/padhle akshay

PRESENTS

Light Reflection and Refraction

NO BAKWAS

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WHY THESE NOTES ???

- TOUCHES EVERY CORNER OF NCERT
- INCLUDES NCERT ACTIVITIES (AKQ), BOXES(BKQ) & EXEMPLAR (EKQ)
- EACH LINE, FLOWCHART & DIAGRAM IS MOTIVATED FROM PYQs
- APPROVED BY 3 CBSE TOPPERS

& SCAN & DONATE

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Light

Light is a radiant energy, usually referring to electromagnetic radiation which has wavelength 3800Å-7600Å and help us to see various object.

Properties

- It is non-mechanical wave as it doesn't require any medium to travel.
- It is a transverse, electromagnetic wave.
- Speed of light in vacuum is 299,792,458m/s (approx 3x10^8m/s).

Diffraction

If an opaque object on the path of light become very small, light has tendency to bend around it and not walk in a straight line - an effect knowns as the diffraction of light.

Modern quantum theory of light

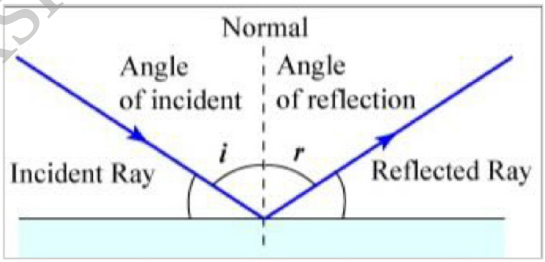
In this theory light is neither wave nor a particle- it reconciles the particle properties with the wave nature.

Reflection of light

When light travelling from one medium falls one the surface of another medium, a portion of the incident light is turned back into the first medium.This is called reflection of light.

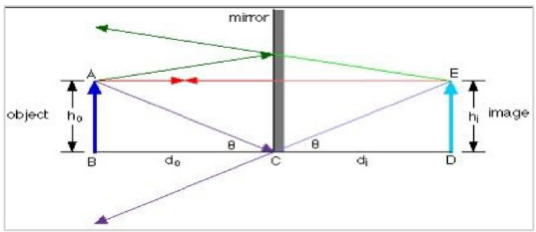
Laws of reflection

- The angle of reflection is equal to the angle of incidence.
- The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.



Plane mirror properties

- Image formed is virtual and erect.
- Size of the image is equal to the size of the object.
- The distance of image behind the mirror is equal to the distance of the object from the mirror.
- The image is laterally inverted.



A.K.Q - 10.1.

? **Do you get the image? Is it smaller or larger?**

✅**Answer**: Yes, the image of the face formed on outer curved surface is smaller in size.

? **Move the spoon slowly away from your face. Observe the image. How does it change**

✅**Answer**: The size of image gradually decreases with a increase in field of view.

? **Reverse the spoon and repeat the Activity. How does the image look like now?**

✅**Answer**: Earlier, when the spoon was close the image formed on the inner curved surface was erect and magnified and as we moved the spoon slowly away from our face, the image transitioned to a inverted image with gradual decrease in its size.

? **Compare the characteristics of the image on the two surfaces.**

✅**Answer : Outer Surface**

(i) Image is always erect

(ii) Image size is gradually decreases as we move away the spoon

Inner Surface

(i) The image is erect when spoon is close and inverted when spoon is away

(ii) Image size is larger when spoon is close and it is smaller when spoon is moved away

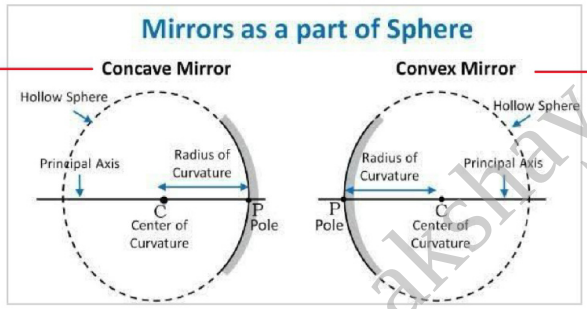
P.Y.Qs

Question: The laws of reflection hold true for :
(a) plane mirrors only
(b) concave mirrors only
(c) convex mirrors only
(d) all reflecting surfaces

Answer: d
The laws of reflection hold true for all the reflecting surfaces, i.e. all mirrors (either plane or spherical) regardless of their shape.

Spherical mirror

It is a mirror whose reflecting surface forms a part of a hollow spheres.



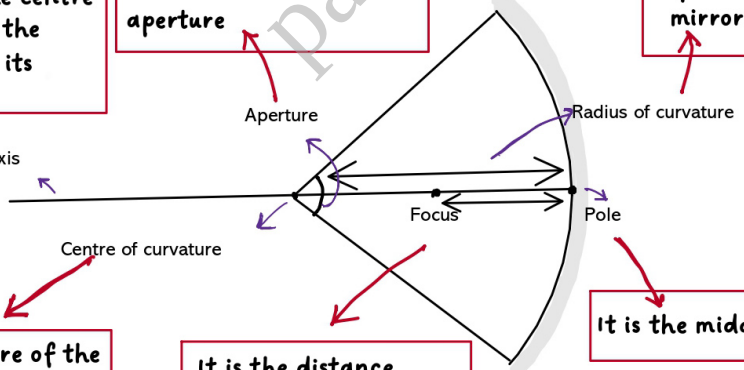
The reflection of light take place from the inner hollow sphere

The reflection of light take place from the outer bulged surface

The line passing through the pole and the centre of curvature of the mirror is called its principal axis

The angle subtended by the circular boundary of the mirror is called its aperture

It is the radius of the sphere of which the mirror forms a part



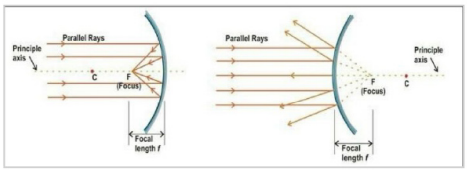
It is the centre of the sphere of which the mirror forms a part

It is the distance between the focus and the pole of the mirror

It is the middle point of the spherical mirror

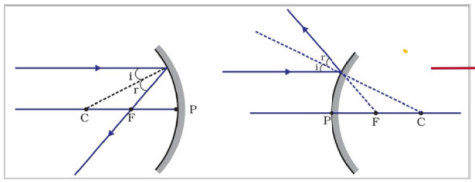
Principal focus

It is point on the principal axis where a beam of light parallel to the principal axis either actually converts to or appears to diverge from, after reflection from the mirror.

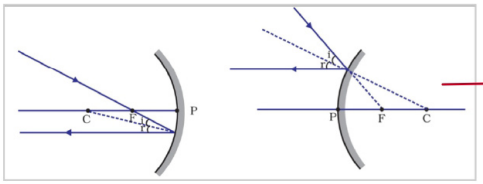


Rules to Draw Ray Diagram

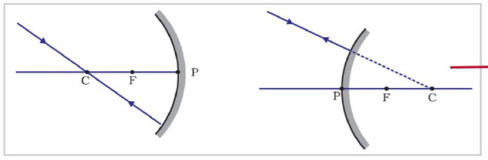
CONCAVE CONVEX



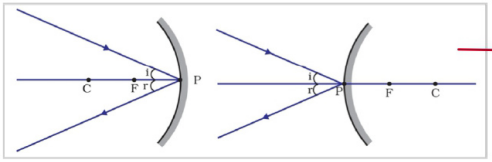
जब ray principal axis से parallel होकर जाए, तब Ray mirror से Reflect होकर focus से pass हो जाएगी



जब ray focus से pass होके जाएगी, तब वो Reflect होकर Principal axis के parallel चली जाएगी

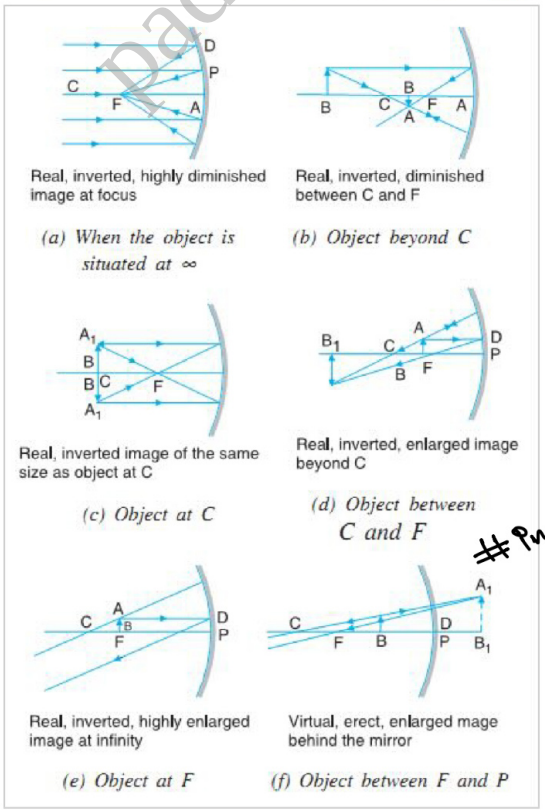


जब ray centre से pass होके जाएगी, तब वह reflect होके उसी path पर वापस आ जाएगी यानी centre से ही pass हो जाएगी।



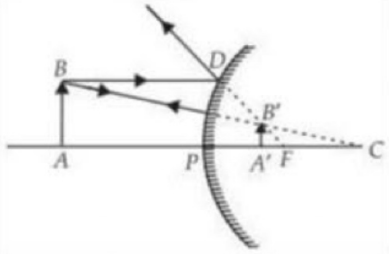
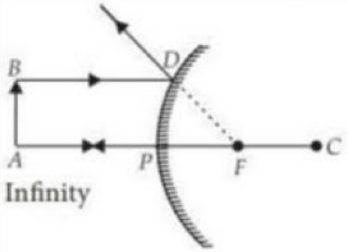
जब ray direct जाके pole पे गिरे तब वह जिस angle से pole पे गिरी है, उसी angle से वापस reflect हो जाएगी (बिल्कुल एक Plane mirror जैसे)

Image formation by concave mirror



#Important hai

Image formation by convex mirror

Ray diagram	Object position	Image position	Nature of image
	Between infinity and the pole	Behind the mirror between the focus and the pole	Virtual, smaller and erect # important hai
	At infinity	Behind the mirror at the focus *F*	Virtual, point-sized and erect

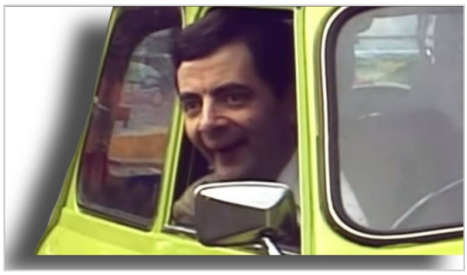
Use of concave mirror

- In torches, search light and vehicle headlight to get powerful parallel beam of light
- Used in shaving mirror
- Dentist use to see large image of teeth
- To concentrate sunlight to produce heat in solar furnaces

Use of convex mirror

? **Why driver prefers to use a convex mirror as rear-view mirror?**

We use convex mirror as a rear view mirror in the vehicles because convex mirror always forms virtual, erect and diminished images irrespective of distance of the object. A convex mirror enables a driver to view large area of the traffic behind him. Convex mirror forms very small image than the object. Due to this reason convex mirrors are used as rear view mirrors in vehicles.



A.K.Q 10.2.

? **What do you observe? Why?**

✅**Answer:** The paper burns and catches fire. This is because the light from the Sun is converged (concentrated) at a point of paper as a bright spot (image of the Sun). This point is the focus of the concave mirror. It produces heat and ignites the paper.

Sign convention for reflection by spherical mirror

- The object is always placed to the left of the mirror. This implies that the light from the object falls on the mirror from the left hand side.
- All distance parallel to the principal axis are measured from the pole of the mirror.
- All the distance measure to the right of the origin (along +X axis) are taken as positive while those measure to the left of the origin (along -X axis) are taken as a negative.
- Distance measure perpendicular to, and above the principal axis (along +Y axis) are taken as positive.
- Distance measure perpendicular to, and below the principal axis (along -Y axis) are taken as negative.

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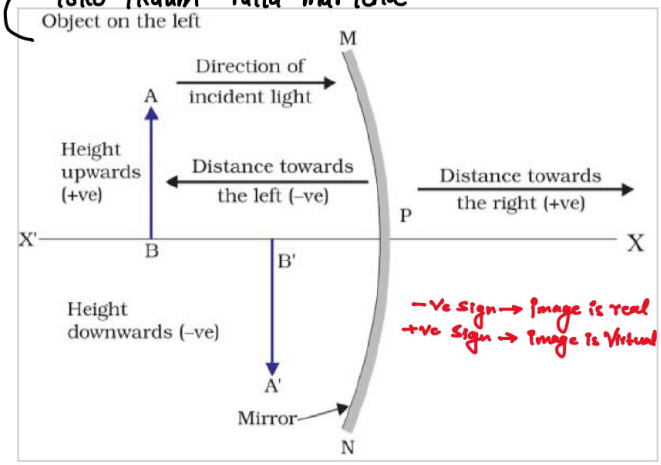


Mirror Formula

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

V = image distance
U = object distance
F = focal length

Magnifications

$$m = \frac{\text{Height of the image}}{\text{Height of the object}}$$

$$m = \frac{h'}{h} = \frac{-v}{u}$$

$$\boxed{m = \frac{-v}{u}}$$

a.K.Q 10.6.

? **Could you see a full-length image?**
✅**Answer**: No.
? **Try with plane mirrors of different sizes. Did you see the entire object in the image?**
✅**Answer**: No.
? **Repeat this Activity with a concave mirror. Did the mirror show full length image of the object?**
? ✅**Answer**: No.
Now try using a convex mirror. Did you succeed? Explain your observations with reason.
? ✅**Answer**: Yes. In a convex mirror, we can see full length image of distant object with wider field of view.

Refraction of light

The phenomena of bending of light at the surface separating to Media is commonly known as refraction of light
Example:

- Spoon dipped in water
- Standing in clear full of water
- The bottom of a glass tumbler filled with water appear rest did you see

a.K.Q. 10.8.

? **Keep looking for the coin from your position. Does the coin become visible again from your position? How could this happen?**
✅ Answer: Yes. The coin becomes visible again. This is because the coin appears slightly raised above its actual position due to the refraction of light.

a.K.Q 10.5.

? **Observe the image of the pencil in the mirror. Is the image erect or inverted? Is it diminished or enlarged?**
✅**Answer**: Its image in the mirror is erect and diminished.
? **Move the pencil away from the mirror slowly. Does the image become smaller or larger?**
✅**Answer**: The image becomes smaller.
? **Repeat this Activity carefully. State whether the image will move closer to or farther away from the focus as the object is moved away from the mirror?**
✅**Answer**: The image moves closer to the focus.

a.K.Q. 10.7.

? With your eye to a side above water, try to pick up the coin in one go. Did you succeed in picking up the coin?
✅ Answer: No.
? Repeat the Activity. Why did you not succeed in doing it in one go?
✅ Answer: Reflected light coming from the submerged coin in water (denser medium), on entering air (rarer medium), bend away from the normal due to refraction of light and image size becomes larger than its actual size. Thus, coin appears to be closer than its actual distance.
? Ask your friends to do this. Compare your experience with theirs.
✅ Answer: Same result.

A.K.Q. 10.9.

? Look at the portion of the line under the slab from the sides. What do you observe? Does the line under the glass slab appear to be bent at the edges?

✅ Answer: The line under the glass slab appears to be bent at the edges. It is due to the refraction of light.

? Next, place the glass slab such that it is normal to the line. What do you observe now? Does the part of the line under the glass slab appear bent?

✅ Answer: The part of the line under the glass slab does not appear bent. It appears in a straight line. Because a ray of light perpendicular to the plain of a refracting medium does not change its angle due to refraction.

? Look at the line from the top of the glass slab. Does the part of the line, beneath the slab, appear to be raised? Why does this happen?

✅ Answer: Yes. Part of the line appears to be raised. This is due to the refraction of light.

Refractive Index

The ratio of the speed of the light in vacuum to the speed of the light in medium is called the refractive index of the medium.

★ Refractive index (x) = C/V

C = the speed of the light in vacuum.

V = the speed of light in medium.

➢ Larger the refractive index of a medium greater is the bending of light when it enters the medium from air oblique usually.

Air=1.0003
Ice=1.31
Water=1.33
Alcohol=1.36
Diamond=2.42

← Some important refractive index to learn

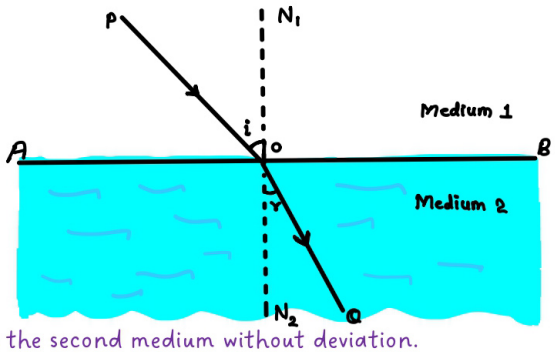
? **Why does light bend when it enters in different medium?**

The fact that light travels at a different speed in different material. Therefore, when it travels from one medium to another it either speed up or slower down. The amount by which it's Speed change determine the amount by which it change its direction.

Laws Of Refrection

- The incident ray, the refracted ray and the normal to the refraction surface at the point of incidence are in the same plane.
- The ratio of sin of angle of incidence to the sin of angle of refraction is Constant, for the given pair of media. This law is also known as Snell Law.

$$\frac{\sin i}{\sin r} = \text{Constant} = \frac{n_2}{n_1}$$



➢ Refractive index of the 2nd medium with Respect to 1st medium

$$n_{21} = \frac{n_2}{n_1} = \frac{c/v_2}{c/v_1} = \frac{v_1}{v_2}$$

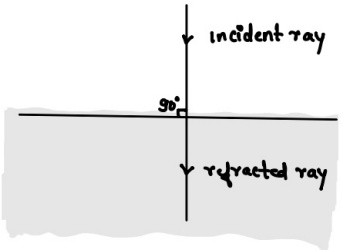
$$n_{12} = \frac{v_2}{v_1} \quad \text{Thus} \quad \boxed{n_{12} = \frac{1}{n_{21}}}$$

★ If a ray falls perpendicularly on the refracting surface, it goes into the second medium without deviation.

When $i=0$ $\frac{\sin i}{\sin r} = n$

$\frac{\sin 0}{\sin r} = n$

$\boxed{n = 0}$



∴ But the speed of the light change.

P.Y.Qs

Question: The refractive index of glass with respect to air is 3/2. The refractive index of air with respect to glass will be :

$$\Rightarrow {}_{a}\mu_{g} = \frac{n_g}{n_a} = \frac{3}{2}$$

$$\Rightarrow {}_{g}\mu_{a} = \frac{n_1}{n_2} = \frac{2}{3}$$

If refractive index of glass w.r.t air is 3/2, then refractive index of air w.r.t glass will be its reciprocal 2/3.

P.Y.Qs

Question: The absolute refractive index of Ruby is 1.7. Find the speed of light in Ruby. The speed of light in vacuum is 3×10^8 m/s.

Given,
Refractive Index (R.I) of Ruby = 1.7
Speed of light in Vaccum (C) = 3×10^8 m/s
Speed of light in Ruby (VR) =?

$$R.I = \frac{\text{speed of light (Vacuum)}}{\text{speed of light (medium)}}$$

$$R.I = \frac{C}{V_R}$$

$$1.7 = \frac{3 \times 10^8}{V_R}$$

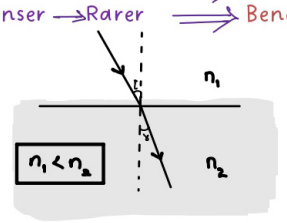
$$V_R = \frac{3 \times 10^8}{1.7}$$

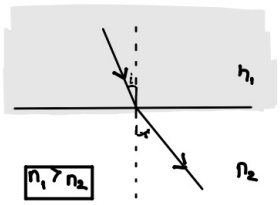
$$V_R = 1.764 \times 10^8 \text{ m/s}$$

Optically Denser and Rarer Media

Of a pair of transparent media, the one that has the higher refractive index is called the optically denser medium of the two, while the one that has the lower refractive index is called the optically rarer medium.

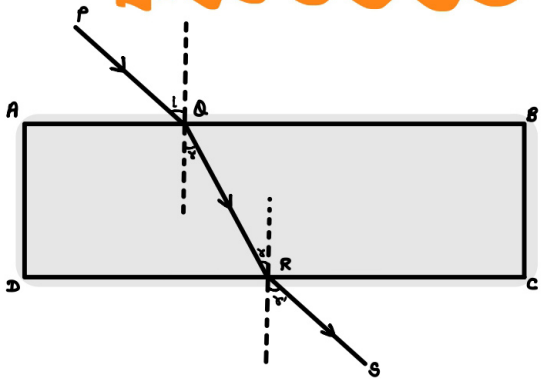
★ Rarer ⟶ Denser ⟹ Bends towards normal (slow down)
★ Denser ⟶ Rarer ⟹ Bends away from normal (speed up)





Optically denser does not mean greater mass density (mass per unit volume)
For example: kerosene is lighter than water(it float on water) but it has a higher refractive index, that is, it is optically denser than water.

Passage of light through Rectangular slab



$$\frac{\sin i}{\sin r} = n \text{ and}$$

$$\frac{\sin r}{\sin i} = \frac{1}{n}$$

$$\frac{\sin r'}{\sin r} = \frac{1}{n}$$

$$\sin r' = n \sin r$$

$$\sin r' = \sin i$$

$$\boxed{r' = i}$$

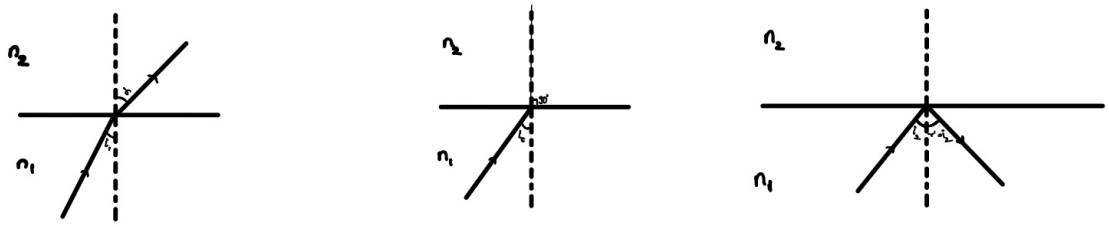
On Passing through a transparent slab with parallel faces, a ray is displaced parallel to itself.
→ for a thin slab, the displacement is negligible.

Question: What is the refractive index gradient?
Answer: With respect to distance in the particular material, the rate of change of the refractive index is known as the refractive index gradient. Here, the slope of the refractive index profile at any point is the distance. Refractive index gradient is articulated in terms of reciprocal of a unit of distance, it is a vector point function.

Total Internal Reflection

The total reflection of light travelling in a medium of higher refractive index, when it is incident on the boundary with another medium of lower refractive index at angle greater than the critical angle, is called total internal reflection.

- For a particular value of 'i', the angle of refraction become 90°, called the critical angle 'ic'.



for $i = i_c$, $r = 90°$ from Snell's law

$$\frac{\sin r}{\sin i} = \frac{n_2}{n_1}$$

$$\frac{\sin i_c}{\sin 90°} = \frac{\sin i_c}{1} = \frac{n_2}{n_1}$$

$$\boxed{\sin i_c = \frac{n_2}{n_1}}$$

Lenses

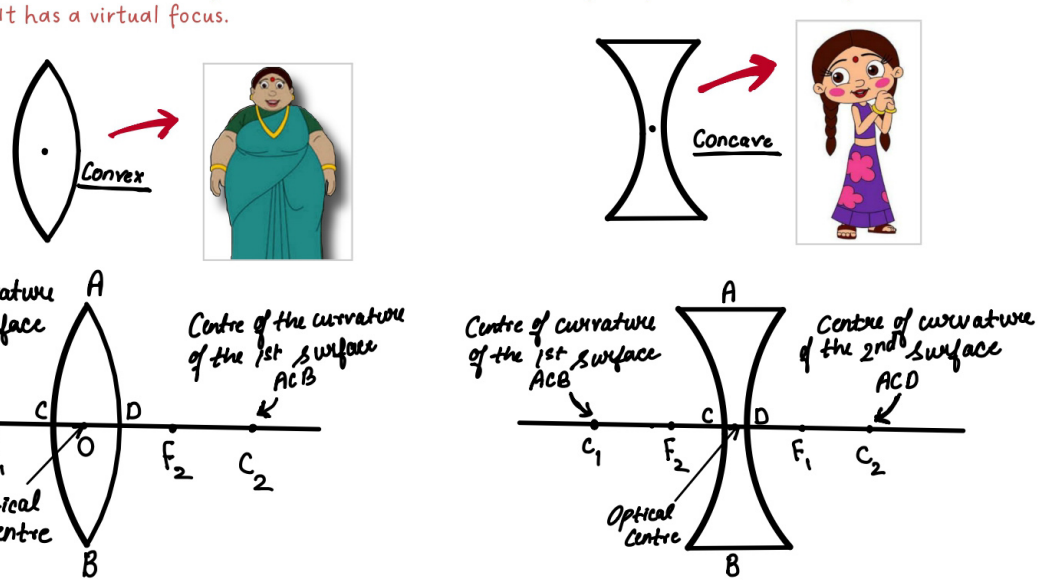
A transparent material bounded by two surfaces of which at least one is curved is called a lens.

Converging lens

- A lens that is thicker at the middle than at the edges is called a convex lens. It converges a parallel beam of light on refraction through it. It Has real focus.

Diverging lens

- A lens that is thicker at the edge is Called a concave lens. It diverge a parallel beam of light on refraction through it. It has a virtual focus.



Centre of curvature

The Centre of the surface of a lens is the centre of the sphere of which it form a part. Because a lens has two surface, so it has two centres of curvature.

Radius of curvature

The radius of curvature of the surface of a lens is the radius of the sphere of which the surface forms a part.

Principal axis

It is the line passing through the two centres of curvature of the lens.

Principal focus

A beam of light parallel to the principal axis either converge to a point or appears to diverge from a point on the principal axis after refraction through the lens. This point is called the principal focus. A lens hast two foci, but principal focus is only one where the light Converge or appears to diverge

Optical centre

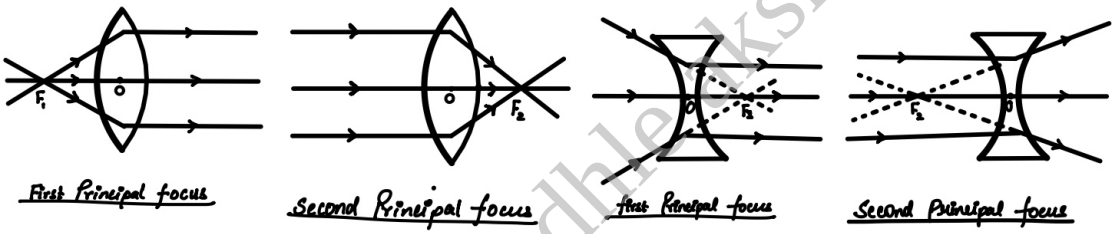
It is a point situated with in the lens through which a ray of light passes undeviated.

Focal length

It is the distance between the principal focus and the optical centre of the lens.

Aperture

It is the diameter of the circular boundary of the lens.



Power of Lens

The power of lens is defined as the reciprocal of its focal length.

$$P = \frac{1}{f(\text{metre})}$$

- The unit is called diopter (D).
- The power of a convex lens is positive and that of a concave lens is negative.

LENS

CONCAVE
v= -ve (real image)
v= +ve (virtual image)
Concave lens doesn't forms real images

CONVEX
v= -ve (virtual image)
v= +ve (real image)

MIRROR

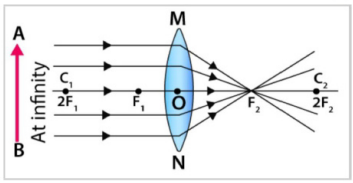
CONCAVE & CONVEX
v= -ve (real image)
v= +ve (virtual image)
Convex mirror doesn't forms real images

A.K.Q. 10.11.

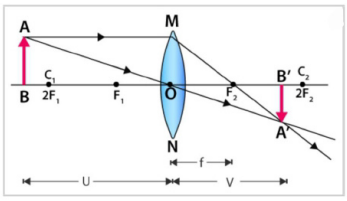
? **Hold the paper and the lens in the same position for a while. Keep observing the paper. What happened? Why? Recall your experience in Activity 10.2.**

✅ **Answer:** The paper begins to burn and may catch fire. The parallel rays of light from the Sun are converged by the lens at the sharp bright spot on paper. It generates heat and causes the burning of paper.

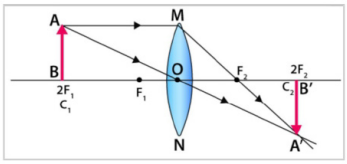
Image formed by convex lens



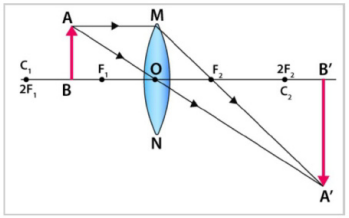
Object - At infinity
Image - At focus F_2
Highly diminished point sized
Real and inverted



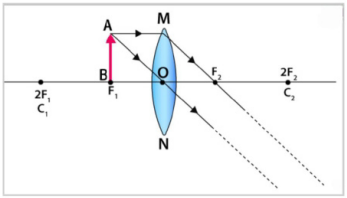
Object - between infinity and $2F_1$
Image - Between F_2 and $2F_2$
Diminished
Real and Inverted



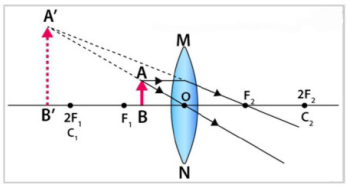
Object - At $2F_1$
Image - At $2F_2$
Same size
Real and Inverted



Object - Between F_1 and $2F_1$
Image - beyond $2F_2$
Enlarged
Real and Inverted

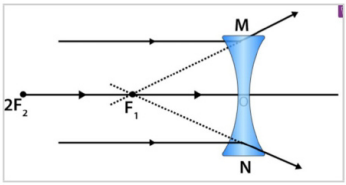


Object - At focus F_1
Image - At infinity
Highly enlarged
Real and Inverted

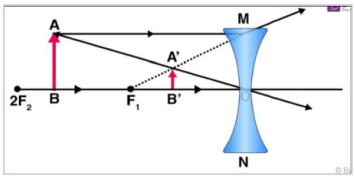


Object - between focus F_1 and optical centre O
Image - same side of the lens as the object
Enlarged
Virtual and erect

Image formed by concave lens



Object - At infinity
Image - At focus F_1
Highly diminished point sized
Virtual and Erect



Object - between infinity and optical centre O
Image - between focus F_1 and optical centre
Diminished
Virtual and Erect

Sign convention for spherical mirror

- We follow sign convention, similar to the one used for spherical mirror.
- We apply the rule for sign of distance except that all measurement are taken from the optical centre of the lens.
- The focal length of a convex lens is positive and that of a concave lens is negative.

Lens formula

★ $$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

v = image distance
u = object distance
f = focal length

Magnification

★ $$m = \frac{\text{Height of the image}}{\text{Height of the object}} = \frac{h'}{h} = \frac{v}{u}$$

Power

- 1 diopter is the power of a lens whose focal length is 1 metre. (1D = 1m⁻¹)
- The net power (p) of the lenses placed in contact is given by the algebraic sum of the individual powers P_1, P_2, P_3, P_4 ..... as

  $P = P_1 + P_2 + P_3 + P_4 + ...+ P_n$
- The simple additive property of the powers of lenses can be used to design lens system to minimise certain defects in images produced by a single lens.

E.K.Q

? **Question - Which of the following can make a parallel beam of light when light from a point source is incident on it?**

(a) Concave mirror as well as convex lens
(b) Convex mirror as well as concave lens
(c) Two plane mirrors placed at 90° to each other
(d) Concave mirror as well as concave lens

✅**Answer** - A

P.Y.Qs

Question: Two convex lenses with power 2 dioptre are kept in contact with each other. The focal length of the combined lens system is

Solution:
Power = 1/f
Power = 2
-> f=0.5m
Combined Power = 4 dioptre
Combined focal length = 0.25m

? **Question - Magnification produced by a rear-view mirror fitted in vehicles**

(a) is less than one
(b) is more than one.
(c) is equal to one.
(d) can be more than or less than one depending upon the position of the object in front of it.

✅**Answer** - A

? **Question- In torches, search lights and headlights of vehicles, the bulb is placed of**
(a) between the pole and the focus of the reflector
(b) very near to the focus of the reflector
(c) between the focus and centre of curvature of the reflector
(d) at the centre of curvature of the reflector.
✅**Answer** - D.

? **Question - In which of the following, the image of an object placed at infinity will be highly diminished and point sized?**
(a) Concave mirror only
(b) Convex mirror only
(c) Convex lens only
(d) Convex mirror, convex mirror, concave lens and convex lens
✅**Answer** - D

? **Question - You are given water, mustard oil, glycerine, and kerosene. In which of these media, a ray of light incident obliquely at some angle would bend the most.**
(a) Kerosene
(b) Water
(c) Mustard oil
(d) Glycerine
✅**Answer** - D

? **Question - A convex lens of focal length 20 cm can produce a magnified virtual as well as real image. Is this a correct statement? If yes, where shall the object be placed in each case for obtaining these images?**
✅**Answer** - Yes, for getting virtual image the object has to be placed between the optical centre and the focus. For real and enlarged image, the object should be placed between F and 2F.

? **Question - Why does a light ray incident on a rectangular glass slab immersed in any medium emerges parallel to itself?**
✅**Answer** - Due to variation in speed of light in different medium, light bends as it moves from one medium to another. Since, there are two surfaces for reaction which are parallel the light ray should bend in opposite sense in them equally, the emerging light ray is always parallel to the incident ray.

? **Question - Under what condition in an arrangement of two plane mirrors, incident ray and reflected ray will always be parallel to each other, whatever may be angle of incidence.**
✅**Answer** - When two plane mirrors are placed at right angle with each other, then the incident ray and reflected ray will always be parallel to each other, irrespective of the angle of incidence.

P.Y.Qs

Question: An object is placed at a distance of 60 cm from a concave lens of focal length 30 cm.
(i) Use the lens formula to find the distance of the image from the lens.
(ii) List four characteristics of the image (nature, position, size, erect/inverted) formed by the lens in this case.

SOLUTION
We have.
(i) Object distance, U= -60 cm
Focal length of the concave lens, f =-30 cm

Using lens formula $\rightarrow \frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$\Rightarrow \frac{1}{v}-\frac{1}{(-60)}=\frac{1}{(-30)}$

$\Rightarrow \frac{1}{v}=\frac{-1}{30}-\frac{1}{60}$

$\Rightarrow \frac{1}{v}=\frac{-3}{60}$

V= -20 cm
The image will be formed at a distance of 20 cm in front of the lens.

(ii) Nature of the image is virtual. The position of the image is between F1 and optical center O.
Size of the image is diminished. The image is Erect.

P.Y.Qs

Question: A security mirror used in a big showroom has radius of curvature 5 m. If a customer is standing at a distance of 20 m from the cash counter, find the position, nature and size of the image formed in the security mirror.

Object distance, U=-20m
Radius of curvature, R = +5 m
Then, focal length, f = 5/2 = +2.5m (f = R2)

To find: The position, nature, (v) and size of the image (h').

Solution: From the mirror formula. we know that
1/V + 1/U = 1/c
Substituting the given values we get-
1/V + 1/(-20) = 1/2.5
1/V - 1/20 = 10/25
1/V= 10/25 + 1/20
1/V = 40 + 5/100
1/V = 45/100
V= 100/45
V= 20/9
V= +2.2m
Thus, the position or distance of the image, V is 2.2m from the mirror, and the positive sign implies that it forms on the right side of the image.

Therefore, the nature of the image will be virtual and erect, and its size will be diminished, as the convex mirror always formed a virtual, erect, and diminished image regardless of the object distance from the mirror.
Now, from magnification formula we know that
m = V/U
m=-2.2/-20
m = -22/200
m = -0.11

Thus, the height of the image, h' is 0.11 times smaller than the object.