# Reflection, Refraction and Refractive Index

September 27, 2024

Issue 9 - September 2024,Science

*Refraction of bananas through glass*

Have you ever noticed how a straw looks bent when placed in a glass of water, or how a pool seems shallower than it really is? These everyday sights may seem like optical illusions, but they're actually examples of something fascinating that happens to light. When light moves through different materials, it behaves in surprising ways, and this change can affect what we see.

This is all due to a property of light called **refraction**. Refraction is the bending of light as it passes from one material to another, and it's responsible for the way light behaves in lenses, prisms, and other optical devices. Understanding refraction can help us explain why a straw looks bent in water, why a pool looks shallower than it is, and even why rainbows form in the sky.

In a previous blog, we discussed about optics and light. In this blog, we will delve deeper into the concept of refraction and refractive index. We will explore how and why light behaves differently when it moves from one material to another, and how this change in behavior can be quantified using the refractive index. By the end of this blog, you will have a better understanding of refraction and its role in shaping the world around us.

But first things first, let's start with the basics. What exactly is refraction, and how does it work? To answer these questions, we need to understand a few key concepts about light and its behavior.

# Why does light reflect or refract?

Light is a form of electromagnetic radiation that travels in waves. When light waves encounter a boundary between two materials, such as air and water, they can be reflected, absorbed, or transmitted through the material. To understand refraction, we need to first understand **reflection**.

**Reflection** is the bouncing back of light waves when they encounter a boundary between two materials. When light waves hit a surface, they can be reflected in different directions depending on the angle of incidence and the properties of the material. Reflection occurs because the atoms and molecules in a material absorb and re-emit light waves, causing them to change direction. This change in direction is what we perceive as reflection.

You must have notices that reflection only occurs when a surface is **smooth and shiny**. For example, when you look at yourself in a mirror, you see a clear reflection of your face because the mirror’s surface is smooth and flat.

But that’s not really what reflection is. Actually, reflection occurs on **all surfaces**, if you can see an object, then it is because light has reflected off it and entered your eyes!

Now, have you ever shone a light through a transparent glass or plastic object?

Light does not really reflect nor does it completely pass through the object. What happens in such cases?

Actually, both **reflection** and **refraction** take place. When light hits the surface of the object, some of it is reflected back, while the rest is refracted or bent as it passes through the object. This bending of light is what we call refraction.

# The intricacies of Refraction

Let us finally understand what refraction is.

There are two things that happens to light when it passes through an object or in scientific terms, when it passes from one medium to another.

1. Light changes speed
2. Light changes direction

## The change in direction

When a ray of light approaches a boundary between two materials, the electromagnetic wave is at an angle to the boundary. This causes one part of the wave to enter the material before the other, leading to a mismatch, once the wave is inside the medium, its direction is slightly altered causing the bend.

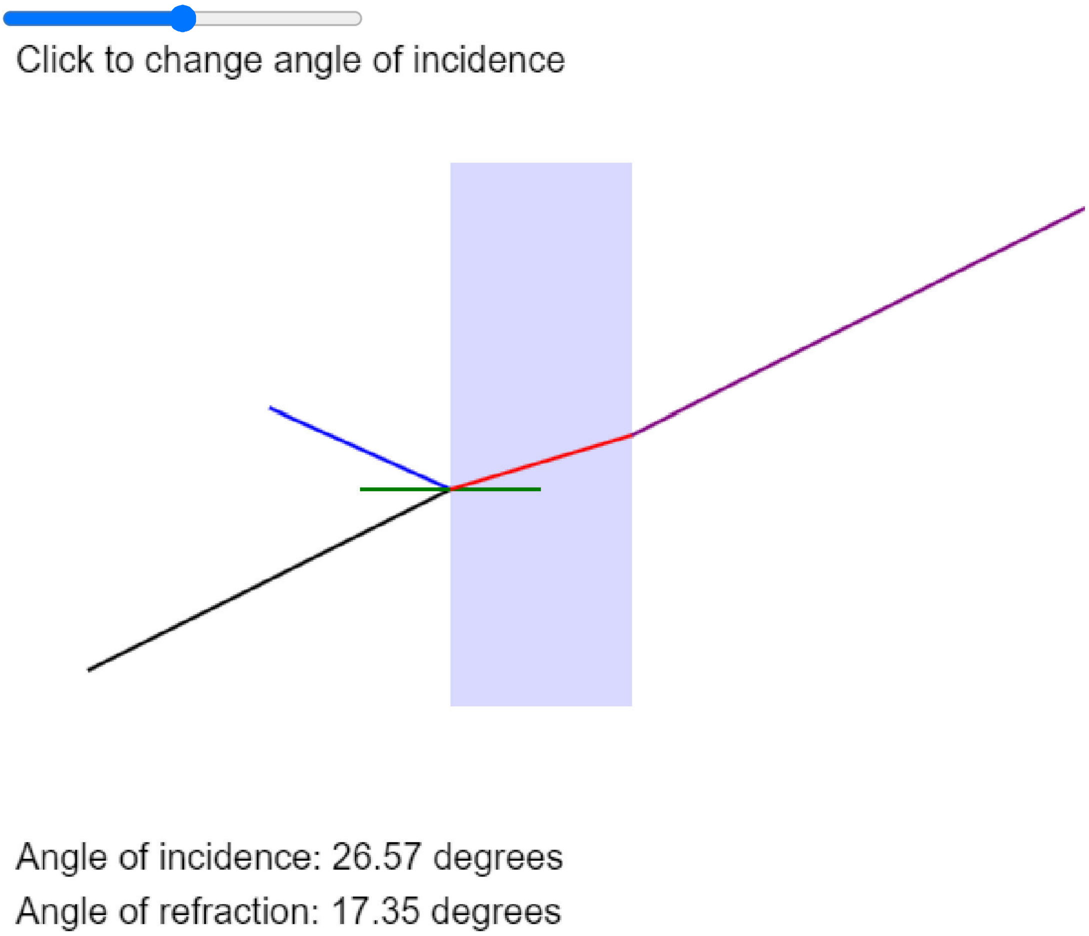
## The change in speed

Light is an electromagnetic wave, when it approaches a boundary between two materials, the electromagnetism of the light interacts with the atoms and molecules of the material. This interaction causes the atoms to oscillate and interfere with the light wave, causing it to change speed.

The amount of change in speed and direction depends on the angle at which the light wave hits the boundary and the properties of the material, namely its optical density or refractive index.

Understood? Have a go at the below simulation to understand it better.

Refractive Index: 1.5




Here the **black** line represents the incident ray. The **red** line represents the refracted ray. The **blue** line represents the reflected ray. The **green** line is the normal line. The **purple** line is ray after it exits the medium. When light goes from the medium to air, it is refracted again. If you notice, the incidence black line is parallel to the purple line.

# Refractive Index

**Refractive index** is the ability of a medium to refract light. It is a measure of how much the material affects the light passing through it.

The refractive index (RF) of a medium is the ratio of the speed of light in a vacuum to the speed of light in the medium.

The refractive index of vacuum or air is 1 (technically 1.0003 for air and 1 for vacuum). For water refractive index is 1.33 and for glass it is 1.5.

## How is it measured?

The refractive index of a medium is measured by passing light through the medium and measuring the angle of refraction.

The relative refractive index of an optical medium 2 with respect to medium 1 is given by the formula:

$$n_{21} = \frac{c_2}{c_1}$$

where $c_1$ is the speed of light in medium 1 and $c_2$ is the speed of light in medium 2.

If medium 1 is vaccuum, then the refractive index of medium 2 is simply represented as $n_2$. This is also called as the absolute refractive index of medium 2.

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

$$n = \frac{c}{v}$$

where n is the refractive index, c is the speed of light in vaccuum and v is the speed of light in the medium.

Since the speed of light in vaccuum is a constant, the refractive index of a medium is inversely proportional to the speed of light in the medium.

$$n \propto \frac{c}{v}$$

By applying the Snell's Law, we can say:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

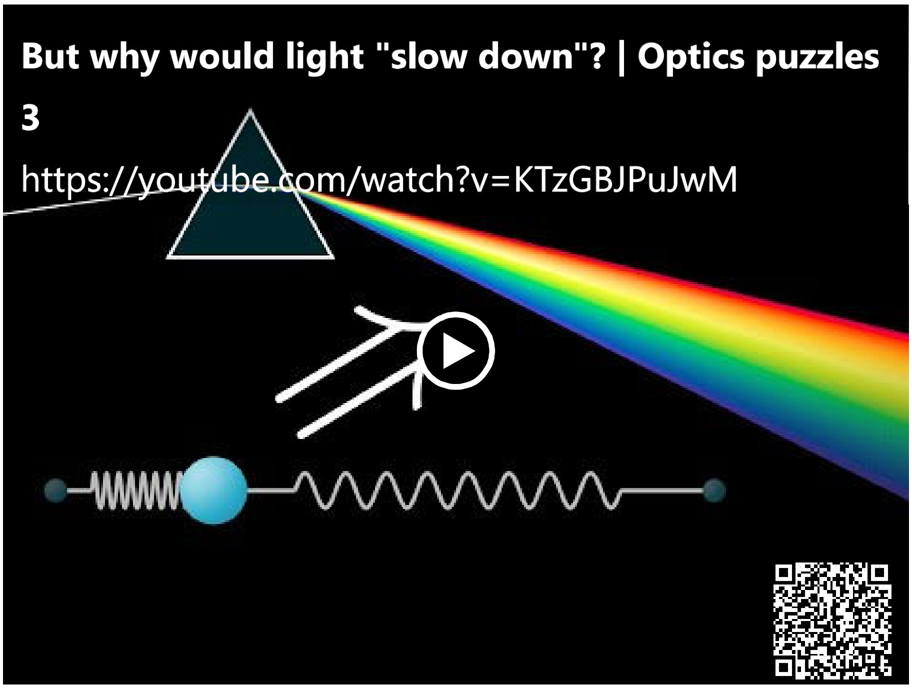
Where $n_1$ and $n_2$ are the refractive indices of the two mediums and $\theta_1$ and $\theta_2$ are the angles of incidence and refraction respectively.

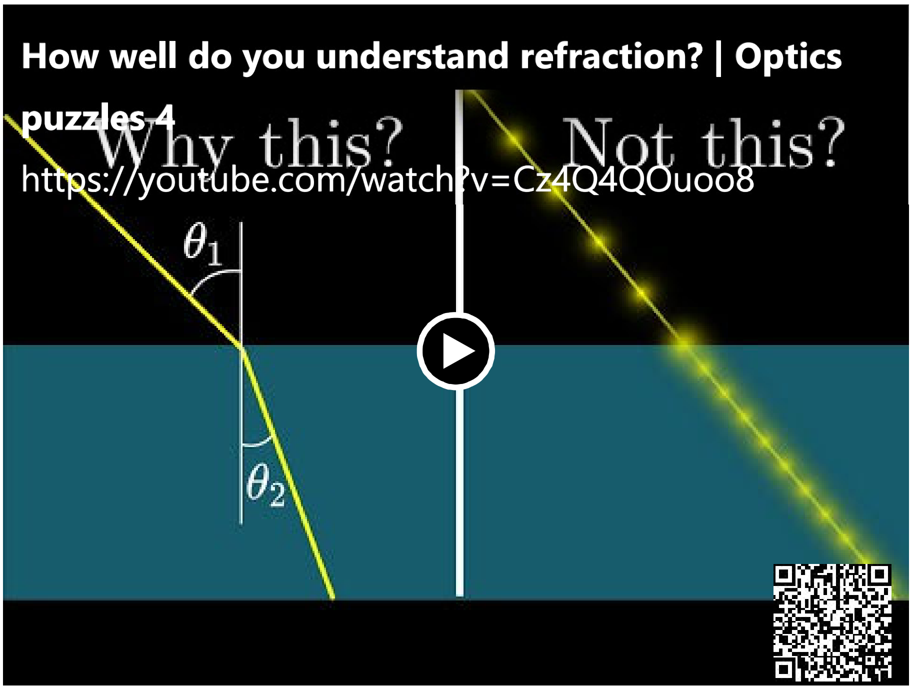
Therefore, we can say that:

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1} = \frac{v_1}{v_2}$$

And that's it. That's refraction in a nutshell. There is a lot more about refraction. Such as the phenomenon of total internal reflection, or diffraction (the one that causes rainbows).

This blog is heavily inspired by the amazing works of 3blue1brown on youtube. I highly recommend checking it out.



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About the Author Ayush Deshpande is a passionate developer with a Computer Science Degree. With experience in building large-scale websites, he loves sharing his knowledge of programming, web development, and anything else that interests him. He enjoys breaking down complex topics into easy-to-understand concepts, especially adding an interactive touch. Outside of coding, he leads tech events and workshops, aiming to inspire young minds to explore the enjoyable parts of academics.

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