ALLEN®

OPTICS : REFRACTION OF LIGHT

You might have observed that a lemon kept in water in a glass tumbler appears to be bigger than its actual size, when viewed from the sides. All these dayto-day experiences are based on a phenomenon called 'refraction'.

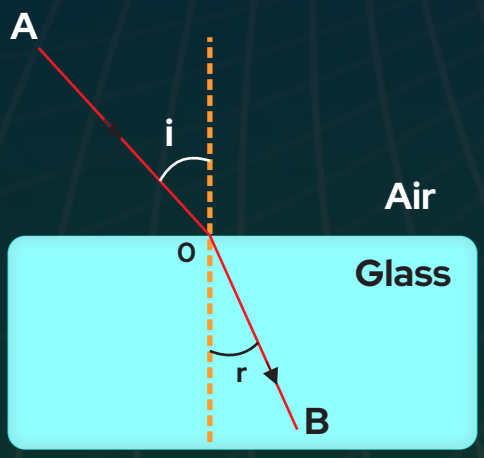
Principle of least time

We all know that light ordinarily travels in straight lines. In going from one place to another, light will take the most efficient path and travel in a straight line.

This idea, which was formulated by the French scientist Pierre Fermat in about 1650, is called Fermat's principle of least time.

Refraction of light

The phenomenon of change in path of light when it passes from one medium to another is called 'refraction'.



Optically rarer medium

A transparent medium in which the speed of light is more is called 'optically rarer medium' (or simply 'rarer medium').

Optically denser medium

A transparent medium in which the speed of light is less is called 'optically denser medium' (or simply 'denser medium').

Cause of Refraction

The bending of light takes place when it passes from one medium to another because speed of light changes from one medium to another. Speed of light is different in different media.

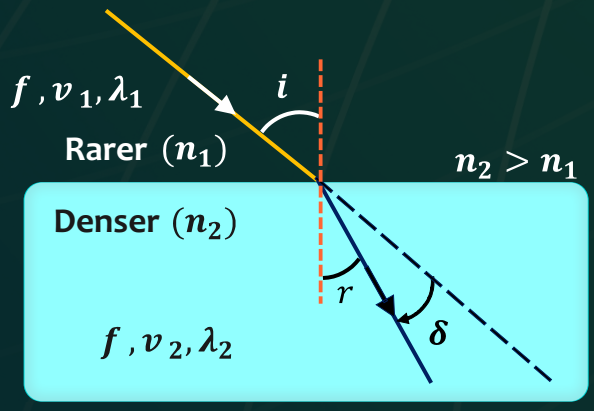
What does not change during refraction of light?

The frequency of light does not change during the refraction of light. The speed and wavelength of light change during refraction of light.

$$\frac{V_1}{V_2} = \frac{\lambda_1}{\lambda_2}$$

REFRACTION THROUGH

	Rarer to denser	Denser to rarer
1.	Refracted ray bends towards the normal	Refracted ray bends away from the normal
2.	Frequency unchanged	Frequency unchanged
3.	Speed decreases	Speed increases
4.	Wavelength decreases	Wavelength increases
5.	Angle of incidence is greater than angle of refraction	Angle of incidence is less than angle of refraction



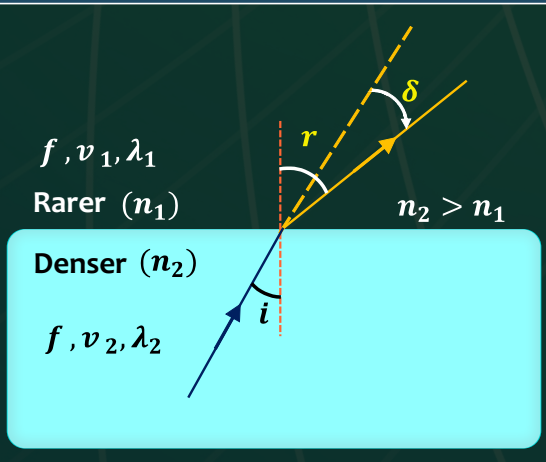
$i > r$

$v_1 > v_2$

$\lambda_1 > \lambda_2$

$\delta = i - r$

Light rays bend towards the normal after refraction.



$i < r$

$v_1 > v_2$

$\lambda_1 > \lambda_2$

$\delta = r - i$

Light rays bend away from the normal after refraction

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Laws of refraction

The incident ray, the normal to the refracting surface at the point of incidence and the refracted ray, all lie in the same plane.

Laws of refraction

The ratio of sine of angle of incidence to the sine of angle of refraction is constant for two given media.

$$\frac{\sin i}{\sin r} = \text{constant} = n_{21} \quad \textbf{(Snell's Law)}$$

n_{21} = Refractive index of medium 2 with respect medium 1



Angle of deviation (δ)

The angle through which the incident ray of light is deviated from its original path when it is refracted while passing from one transparent medium to another is called 'angle of deviation'

Relative refractive index of a medium (n_{21})

The relative refractive index of a medium 2 with respect to medium 1 is the ratio of speed of light in medium 1 to the speed of light in medium 2.

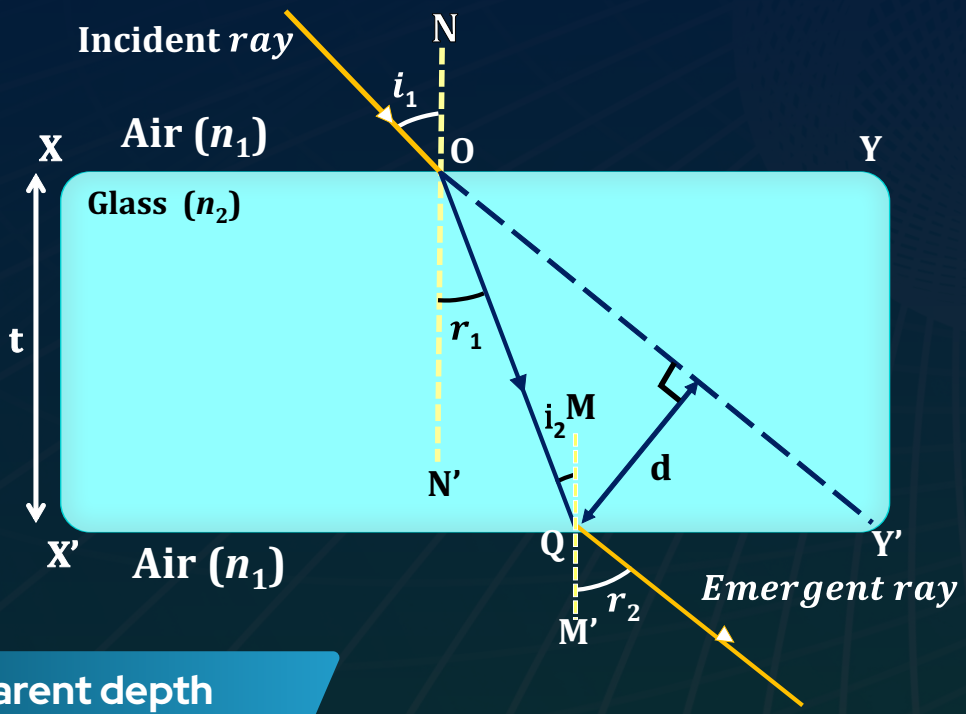
$$n_{21} = \frac{\text{speed of light in medium 1}}{\text{speed of light in medium 2}} \quad \text{or} \quad \boxed{n_{21} = \frac{V_1}{V_2}}$$

Absolute refractive index of a medium

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

Refraction Through A Glass Slab

incident Ray Is Parallel To The Emergent Ray But The Incident Ray Is Laterally Displaced.



Apparent depth

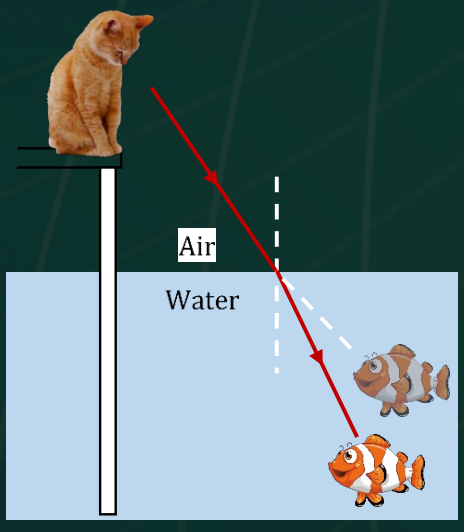
When an object lying inside an optically denser medium is seen from a rarer medium, its depth appears to be less than its real depth. This depth is called 'apparent depth'.

Ex. Fish In The Aquarium

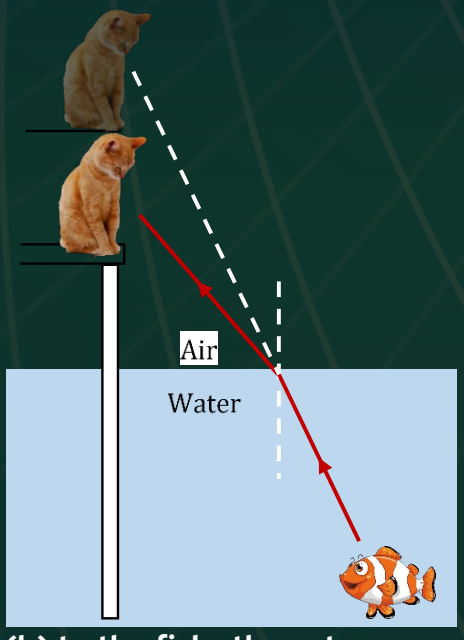
$$n_{12} = \frac{\text{Real depth}}{\text{Apparent depth}}$$







(a) to the cat on the platform the fish looks closer to the surface of water then it really is.



(b) to the fish , the cat seems to be farther from the surface then it actually is.

IMAGE FORMATION BY A CONVEX LENS

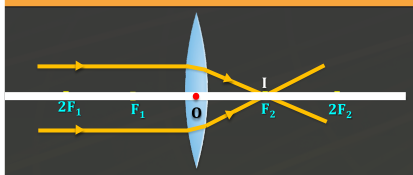
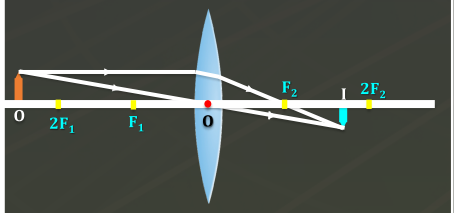
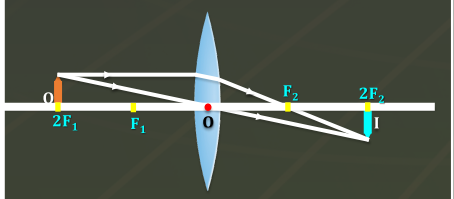
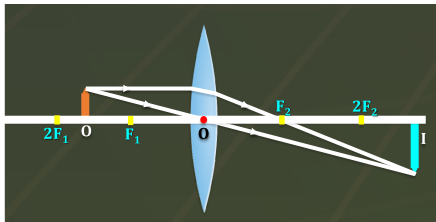
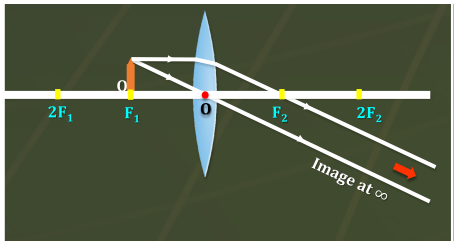
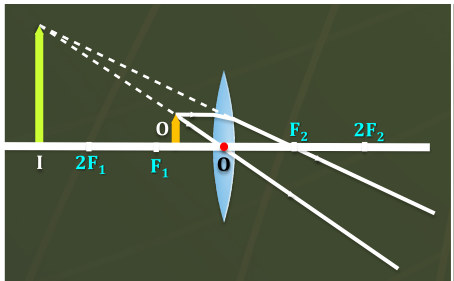
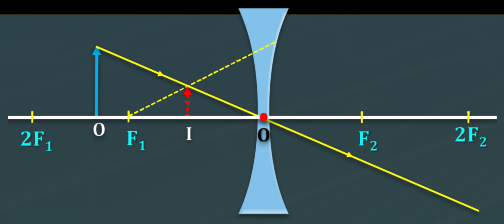
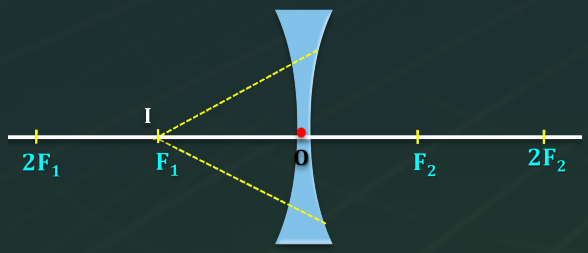
	Position of the object	Position of the Image	Size of the Image	Nature of the Image
	At infinity	Zero	Highly diminished, point sized	Real & inverted
	Beyond $2F_1$	Between F and 2F	Diminished	Real & inverted
	At $2F_1$	At 2F	Same size	Real & inverted
	Between F_1 and $2F_1$	Beyond 2F	Enlarged	Real & inverted
	At F	At infinity	Highly enlarged	Real & inverted
	Between O and F_1	At infinity	Enlarged	Virtual & erect

IMAGE FORMATION BY CONCAVE LENS

	Position of the Image	Position of the Image	Size of the Image	Nature of the Image
	At infinity	At focus F	Highly diminished, point sized	Virtual and erect
	Between ∞ and O	Between O and F same side as the object	Diminished	Virtual and erect

Uses of Lens

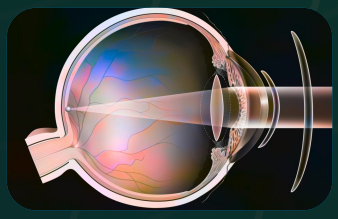
Convex lens

- In all the optical instruments like, magnifying glass, microscope, binoculars, telescope, cameras, overhead projectors.

In magnifying glass



In eye lens



In spectacles



Concave lens

- In door lenses, for correction of vision.



In door lenses



For correction of vision *(Contact lenses)*



For correction of vision

Lens Formula

The relationship between object distance (u), the image distance (v) and the focal length (f) is given by lens formula.

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

- The distance of the object from optical centre of the lens is called the object distance (u).
- The distance of the image from optical centre of the lens is called the image distance (v).

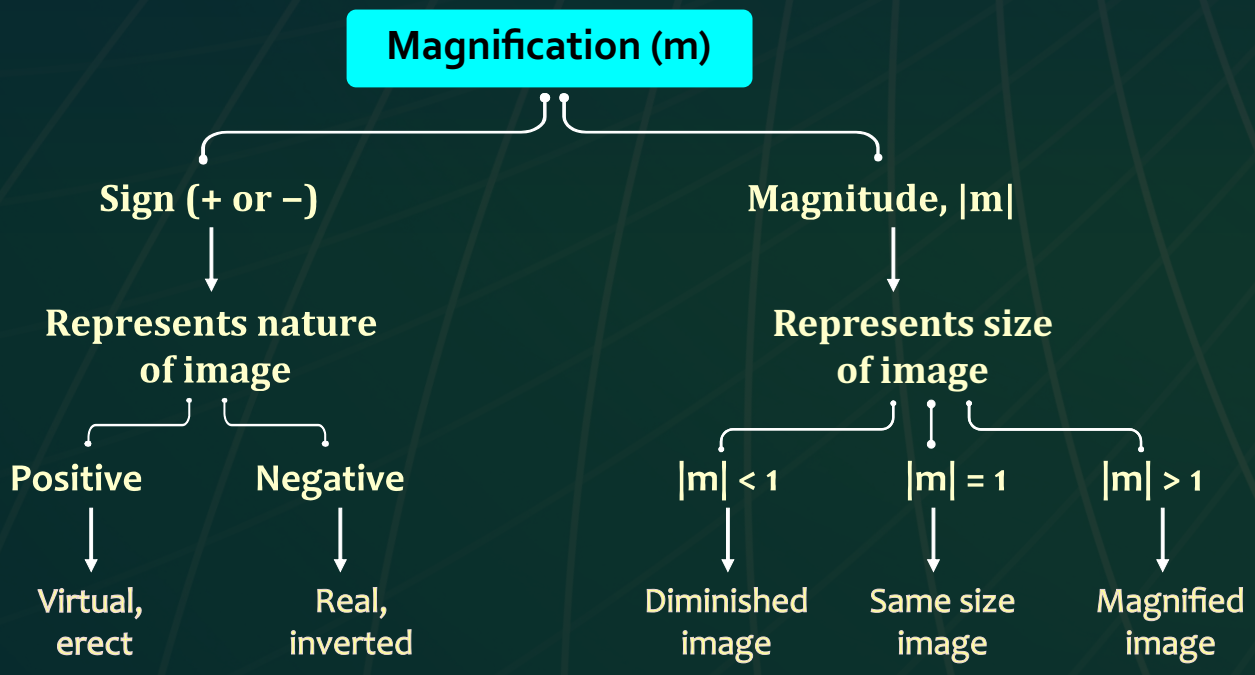
Magnification (m)

The ratio of height of image (h_2) to the height of object (h_1) is called magnification or linear magnification.

$$m=\frac{h_2}{h_1}$$

- The magnification (m) is also related to the object distance (u) and image distance (v).

$$m=\frac{h_2}{h_1}=\frac{v}{u}$$





Power of lens

Reciprocal of its focal length. $P = \frac{1}{f}$

- Unit of power of lens = Diopter (D)
  1 diopter = $1\ m^{-1}$

➔ Power of convex lens (converging lens) is 'positive'

➔ Power of concave lens (diverging lens) is 'negative'.