Refraction of light at plane surfaces

Refraction of light
Definition:
The direction of propagation of an obliquely incident ray of light that enters the other medium, changes at the interference at the interface of the two media. This phenomenon is called as refraction of light.
Refraction is the change in direction of wave propagation due to a change in its transmission med

The phenomenon is explained by the conservation of energy and the conservation of momentum. Due to change of medium, the phase velocity of the wave is changed but its frequency remains constant.

Terms related to refraction

Incident ray: The ray which falls on the surface of separation(or interface) to enter into the new me
Refracted ray: The ray in the second medium, obtained after refraction.
Normal: Imaginary straight line perpendicular to the refracting surface at the point of refraction.
Angle of incidence (i): Angle between the incident ray and the normal.
Angle of refraction (r): Angle between the refracted ray and the normal.

Example

Examples of refraction
Some common examples of refraction in our daily life include the formation of rainbow, blue colour of sky and oceans, reddish sun during sunrise and sunset, etc.

Rarer and Denser Medium

When light refracts from one medium to another, one of the medium is termed as rarer and other is termed as denser. Hence rarer and denser medium is a relative term. The medium in which speed of light is more is termed as a rarer medium and the medium in which the speed of light is less is termed as a denser medium.
When light refracts from rarer to denser medium it bends towards the normal as shown in the figure above.

Refractive index

Refractive index of a medium is defined as the ratio of the speed of light in vacuum to the speed of light in air.

μ or $n=cv$

Note: $\mu \geq 1$

It is usually found using Snell's laws of refraction.

Definition

Optical density of medium

Definition:

The optical density of a material is a logarithmic ratio of the falling radiation to the transmitted radiation through a material. It is also referred as a fraction of absorbed radiation at a particular w
The speed of light depends on the characteristics of the medium on which it is incident; the optical density of the medium influences the speed of light.

Optical density of the medium refers to the sluggish tendency of the atoms of a material to retain the energy absorbed from the electromagnetic wave in the form of vibrating electrons before being reemitted as an electromagnetic disturbance.

The refractive index of the material is an indicator of its optical density. Spectrometer is used to measure the optical density of a material.

Law

Laws of refraction

According to laws of refraction (Snell's Laws):

1. The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same p
2. The ratio of the sine of the angle of incidence i 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 w.r.t. the first medium.

$1\mu 2=\sin i/\sin r$

Note:

1. When light ray is incident normally, only speed changes and direction of light remains the sam
2. When light ray passes from rarer medium to denser medium, it bends towards the normal.
3. When light ray passes from denser medium to rarer medium, it bends away from the normal.

Snell's Law
The ratio of the sine of the angle of incidence to the sine of angle of refraction is constant. This is known as the Snell's Law.
From Snell's Law, we have

$n1\sin\theta1=n2\sin\theta2$
hence,

$\sin\theta1/\sin\theta2=n2/n1=v1/v2=\lambda1/\lambda2$

Critical angle

When the angle of incidence in water reaches a certain critical value, the refracted ray lies along the boundary, having an angle of refraction of 90-degrees. This angle of incidence is known as the critical angle; it is the largest angle of incidence for which refraction can still occur. For any angle of incidence greater than the critical angle, light will undergo total internal reflection.

Definition:
The angle of incidence beyond which rays of light passing through a denser medium to the surface of a less dense medium are no longer refracted but totally reflected.
Definition
Total internal reflection (TIR)

Introduction:
When light travels from an optically denser medium to a rarer medium at the interface, it is partly reflected back into the same medium and partly refracted to the second medium. This reflection is called the internal reflection.

Definition:
Total internal reflection is defined as the complete reflection of a light ray at the boundary of two media, when the ray is in the medium with greater refractive index.

Optical fibre and it uses

An optical fiber or optical fibre is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair. Optical fibers are used most often as a means to transmit light between the two ends of the fiber and find wide usage in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths than wire cables. Fibers are used instead of metal wires because signals travel along them with lesser amounts of loss; in addition, fibers are also immune to electromagnetic interference, a problem from which metal wires suffer excessively.

The uses of optical fibre are given bellow:

1. Communication - Telephone transmission method uses fibre-optic cables. Optical fibres transmit energy in the form of light pulses. The technology is similar to that of the coaxial cable, except that the optical fibres can handle tens of thousands of conversations simultaneously.
2. Medical uses - Optical fibres are well suited for medical use. They can be made in extremely thin, flexible strands for insertion into the blood vessels, lungs, and other hollow parts of the body. Optical fibres are used in a number of instruments that enable doctors to view internal body parts without having to perform surgery.
3. Simple uses - The simplest application of optical fibres is the transmission of light to locations otherwise hard to reach. Also, bundles of several thousand very thin fibres assembled precisely side by side and optically polished at their ends, can be used to transmit images.

Total internal reflection is a powerful tool since it can be used to confine light. One of the most common applications of total internal reflection is in fibre optics. An optical fibre is a thin, transparent fibre, usually made of glass or plastic, for transmitting light. The construction of a single optical fibre is shown in the figure.The basic functional structure of an optical fiber consists of an outer protective cladding and an inner core through which light pulses travel. The overall diameter of the fiber is about 125μm and that of the core is just about 50μm. The difference in refractive index of the cladding and the core allows total internal reflection in the same way as happens at an air-water surface show in the figure . If light is incident on a cable end with an angle of incidence greater than the critical angle then the light will remain trapped inside the glass strand. In this way, light travels very quickly down the length of the cable over a very long distance (tens of kilometers). Optical fibers are commonly used in telecommunications, because information can be transported over long distances, with minimal loss of data. Another common use can be found in medicine in endoscopes. The field of applied science and engineering concerned with the design and application of optical fibers are called fiber optics.

An incident light gets refracted into the diamond crystal. Dispersion causes the light to split into different colours that are seen in the diamond crystal. Due to high refractive index of diamond (around 2.4), diamond has a very small critical angle. Thus most of the rays of light go multiple total internal reflections before they refract out of the crystal.