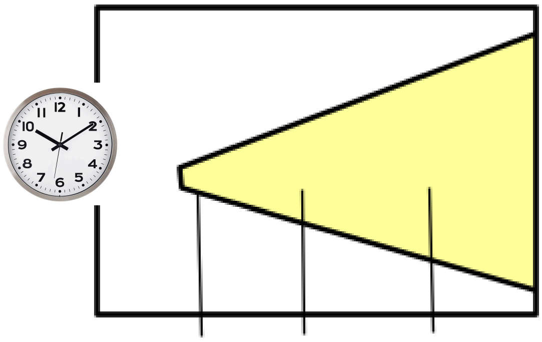
Look around your darkened room at night. You cannot see an object in the dark. This means that eyes alone cannot see any object. It is only when light from an object enters our eyes that we see the object. Thus, **light is a form of energy which excites our sense of sight**.

Sources of light

During the day, the primary source of light is the Sun and the secondary source is the brightness of the sky. Other common sources are flames, electric bulbs, tube lights (fluorescent tubes), compact fluorescent lamps (CFLs) and light emitting diodes (LEDs).

2. Luminous and nonluminous objects

Look around, in a darkened room at night. You cannot see the object in the dark. This means that eye alone cannot see any objects. It is only when light from an object enters our eyes that we see the object. **Thus, light is a form of energy which excites our sense of vision**.



Luminous
body
Light
Non-luminous
body

Luminous and non-luminous objects

(i) Luminous body : An object which emits light by itself is called a luminous source of light. The Sun and the stars are natural, luminous sources of light. Electric bulbs, lanterns, fluorescent tubes and candles are artificial sources of light.

(ii) Non-luminous body : A body which does not emit light of its own is called a non-luminous body.

A non-luminous body becomes visible only when light from a luminous body falls on it. We are able to see a non-luminous object because the light reflected by it enters our eyes and produces the sensation of sight.

> Natural sources including the Sun and other stars are luminous objects. They produce light by a continuous process called 'nuclear fusion' in which simpler elements combine to form bigger elements.
>
> **SPOT LIGHT**

The Moon is a non-luminous body which shines, and is visible because it reflects the light that it receives from the Sun. In other words, moon light is reflected sunlight.

Building Concepts 1

How could we see non-luminous objects and luminous objects ?

Explanation

When the light falls on a non-luminous object, it reflects a part of the light towards us. When this light reaches our eyes, we could see an object. A luminous object emits its own light. When this light reaches our eyes, we could see a luminous object. Thus, for us to see an object, it must reflect or emit some light that reaches our eyes.

3. Objects

Opaque objects

An object is said to be **'opaque'** if it does not allow any light to pass through it. An opaque object reflects a part of the light falling on it and remaining part is absorbed by it.

Transparent objects

An object is said to be **'transparent'** if it transmits most of the light falling on it. Only a very small part of light may be absorbed or reflected from it. We can see clearly an object present behind the transparent object. e.g. a plain glass slab is a transparent object
(or medium).

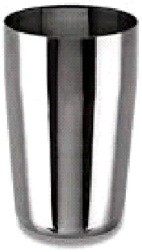
Translucent objects

An object is said to be **'translucent'** if it transmits a part of the light falling on it that is not sufficient to see clearly an object present behind it.

☞ For a highly polished surface or mirror, most of the light falling on it gets reflected. For a transparent medium like glass or water, most of the light falling on it gets transmitted.

Active Physics 1

1. Take a steel tumbler, a glass tumbler and a milky or tinted glass tumbler. Take three wax candles of sizes smaller than the heights of the tumblers.
2. Place one candle each inside the above tumblers. Now, ignite all the three candles placed inside the tumblers. You will not see candle or its flame placed in the steel tumbler [see figure (a)]. You will see the candle and its flame clearly placed in the glass tumbler [see figure (b)]. The candle and its flame will appear to you blurred that was placed in the milky or tinted glass tumbler [see figure (c)].



(a) A steel tumbler : we cannot see any object like an ignited candle placed inside it.

(b) A plain glass tumbler : we can see clearly any object like an ignited candle placed inside it.

(c) A tinted or milky glass tumbler :
we cannot see clearly any object like an ignited candle placed inside it.

Active Physics 1

Thus, we can conclude that the steel tumbler is an opaque object, the glass tumbler is a transparent object and the milky or tinted glass tumbler is a translucent object.

Some basic terms

Ray of light : A ray of light is the direction in which light travels.

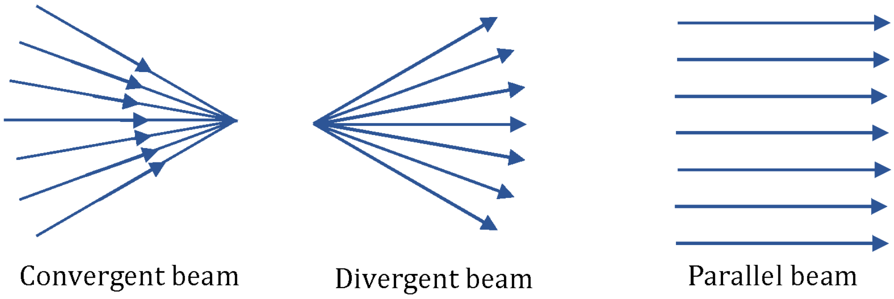
Ray of light

Beam of light : A bundle of light rays is called **beam of light (or light beam)**.

Convergent beam : A beam of light in which all the rays move towards a single point is called **convergent beam** (figure (a)).

Divergent beam : A beam of light in which all the rays emerge out from a single point is called **divergent beam** (figure (b)).

Parallel beam : A beam of light in which all the rays are parallel to each other is called **parallel beam** (figure (c)).



Various beams of light

4. Rectilinear propagation of light

On a misty night, you may have seen the beams of light from the headlamps of a car, or you may have had fun watching the powerful beams of light rotated in the sky by circus companies or the organisers of a fair. You may even have seen beams of sunlight making their way through the clouds or through the leaves of trees. Perhaps you have noticed that all such beams of light are always straight. **Light always travels in straight lines. This is called the rectilinear propagation of light.**

> Human-made light sources, such as candles and lamps, rely on chemical reactions or electricity to produce light.
>
> **SPOT LIGHT**

There are three main effects of rectilinear propagation of light

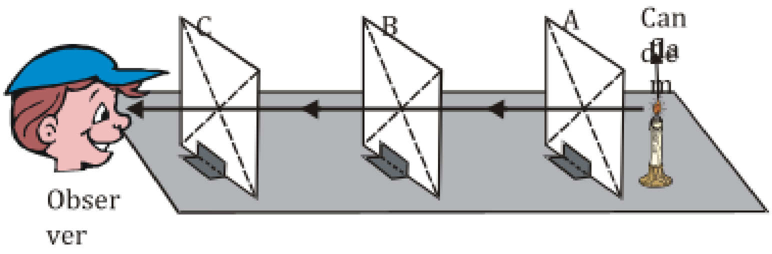
1. Formation of shadows 2. Formation of eclipse 3. Formation of images

Active Physics 2

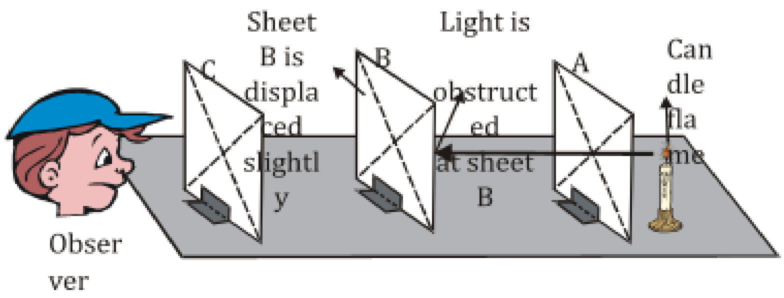
1. Take three rectangular cardboard sheets of equal size and make a tiny hole using a pin in the centre of each. The centre of the cardboard can be located by drawing the diagonals of the rectangular sheets. The point of intersection of the diagonals is the centre of the cardboard sheet.
2. Now, fix each cardboard sheet in vertical position by simply pasting them on a wooden or cardboard base using an adhesive (glue) so that their centres are in the same horizontal line [see figure (a)]. Let us mark these sheets as A, B and C.
3. Place a burning candle in front of the sheet A and look through the pin hole in sheet C. You will see the candle clearly.

4. Now remove the sheet B from its position and paste it again at small distance away from its original position [see figure (b)]. Again look through pin hole C. This time you will not see the candle.

From this activity, we conclude that light travels in a straight line. When pin holes on the cardboard sheets are in straight line, the light passes through them. When pin holes on the cardboad sheet are not in straight line, light fails to pass through them.



(a) Candle flame can be seen as all three sheets are in a straight line



(b) Candle flame cannot be seen as all three sheets are not in a straight line

Active Physics 2

Properties of light

(1) Light is a form of energy that travels in the form of waves.

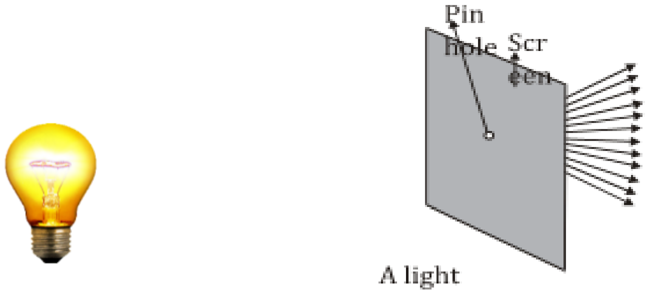
(2) Light waves spread out in all directions as they move away from a source.

(3) Light can travel through empty space (vacuum), without needing a solid, liquid, or gas medium.

(4) Light rays from any source always travel in straight lines. This is called rectilinear propagation of light.

(5) Regardless of its source, a ray of light will not change direction unless it travels through a different medium or is disturbed in some way.

(6) A light wave will spread out if it travels past the edge of a object or if it moves through a narrow opening.



Light waves spread out in all directions
if they pass through a very small hole

(7) Light travels through space at the fastest speed, about 300000 km/s or 3×10^8 m/s. The speed of light is represented in scientific formulas by the letter 'c'. In other transparent medium like water or glass, the speed of light is slightly less than the speed of light in space.

(8) Light has colours. Ordinary light that we see in everyday life is called white light as it appears white to us. This white light consists of seven colours namely violet, indigo, blue, green, yellow, orange, red.

(9) Light has different intensities i.e., it can be bright or dim. For example, a 100 W bulb will glow brighter than a 40 W bulb. Sunlight in early morning is dimmer than the sunlight in the afternoon.

5. Reflection of light rays

As light hits an object, some of the light is reflected or bounced off the object. The light travels back to your eye and lets you to see the object.

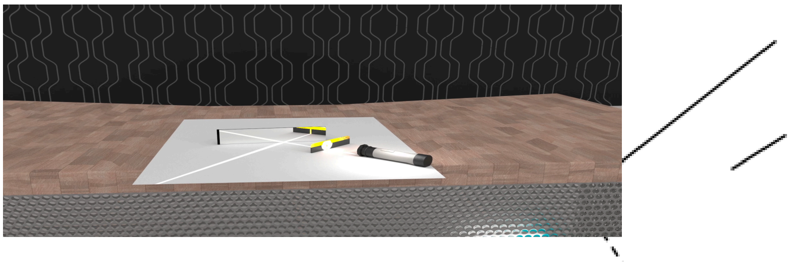
☞ Reflection is the bouncing of light rays off a surface. In other words, 'reflection' is the sending back of all or a part of a beam of light as it strikes a surface.

Active Physics 3

1. Fix a white sheet of paper on a drawing board or a table. Take a comb and close all its openings using a black paper sheet except one in the middle. Hold the comb perpendicular to the sheet of paper.
2. Mark a point O at the middle of the bottom edge of the mirror. Then use the protractor and the ruler to draw a line on the paper perpendicular to the mirror from the mark. Label this line N. This line is called **'normal'**. Draw a line on the paper from O at a particular angle say 30° to line N.

3. Turn on the flashlight (torch) and place it so the beam is along the 30° line. This is the angle of incidence. Measure and record the angle that the reflected beam makes with line N. This is the angle of reflection.

4. Now, measure the angle of reflection (r). You will find that the angle of reflection is 30°. Repeat this activity, by making other angles such as 45°, 60° with the line N. In each case, you will find that the **'angle of incidence is equal to the angle of reflection'**.



Active physics 5

☞ The angle between an incoming light ray and a surface is equal to the angle between the reflected light ray and the same surface. This relationship is called the **law of reflection**.

Some basic terms

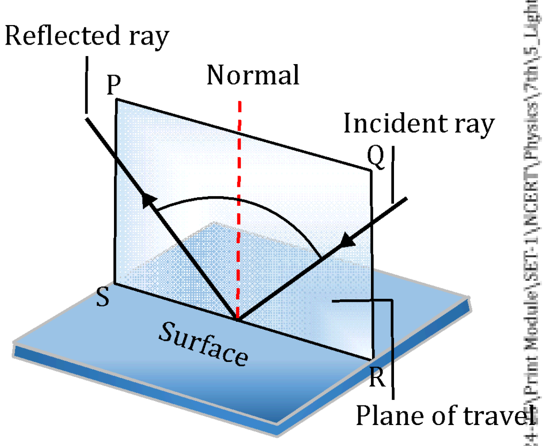
Incident ray : The ray of light which falls on the mirror surface is called 'incident ray'.

Reflected ray : The ray of light which is sent back by the mirror is called 'reflected ray'.

Point of incidence : The point at which the incident ray falls on the mirror is called 'point of incidence'.

Normal : A line perpendicular to the surface of mirror passing through the point of incidence is called 'normal'.

Angle of incidence : The angle made by incident ray with the normal at the point of incidence is called 'angle of incidence'.



Reflection of light

Angle of reflection : The angle made by reflected ray with the normal at the point of incidence is called 'angle of reflection'.

First law

The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.

Second law

The angle of incidence is equal to the angle of reflection.

$$\angle i = \angle r$$

Quick Tips

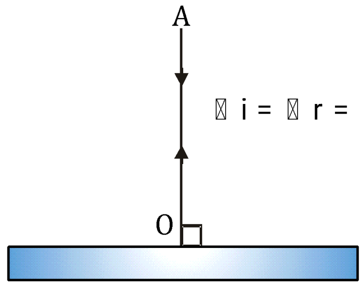
- In first law of reflection when we talk about same plane we are basically talking about two dimensional plane (See above figure PQRS).

Building Concepts 2

How is a ray of light reflected when it is incident normally on a plane mirror?

Explanation

For a ray incident normally on a surface, the angle of incidence i = 0°, therefore the angle of reflection r = 0°. Thus, a ray of light AO incident normally on a surface is reflected along the same path OA as shown in figure.



Reflection of light ray when it is incident normally on a plane mirror.

Be Alert !

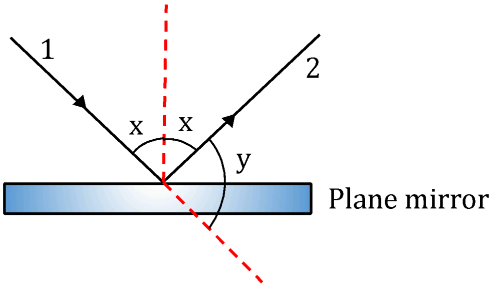
When light incident normally over a reflecting surface angle between incident ray and reflecting surface is 90° but angle of incidence and angle of reflection = 0

Building Concepts 3

How can you find the angle between the incident ray and the reflected ray?

Explanation

Let an incident ray 1 falls on a plane mirror at an angle of incidence x, then by the law of reflection, the angle of reflection is also x.



Finding angle between incident ray and reflected ray

Now, we can find angle y (angle between the incident ray and the reflected ray) from the figure,

$x + x + y = 180°$ (angle of a straight line is 180°)

or $2x + y = 180°$ or $y = 180° - 2x$

Angle y is also known as angle of deviation.

Quick Tips

Whenever angle between incident ray(Original path) and reflected ray is asked we always find angle of deviation.

Numerical Ability 1

Figure shows an incident ray AO and the normal ON on a plane mirror. The angle which the incident ray AO makes with the mirror is 30°. Find the angle of incidence and angle of reflection. What is the angle between the incident ray and the reflected ray?

Plane mirror
N
A
r
i
y
30°

Numerical Ability 1

Solution

As shown in the figure, the angle between the surface of the mirror and the incident ray is 30°.

$\angle i + 30° = 90°$

$\angle i = 90° - 30° = 60°$ $\angle i = 60°$

$\angle i = \angle r$ (According to law of reflection)

$\angle r = 60°$

Given, the angle of incidence, x = 60°.

The angle between the incident ray and reflected ray is given by,

$y = 180° - 2x$

$y = 180° - 2 \times 60°$

$y = 180° - 120° = 60°$

Do You Remember ?

- An angle is made up of two rays that have the same end point.

0°

180°

90°

Check your Concepts 1

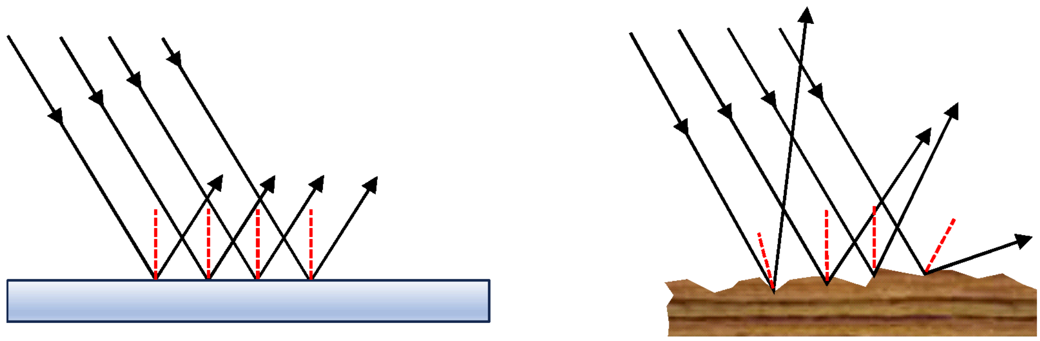
1. Do we see all objects due to reflected light ?
2. What are the uses of transparent, translucent and opaque materials ?
3. Is it possible to have a ray of light ?

6. Regular and diffuse reflection

Regular reflection (specular reflection)

If a parallel beam of light is incident on a smooth plane mirror, the reflected beam is also a parallel beam. This reflection is called ‘regular reflection’.

Reason : The light rays strike the smooth surface at same angles of incidence. This is because all the normals are parallel to each other on the smooth surface. Thus, the light rays get reflected at same angles of reflection. That is why, the rays of reflected beam remains parallel to each other [figure (a)].



Smooth Surface Regular reflection   Rough Surface Diffuse reflection

Reflection through smooth and rough surfaces

Diffuse reflection (irregular reflection)

If a parallel beam of light is incident on a rough surface or mirror, the rays of light become non-parallel to each other. Such a reflection is called 'diffuse reflection'.

Reason : The light rays strike the rough surface at many different angles of incidence. This is because all the normal are not parallel to each other on the rough surface. Thus, the light rays get reflected at many different angles. That is why, the rays of reflected beam become non-parallel to each other [figure (b)].

Building Concepts 4

Why do you see your image in water when you stand on the edge of a lake and look in the water ? Is it always possible to see a clear image in water ?

Explanation

You see your image in water due to reflection of light from the surface of water. When light bounces off a smooth surface of lake, the reflection is clear. You can see exactly what is reflected. But if a strong wind blew across the smooth lake, it would be hard to see your reflection clearly in the wavy water. The light would be bouncing off in all directions, and your reflection would be blurry (unclear).

Check your Answers 1

1. Almost everything we see around us, can be seen due to reflected light. Moon, for example, receives light from the Sun and reflects it, that's why we see the Moon.

2. Transparent materials are used in making window panes, spectacles, binoculars, telescopes etc. Windows and doors are made of translucent materials so that only a small amount of light can enter the room. Opaque objects are used when we do not want to allow light to pass through it.

3. A ray of light is an idealization. In reality, we have a narrow beam of light which is made up of several rays. For simplicity, we use the term ray for narrow beam.

7. Plane mirror

When you look into a plane mirror, you see a clear image of yourself. The image is formed due to reflection. Reflection always involves two rays - an incoming or "incident" ray and an outgoing or "reflected" ray.

When an object is viewed in a mirror, the eyes take in the light that has been reflected. But the brain assumes that the light rays have reached the eyes in straight lines.

The brain works backwards along the light paths and perceives an image behind the mirror.

Reflection from plane mirrors

A mirror is a highly polished surface used to reflect the light falling on it. Mirrors are usually made by depositing a thin layer of silver metal on one side of a plane glass sheet.

Some basic terms

Object : Anything which gives out light rays either of its own or due to reflection is called an 'object'.

Point object : An object whose dimensions are negligibly small is called 'point object'

Extended object : An object whose dimensions are quite large is called 'extended object'

Point objects	·	Symbols used in
Extended objects	↑	ray diagrams

Image : An image of an object is formed when light rays coming from the object meet or appear to meet at a point after reflection from a mirror or refraction from a lens.

Real image : A real image is one which is formed when the light rays actually meet at a point and which can be obtained on a screen.

Virtual image : A virtual image is one which is formed when the rays do not actually meet at a point but they appear to meet at a point. Such images cannot be obtained on the screen.

Reflection from plane mirror

Quick Tips

- Virtual image is always erect.
- Real image is always inverted.

Image formed by a plane mirror

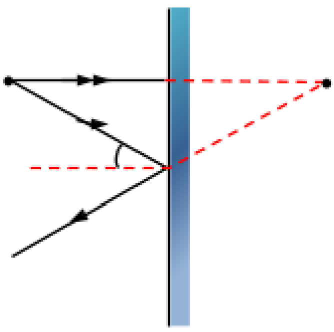
The properties of image formed by plane mirrors are

(1) The image is virtual and erect.

(2) The distance of image from mirror is equal to distance of object from mirror.

(3) The size of image is exactly equal to the size of object.

(4) The image is laterally inverted.



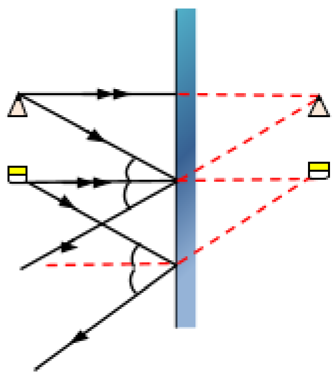


Image
Object
i

r

(a) Formation of
image of a point object

Image
Object
r
A'
A
B
B'
i
i'
r'

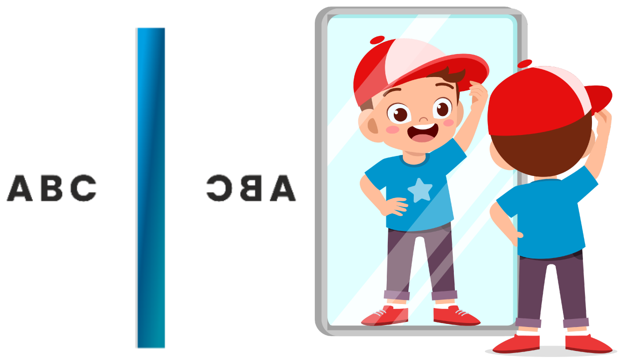
(b) Formation of
image of an extended object
Formation of image by a plane mirror

Quick Tips

If the object is shifted by the distance 'd' towards mirror, the image will also shift by the same distance 'd' towards the mirror. If an object moves with a speed 'v' towards (or away) from the mirror, the image to him will appear to move with a speed '2v' towards (or away) from him.

Lateral inversion

When an asymmetric object is placed in front of a plane mirror, then the right side of the object appears to be the left side of image and the left side of the object appears to be the right side of its image. This change of sides of an object seen in the image is called 'left - right inversion' or 'lateral inversion' (see figure). The image is inverted side ways, thus, also called 'side ways inversion'.



Lateral inversion of image in a plane mirror

SPOT LIGHT

The word 'AMBULANCE' is written from right to left. Since in the mirror, the image is laterally inverted so the driver of the vehicle ahead can read "AMBULANCE" written on it.

Check your Concepts 2

1. Why does wet surface glow more than a dry surface ?

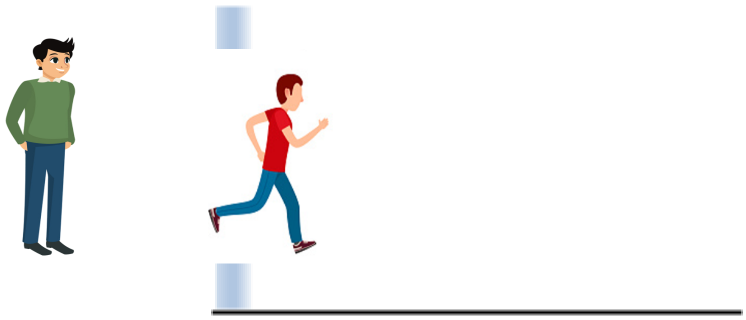
2. Which is easier, to read from rough pages or to read from glossy (shinny) pages ? Explain your answer.

3. Find out the letters of English alphabet in which the image formed in a plane mirror appear exactly like the letter itself.

4. How is a mirror made ?

Building Concepts 5

Man A is standing, and facing a plane mirror while man B is running towards him from behind at a speed of 1 ms^{-1}. How fast does the image of man B seem to be running as observed by (a) man A (b) man B ?



Mirror

Man A

←1 ms^{-1}
Man B

Building concepts 5

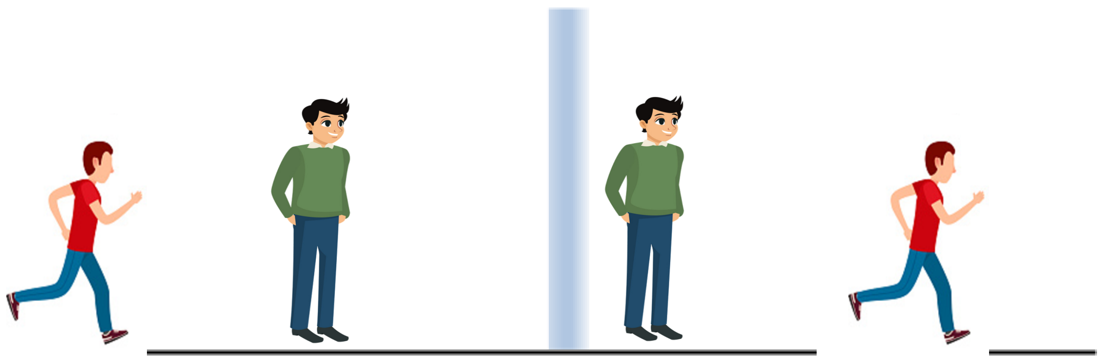
Explanation

In the above figure, man A is standing facing a plane mirror while man B is running towards the same mirror (coming from behind man A) at speed 1 m/s.

Following conclusions can be drawn in this event :

(a) If man A observes in the mirror, the image of man B in the mirror seems to moves towards him at speed 1 m/s.

(b) Man B is running towards mirror at speed 1 m/s. Also, his image in the mirror is running towards him at speed 1 m/s. Since the direction of motion of both 'man B' and his image are opposite to each other, the speed of 'image of man B' as seen by the 'running man B 'will be 1 m/s + 1 m/s = 2 m/s.



Mirror

Man A

$\leftarrow$1 ms^{-1}
Man B
Image of
Man A

1 ms^{-1} $\longrightarrow$
Man B

Building concepts 5

Check your Answers 2

1. A wet surface glows more than a dry surface because wet surface is more smooth than normal surface so regular reflection of light takes place.
2. It is much easier to read from rough pages which provide for diffuse reflection. Glossy pages result in specular reflection and cause a glare (a shine). The reader may see an image of the light bulb which illuminates the glossy page.
3. A, H, I, M, O, T, U, V, W, X, Y
4. To make a mirror, a thin and uniform glass is taken. One surface of the mirror is made opaque by silvering it. Over the silvered surface, another thin coating of red lead oxide is given which protects the silvering of the mirror.

8. Spherical mirrors

A spherical mirror is that mirror whose reflecting surface is curved part of hollow sphere.
Suppose a hollow sphere has a polished mirror surface on the inside as well as outside. By removing a section of the sphere, a double-sided spherical mirror is obtained with a concave reflecting surface on one side and a convex reflecting surface on the other
(see figure).

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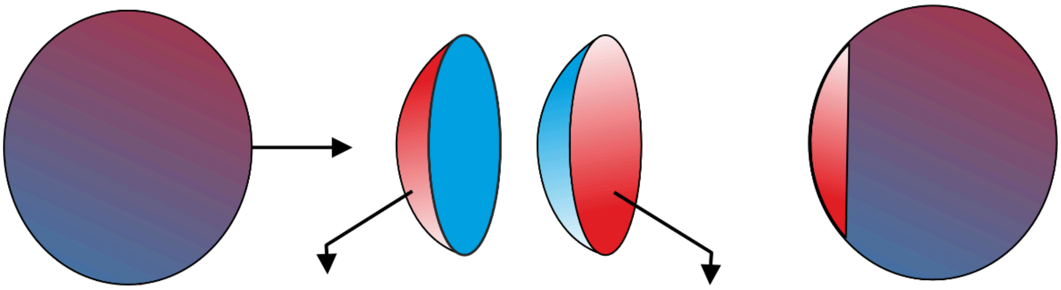
☞ The concave reflecting surface is curved inwards. The convex reflecting surface is curved outwards.



A hollow
sphere
Convex
mirror
Concave
mirror
A spherical mirror formed from a hollow sphere.
+

Concave mirror

A spherical mirror in which the reflection of light takes place at bent-in surface is called 'concave mirror'.

Concave mirror is also called **'converging mirror'**. This is because the parallel beam of light after reflection, converge at a single point [Figure (a)].

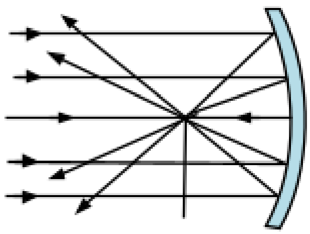
Convex mirror

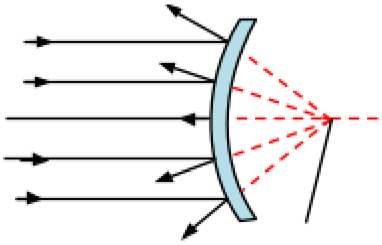
A spherical mirror in which the reflection of light takes place at bulging-out surface is called 'convex mirror'.

Convex mirror is also called **'diverging mirror'**. This is because the parallel beam of light after reflection, appears to diverge from a single point.

Concave mirror is silvered on the outside of the sphere and convex mirror is silvered on the inside of the sphere.

> Spherical mirror can be thought of as a portion of a sphere that was sliced away and then silvered on one of the sides to form a reflecting surface.
>
> **SPOT LIGHT**





Virtual focus
(b) A convex mirror

Real focus

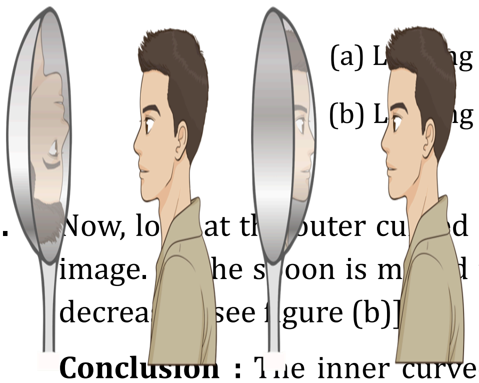
(a) A concave mirror

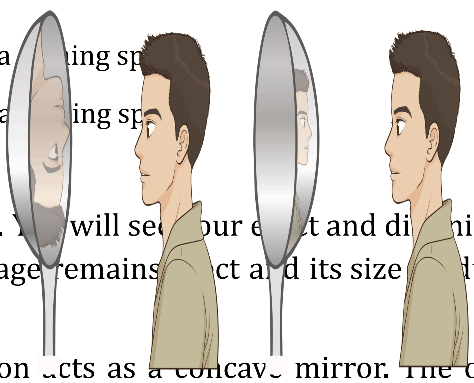
(c) Image seen from concave mirror (d) Image seen from convex mirror

Action of concave mirror and convex mirror.

Active Physics 4

1. Take a large shinning spoon and look at its inner curved surface. When your face is quite close to the spoon, you will see your erect and magnified image. Now, slowly move the spoon away from you. You will see your inverted and magnified image. As the spoon is moved further away, the inverted image gradually decreases [see figure (a)].





(a) Looking at the inner surface of a shining spoon

(b) Looking at the outer surface of a shining spoon

Active Physics 4

2. Now, look at the outer curved surface of the spoon. You will see your erect and diminished image. As the spoon is moved further away, the image remains erect and its size gradually decreases [see figure (b)].

Conclusion : The inner curved surface of the spoon acts as a concave mirror. The outer curved surface of the spoon acts as a convex mirror.

Some basic terms related to spherical mirrors

Centre of curvature : The point in space that represents the centre of the hollow sphere from which the spherical mirror was cut is called 'centre of curvature'.

The centre of the hollow sphere from which the spherical mirror is formed is called **'centre of curvature'**.

Pole (or vertex) : The middle point on the surface of a spherical mirror is called 'pole'.

The geometric centre of the curved mirror surface is called **'pole'**.

Radius of curvature : The radius of hollow sphere from which the mirror is formed is called 'radius of curvature'.

The distance between the centre of curvature and the pole of a spherical mirror is called **'radius of curvature'**.

Principal axis : A line passing through the pole and the centre of curvature of the spherical mirror is called 'principal axis'.

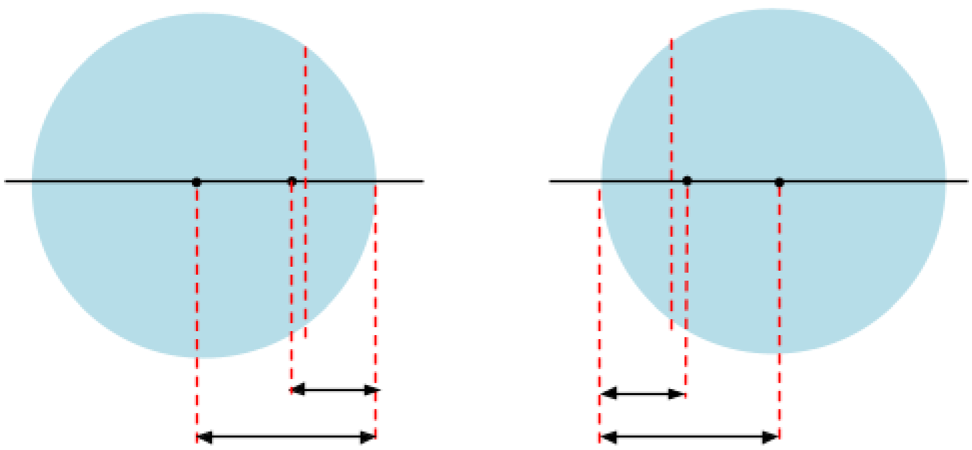
An imaginary line drawn through the pole, perpendicular to the surface of the spherical mirror at the pole is called **'principal axis'**.

Principal focus : The point on the principal axis where all rays parallel to principal axis either converge or appear to diverge after reflection is called 'principal focus'.

Focal length : The distance between the focus and pole of a spherical mirror is called 'focal length'.

For concave mirrors, centre of curvature and principal focus are real. For convex mirrors, centre of curvature and principal focus are virtual.

SPOT LIGHT



(b) A Convex mirror
R
Principal
axis
Virtual space

A
Real space
P
F
C
B
f
(a) A Concave mirror
R
Principal
axis
Real space
A
Virtual
space
C
P
F
B
f

C : Center of curvature ; F : Principals focus ; P : Pole or vertex ; f : focal length ;
R : Radius of curvature

Basic geometry and terms of concave and convex mirrors

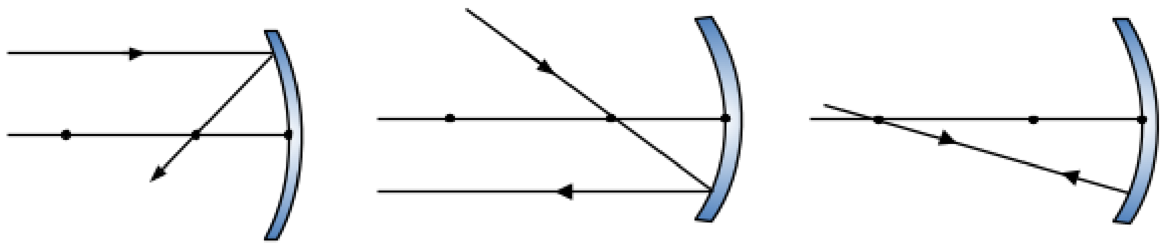
9. Rules to obtain images in spherical mirrors

Concave mirrors

(1) The ray parallel to the principal axis, after reflection, passes through the principal focus F of a concave mirror. [see figure (a)]

(2) A ray passing through the principal focus of a concave mirror, is reflected parallel to the principal axis. [see figure (b)]

(3) A ray passing through the centre of curvature of a concave mirror, is reflected back along its own path. [see figure (c)]



(b)
P
F
C
(c)
P

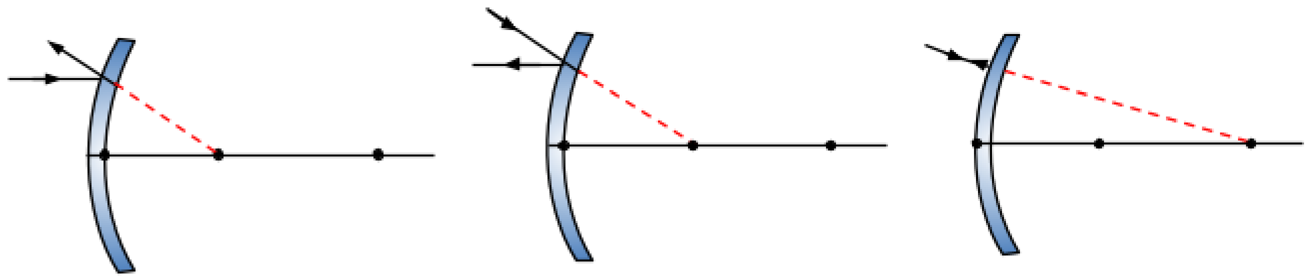
F
C
P
F
C
(a)
Rules for concave mirrors to obtain images

Convex mirrors

(1) The ray parallel to the principal axis, after reflection, appears to diverge from the principal focus of a convex mirror. [see figure (a)]

(2) A ray which is directed towards the principal focus in a convex mirror, is reflected parallel to the principal axis. [see figure (b)]

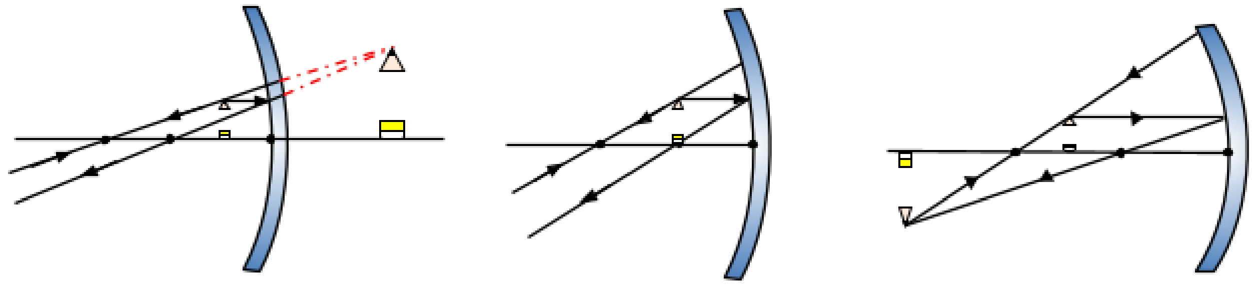
(3) A ray directed towards the centre of curvature in a convex mirror, is reflected back along its own path. [see figure (c)]



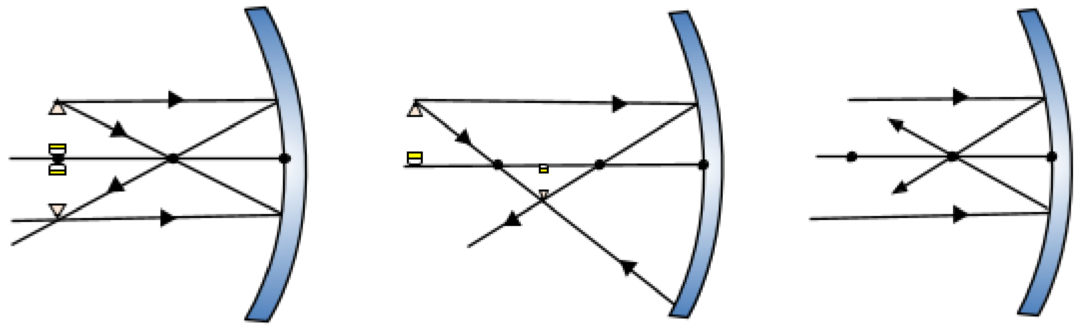
P
C
F
(a)
(b)
P
C
F
(c)
P
F
C

Rules for convex mirrors to obtain images

10. Image formation by a concave mirror



A'
C
B'
A
B
F
P
(a) Object placed between pole and focus
C
A
F
P
(b) Object placed at focus
B
A'
C
B'
A
B
F
P
(c) Object placed between
focus and centre of curvature



C
A
P

(d) Object placed at C
F
B'
B
A'
A'
C
B'
B
F
P
(e) Object Placed beyond C
A
C
P
(f) Object at infinity
F
Images formed by a concave mirror

Image formation by concave mirror

Position of the object	Position of the Image	Size of the image	Nature of the image
Between P and F	Behind the mirror	Enlarged	Virtual and erect
At F	At infinity	Highly enlarged real and inverted	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At C	At C	Same size	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At infinity	At the focus F	Highly diminished, point-sized	Real and inverted

Active Physics 5

1. Take a concave mirror and allow the sun rays to fall on it. Take paper and move it towards the concave mirror till you obtain a bright sharp spot of light on it. The spot obtained is the image of the sun.

2. Now, measure the distance between paper and the concave mirror. This distance is an approximate focal length of the concave mirror.

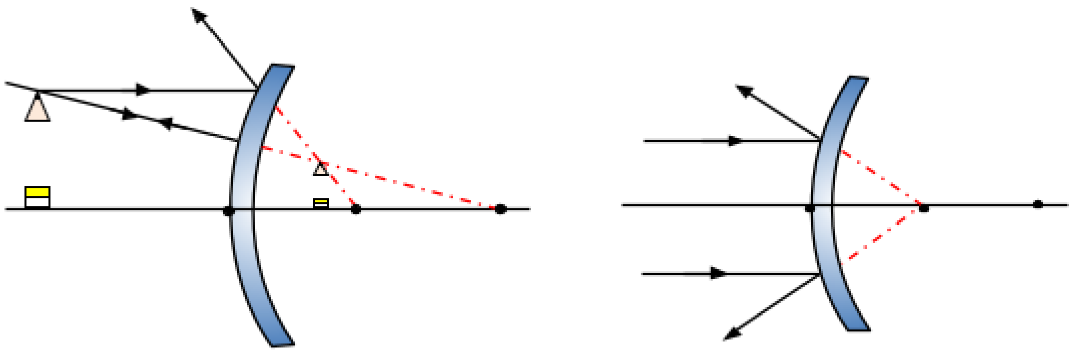
Active Physics 5

3. If this spot is kept on the paper for few minutes, the paper will start burning. This is because the light energy gets converted into heat energy.

11. Image formation by a convex mirror

The image formed by a convex mirror is always behind the mirror that is, it is always virtual and erect. Also, the size of image is always diminished, that is, its size is always smaller than that of the object.

The rays parallel to principal axis, after reflection, appears to diverge from the principal focus of the convex mirror [see figure (b)]. The image formed at the focus, behind the mirror is highly diminished. The image is virtual and erect.



C
F
P
(b) Object at infinity
P
C
F
(a) Object placed at some finite distance

B'
A'
B
A

Images formed by a convex mirror

Image formation by convex mirror

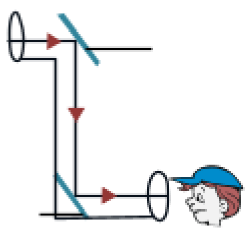
Position of the object	Position of the image	Size of the image	Nature of the image
Between infinity and the pole P	Between P and F, behind the mirror	Diminished	Virtual and erect
At infinity	At the focus F, behind the mirror	Highly diminished, point-sized	Virtual and erect

12. Uses of mirror

Plane mirrors and curved mirrors find a wide range of applications.

Plane mirrors

These are used as looking glasses and for making instruments like periscopes and kaleidoscopes. Plane mirrors are also used on stage to create illusions and effects.



Mirror

Mirror

(a) Plane mirror used as looking glass (b) A periscope (c) Working of a periscope

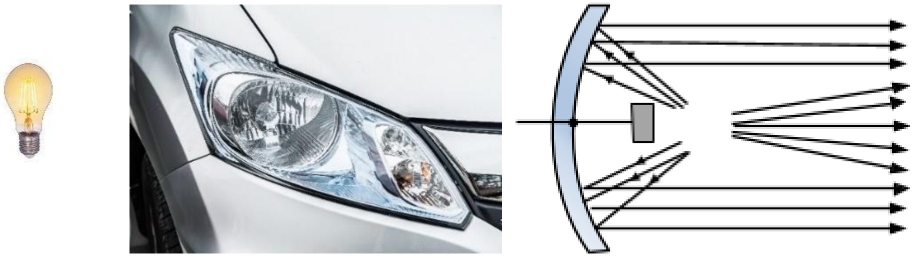
Uses of plane mirror

Concave mirrors

(i) Shaving mirror : Used as a shaving mirror since it gives rise to an erect and enlarged image when the object is placed close enough, i.e., within its focal length.

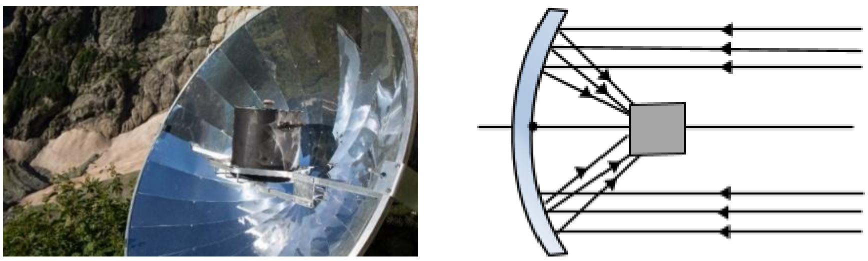
Concave mirror as magnifier

(ii) Reflectors : Head lights of cars and search lights use concave mirrors to produce a strong parallel beam of light. In reflectors, the source of light is placed at the focus, which, after reflection forms a parallel beam.



A bulb placed at the focus of a concave mirror produces a strong, almost parallel beam

(iii) In solar furnace : The parallel beam of the Sun's rays are converged and their energy that is focused at a point is sufficient to generate adequate heat for cooking and other purposes.



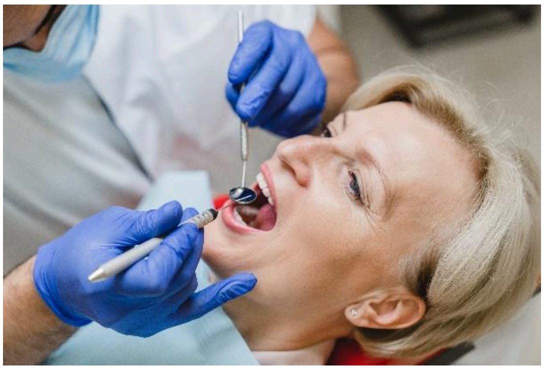
Solar

furnace

A solar furnace placed at the focus of a concave mirror

(iv) In hospital and clinics : Doctors use concave mirrors to focus light and magnify the internal body parts such as the teeth, ear, nose, throat.

(v) To see far object on screen : Concave mirrors can be used to see the image of far objects formed on screen.



Concave mirror used by doctor

Formation of image of far object

Convex mirrors

(i) **Street lamps :** Street lamps also use convex mirrors to diverge light over an extended area.

(ii) **Rear view mirrors :** Convex mirrors are used as rear view mirrors to see erect but smaller image of the vehicle (see figure).

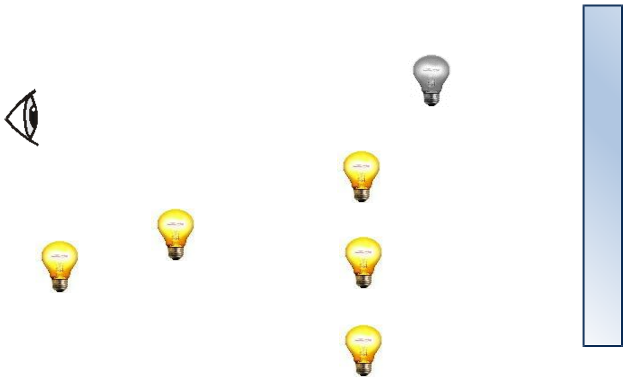
(a) Street lamp

(b) Rear view mirror in a vehicle

Uses of convex mirror

Check your Concepts 3

1. A person is facing a mirror, observing a light bulb. At what position does the person see the image of the light bulb?



Mirror

1

2

3

4

5

Light
bulb
Eye

Check your concepts 3

2. Identify the type of mirror that is used by dentist.

3. A real, extended object when placed in front of a mirror, a virtual and erect image is formed. Predict the type of mirror if (a) the image is diminished (b) the image is exactly same size as that of the object (c) the image is magnified.

13. Lenses

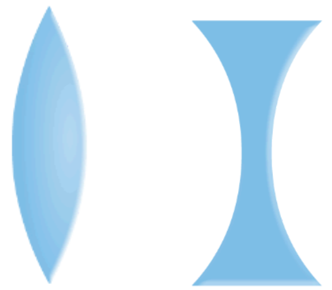
A lens is a piece of transparent glass bound by spherical surfaces.

Convex lens : A convex lens is a piece of a transparent glass bound by two bulging out surfaces. It is thick at the middle and thinner at the edges. It is also called 'double convex lens' or 'biconvex lens'.

☞ A convex lens is a 'converging lens' because the light rays after refraction through it, converge to meet at a single point.

Concave lens : A concave lens is a piece of transparent glass bound by two bent-in (or bulging-in) surfaces. This is thin in the middle but thicker at the edges. It is also called 'double concave' or 'biconcave lens'.

☞ A concave lens is a 'diverging lens' because the parallel beam of light rays after refraction through it, appear to diverge from a single point (figure).



(a) Convex lens (b) Concave lens

Different types of lenses

Quick Tips

- Lenses also formed from a hollow sphere glass.
- Parallel rays appear or converge to meet at a single point name as a focus.
- Magnified means that image is formed larger than the object.
- Diminished means image is formed smaller than object.

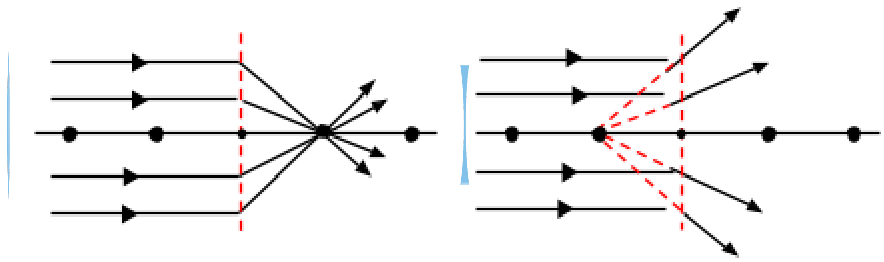
Basic terms used in lenses

Optical centre : The middle point of a spherical lens is called its 'optical centre'.

Principal axis : The line passing through the optical centre of the lens which is perpendicular to both the faces of the lens is called its 'principal axis'.

Principal focus : The point on the principal axis of a lens where all the rays parallel to principal axis, converge or appear to diverge after refraction is called 'principal focus'.

Focal length : The distance between the focus and the optical centre of a lens is called its 'focal length'.



$2F_2$

F_2

$2F_1$

F_1

$2F_1$

F_1

2F$_2$

F$_2$

Nature of convex lens and concave lens

Quick Tips

- F_1 = principle focus 1, F_2 = principle focus 2, $2F_1$ = centre of curvature 1, $2F_2$ = centre of curvature 2.
- Parallel rays appear or converge to meet at a single point name as a focus.

Check your Answers 3

Mi

1

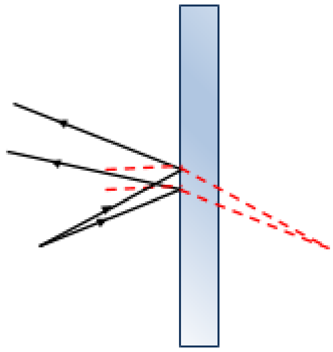
2

3

4

5

Light
bulb
Eye



Check your answers 3

1. The person see the image of the light bulb at position 3. This is because the image is formed exactly in front of the object. Also, the distance of the object from the mirror is exactly equal to the distance of the image from the mirror. explains how the person sees the image using ray diagram.

2. Concave mirror is used by dentist because it is used as magnifier.

3. (a) A virtual, erect and diminished image is formed in a convex mirror.
(b) A virtual, erect and same size image is formed in a plane mirror.
(c) A virtual, erect and magnified image is formed in a concave mirror.

Active Physics 6

1. Take a convex lens and allow the sun rays to fall on it. Take paper and move it towards the convex lens till you obtain a bright sharp spot of light on it. The spot obtained is the image of the sun. Now, measure the distance between paper and the concave mirror. This distance is an approximate focal length of the convex lens.

Active Physics 6

2. If this spot is kept on the paper for few minutes, the paper will start burning. This is because the light energy gets converted into heat energy.

14. Image formation by a convex lens

The image formed by a convex lens can be real and virtual, depending upon the distance between the lens and the object.

The image obtained from the lens is enlarged when the object is placed between optical center and the focus. This image is virtual and erect.

Image formed by a convex lens when object is placed between optical center and focus.

The size of the image formed in a convex lens varies when the object is moved beyond focus, away from the lens. The image formed is real and inverted and it's size gets reducing as the object is moved away from the lens.

(a) (b)

Image formed by a convex lens for different distances between the lens and the object.

15. Image formation by a concave lens

The image formed by a concave lens is always on the same side as the object and it is always virtual and erect. Also, the size of image is always diminished, that is, its size is always smaller than that of the object.

Image formation by a concave lens

Uses of curved lenses

(i) Convex lens is used as a magnifying glass as it can formed enlarged and erect image of an object.

(ii) There is a convex lens in each eye. The lens collects light from an object in front of it and focuses it on the retina. The retina sends the information of the image to the brain through optic nerves.

(iii) Lenses are used in spectacles to correct short-sightedness and long sightedness.

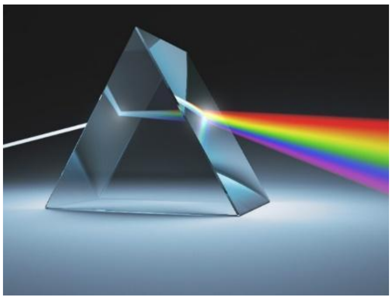
(iv) Lenses are used in optical instruments like cameras, binoculars, microscopes, telescopes.

Uses of lenses

16. Dispersion of white light

Sunlight is referred to as white light. It consists of seven colours. When white light travels through a triangular cross-section piece of glass called a **prism**, a rainbow-like pattern appears on the other side. This effect is called **dispersion**. Dispersion is a method of demonstrating that white light is composed of many different colours (wavelengths) of light.

☞ The phenomenon of splitting up of white light into its constituent colours is called **'dispersion of light'**.



Dispersion of light

When light is made to pass through prism, the lights of different colours travel with different speeds. The red light travels the fastest, thus bending the least, while violet light is the slowest, bending the most.

Some of the examples of dispersion of white light are formation of a rainbow and a CD placed in the sun. A rainbow is formed when the white light from the sun is splitted into seven colours by the water drops present in the sky during the rainy season.

A rainbow

A CD placed in the sun

Building Concepts 6

How do we see colour of any object ?

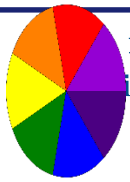
Explanation

As you know, sunlight (or white light) is composed of seven colours, some colours are absorbed by objects and the rest reflected. The colour of the object observed by human eye is the colour reflected by that object.

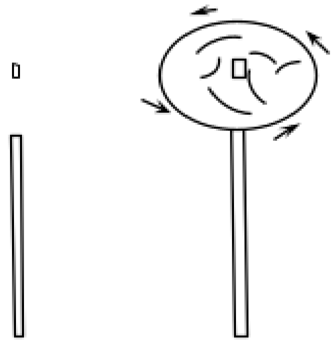
For example, a red rose appears red because it reflects back to our eyes only the red colour and absorbs the rest. Similarly the leaves of a plant appear green as they reflect green colour to our eyes and absorb the rest.

Building Concepts 7

Publishing\PNCF\2024-25\Print Module\SET-1\NCERT\Physics\7th\5_Light



is Newton's colour disc? What does the Newton's colour disc experiment ish about the nature of white light ?



Y

G

B

I

V

R

O

(a)

(b)

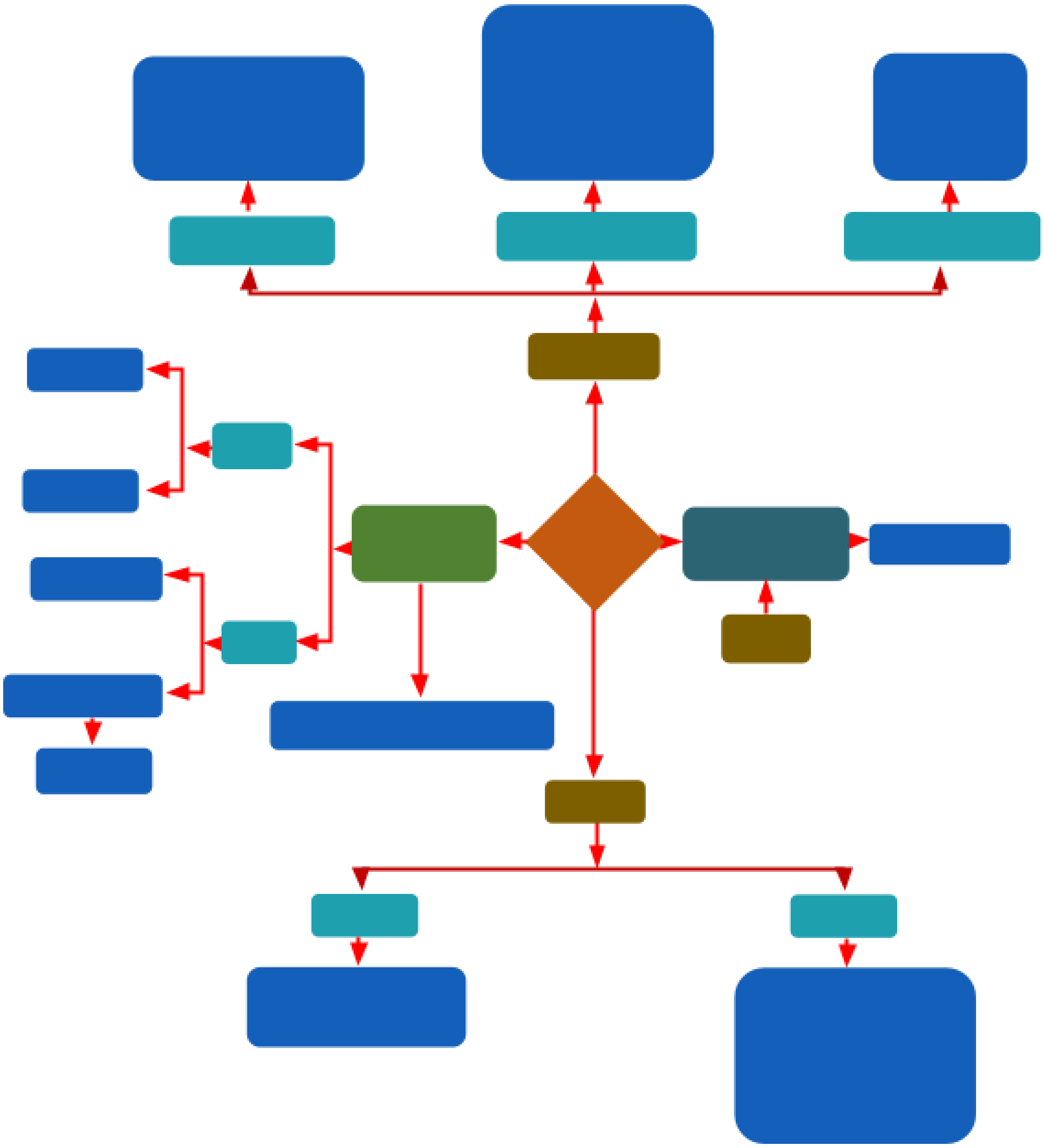
(b) It appears white on rotating

Explanation

Newton's colour disc is a metallic or cardboard disc painted with seven colours of the spectrum (see figure). The sector of each colour is painted in the order and ratio of amount of colour found in solar spectrum, i.e., VIBGYOR. When the disc connected to a wheel is rotated at a high speed in a vertical plane, disc appears dull white. It establishes that recombination of the spectrum colours (VIBGYOR) gives white light.

The coloured disc appears white because of a property of our eyes called **persistence of vision**. This means that an image formed by the eye remains for a fraction of a second. When the disc is rotated at a high speed, the images of the different colours overlap in our eyes and the brain perceives it as white.

Concept Map



$\angle i = \angle r$

Some Basic Terms

1. **Transparent** : It is an object through which we can see object clearly.
2. **Refraction** : When a light travel from one medium to another medium.
3. **Spectrum** : Band of seven colours formed after dispersion of light.
4. **Bulging out** : Surface which is curved outward, sticking out.
5. **Intensity** : The quantity of energy the wave convey per unit time.
6. **Normally** : When a light ray falls on a surface at a right angle.
7. **Medium** : It is a substance through which light can propagate.
8. **Dispersion –** process of white light splitting into its constituent colours.
9. **Erect** : a straight vertical position, or standing up or out from a surface or body
10. **Rectilinear** – it is used to mean "straight," so if something moves in a straight line, it has rectilinear motion.
11. **Fusion** : Fusion occurs when two atoms slam together to form a heavier atom, like when two hydrogen atoms fuse to form one helium atom.
12. **Amplitude** : The maximum displacement or distance moved by a point on a vibrating body or wave measured from its equilibrium position.
13. **Diminished** : To make less or cause to appear less.
14. **Vertex** : A point where two or more edges meet.
15. **Spectrum** : Spectrum is the band of colours obtained on a screen when white light passes through a prism and splits into its constituent colours.

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