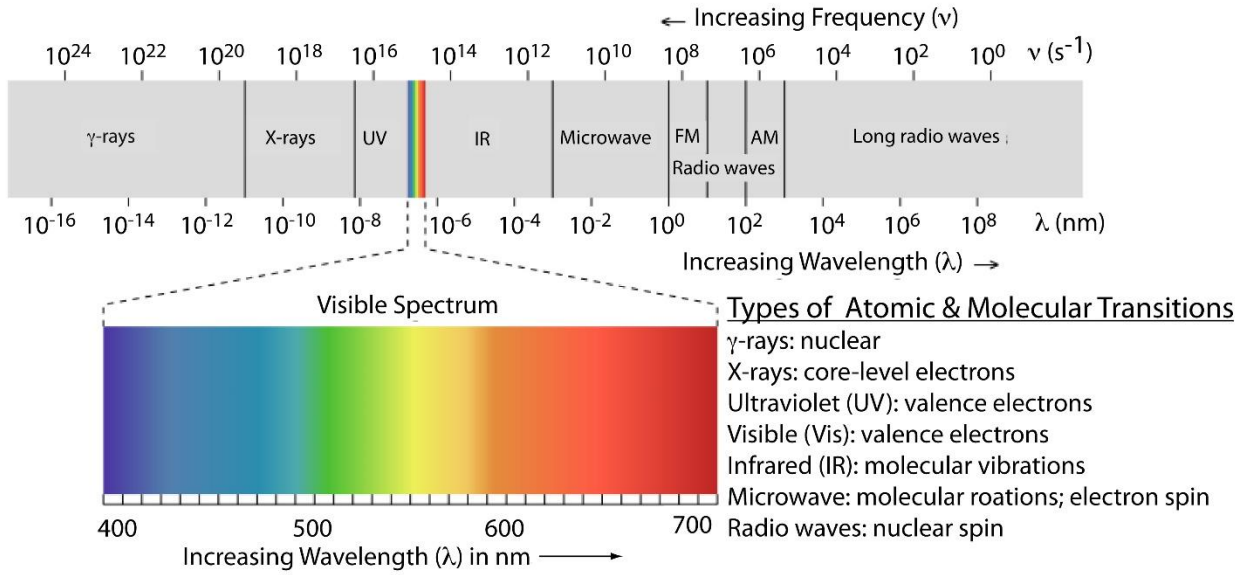
EDUBELA by Krishanu Roy©

Physics Class

for 12th Class CBSE

Chapter–9: Ray Optics and Optical Instruments

Unit–VI, Optics,30



The Human Eye is sensitive to detect electromagnetic waves within a small range of the electromagnetic spectrum. **Electromagnetic radiation belonging to this region of the spectrum (wavelength of about 400nm to 750nm) is called light.**

Light travels with enormous **speed (3 X 10^8 m/s)**, and it travels in a straight line in various situations.

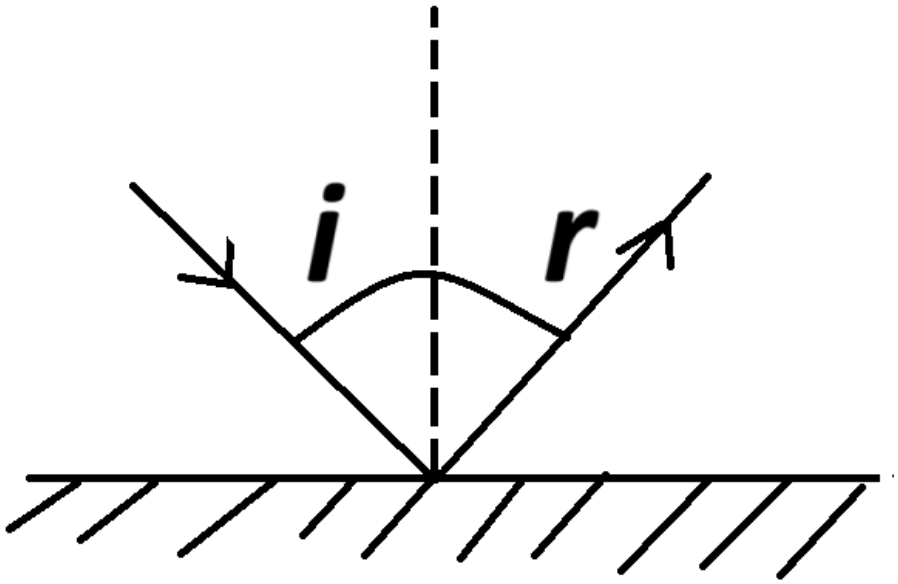
The wavelength of light is very small compared to the size of ordinary objects, so it is considered that it travels along a straight line.

The path of light is called a Ray of light.

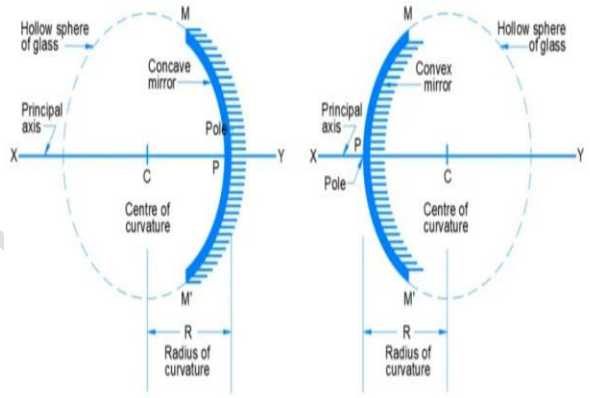
And a bundle of such rays constitutes a beam of light.

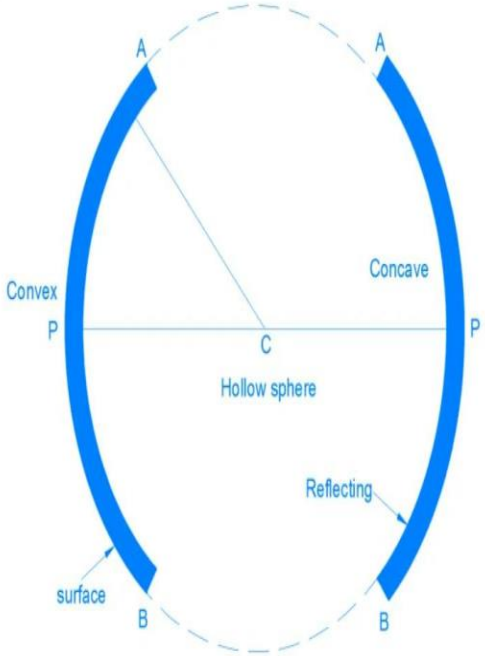
I. Reflection of Light by Spherical Mirrors:

Laws of Reflection :



- **The angle of incidence = The angle of reflection; i.e., ∠i= ∠r.**
- **The incident ray, reflected ray, and normal to the reflecting surface at the point of incidence all lie in the same plane.**

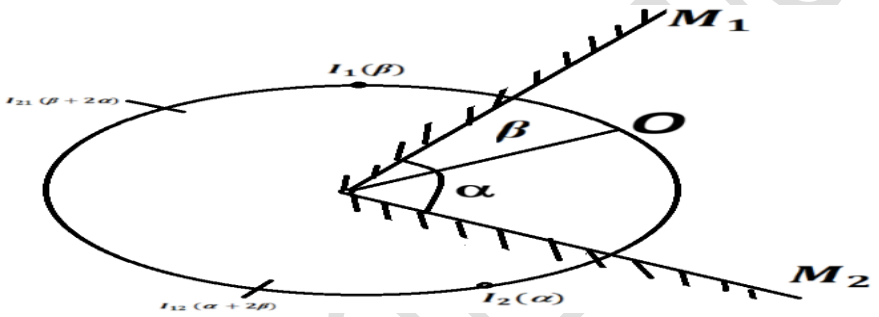




Spherical Mirrors

- Concave Mirror
- Convex Mirror

Number of images formed by Two Inclined Plane Mirrors:

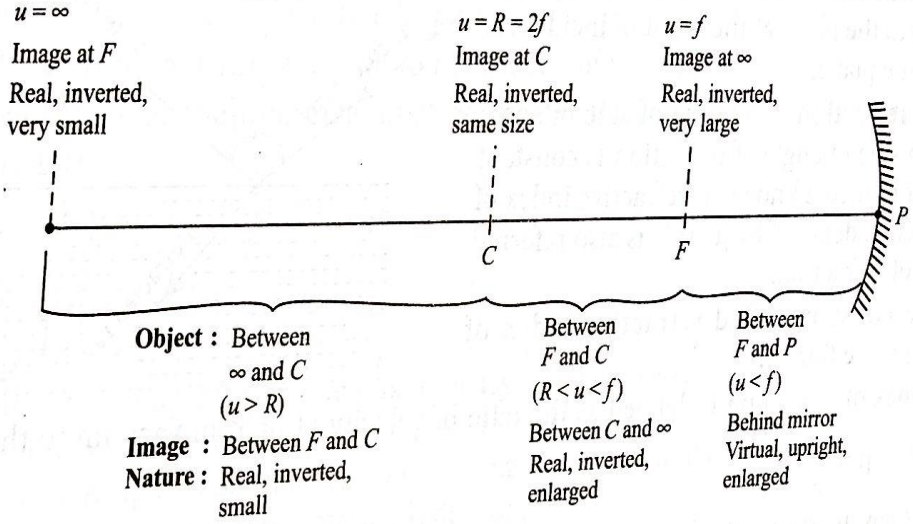
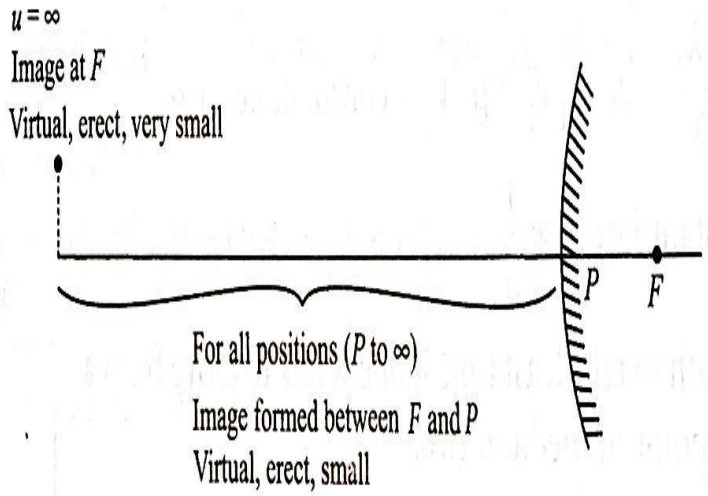


- **For two inclined plane mirrors M_1 and M_2,**
  I_1 = image O by M_1 ; I_2 = image of O by M_2
  I_{21} = image of I_2 by M_1; I_{12} = image of I_1 by M_2 and so on.
- **Total number of images is given by :**

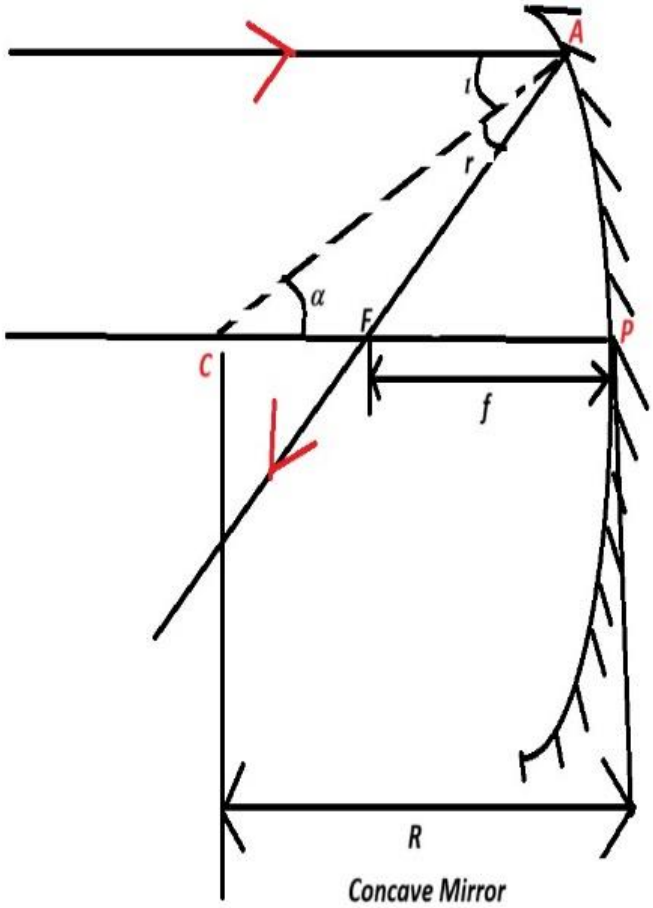
$\frac{360^\circ}{\theta}$ = N with some special cases; $\theta = \alpha + \beta$

Case (i): If NNN is an even number, then the number of images will be N−1N - 1N−1, because the last two images will coincide with each other.
Case (ii): If NNN is an odd number and the object is not at an angle θ/2\theta/2θ/2, then the number of images will be NNN.
Case (iii): If NNN is an odd number and the object is at an angle θ/2\theta/2θ/2, then the number of images will be N−1N - 1N−1.
Case (iv): If NNN is not an integer, then count the number of images manually.

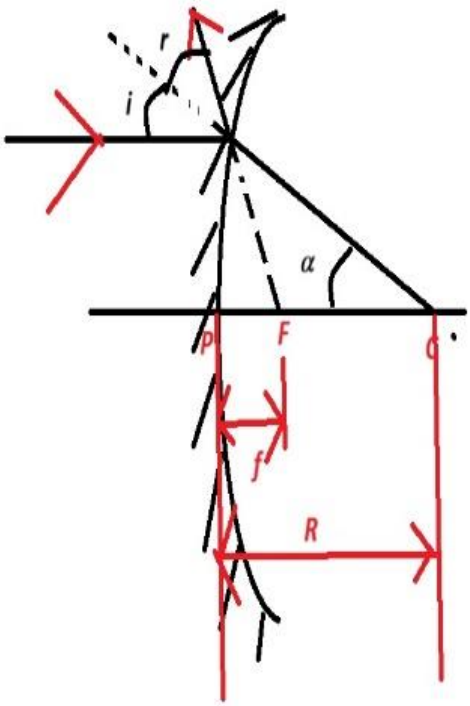
Spherical Mirror	
Concave Mirror	Convex Mirror
The mirror in which the inner surface towards the centre of curvature is reflecting surface.	The mirror in which the outer surface, away from the centre of curvature is reflecting surface.

Concave Mirror	Physics | Ray Optics and Optical Instruments **Characteristics of Image Formed by Spherical Mirrors** › **Concave mirror** 
Convex Mirror	› **Convex mirror** 

II. Relation between f and R of Spherical Mirrors



Concave Mirror



Convex Mirror

By the law of reflection, i = r ……(i)
Also, i = α ……(ii)

(Alternate angles (equal), Corresponding Angles(equal))

From equations (i) &(ii),we get :

r = α

and hence,

AF = FC……(iii)

For paraxial rays,i.e. rays incident at points close to the pole

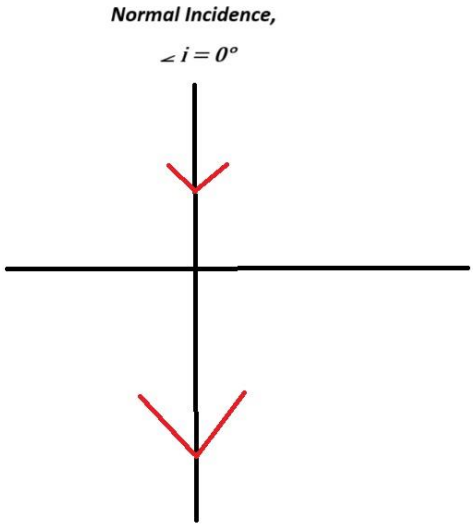
AF = PF……..(iv)

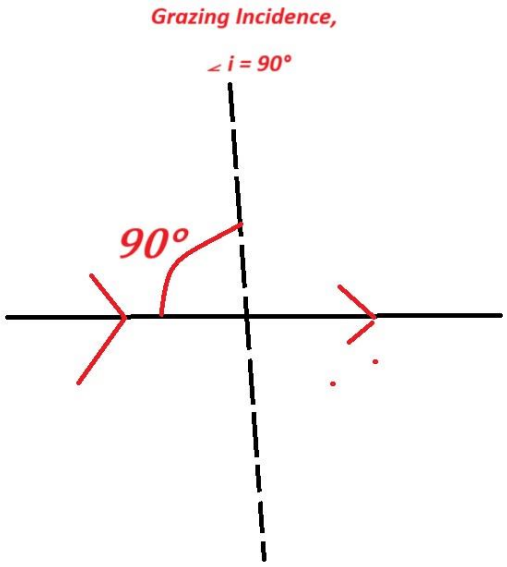
From equations (iii)& (iv), FC = PF+FC –

Or, ***For Parallel rays in spherical mirrors, the radius of curvature R is equal to twice the focal length f.***

III. General Concepts Used in Geometrical Optics :

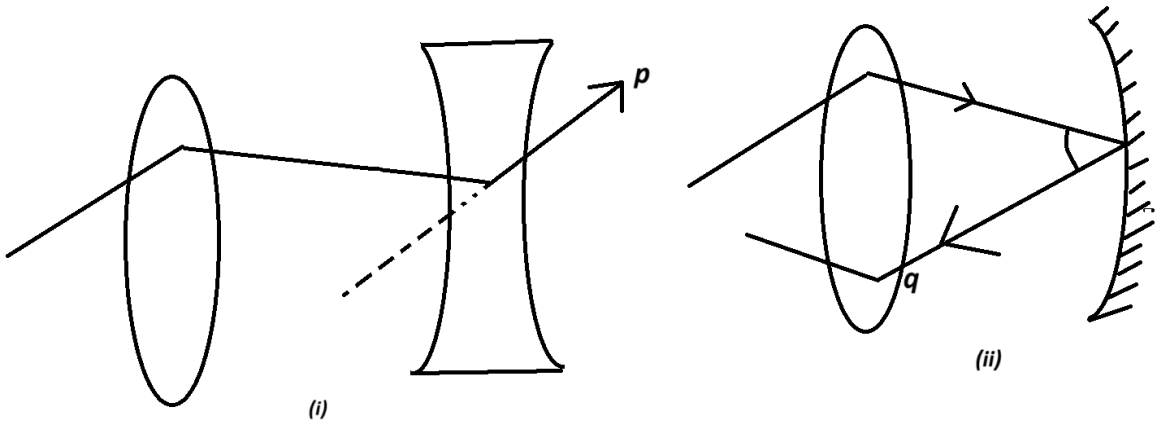
Normal incidence refers to the angle of incidence (measured relative to the normal) being **0°**. If the angle of incidence is **90°**, it is called a **grazing incidence.**





2. An image is formed either by reflection or refraction. A minimum of two (reflected or refracted) rays is required for image formation. The more number of ways, the more will be intensity of Images.

3. A light is only reflected on a silver surface. Without any reflecting surface on the path of the ray of light keeps on moving.

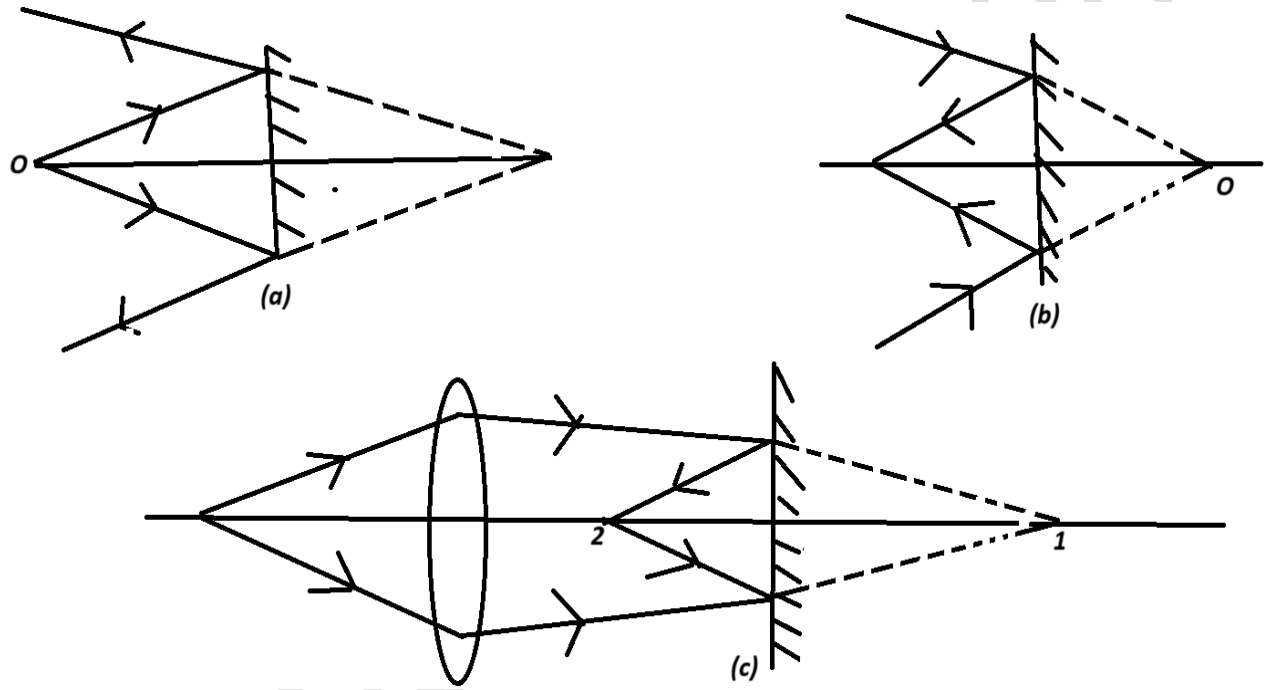


In figure(i): For image formation, if reflected ray- p is required to then we will take it as a dotted line.

In figure (ii): For image formation, if reflected ray q is required to the right of the concave mirror, then we will take it as a dotted line.

IV. Real Object, Virtual Object, Real Image and Virtual Image:

The point where the rays meet (or appear to meet) before refraction or reflection is called the object, and the point where the rays meet(or appear to meet) after refraction is called the Image. Further object(or image and virtual lines if dotted lines meet is real if dark lines meet.



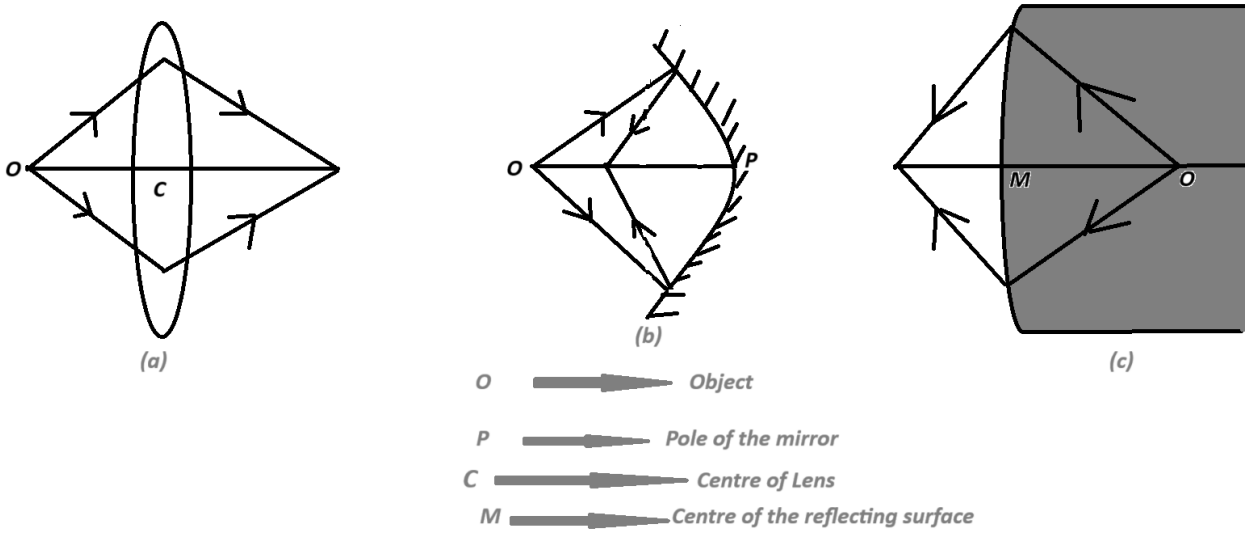
In Figure (a), the object is real, while the image is virtual. In fig. (b), the object is virtual while its image is real.

In Figure (c), the object is real. Its image is formed by the lens ($i.e.I_1$). But, it acts as a virtual object for a mirror, which forms an image (I_2).

The virtual images cannot be taken on screen. But, they can be seen by our eye. Because our eye lens forms a real image on our retina. Thus, if we put a screen at I in the above figure (a), no image will be formed on it.

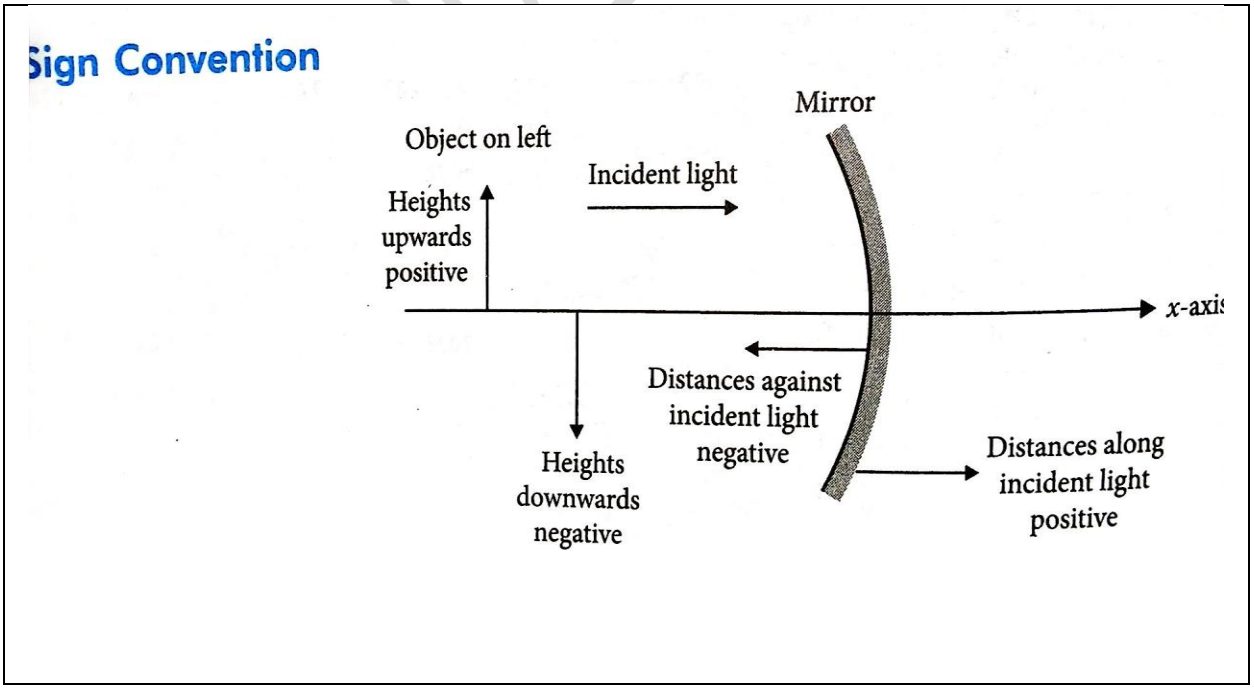
At the same time, if we put the screen at I in Figure (b), an image will be formed,

Normally, the object is kept at the left-hand side of the optical instrument(mirror, lens, etc.), i.e. the ray of light travels from left to right. Sometimes, it may happen that the light is travelling in the opposite direction. See the figure below.



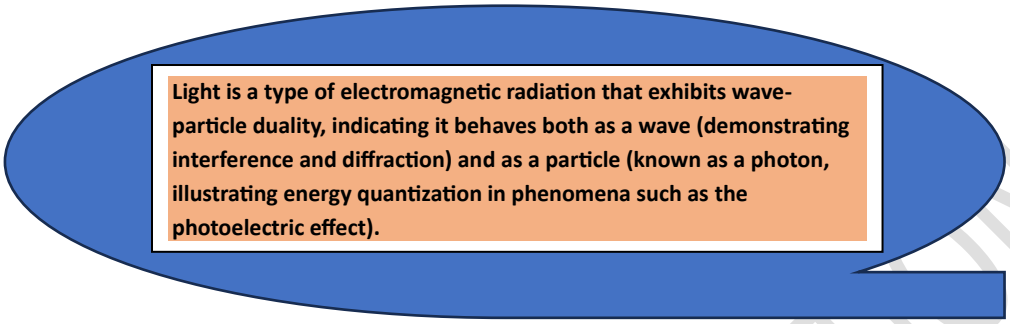
In figures (a) and (b), light is travelling from left to right and in figure (c) it is travelling from right to left.

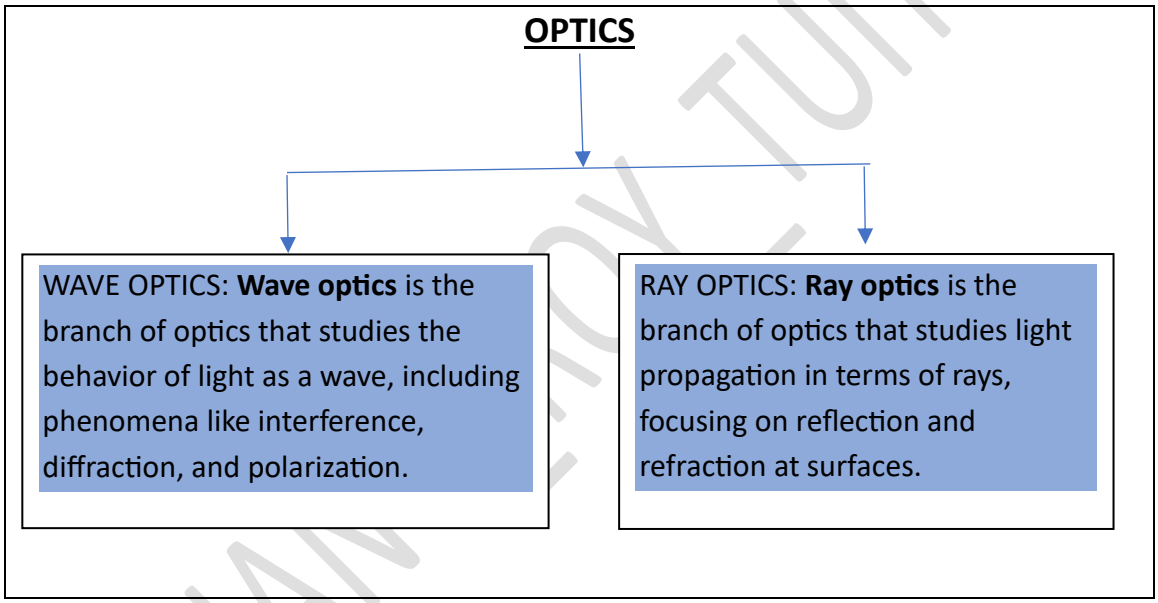
V. Sign Convention:



VI. DEFINITION OF OPTICS:

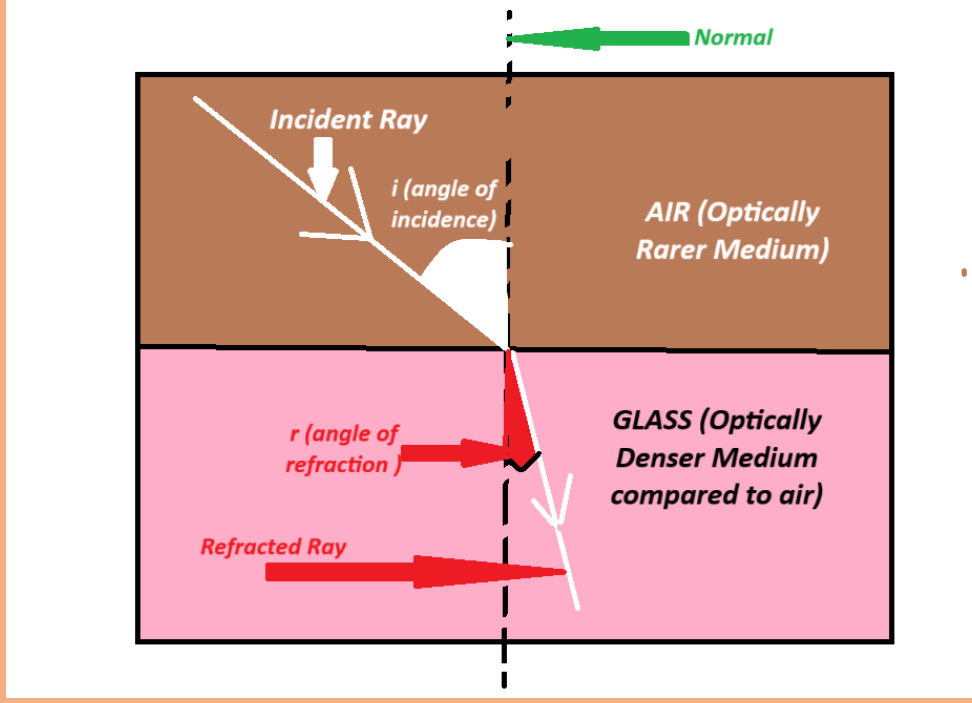
Optics is the branch of physics that deals with the study of ***light***, its behavior, and its interactions with matter.



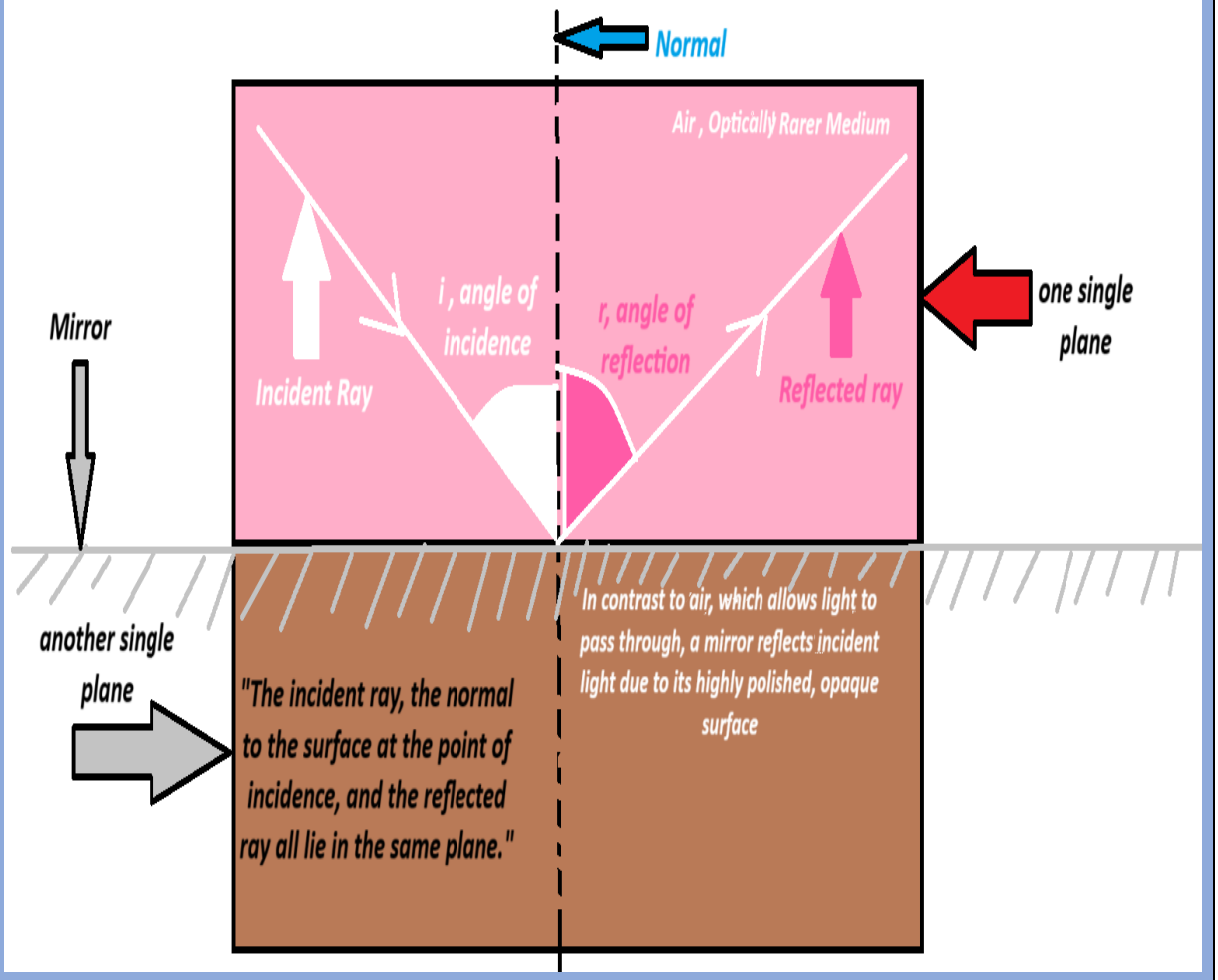


VII. Behavior of Light at the Interface of Two Media

1. Refraction of Light



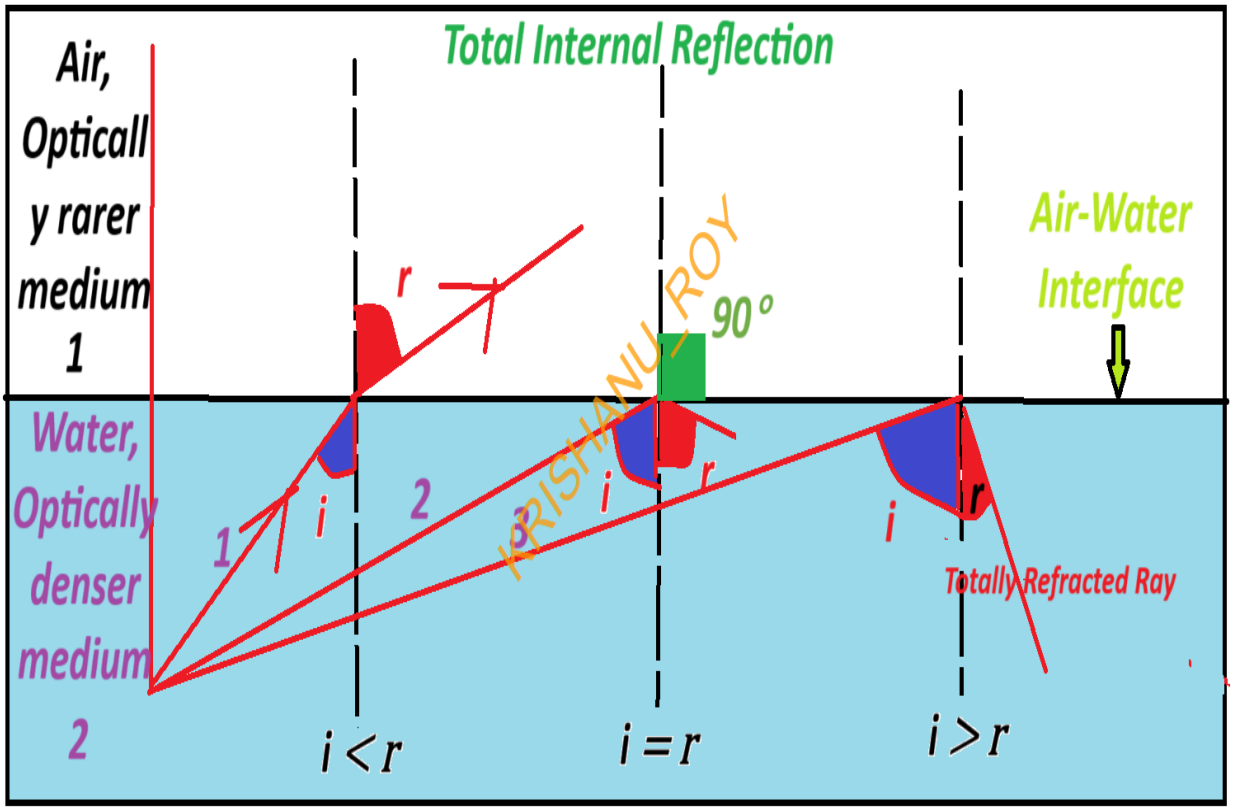
2. Reflection of Light



3. Total Internal Reflection (TIR):

- **TIR happens only under specific conditions**:
  - Light must travel from a **denser to a rarer medium** (e.g., water to air).
  - The **angle of incidence must be greater than the critical angle**.

When these conditions are met, **all** the light is reflected into the denser medium, and **no refraction occurs**. So it's a special case of **100% reflection**.



VIII. Definition of Focal Point (F):

A **focal point (F)** is a specific spot where light rays converge after passing through a lens or reflecting from a mirror. It is an essential concept in optics and photography as it determines where images are formed and how they are focused.

• In a concave mirror (converging mirror), the reflected rays meet at the focal point.

• In a convex mirror (diverging mirror), the reflected rays seem to diverge from a point behind the mirror — this point is known as the focal point.

The ***focal point is located at a distance f = R/2 from the mirror's pole (P)***, where R is the radius of curvature.

IX. SPHERICAL MIRRORS

📘 Key Terms Related to Spherical Mirrors

1. Spherical Mirror: A mirror with a surface that forms part of a sphere.
    - Types: Concave (inward) and Convex (outward).
2. Pole (P): The center of the mirror's surface.
3. Center of Curvature (C): The center of the sphere from which the mirror is a part.
4. Radius of Curvature (R): The distance between the pole and the center of curvature.
5. Principal Axis: The straight line passing through the pole and the center of curvature.
6. Focus (F): The point on the principal axis where parallel rays converge (concave) or appear to diverge (convex).

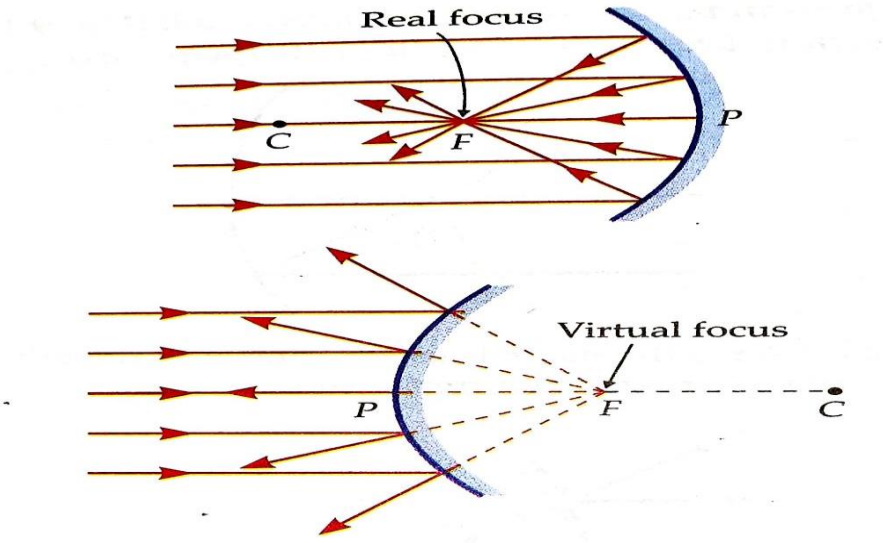


Fig. Principal focus of a concave mirror (PICTURE UP) a convex mirror (PICTURE DOWN).

7. **Focal Length (f):** Distance between the pole and the focus. $f = R/2$

8. **Aperture:** The effective diameter of the mirror.

9. **Object Distance (u):** Distance from the object to the pole.

10. **Image Distance (v):** Distance from the image to the pole.

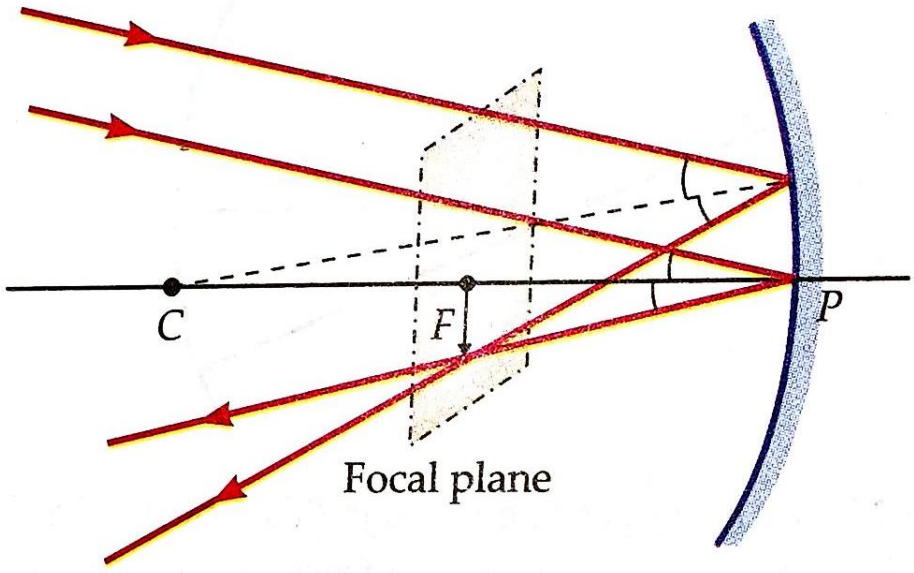


Fig. Focal plane of concave mirror.

NOTE A line joining any point of the spherical mirror to its centre of curvature, will be *normal* to the *mirror* at that point.