

TGES

REFRACTION OF LIGHT AT
PLANE SURFACES

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2013

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REFRACTION, LAWS OF REFRACTION AND REFRACTIVE INDEX

REFRACTION OF LIGHT

Change of medium causes partial reflection and refraction:

In a homogeneous transparent medium, light travels in a straight line path. But when a ray of light travelling in one transparent medium strikes obliquely on the surface of another transparent medium, a part of the light returns back into the same medium which is called the reflected light and the rest of the light travels into the other medium, in a direction different from its initial path which is called the refracted light.

Thus, at the boundary separating the two media, light suffers a partial reflection and partial refraction.

The change in direction of the path of light, when it passes from one transparent medium to another transparent medium, is called refraction.

SOME SIMPLE DEFINITIONS

(i) **Incident ray:** A ray of light, travelling towards another optical medium, is called incident ray.

(ii) **Point of incidence:** The point, where an incident ray strikes another optical medium is called the point of incidence.

(iii) **Normal:** A perpendicular drawn at the point of incidence is called normal.

(iv) **Angle of incidence:** The angle which the incident ray makes with the normal is called angle of incidence.

(v) **Refracted ray:** A ray of light which deviates from its path on entering in another optical medium is called refracted ray.

(vi) **Angle of refraction:** The angle which the refracted ray makes with the normal is called angle of refraction.

The direction in which the ray of light bends depends upon:

1. The medium through which the ray of light is initially travelling
2. The optical density of the two media which gives rise to the phenomenon of refraction.

The following situations can arise

(1) *When a ray of light travels from a rarer medium to a denser medium, it bends towards the normal* (i.e. $\hat{i} > \hat{r}$) as shown in the fig 1.1. The deviation of the ray is $\delta = i - r$

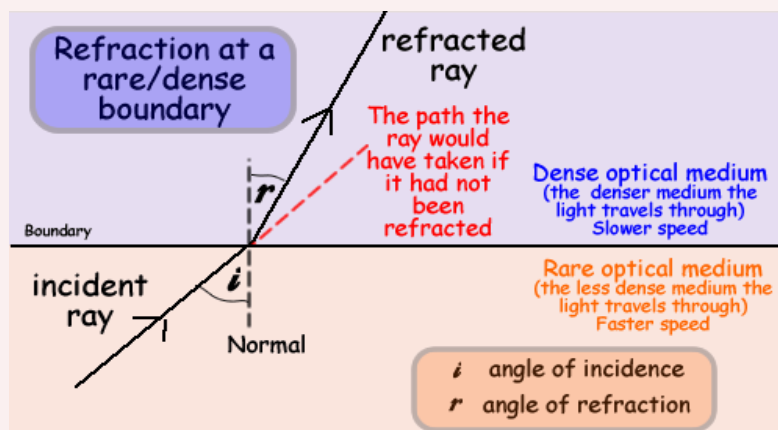


Fig 1.1

(2) When a ray of light travels from a denser medium to a rarer medium it bends away from the normal (i.e. $\hat{i} < \hat{r}$) as shown in Fig-1.2 .The deviation of the ray is $\delta = r - i$

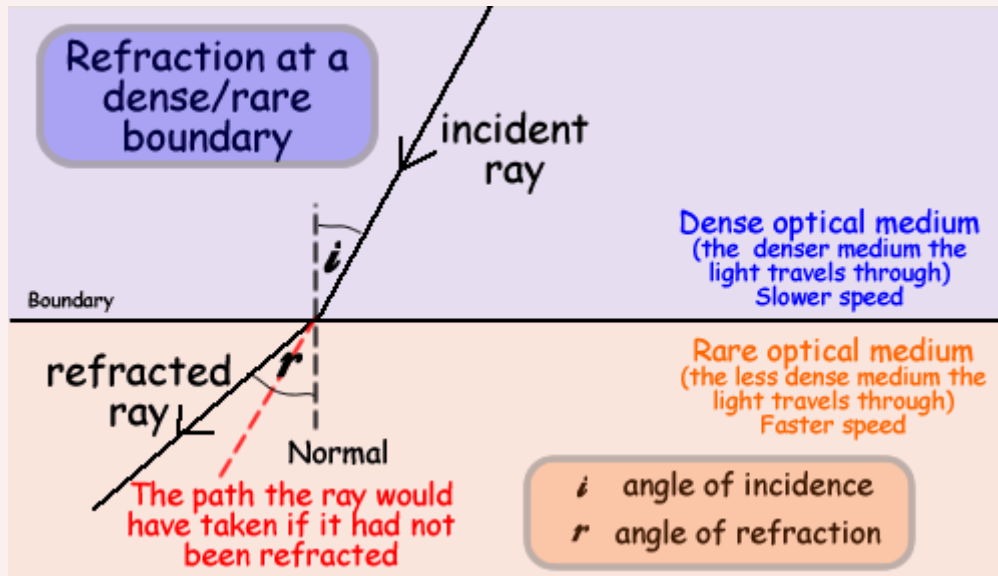


Fig-1.2

(3) The ray of light which is incident normally on the surface separating the two media passes undeviated.

Thus if angle of incidence is 0° , then angle of refraction is 0° . The deviation is zero. (I.e. $\delta = 0$)

Causes of refraction

The refraction of light occurs because light travels with different speeds in different media. When a ray of light passes from one medium to another, its direction changes because of change in its speed.

LAWS OF REFRACTION

The refraction of light obeys the following two laws of refraction:

(1) The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.

(2) The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant for the pair of given media. This constant is called the refractive index of the second medium with respect to the first medium.

$$\frac{\sin i}{\sin r} = {}_1\mu_2$$

The above laws are known as Snell's laws.

Refractive index

The refractive index of second medium with respect to the first medium is defined as the ratio of the sine of the angle of incidence in the first medium to the sine of the angle of refraction in the second medium.

Refractive index has no unit as it is the ratio of two similar.

Relationship between refractive index and speed of light

The refractive index of a medium is defined with respect to vacuum is called the absolute refractive index of the medium.

The absolute refractive index of a medium is defined as the ratio of the speed of light in vacuum to the speed of light in that medium, i.e.

$$\mu = \frac{\text{speed of light in vacuum or air } (c)}{\text{speed of light in that medium } (v)}$$

The absolute refractive index of a transparent medium is always greater than 1, because speed of light in any medium is always less than that in vacuum.

The refractive index of glass is 1.5; it means that the light travels in air 1.5 times faster than in glass.

Conditions for no change in direction of light ray on refraction

1. When the angle of incidence at the boundary of two media is zero
2. When the refractive index of medium 2 is same as the refractive index of medium 1.

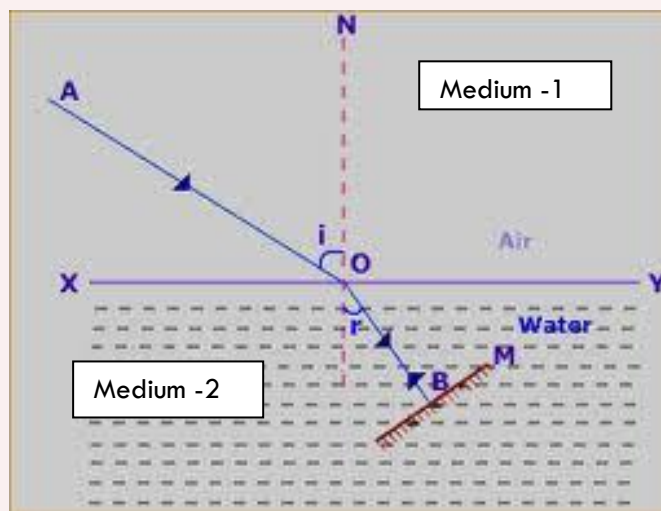
Factors affecting the refractive index of a medium

1. **Nature of the medium (optical density):** Smaller the speed of light in a medium relative to air, higher is the refractive index of that medium.
2. **Temperature:** with increase in temperature, the speed of light in medium increases, so the refractive index of medium decreases.
3. **The colour or wavelength of light:** In a medium, red light travels faster than the violet light, therefore the refractive

index of a medium is more for violet and less for red light. Thus refractive index increases with the decrease in wavelength.

Principle of reversibility of the path of light

According to the principle of reversibility, if a ray of light travels from medium 1 to medium 2 along a certain path, it will follow exactly the same path, while travelling from medium 2 to medium 1. In other words, the path of light is reversible.



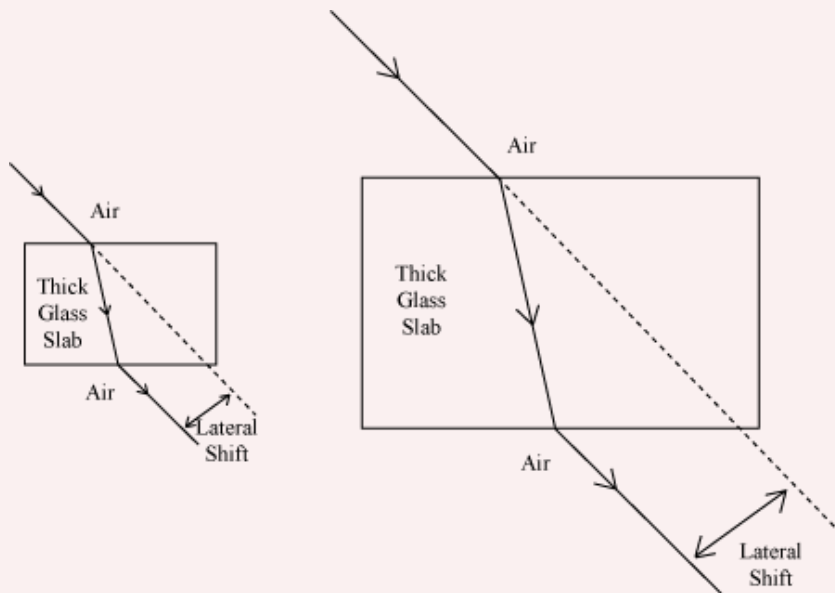
$${}_1\mu_2 = \frac{\sin i}{\sin r}$$

$${}_2\mu_1 = \frac{\sin r}{\sin i}$$

$${}_1\mu_2 = \frac{1}{{}_2\mu_1}$$

Lateral Displacement

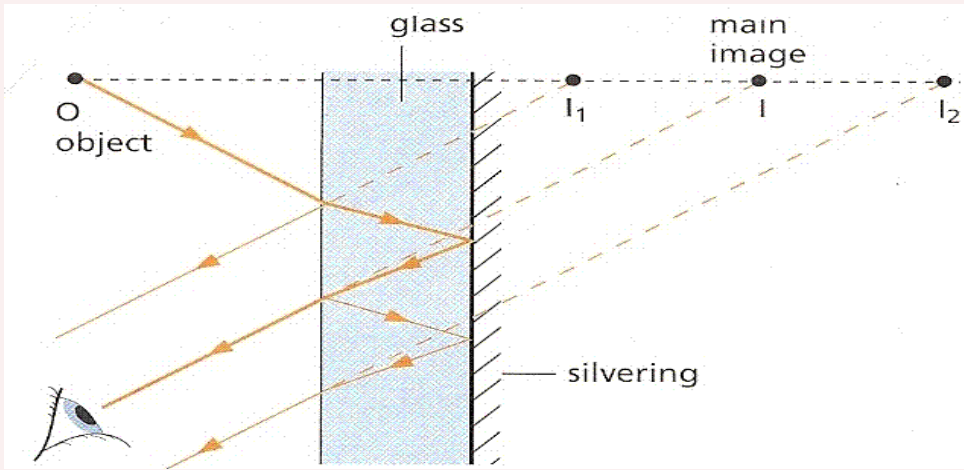
The perpendicular distance between the path of emergent ray and the path of incident ray is called the lateral displacement.



The lateral displacement depends on

1. **The thickness of the glass block:** Lateral displacement increases with the increase in thickness of the medium.
2. **The angle of incidence:** Lateral displacement increases with the increase in angle of incidence.
3. **The refractive index of glass, and therefore also on the wavelength of light used:** Refractive index increases with the decrease in wavelength of light, so lateral displacement increases with the decrease in wavelength of light.

Multiple images in a thick plane glass plate or thick mirror



If an object is placed in front of a thick plane glass plate and is viewed obliquely, a number of images are seen. Out of these images, the second image is the brightest, while others are of diminishing brightness.

When a ray of light falls on the surface of the glass slab, a small part of light about 4% is reflected forming a faint virtual image at I_1 , while a larger part of light nearly 96% is refracted inside the glass. The ray which now strikes is strongly reflected back by the mirror. The image I formed is therefore the brightest image