VIVEKANAND EDUCATION SOCIETY'S POLYTECHNIC

Study Material

Program Code: Common to all 1st sem

Semester: 1

Course Name: Basic Science (Physics)

Course Code: 22102

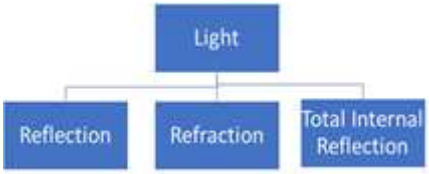
Topic Name: Heat and Optics

UO3e.Distinguish the phenomena of total internal refection for the given media.

LO5: Students will be able to explain reflection, refraction and total internal reflection .

Course Expert: Mrs. Deepa Gupte	**Date: 21/9/2020**

Concept Map:



Key words: Reflection, Refraction and Total internal reflection

Key Questions: What is Total internal reflection

Key Definition/Formula: Reflection, Refraction and Total internal reflection, Snell's law, critical angle

Diagram:

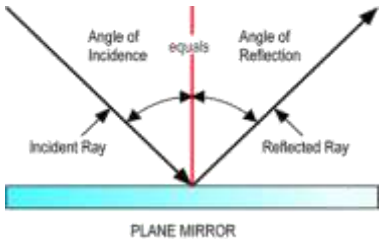
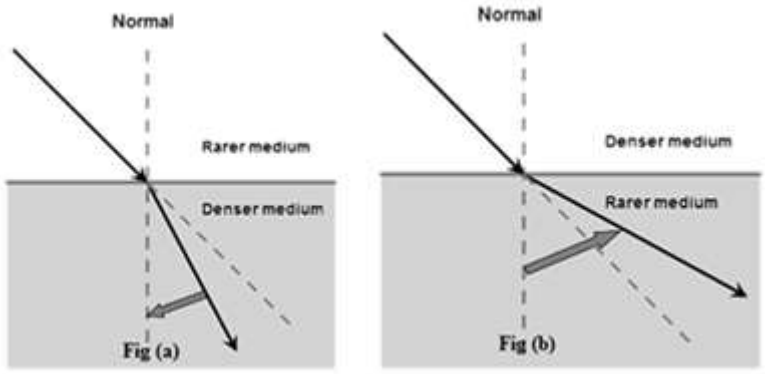


Fig 1(above) Fig 2(below)



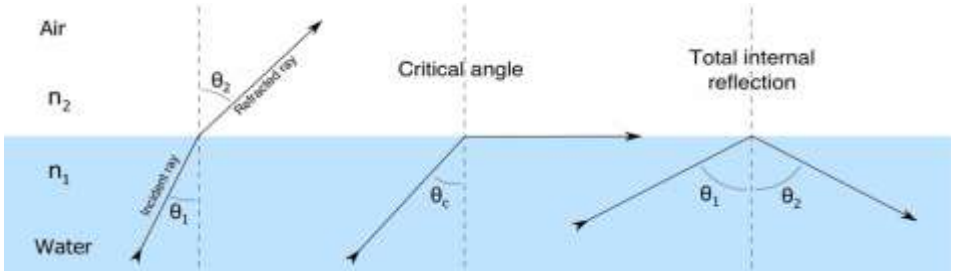


Fig 3: Total Internal Reflection

Notes:

Introduction:

In this topic, we consider the phenomena of reflection, refraction and total internal reflection of light. Using the basic laws of reflection, refraction and total internal reflection (T.I.R), we shall study the principle, structure of optical fiber and propagation of light through it.

Laws of Reflection:

When a ray of light falls on a smooth polished surface (mirror) it is reflected from the surface.

As shown in Fig. 1, AB is the incident light on the mirror surface MM. BN is normal to the surface and BC is the reflected ray. The angle between the incident ray and the normal to the reflecting surface i.e., ∠i is the angle of incidence. The angle between the reflected ray and the normal to the reflecting surface i.e., ∠r is the angle of reflection. The plane containing the reflected ray and normal is known as the plane of reflection.

Following are the two laws of reflection

1. The incident ray normal and reflected ray, all lie in one plane.

2.The angle of incidence (i) is equal to the angle of reflection (r) i.e. i = r

Refraction of monochromatic light:

A source of light with single frequency (or wavelength) is called monochromatic light.

Fig 2., shows a monochromatic light travels in a straight line in a homogenous medium, but when a ray of monochromatic light is incident on plane transparent medium such as glass, it is observed that a part of light (ray PQ) gets reflected back into the first medium (1) while the remaining part of light (ray PR) enters the second medium (2).

The direction of propagation of light changes when a monochromatic ray of light travels from one transparent medium to another transparent medium. This phenomenon is called refraction of light. This bending of light is called refraction. The ray IP is incident ray,

PQ is the reflected ray and PR is called refracted ray.

Laws of refraction (Snell's law):

Following are the two laws of refraction.

1. The incident ray, the refracted ray and the normal to the surface of separation of two media lies in one plane.

2. For any two media, the ratio of the sine of angle of incidence to the sine of angle of refraction is a constant.

The constant is called the refractive index of the second medium with respect to the first medium.

For a given pair of media, refractive index is written as

$$\frac{\sin i}{\sin r} = \mu_{12} = \frac{\mu_1}{\mu_2}$$

If the light passes from first medium to second medium, then the refractive index of first medium with respect to second medium is written as $\frac{\sin i}{\sin r} = \mu_{12} = \frac{\mu_1}{\mu_2}$

This law is known as Snell's law.

Total Internal Reflection (T.I.R.):

When a ray light passes from an optically denser medium into an optically rarer medium, the refracted ray is bent away from the normal. It is evident that the angle of refraction is always greater than the angle of incidence and its value increases as the angle of incidence increases as shown in figure 5.5. A stage reaches when for a certain angle of incidence i_c called the critical angle, the angle of refraction is 900, thus the ray instead of being refracted is totally reflected back in a denser medium.

Principle of T.I.R: When a ray light passing from a denser medium to a rarer medium at an angle greater than the critical angle, the ray instead of being refracted is totally reflected in a denser medium. This phenomenon is called the total internal reflection

Conditions of T.I.R:

1. The ray of light must travel from an optically denser medium into an optically rarer medium.

2. The angle of incidence in the denser medium should be greater than the critical angle for a given pair of media.

- Critical Angle: When a light ray passes from a denser medium to a rarer medium, the angle of incidence at which the angle of refraction is 90°, is called critical angle.
- We know, if $r = 90° \; at \; i = \; i_c, \; then \; \mu_{21} = \frac{\mu_2}{\mu_1} = \frac{sini_c}{sin90°}$
- Let for optically denser medium $\mu_1 = \mu$ and for air $\mu_2 = 1$.
- $\therefore \quad \frac{1}{\mu} = \frac{sin\,(i_c)}{1} \quad \Rightarrow \quad sin(i_c) = \frac{1}{\mu} \quad \Rightarrow \quad i_c = \sin^{-1}\left(\frac{1}{\mu}\right)$
- Thus the above equation is used to find critical angle provided the refractive index of denser medium is known.
- Similarly for two different media, the critical angle is calculated as

$$i_c = \sin^{-1}\left(\frac{\mu_1}{\mu_2}\right)$$

where μ_1 and μ_2 are the refractive index of the rarer and the denser medium respectively.

Link to YouTube/ OER/ video/ebook:https://nptel.ac.in/content/storage2/courses/105107122/modules/module2/lesson1.htm

Key Take away: Reflection, Refraction and Total internal reflection

Formative Assessments

<22102>: < Common to all 1st semester>: <Common to all>: <Heat and Optics>: <UO3e: Distinguish the phenomena of total internal refection for the given mediam>: <Assessments>: <Formative>

<Mrs. Deepa Gupte>

Assessment Type: Formative Assessments:

Set 1: Question No 1	Set 1: Question No 2	Set 1: Question No 3
Which is the correct formula to find refractive index of glass slab?	A star appears twinkling in the sky because of _____.	The speed of light is 1.2×108 m/s in diamond. Find the refractive index of diamond if the speed of light in air is 3×108 m/s
a) sin i/sin r	a) scattering of light by atmosphere	a) 1
b) sin r/sin i	b) reflection of light by atmosphere	b) 1.5
c) sin ((A+δm)/2)/ sin(A/2)	c) refraction of light by atmosphere	c) 2.5
d) sin (A/2)/ sin((A+δm)/2)	d) diffraction of light by atmosphere	d) 3
Ans: <a>	Ans: <c>	Ans: <c>

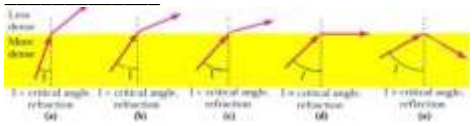
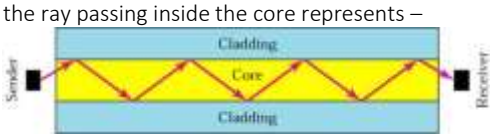
Set 2: Question No 1	Set 2: Question No 2	Set 2: Question No 3
Critical angle is the angle at which the angle of refraction is _____.	Total internal reflection occurs when _____.	Critical angle of water when refracted angle is 90° and refractive index for water and air is 1.33 and 1 is _____.
a) 0°	a) light passes from a denser to a rarer medium	a) 48.8°
b) 90°	b) light comes into air from vacuum	b) 49.1°
c) 180°	c) light goes to vacuum from air	c) 50°
d) 45°	d) light passes from rarer to denser medium	d) 51°
Ans: <b>	Ans: <a>	Ans: <a>

Practice Worksheet

<22102> : <Common to all 1st Semester> : < Common to all 1st Semester>: <Heat and optics>: <UO1e> : <Assessments> : <Worksheet>

< Mrs. Deepa Gupte >

Assessment Type: Practice Worksheets:

A) A ray of light is incident on a plane mirror and the angle of incidence is 25°. What is the angle of reflection? a. 0° b. 25° c. 50° d. 100°	B) Which is the correct formula for critical angle? a. ic = sin-1(μ1/μ2) b. ic = sin-1(μ2/μ1) c. ic = sin-1μ d. ic = sin-1(1/μ)
Ans A: b	Ans B: a
C) In TIR, a ray light passing from a denser medium to a rarer medium at an angle greater than the critical angle, gets totally reflected in a _____ medium a. denser b. rarer c. Both (A) and (B) d. None of the above	D) Mirage is an example of - a. refraction of light only b. total internal, reflection of light only c. refraction and total internal reflection of light d. dispersion of light only
Ans C: a	Ans D: c
E) From the figure, if the angle of incidence is greater than critical, then the refracted ray will be reflected back and this phenomenon is called _____  a. Reflection b. Refraction c. total internal reflection d. dispersion	F) In the following diagram of optical fibre, what does the ray passing inside the core represents –  a. Reflection b. Refraction c. total internal reflection d. dispersion
Ans E: c	Ans F: c
G) If the absolute refractive indices of water and glass are 4/3 and 3/2, respectively, then what will be the ratio of velocity of light in water to glass? a. 2 b. 8/9 c. 9/8 d. 1/2	H) The speed of light is 1.2×108 m/s in diamond. Find the refractive index of diamond if the speed of light in air is 3×108 m/s a. 1 b. 1.5 c. 2.5 d. 3
Ans G: b	Ans H: c
I) Speed of light in quartz is 1.95 x 108 m/s. The refractive index of quartz is _____ a. 1 b. 1.5 c. 1.52 d. 1.54	
Ans I: d	Ans J: