What is light? → It is a form of energy

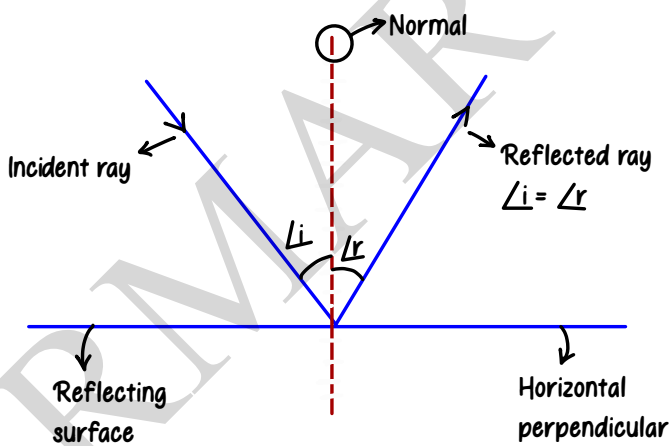
- It has dual nature → Particle and as a form of wave
- Light is a form of transverse wave
- It can travel in vacuum
- It can be polarised

Reflection of Light

- When a ray of light approaches a smooth polish surface, and the light ray bounces back

Laws of Reflection

1. The angle of incidence = The angle of reflection
2. Incident ray, reflected ray and normal ray → all lie in the same plane

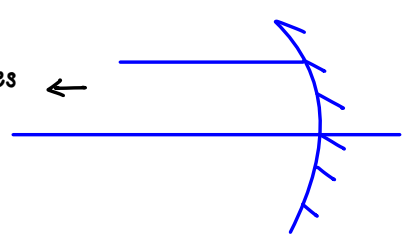


Types of Mirror

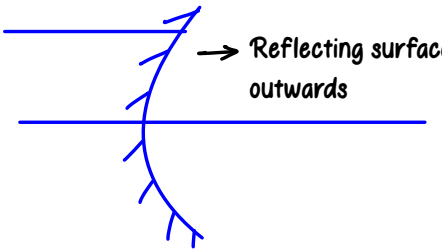
- Plane Mirror
- Spherical Mirror → Convex Mirror
- Concave Mirror

Concave Mirror

Reflecting surfaces curved inwards ←

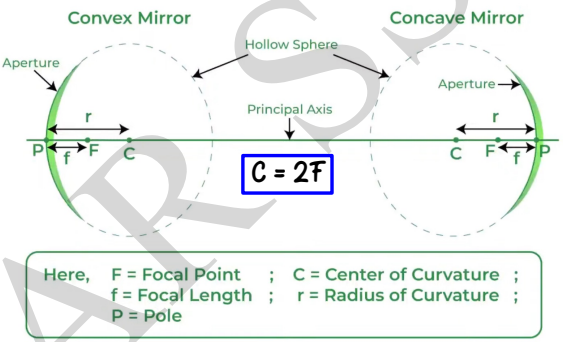


Convex Mirror



Concave Mirror

Convex Mirror



Types of Image

Real Image

- It can be obtained on screen
- It is inverted

Virtual Image

- It cannot be obtained on screen
- It is erect

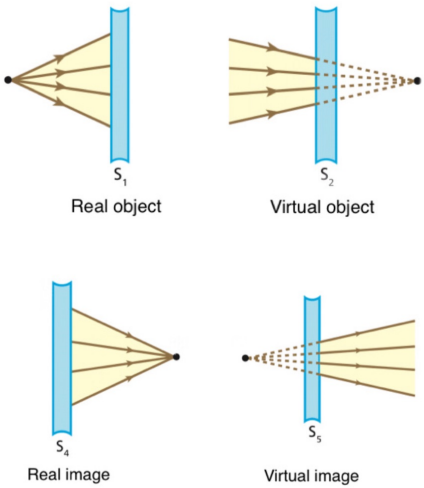
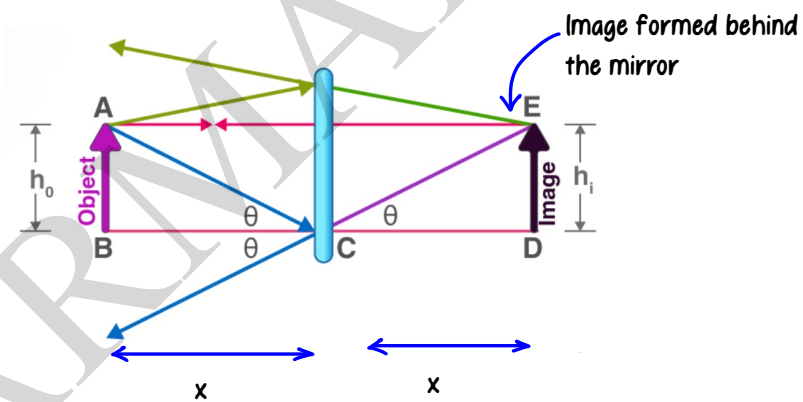


Image Formation



Plane Mirror

1. Image distance = Object distance
2. Object size = Image size
3. Erect → Virtual
4. Laterally inverted: Left → Right
   Right → Left

Location, size and nature of image formed by Spherical Mirrors

Concave Mirror

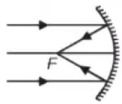
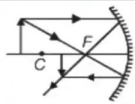
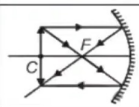
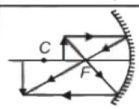
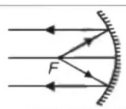
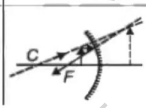
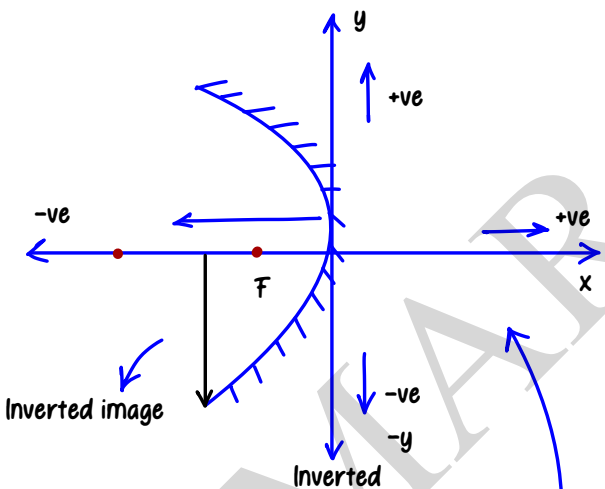
Position of object	Figure	Position of image	Nature of image
1. At infinity		At the principal focus or in the focal plane	Real, inverted, extremely diminished in size
2. Beyond the centre of curvature		Between the principal focus and centre of curvature	Real, inverted and diminished
3. At the centre of curvature		At the centre of curvature	Real, inverted and equal to object
4. Between focus and centre of curvature		Beyond centre of curvature	Real, inverted and bigger than object.
5. At the principal focus		At infinity	Extremely magnified
* 6. Between the pole and principal focus		Behind the mirror	Virtual, erect and magnified

Image Fromation of Concave Mirror

	Object	Image	Nature
1.	∞	Focus	Real and Inverted, extremely diminished
2.	Beyond C	C and F	Real and Inverted, diminished
3.	At C	At C	Real and inverted, equal
4.	B/W C and F	Beyond C	Real and inverted, enlarged
5.	At F	∞	Real and inverted, highly enlarged

Image Formation of Convex Mirror

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



Numericals

Sign convention

u: object distance → -ve (always)

v: image distance

f: focal length → Concave: -ve, Convex: +ve

R: radii of curvature

$R = 2F$

Mirror Formula

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

$$\text{Magnification} = \frac{h_i}{h_o} = -\frac{v}{u}$$

h_i: Height of image

h_o: Height of object

An object, 4.0 cm in size, is placed at 25.0 cm in front of a concave mirror of focal length 15.0 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image?

→Find the nature and the size of the image.

Given:

u = −25 cm

f = −15 cm

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

$\frac{1}{v} + \left(\frac{-1}{25}\right) = -\frac{1}{15}$

$\frac{1}{v} = \frac{1}{25} - \frac{1}{15}$

$\frac{1}{v} = \frac{3-5}{75}$

$\frac{1}{v} = \frac{-2}{75}$

$\frac{-75}{2} = -37.5$ cm → Inverted

$\frac{h}{4\text{ cm}} = \frac{-37.5}{-25}$

$\frac{37.5 \times 4}{25}$ → Enlarged image

$h_i = -6$ cm

Uses of Mirror

Concave → Magnifying

- Shaving mirror
- Torchlight
- Dentist mirror
- Used in solar furnace

Convex → Diminishing

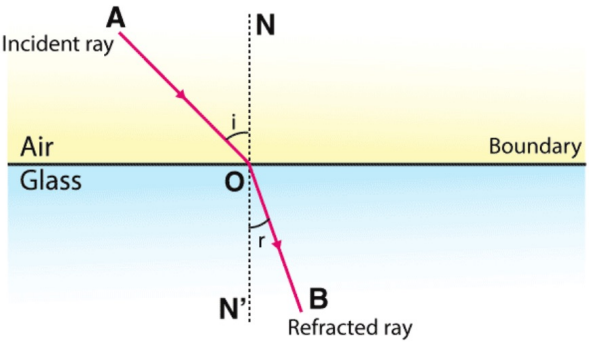
Rear view mirror in vehicle

Security reasons → In ATMs

Sunglasses

Reflection in street light

Refraction of Light



Types of Medium

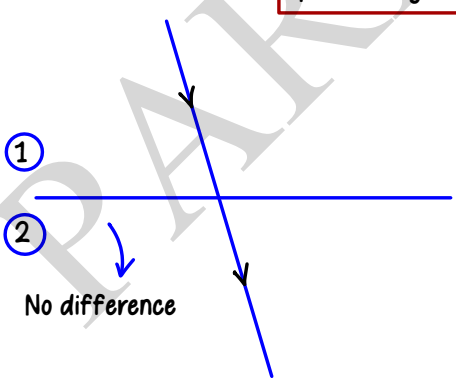
1. Rare Medium
2. Denser Medium

→ Medium with more Density

Air: rarer
Water
Glass: denser

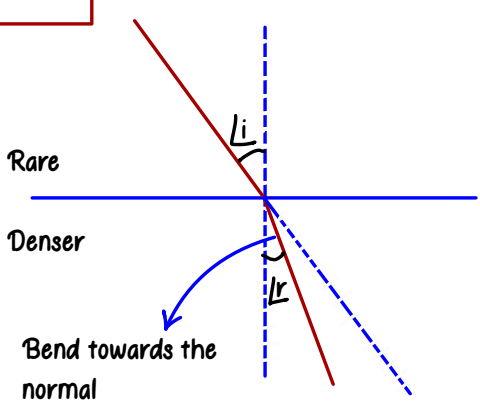
When a ray of light travels, its path changes

Case A



No difference

Case B

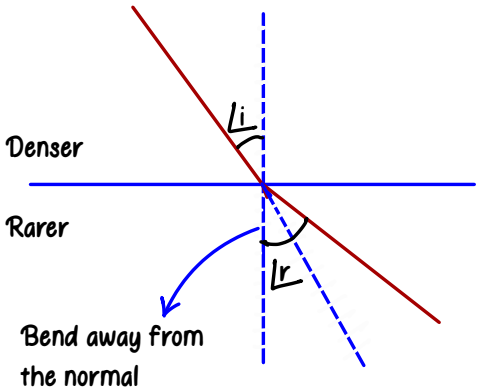


Bend towards the normal

$\angle i > \angle r$

- Light ray path is rectilinear

Case C

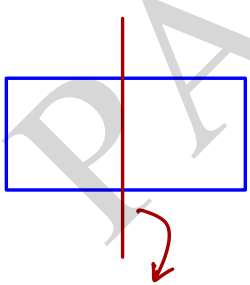


∠i < ∠r

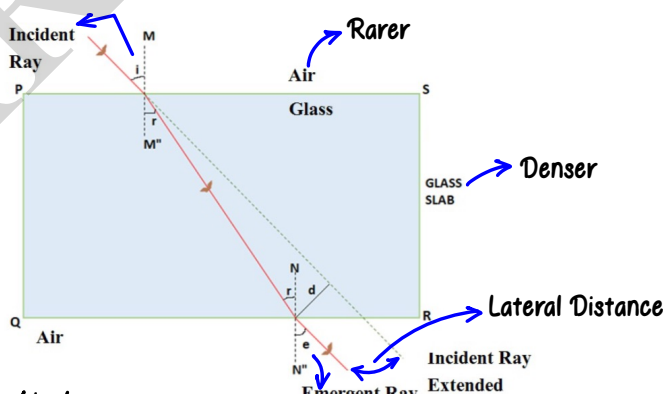
Laws of Refraction

1. Incident ray, refracted, ray and normal ray → all lie in same plane
2. $\frac{\sin i}{\sin r}$ = constant → Given pair of media and light of particular wavelength
   - media → Two mediums

Refraction through a Glass Slab



No refraction if strikes at 90°



∠i = ∠e

Angle of incidence = angle of emergence

Refractive Index → Represented with "n" or "μ"

$$n = \frac{\text{Speed of light in air/vacuum}}{\text{Speed of light in given medium}}$$

$$n_{QP} = \frac{V_P}{V_Q}$$

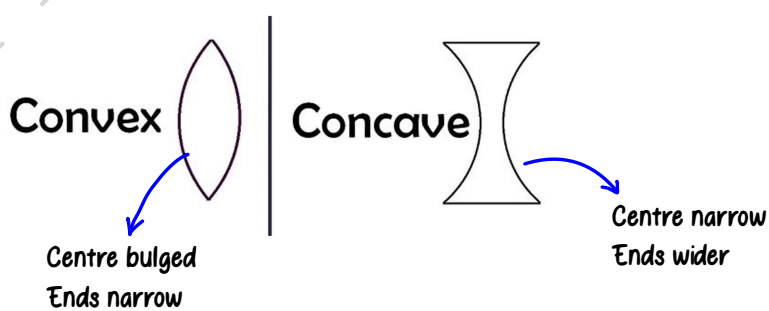
Speed of light in air/vacuum: 3×10^8 m/s

Material medium	Refractive index	Material medium	Refractive index
Air	1.0003	Canada Balsam	1.53
Ice	1.31		
Water	1.33	Rock salt	1.54
Alcohol	1.36		
Kerosene	1.44	Carbon disulphide	1.63
Fused quartz	1.46	Dense flint glass	1.65
Turpentine oil	1.47	Ruby	1.71
Benzene	1.50	Sapphire	1.77
Crown glass	1.52	Diamond	2.42

Densest medium

Spherical Lens

- Lens is transparent
- Forms image through refraction



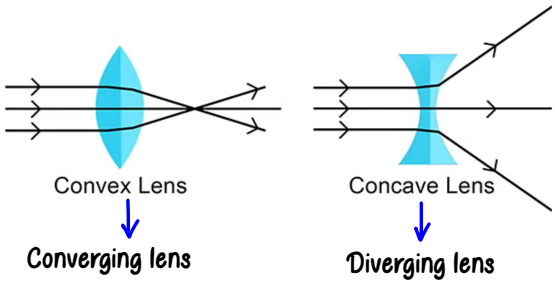
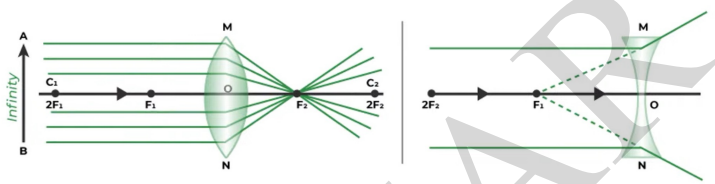


Image Formation



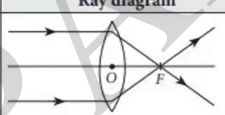
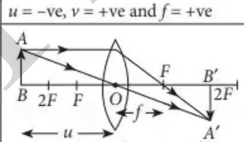
Convex Lens = Concave Mirror
(Converging Lens)

Concave Lens = Convex Mirror
(Diverging Lens)

Image Formation in Convex Lens

Same as Concave Mirror

▸ **Image formation by lenses :**

Convex lens				
	Ray diagram	**Position of object**	**Position of image**	**Nature of image**
(a)	 u = –ve, v = +ve and f = +ve	At infinity	At F	Real, inverted and highly diminished
(b)	 u = –ve, v = +ve and f = +ve	Between infinity and 2F	Between F and $2F$	Real, inverted and diminished

Beyond C (same)

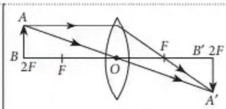
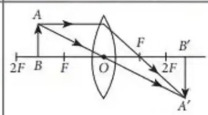
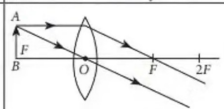
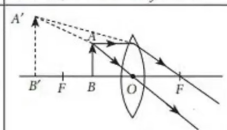
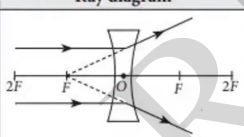
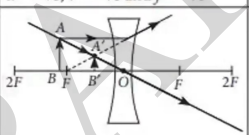
(c)	 u = –ve, v = +ve and f = +ve	At $2F$	At $2F$	Real, inverted and same sized
(d)	 u = –ve, v = +ve and f = +ve	Between F and $2F$	Beyond $2F$	Real, inverted and enlarged
(e)	 u = –ve, v = +ve and f = +ve	At F	At infinity	Real, inverted and enlarged
(f)	 u = –ve, v = –ve and f = +ve	Between F and O	On the same side of the lens	Virtual, erect and enlarged

Image Formation of Concave Lens

Same as Convex Mirror

Concave lens				
	Ray diagram	Position of object	Position of image	Nature of image
(a)	 u = –ve, v = –ve and f = –ve	At infinity	At F	Virtual, erect and highly diminished
(b)	 u = –ve, v = –ve and f = –ve	Between infinity and O	Between F and O	Virtual, erect and diminished

Uses

Concave Lens

- In treatment of Myopia

Convex Lens

- In treatment of Hypermetropia
- Used as magnifying lens
- In camera lens

A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens?

Also, find the magnification produced by the lens.

$f = -15$ cm

$u = ?$

$v = -10$ cm

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

Magnification formula $= \frac{h_i'}{h_o} = \frac{v}{u}$

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

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

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

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

$$\frac{1}{u}$$

$u = -30$

$$m = \frac{-10}{-30}$$

$$m = \frac{1}{3}$$

$m = 1 \rightarrow$ object size = image size (same size)

$m < 1 \rightarrow h_o > h_i$ (Diminished)

$m > 1 \rightarrow h_o < h_i$ (Enlarged)

Power of Lens

$$\text{Power} = \frac{1}{\text{Focal Length}}$$

Focal Length: +ve → Convex; −ve → Concave

$$\frac{1}{m} = m^{-1}$$

Dioptre (S.I unit of power of lens)

Diffraction: it is bending of light around the corner of an obstacle

Question

- Convex lens = 5cm
- Concave lens = 10 cm → −10
- Convex lens = 2 cm

When all the focal length is added what power do we get?

Sol: 5 − 10 + 2 = −3 → Concave lens