Direction of Bending
Lesson Notes

Learning Outcomes

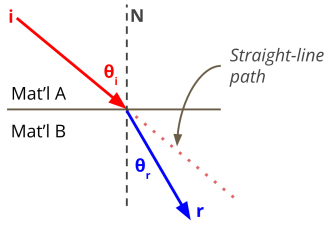
- How can one predict the direction that an incident ray refracts when it crosses a boundary?

Bending Towards vs. Away From the Normal

When light crosses a boundary between two materials, the speed, wavelength, and direction of the wave changes.

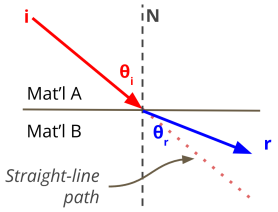
Refraction: Change in direction of a light wave; "bending" of light's path.

Towards the Normal



The refracted ray (**r**) is closer to the normal line (**N**) than the incident ray (**i**) is.

Away From the Normal



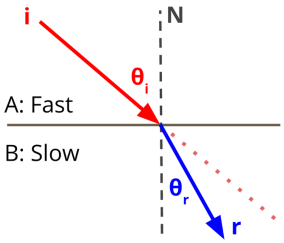
The refracted ray (**r**) is further from the normal line (**N**) than the incident ray (**i**) is.

FST = Fast-to-Slow … Towards

When light refracts from a material where it travels ***fast*** into a material where it travels ***slow***, it bends ***towards*** the normal line.

Example 1

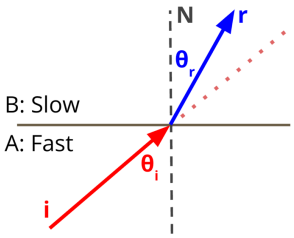
The n of B is larger than A.



$\Theta_i > \Theta_r$

Example 2

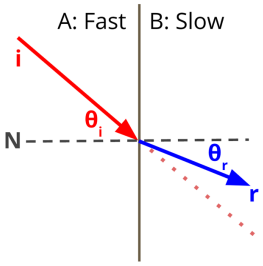
The n of B is larger than A.



$\Theta_i > \Theta_r$

Example 3

The n of B is larger than A.



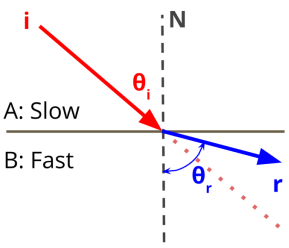
$\Theta_i > \Theta_r$

SFA = Slow-to-Fast … Away

When light refracts from a material where it travels ***slow*** into a material where it travels ***fast***, it bends ***away from*** the normal line.

Example 1

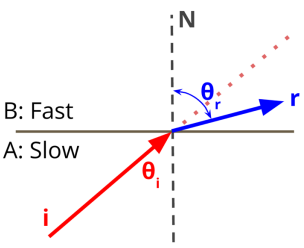
The n of A is larger than B.



$\Theta_i < \Theta_r$

Example 2

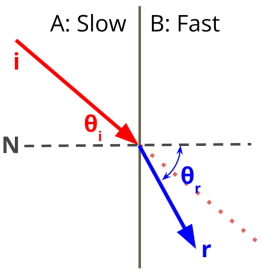
The n of A is larger than B.



$\Theta_i < \Theta_r$

Example 3

The n of A is larger than B.



$\Theta_i < \Theta_r$

Optical Density and the Direction of Bending

- **Optical density** is a property of a material that provides a relative measure of how fast light moves within the material.
- Light travels **faster** in a **least optically dense** medium.
- Knowing the relative optical density of two media, allows one to predict the direction of bending.
- As light travels from a **less optically dense** medium (fast) to a **more optically dense** medium (slow), it bends **towards** the normal line.
- As light travels from a **more optically dense** medium (slow) to a **less optically dense** medium (fast), it bends **away from** the normal line.

n Value and Direction of Bending

- The **index of refraction (n)** is a numerical value that provides an indicator of light speed within a material.
- Every material has its own unique index of refraction value (Water: n=1.33, Diamond: n=2.42, Glass: n=1.52, etc.)
- Light travels **faster** in a medium with a smaller n value.
- As light travels from a **high n** medium (slow) to a **low n** medium (fast), it bends **away from** the normal line.
- As light travels from a **high n** medium (slow) to a **low n** medium (fast), it bends **away from** the normal line.

Bending Rules

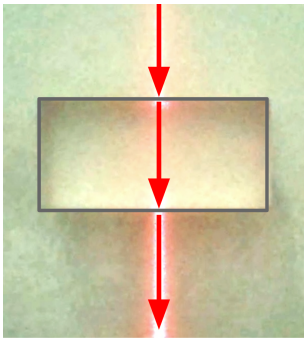
Typical Question: As light travels **from** __(a material with a specific property) ...__ **to** a material with __(the opposite property) ...__ it bends … _____ (towards, away from) the normal line.

From Fast **to** Slow: Towards Normal
From Less Dense **to** More Dense: Towards Normal
From Low n **to** High n: Towards Normal

From Slow **to** Fast: Away From Normal
From More Dense **to** Less Dense: Away From Normal
From High n **to** Low n: Away From Normal

The Lone Exception

When light approaches a boundary along the *normal line*, it will change speed and wavelength … but it will **not** change direction.
This is the lone exception to the rule of refraction occurring as light crosses the boundary.
The angle of incidence for this exception is 0° (measured relative to the normal line).



Refraction does not occur when light approaches along the normal line.