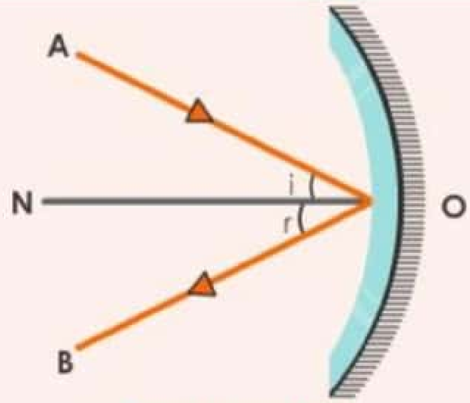
Part I

MIRRORS

1 REFLECTION

When a ray of light is incident at a point on the surface of a mirror, the surface throws **partly or wholly** the incident energy back into the **medium of incidence**. This phenomennon is called reflection.



Concave mirror

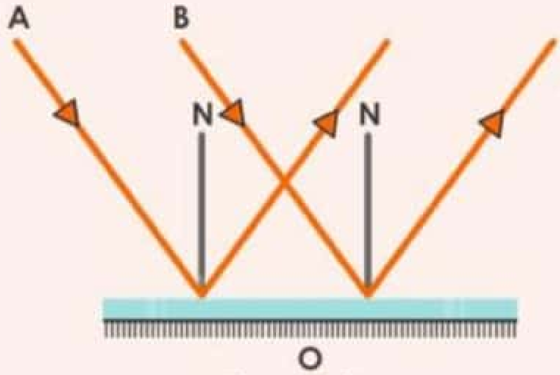
2 LAW OF REFLECTION

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

Note: These laws hold good for all reflecting surfaces either plane or curved.

3 PLANE MIRROR

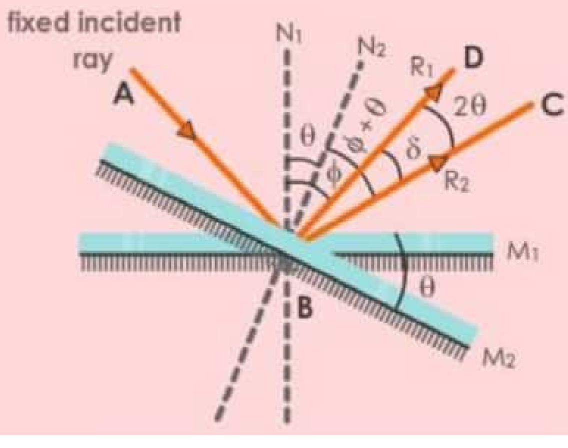
A beam of parallel rays of light, incident on a plane mirror will get reflected as a beam of parallel reflected rays.



Plane mirror

4 ROTATION OF MIRROR

For a **fixed incident light ray**, if the mirror be **rotated** by an **angle** θ (about an axis which lies in the plane of mirror and perpendicular to the plane of incidence), the **reflected ray turns through an angle of** 2θ in the same direction.



Part II

5 NUMBER OF IMAGES FORMED BY TWO INCLINED MIRRORS

θ = Angle between mirrors

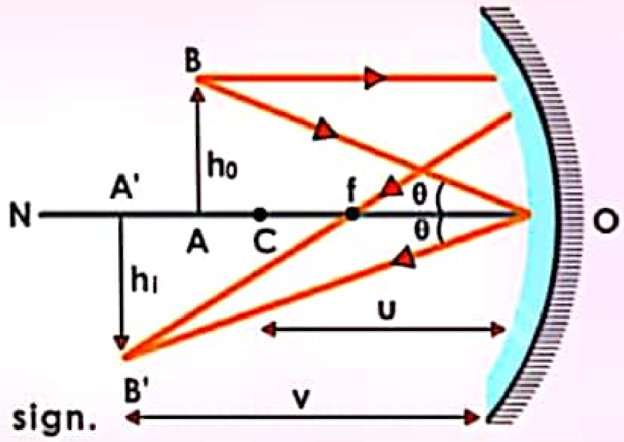
- If $\frac{360^\circ}{\theta}$ = **even number** ; number of images = $\frac{360^\circ}{\theta} - 1$.
- If $\frac{360^\circ}{\theta}$ = **odd number** ; number of images = $\frac{360^\circ}{\theta} - 1$, If the object is placed on the angle bisector.
- If $\frac{360^\circ}{\theta}$ = **odd number** ; number of images = $\frac{360^\circ}{\theta}$, If the object is not placed on the angle bisector.
- If $\frac{360^\circ}{\theta} \neq$ **integer**, then the number of images = **nearest even integer.**

6 TRANSVERSE MAGNIFICATION

$\Delta ABO \sim \Delta A'B'O$

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

- The above formula is valid for **both concave and convex mirror.**
- h_i, h_o, v and u should be **put with appropriate sign.**



7 CONCAVE MIRROR

S.No	Position of object	Details of images			
		Location	Type	Orientation	Magnification
1.	At ∞	At F	real	inverted	$\|m\| << 1$
2.	Between C and ∞	Bet. F and C	real	inverted	$\|m\| < 1$
3.	At C	At C	real	inverted	$\|m\| = 1$
4.	Between F and C	Bet. C and ∞	real	inverted	$\|m\| > 1$
5.	At F	At infinity	real	inverted	$\|m\| >> 1$
6.	Between F and P	Behind the mirror	virtual	erect	$\|m\| > 1$

8 CONVEX MIRROR

Position of object	At infinity	In front of mirror
Details of images	At F, virtual, erect, $\|m\| << 1$	Between P and F, virtual, erect, $\|m\| < 1$

9 VELOCITY IN SPHERICAL MIRROR

Velocity of Image

- Object moving along the principal axis, $V_{IM} = -\frac{v^2}{u^2}(V_{OM})$
- Object moving perpendicular to the principal axis, $\frac{dh_i}{dt} = -\frac{v}{u}\frac{dh_o}{dt}$
- Object moving parallel to the Principal axis, $v_y = \frac{dh_i}{dt} = -h_0\left[\frac{dv}{dt}\cdot\frac{1}{u} - \frac{v}{u^2}\cdot\frac{du}{dt}\right]$

Refraction of Light

$$\mu = \frac{c}{v} = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$$

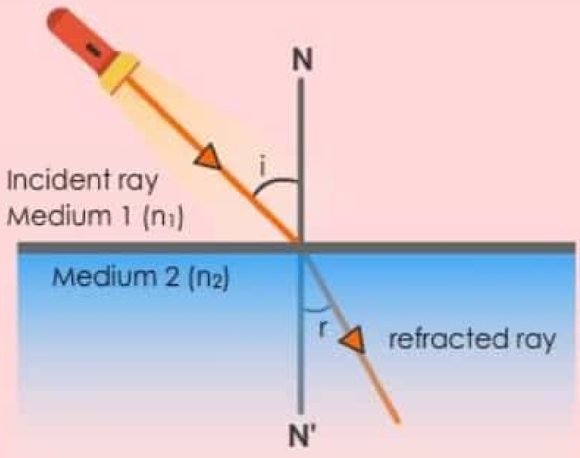
μ = Refractive Index

10 LAWS OF REFRACTION

- The **incident ray, the normal** to any refracting surface at the point of incidence and the **refracted ray,** all **lie in the same plane** called the plane of incidence or plane of refraction.
- $\frac{\sin i}{\sin r}$ = **Constant** for any pair of media and for light of a given wavelength.

This is known as **Snell's Law.**

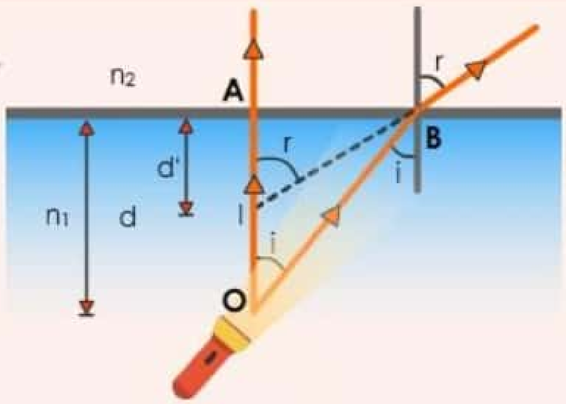
Also, $\frac{\sin i}{\sin r} = \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$



11 APPARENT DEPTH AND NORMAL SHIFT

When the object is in denser medium and the observer is in rarer medium (near normal incidence)

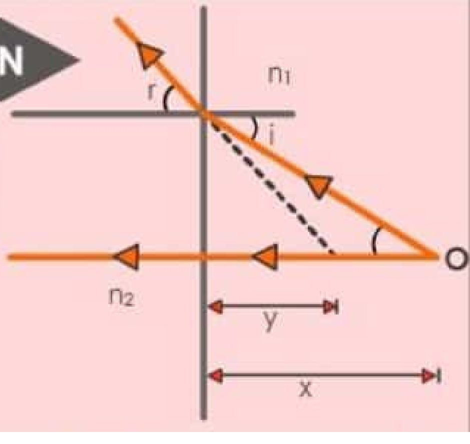
$$\frac{n_2}{n_1} = \frac{d'}{d} = \frac{\text{Apparent depth}}{\text{Real depth}}$$



12 IMAGE VELOCITY IN CASE OF PLANE REFRACTION

$$\frac{n_2}{n_1} = \frac{y}{x} \Rightarrow y = \frac{n_2}{n_1}.x$$

$$\frac{dy}{dt} = \frac{n_2}{n_1}\frac{dy}{dt} \Rightarrow V_{IS} = \frac{n_2}{n_1}V_{OS}$$

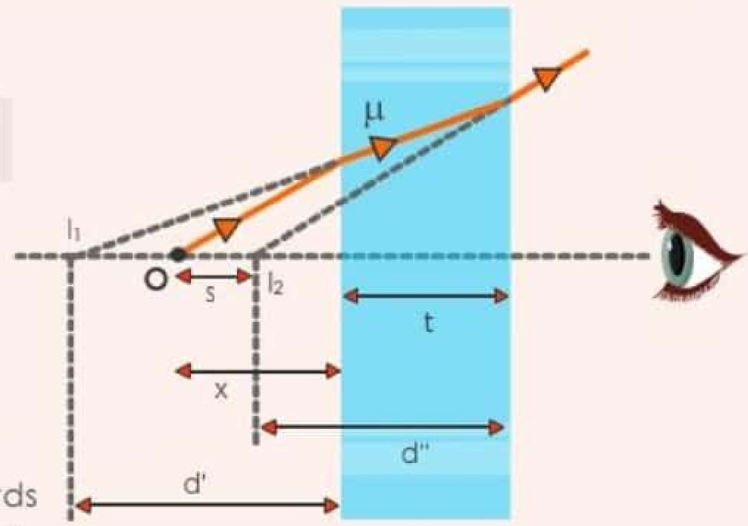


Part IV

13 REFRACTION THROUGH A GLASS SLAB

Apparent shift due to the slab when object is seen normally through the slab

$$S = t\left[1 - \frac{\mu_{surrounding}}{\mu_{slab}}\right]$$



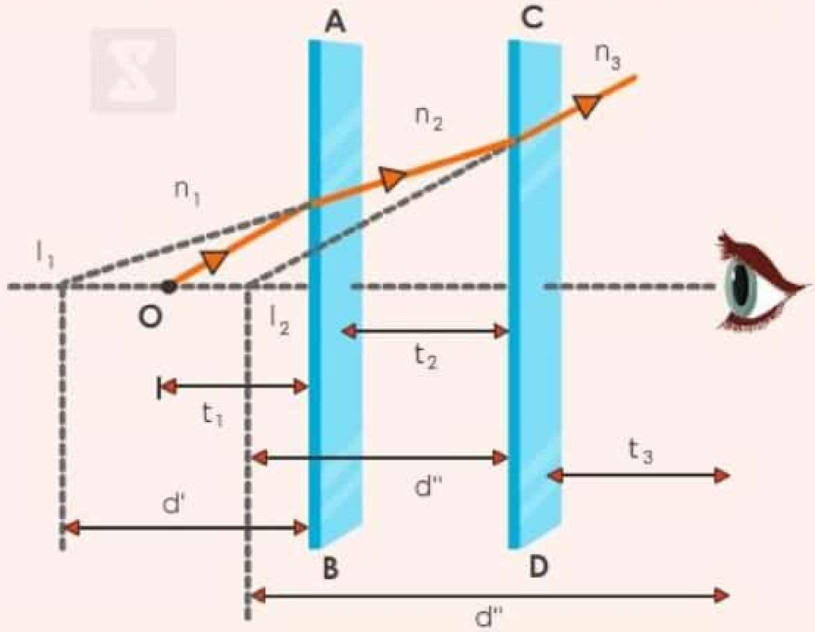
IMPORTANT POINTS

- Rays should be **paraxial.**
- **Medium** on both side of the slab **should be same.**
- Shift comes **out from** the object.
- Shift is **independent** of the **distance of the object** from the slab.
- If shift comes **out Positive** then shift is towards the **direction of incident rays** and vice versa.

Apparent distance between object and observer when both are in different medium

$$d'' = n_3\left[\frac{t_1}{n_1} + \frac{t_2}{n_2} + \frac{t_3}{n_3}\right]$$

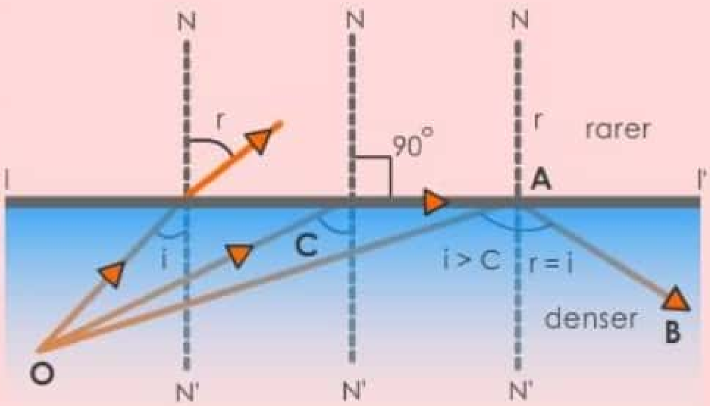
If object and observer are in **same medium** then **shift formula** should be used and if both are in **different medium** then the **above formula** of apparent distance should be used.



14 CRITICAL ANGLE AND TOTAL INTERNAL REFLECTION

Critical angle is the angle made in a **denser medium** for which the **angle of refraction in rarer medium is 90°.**

$$\therefore C = \sin^{-1}\frac{n_r}{n_d}$$



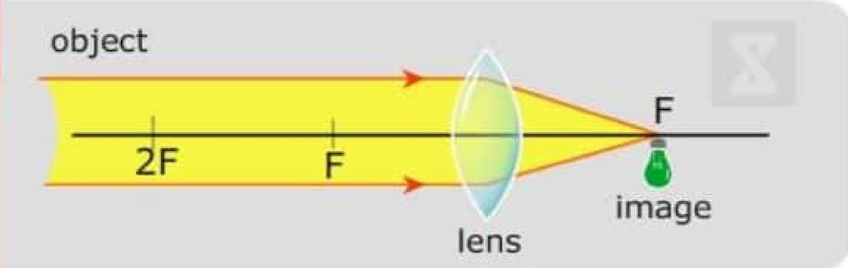
Conditions of Total Internal Reflection

- Light is incident on the interface from denser medium.
- Angle of incidence should be **greater than** the critical angle (i > c).

IMAGE FORMED BY LENSES

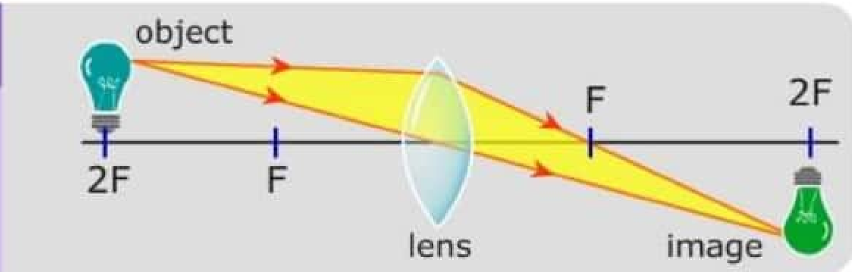
Distant Object

- Real
- Inverted
- Smaller than object
- At Focus



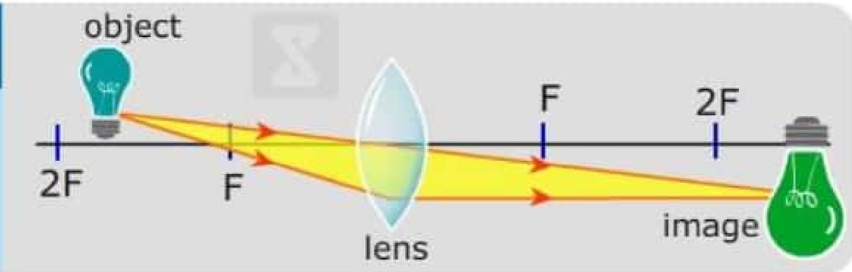
Object at 2F

- Real
- Inverted
- Same size as object
- At 2F



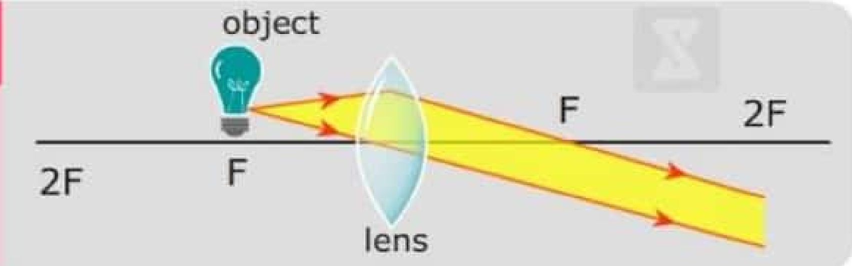
Object between 2F and F

- Real
- Inverted
- Larger than object
- Beyond 2F



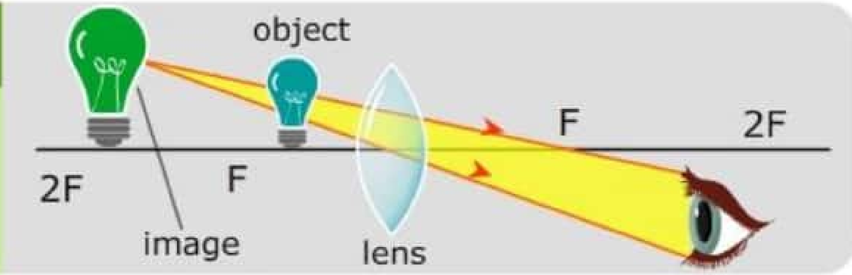
Object at F

- Real
- Inverted
- Highly magnified
- At infinity



Object between F and lens

- Virtual
- Erect
- Magnified
- At same side as object



Images formed by a concave lens

Object is at F

- Virtual
- Upright
- Smaller than object
- Between object and the lens