

# Refraction

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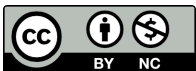
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# CHAPTER 1

# Refraction

- Relate the speed of light to its medium.
- Describe refraction and explain when it occurs.



Is this some kind of magic trick? Or is this straw really broken where it enters the water? The answer to both questions is no. There's nothing wrong with the straw, and no magic is involved. It's simply how light may behave when it enters a new medium.

## Speed of Light and Matter

Light always travels at the same speed across space. That speed, represented by the letter  $c$ , is about 300 million meters per second. However, when light travels through a medium, it travels more slowly. The speed varies for different kinds of matter. The **Table 1.1** gives the speed of visible light in six different materials.

**TABLE 1.1:** Speed of Visible Light in Various Materials

Material	Speed of Visible Light(m/s)
Air	299 million
Water	231 million
Glass	200 million
Vegetable oil	150 million
Alcohol	140 million
Diamond	125 million

**Q:** Predict the speed of visible light through vinegar.

**A:** Vinegar is mostly water, so if you predicted that the speed of light through vinegar would be close to its speed through water, you are correct. The speed of visible light through Heinz® vinegar is about 230 million m/s.

## Bending Light

When light passes from one medium to another, it changes speed. For example, when light passes from air to glass, it slows down. If light strikes a sheet of glass at a  $90^\circ$  angle, or perpendicular to the glass, it slows down but still passes straight through the glass. However, if light enters the glass at an angle other than  $90^\circ$ , the light bends as it slows down. The bending of light as it changes speed in a new medium is called **refraction**. The **Figure 1.1** shows how refraction occurs. Notice that the speed of light changes again as it passes from the glass back to the air. In this case, the speed increases, and the ray of light resumes its initial direction. For a more detailed explanation of refraction, watch this video: <http://www.youtube.com/watch?v=8RM46yvDOHI>

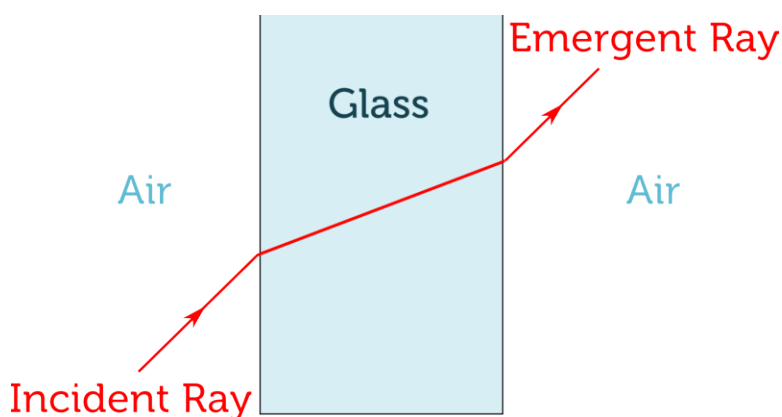


FIGURE 1.1

### What's Your Angle?

The angle at which light bends when it enters a different medium depends on its change in speed. The greater the change in speed, the greater the angle of refraction is. For example, light refracts more when it passes from air to diamond than it does when it passes from air to water. That's because the speed of light is slower in diamond than it is in water.

**Q:** Now can you explain why the straw in the opening image appears to be broken where it enters the water?

**A:** The straw appears to be broken because of refraction. Light slows down and bends when it passes from the water in the glass to the air on its way to your eyes.

### Summary

- Light always travels at the same speed through empty space. That speed, represented by the letter  $c$ , is about 300 million meters per second. However, when light travels through a medium, it travels more slowly.
- If light passes from one medium to another at an angle other than  $90^\circ$ , the light changes speed and bends.  
This bending of light is called refraction.
- The angle at which light refracts when it enters a different medium depends on its change in speed. The greater the change in speed, the greater the angle of refraction is.

## References

1. Joy Sheng. [Diagram of refraction](#) . CC BY-NC 3.0