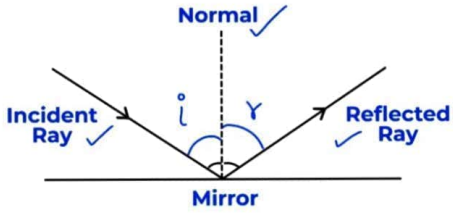
LIGHT REFLECTION AND REFRACTION

Reflection of Light:- The Bouncing back of light when it hits a polished surface like mirror.

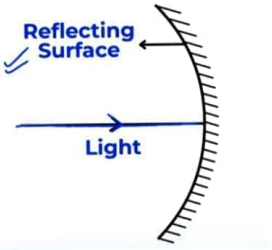
Law of Reflection:-

- $\angle i = \angle r$
  Angle of incidence = Angle of reflection
- The incident ray, the reflected ray & the normal, all lie in the same plane.

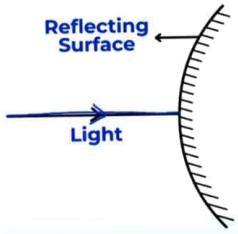


Spherical mirrors

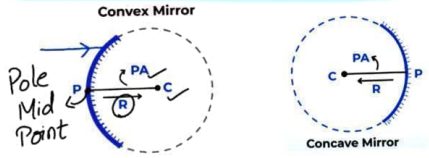
Concave Mirror (Gufa)



Convex Mirror

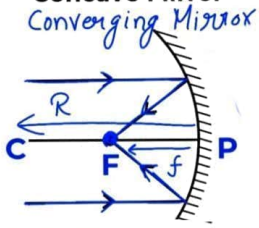


- Pole (P)
- centre of curvature (C)
- Principal Axis (PA)
- Radius of curvature (R)



Principal focus (F) and Focal length (f)

Concave Mirror
Converging Mirror



for spherical mirror $R = 2f$

Convex Mirror
Diverging Mirror

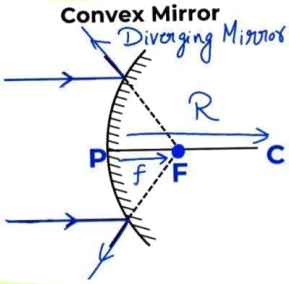


Image formation and characteristics

At least two rays of light meet ⇒ Image
if rays of light actually meet ⇒ Real → ulti inverted ↑↓
if rays of light appear to meet ⇒ Virtual → Erect seedhi ↑↑

Image formation : Concave Mirror – Rules :-

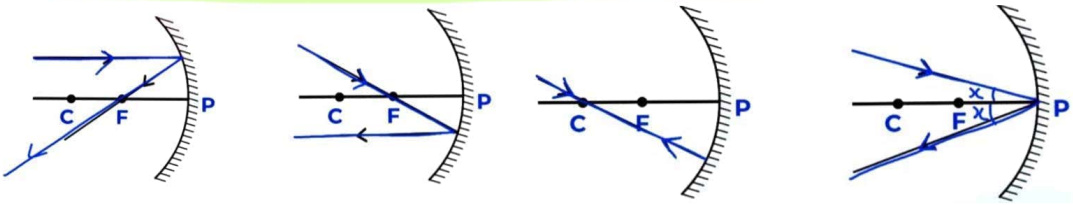
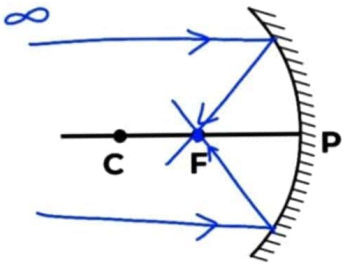


Image formation for Concave Mirrors :-

object at ∞

characteristics

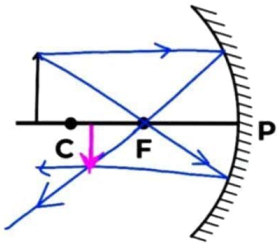
- image at Focus.
- Real, inverted, Highly diminished ↘ point sized



object beyond C

characteristics

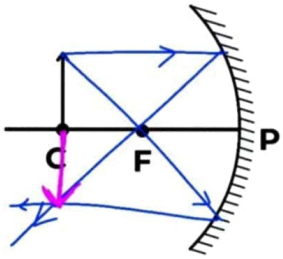
- image between C & F
- Real, inverted, Diminished



object at C special

characteristics

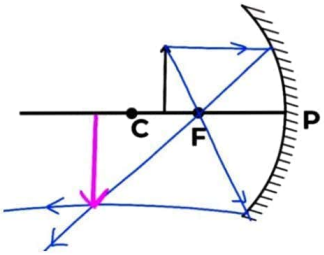
- image at C.
- Real, inverted, same size



object between C and F

characteristics

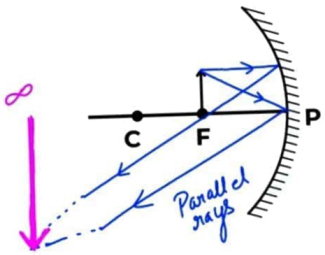
- image beyond C.
- Real, inverted, magnified ↘ Enlarged



object at F

characteristics

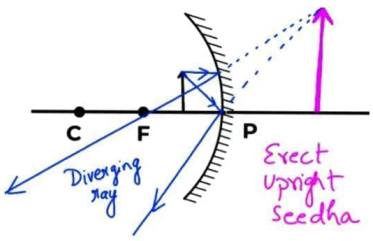
- image at infinity
- Real, inverted, Highly magnified



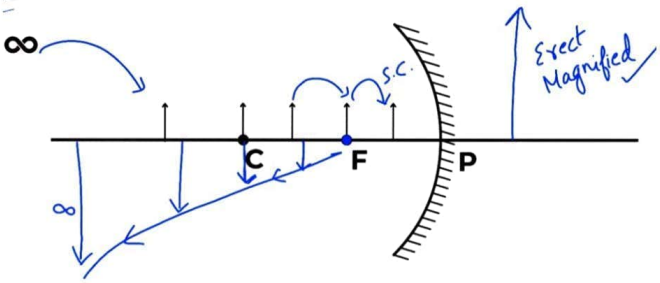
V. special object between F and D

characteristics

- image behind mirror
- virtual, Erect, Magnified

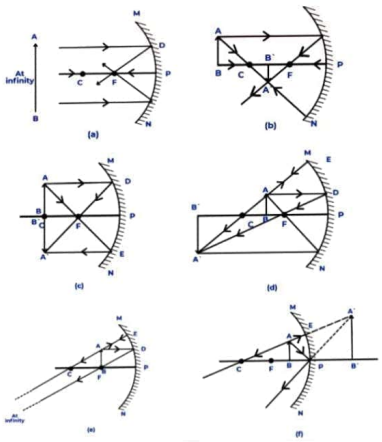


Alakh Sir koncept (ASK) :-

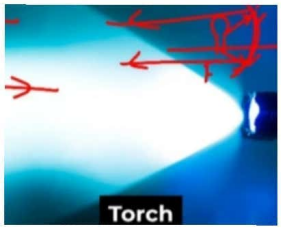


Summary for Concave Mirror

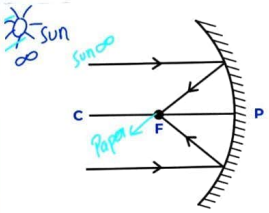
Position of the Object	Position of the Image	Size of the Image	Nature of the Image
At infinity	At the focus F	Highly diminished, point-sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted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



Use of Concave Mirror



To concentrate sunlight to produce heat → solar furnace → object at ∞



An object is placed at a distance of 30 cm from the reflecting surface of a concave mirror of radius of curvature 40 cm. The image formed is

$R = 40cm$ $R = 2f$ $40 = 2f$ $f = \frac{40}{2} = 20cm$

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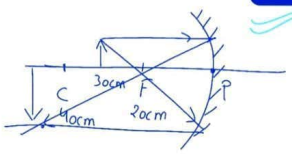
A. Virtual and magnified ✗

B. Virtual and diminished ✗

C. Real and magnified ✓

D. Real and diminished



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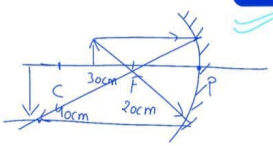
CBSE 2025

A. Virtual and magnified ✗

B. Virtual and diminished ✗

C. Real and magnified ✓

D. Real and diminished



A student wants to obtain an erect image of an object using a concave mirror of 10cm focal length. What will be the distance of the object from mirror?

A. Less than 10 cm ✓

B. 10cm

C. between 10 cm and 20 cm

D. more than 20 cm

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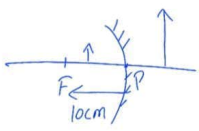

Erect → F & P

The image of an object placed in front of a concave mirror of focal length 15cm is of the same size as the object. The distance between the object and its image is

A. 15 cm

B. 30cm

C. 60 cm

D. Zero ✓

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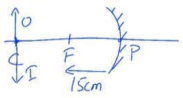


Three concave Mirrors

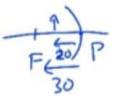
CBSE 2024

Case	Mirror	Focal Length (cm)	C	Object Distance (cm)
1	A	20	40	45
2	B	15	30	30
3	C	30	60	20

→ object beyond C ⇒ Image between C & F → diminished

→ " at C

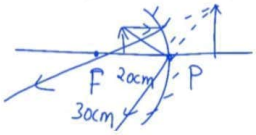
→ " between F & P



a) In which one of the above cases the mirror will form a diminished image of the object? Justify your answer. → A

b) List two properties of the image formed in case 2. Image at C → Real, Inverted, Same size

c) What is the nature and size of the image formed by mirror C? Draw ray diagram to justify your answer. → Image behind the mirror, Virtual, Erect, Magnified



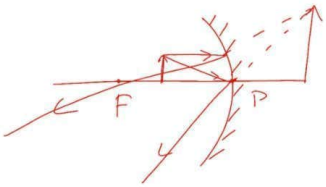
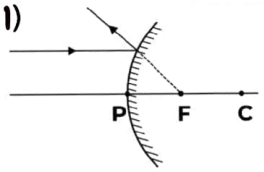
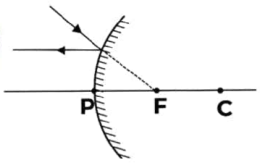


Image formation: Convex Mirrors - Rules

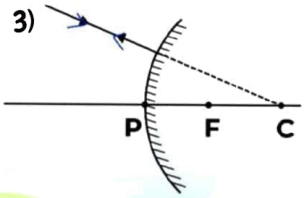
1)



2)



3)



4)

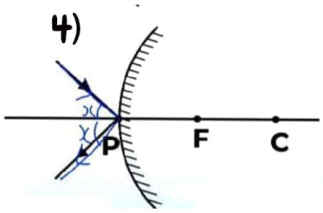
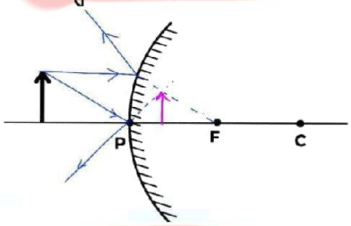


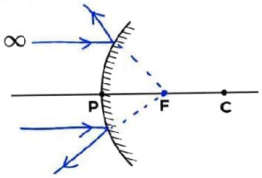
Image formation of Convex Mirror → seedhi choti image

object at finite distance (anywhere except ∞)



- Image between F and P
- Virtual, erect (upright), diminished

object at infinity ∞



characteristics

- image at F.
- Virtual, erect, highly diminished (point sized)

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

Use of convex Mirror

Rear - View mirrors

→ Rear View ⟶ seedhi choti convex

Reason:-
- Upright/erect image
- wider field of view.

Summary - Concave and Convex Mirror

Concave Mirror

- inverted ↓↓↓
- Erect/Upright {Enlarged} (seedhi + Badi image)

Convex Mirror

- only erect and virtual image
- Always diminished (seedhi + choti image)

List four properties of the images formed by convex mirrors when objects are placed anywhere in front of their reflecting surfaces.

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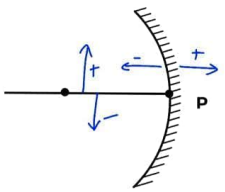
1) Virtual Image
2) Upright / Erect Image
3) Dimnished Image
4) On other side of mirror with respect to object (Between F & P)

Sign Convention

(1) All distances are measured from Pole (P).

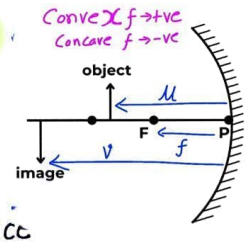
(2) +x axis ⟶
-x axis ⟵

(3) h = +ve ↑
P.A
h = -ve ↓



Mirror Formula

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



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

Note:- 1) u ⟶ always -ve
2) convex → f → +ve

Magnification (m)

$$m = \frac{h_i}{h_o} \qquad m = \frac{-v}{u}$$

h_i = height of image
h_o = height of object

u = object distance
v = image distance

An object is placed at a distance of 10 cm in front of a concave mirror of focal length 15 cm. Use mirror formula to determine the position of the image formed in this mirror.

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

$u = -10cm$

$f = -15cm$

$\frac{1}{-15} = \frac{1}{v} + \frac{1}{-10}$

$\frac{1}{v} = \frac{1}{10} - \frac{1}{15}$

$\frac{1}{v} = \frac{3-2}{30} = \frac{1}{30}$

$v = 30cm.$

An object is placed at a distance of 18 cm from the pole of a concave mirror of focal length 12 cm. Find the position of the image formed in this case.

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Concave

$f = -12cm$

$v = ?$

$u = -18cm$

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

Comment

An object is placed at a distance of 30 cm from the pole of a concave mirror. If its real and inverted image is formed at 60 cm in front of the mirror, the focal length of the mirror is :

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A -15 cm

B -20 cm

C + 20 cm

D + 15 cm

$f = ?$

$u = -30cm$

$v = -60cm$

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

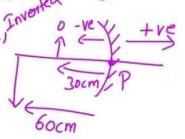
$= \frac{1}{-60} + \frac{1}{-30}$

$\frac{1}{f} = \frac{-1-2}{60} = \frac{-3}{60} = \frac{-1}{20}$

$f = -20cm$

Image is at Screen

Real, Inverted



a) Complete the following ray diagram to show the formation of image :

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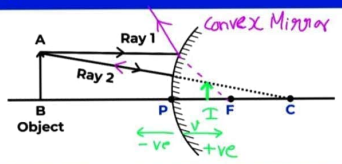

b) Mention the nature, position and size of the image formed in this case. Erect, virtual, diminished Betw F & P

c) State the sign of the image distance in this case using the Cartesian sign convention. +ve

A convex mirror used for rear view on an automobile has a focal length of 1.5 m. If a 3 m high bus is located at 6.0 m from the mirror, use mirror formula to determine the position and size of the image of the bus as seen in the mirror.

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$f = +1.5m$

$u = -6m$

$v = ?$

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

$\frac{1}{1.5} = \frac{1}{v} + \frac{1}{-6}$

$\frac{1}{v} = \frac{1}{6} + \frac{2}{3}$

$= \frac{1+4}{6}$

$\frac{1}{v} = \frac{5}{6}$

$v = \frac{6}{5} = +1.2m$

$h_o = 3m$

$h_i = ?$

$m = \frac{h_i}{h_o}$

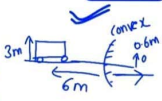
$\frac{1}{5} = \frac{h_i}{3}$

$h_i = \frac{3}{5} = 0.6m$

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

$= \frac{+6}{5}$

$m = \frac{1}{5}$



"The linear magnification produced by a spherical mirror is +3". Based on this statement answer the following questions :

a) What is the type of the mirror? Concave Mirror

b) Where is the object located? Between F & P

c) List two properties of the image formed (other than the size/ magnification). • Virtual • Erect • Behind the mirror

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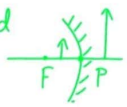
$m = +3$

$h_i = 3 \times h_o$

Erect Magnified



Magnification (m) and Nature of image :-

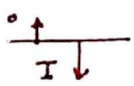
$m = \frac{h_i}{h_o}$

$h_i = m \times h_o$

1) $m = 2$, $h_i = 2 \times h_o$

2) $m = 1/2$, $h_i = \frac{1}{2} h_o$

3) $m = -2$, $h_i = -2 \times h_o$

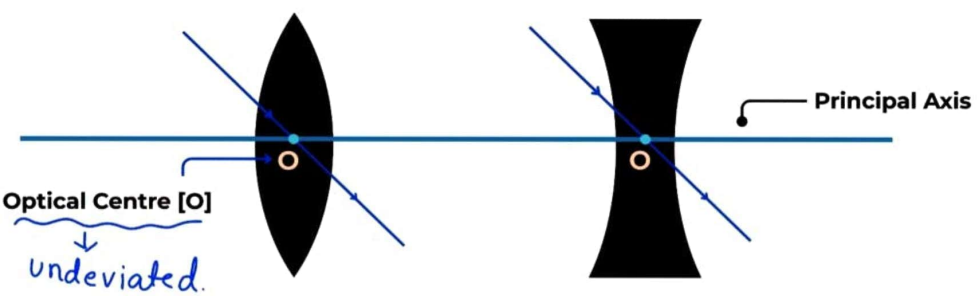


4) $m = -\frac{1}{2}$, $h_i = -\frac{1}{2} h_o$

Spherical lens :-

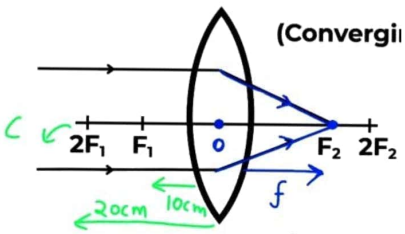
Convex lens (Thick in middle)

Concave lens (Thin in middle)



Principal Focus(F) and Focal length(f)

Convex lens (converging lens)



Note
They have two F, f_1 and F_2 due to two curved surfaces

concave lens (Diverging lens)

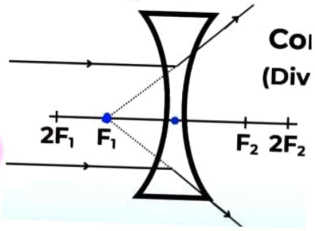
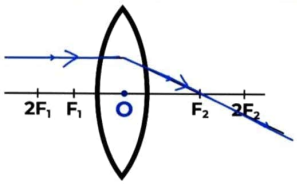


Image formation (convex lens) Rules

1.


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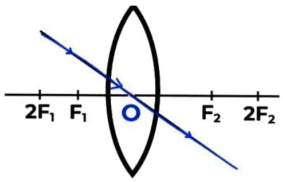

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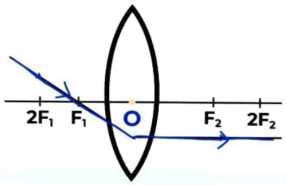
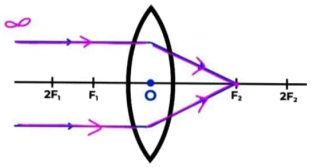
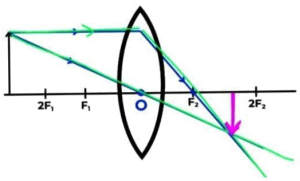


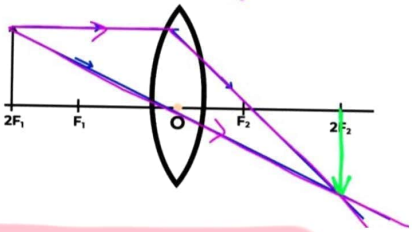
object at ∞
characteristics of image
- Image at F_2
- Real, inverted, Highly diminished



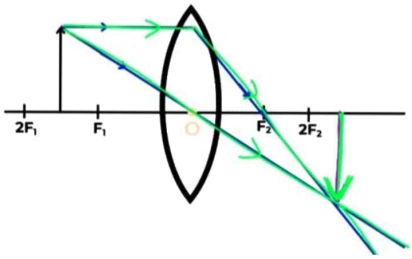
object Beyond 2F1
characteristics of image
- Image between F_2 and $2F_2$
- Real, inverted, Diminished



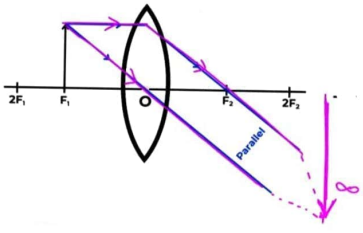
object at 2F1
characteristics of image
- image at $2F_2$
- Real, inverted, same size



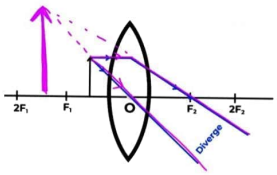
object Between 2F1 and F1
characteristics of image
- image beyond $2F_2$
- Real, inverted, Magnified



object at F1
characteristics of image
- image at ∞
- Real, inverted, Highly magnified



object Between F1 & O
characteristics of image
- image on same side of object.
- virtual, Erect, magnified.



Alakh Sir koncept (ASK):-

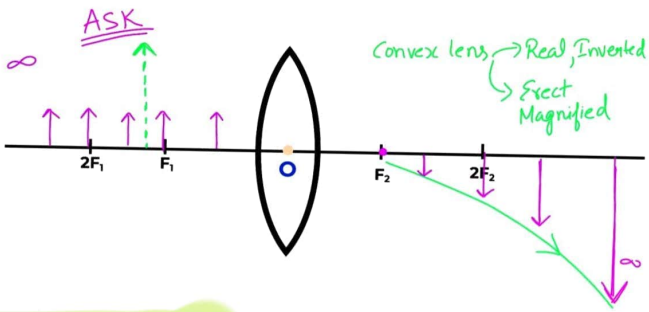
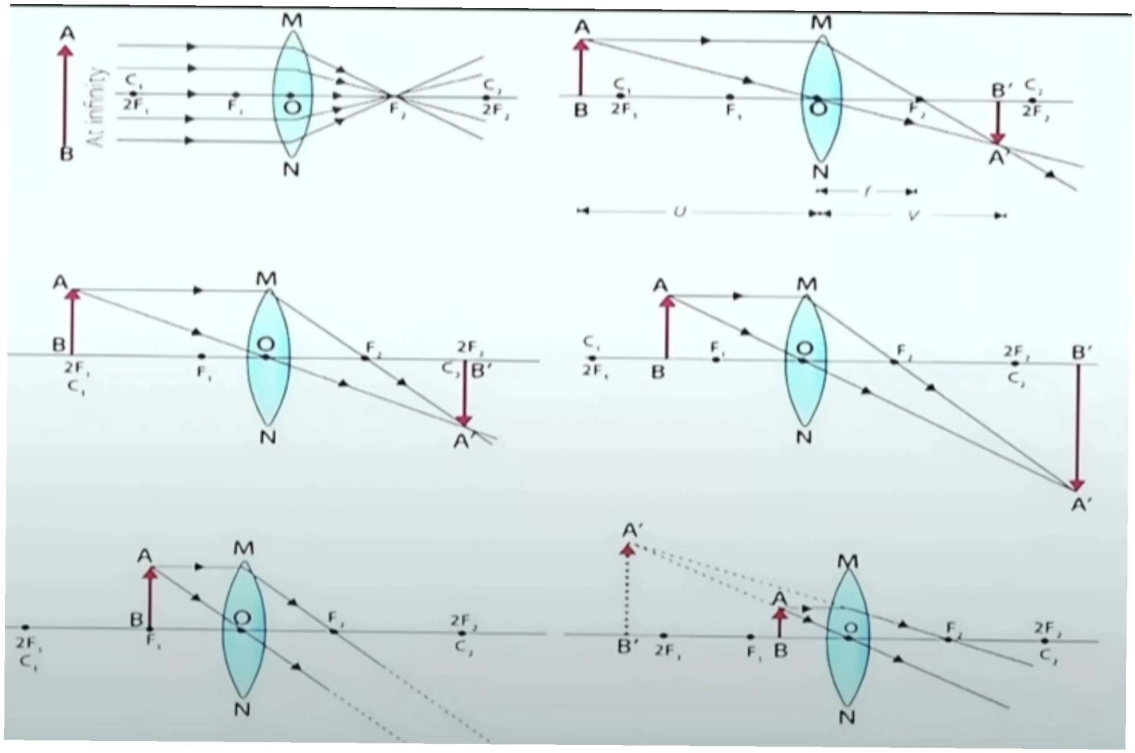


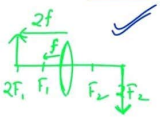
Image formation Summary (Convex lens)

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_2	Highly diminished, point-sized	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At $2F_2$	Same size	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus F_1	At infinity	Infinitely large or highly enlarged	Real and inverted
Between focus F_1 and optical centre O	On the same side of the lens as the object	Enlarged	Virtual and erect



At what distance from a convex lens should an object be placed to get an image of the same size as that of the object on a screen? (CBSE 2024)

- A. Beyond twice the focal length of the lens.
- B. At the principal focus of the lens.
- C. At twice the focal length of the lens.
- D. Between the optical centre of the lens and its principal focus.

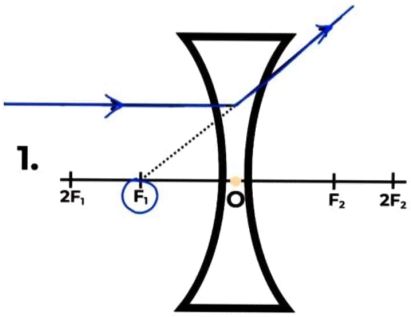


When an object is placed beyond 2F of a convex lens, the nature of the image is formed is : (CBSE 2023)

- A. Real, Inverted and Diminished
- B. Real, Erect and Magnified
- C. Virtual, Erect and Magnified
- D. Real, Inverted and Magnified

Image formation (Concave lens) - Rules

1.



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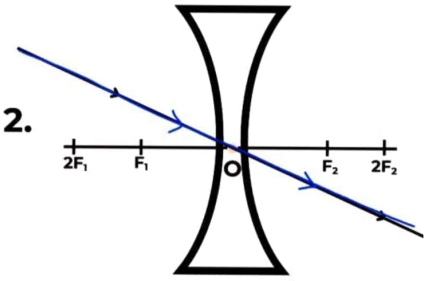
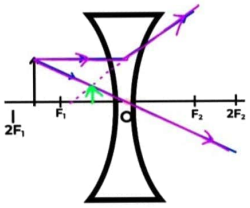


object at finite distance (anywhere except ∞)

characteristics of image

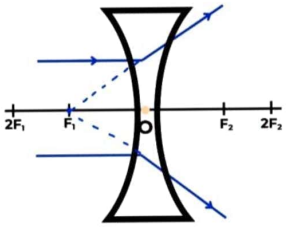
- Image between F_1 and O
- Virtual, Erect, Diminished



object at ∞

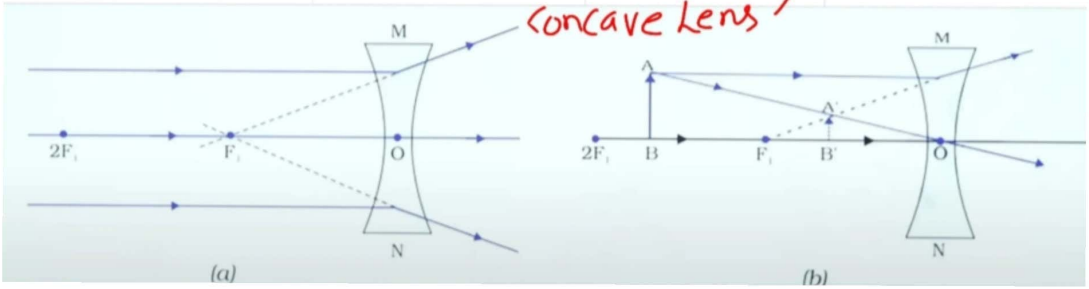
characteristics of image

- image at F_1
- Virtual, Erect, Highly Diminished



Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_1	Highly diminished, point-sized	Virtual and erect
Between infinity and optical centre O of the lens	Between focus F_1 and optical centre O	Diminished	Virtual and erect

Concave Lens



summary of convex and concave lens

convex lens

- Inverted
- Erect / Upright magnified

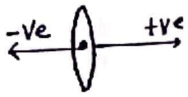
Concave lens

- Erect / Upright
- Diminished (seedhi + chotti image)

Sign Convention, lens formula and Magnification

pole → optical centre

1. Here all distances are measured from the optical centre (O) of the lens.
2. Rest all same rule for sign.



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

$$m = \frac{h_i}{h_o}$$

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

u → -ve
f = +ve
same rule

An object of height 4.0 cm is placed at a distance of 30 cm from the optical centre of a convex lens of focal length 20 cm.

Use lens formula to determine
a) the distance of the image from the optical centre and
b) height of the image formed. 8 cm (Inverted) **(CBSE 2025)**

$f = +20cm$, $u = -30cm$, $h_o = 4cm$, $v = ?$, $h_i = ?$

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

$\frac{1}{20} = \frac{1}{v} - \frac{1}{-30}$

$\frac{1}{v} = \frac{1}{20} - \frac{1}{30}$

$\frac{1}{v} = \frac{3-2}{60} = \frac{1}{60}$

$v = 60cm$

$m = \frac{h_i}{h_o}$

$m = \frac{v}{u} = \frac{60}{-30}$

$m = -2$

$-2 = \frac{h_i}{4}$

$h_i = -8cm$

"The value of magnification 'm' for a lens is -2." Using new Cartesian Sign Convention and considering that an object is placed at a distance of 20 cm from the optical centre of this lens, state :
(i) the nature of the image formed; Real, Inverted, Magnified
(ii) size of the image compared to the size of the object; double of object
(iii) position of the image and v = ? v = +40cm
(iv) sign of the height of the image → -ve **(CBSE 2025)**

$m = \frac{h_i}{h_o}$ | $h_i = m \times h_o$

$m = -2$

$h_i = -2 \times h_o$

Inverted, Real, Magnified

$u = -20cm$

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

$-2 = \frac{v}{u}$

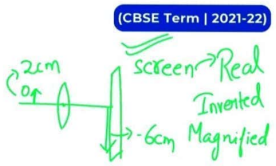
$-2 = \frac{v}{-20}$

$v = +40cm$

The image of a candle flame formed by a lens is obtained on a screen placed on the other side of the lens. According to new cartesian sign convention, if the image is three times the size of the flame, then the lens is

(CBSE Term | 2021-22)

A. Concave and Magnification is +3 ✗
B. Concave and Magnification is -3 ✗
C. Convex and Magnification is -3 ✓
D. Convex and Magnification is +3 ✗



Power of a lens

The power of lens (P) is its ability to converge (convex lens) or diverge (concave lens) rays of light. It is defined as the reciprocal of the focal length (f) of the lens.

$$P = \frac{1}{f}$$

Diaptore (D) → always in metre

$\{ f (\text{in m}) = \frac{cm}{100} \}$

$P = +2$, $P = +5$ } converging convex lens

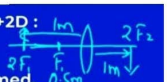
Power of combination

$$P = P_1 + P_2 + P_3 + \dots$$

$$P = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \dots$$

An object is kept at a distance of 1 m from a lens of power +2D :

(i) Identify the type of lens.
(ii) Calculate its focal length and distance of the image fromed.



$P = +2D$

$(f = +ve)$ Convex lens ✓

Converging lens ✓

$P = \frac{1}{f}$ ↗ in metres

$2 = \frac{1}{f}$

$f = \frac{1}{2}m$ ✓

$f = \frac{1}{2} \times 100 = 50cm$

(CBSE 2023)

$f = \frac{1}{2}m$

$u = -1m$

$v = ?$

$\frac{1}{v} = 1$

$v = 1m$

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

$\frac{1}{\frac{1}{2}} = \frac{1}{v} - \frac{1}{-1}$

$2 = \frac{1}{v} + 1$

The power of a combination of two lenses in contact is +1.0D. If the focal length of one of the lenses of the combination is +20.0 cm, the focal length of the other lens would be

A. -120.0 cm

B. +80.0 cm

C. -25.0 cm ✓

D. -20.0 cm

$P = P_1 + P_2$

$P = \frac{1}{f_1} + \frac{1}{f_2}$

$1 = \frac{1}{\frac{20}{100}} + \frac{1}{f_2}$

$1 = 5 + \frac{1}{f_2}$

$f \rightarrow$ in metre

(CBSE Term | 2021-22)

$\frac{1}{f_2} = -4$

$f_2 = -\frac{1}{4}m$

$f_2 = -\frac{1}{4} \times 100 = -25cm$

An object is placed at a distance of 20 cm from the optical centre of a concave lens and its image is formed on the same side of the lens as the object. If the distance of the image from optical centre of the lens is 10 cm, use lens formula to determine:
(i) focal length, and
(ii) power of the lens in new Cartesian sign conventions.

H.W. CBSE 2025

$f = ?$ easy

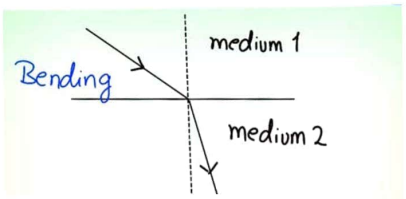
$P = ?$ Comment

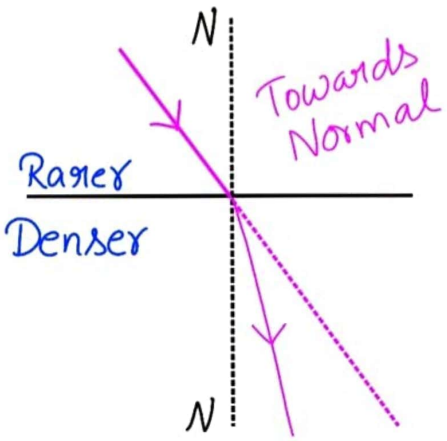
Refraction of light :-

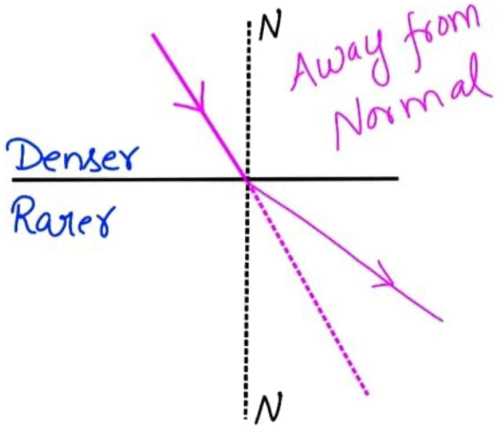
The Bending of light ray when it travels from one medium to another.

Cause of Refraction :-

Refraction occurs because light travels with different speed in different medium.







Denser → Jisme Speed of light कम ho!

Absolute Refractive index (R.I) :-

Absolute R.I of any medium X is n_x

$$n_x = \frac{c}{v_x}$$

$c \rightarrow$ speed light in air / vaccum $= 3 \times 10^8 m/s$

$v_x \rightarrow$ speed of light in X

Absolute R.I of water $\rightarrow n_w$

$$n_w = \frac{c}{v_w}$$

$v_w \rightarrow$ speed of light in water

Absolute R·I of Glass

$$n_g = \frac{c}{v_g}$$

$v_g \rightarrow$ speed of light in glass

$c = 3 \times 10^8 m/s$

$n \propto \frac{1}{v}$

$n \uparrow \; v \downarrow \Rightarrow$ Dense

(1) $n_A = 2$

$n_B = 5 \rightarrow$ Dense $\rightarrow$ speed of light $\downarrow$

Refractive Index (R·I)

R·I of 2 w.r.t 1

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

R·I of A w.r.t B

$$n_{AB} = \frac{n_A}{n_B} = \frac{V_B}{V_A}$$

Absolute refractive indices of water and glass are $\frac{4}{3}$ and $\frac{3}{2}$ respectively

In which one of the two media is the speed of light more?

$_wa$ water

$n_w = \frac{4}{3} = 1.33 \rightarrow v \uparrow \rightarrow$ rarer

$n_g = \frac{3}{2} = 1.5 \rightarrow$ Denser $\rightarrow v \downarrow$

$n_w < n_g$

rarer < Denser

(CBSE 2023)

If the absolute refractive indices of two media X and Y are $\frac{6}{5}$ and $\frac{4}{3}$ respectively, then the refractive index of Y with respect to X will be :

(CBSE 2025)

A $\frac{10}{9}$

B $\frac{9}{10}$

C $\frac{9}{8}$

D $\frac{8}{9}$

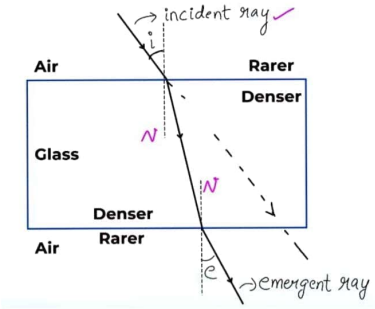
$n_X = \frac{6}{5}$

$n_Y = \frac{4}{3}$

RI Y w.r.t X

$$n_{YX} = \frac{n_Y}{n_X} = \frac{\frac{4}{3}}{\frac{6}{5}} = \frac{4}{3} \times \frac{5}{6} = \frac{10}{9}$$

Refraction Through A Glass slab



Provided medium on both side is same

To remember

- Emergent ray is parallel ~~ray~~ is to the incident ray.
- $\angle e = \angle i$

$\angle$ of emergence — $\angle$ of incidence

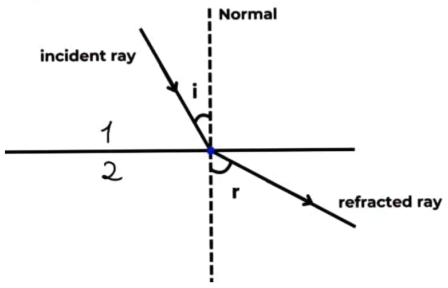
Laws of Refraction :-

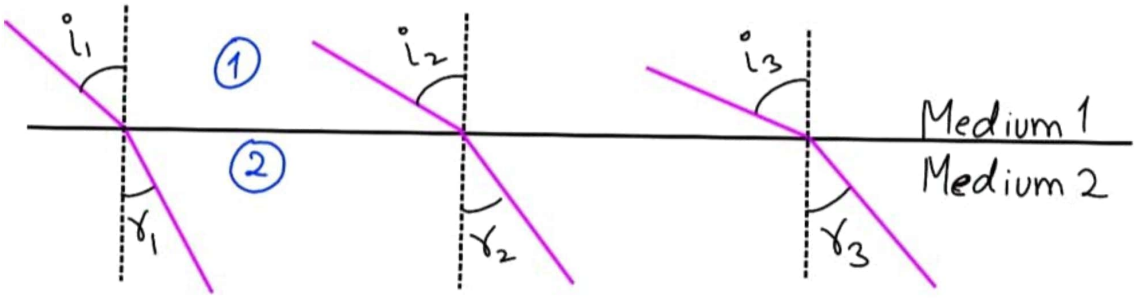
- The incident ray, Normal and the refracted ray lies on the same plane.
- The ratio of sine of Angle of incidence to the sine of angle of refraction remain constant for a given pair of media.

Snell's law

$$\frac{\sin i}{\sin r} = \text{constant}$$

$$\frac{\sin i}{\sin r} = n_{21}$$

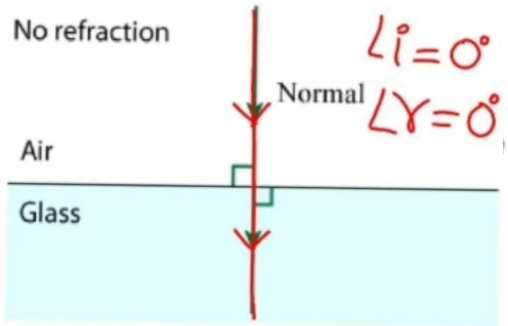


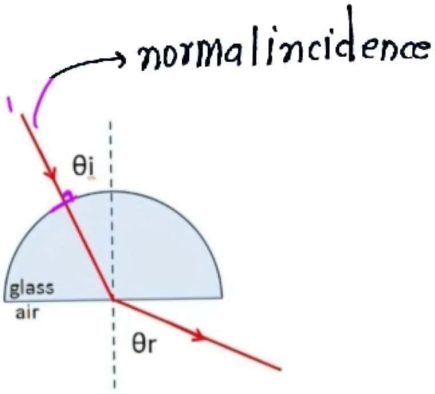


$$\frac{\sin i_1}{\sin r_1} = \frac{\sin i_2}{\sin r_2} = \frac{\sin i_3}{\sin r_3} = n_{21} = \text{constant}$$

Case of No Bonding → No refraction

1) Normal incidence





2) No medium change or no change in refractive index.