Total Internal Reflection
Lesson Notes

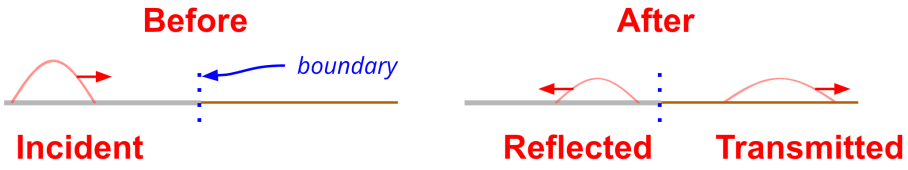
Learning Outcomes

- What is total internal reflection?
- Under what conditions will total internal reflection occur?

Boundary Behavior … Revisited

When an incident wave reaches the boundary with a second medium, a portion of its energy is reflected off the boundary and remains within the incident medium and a portion is transmitted across the boundary.

Know your terminology:

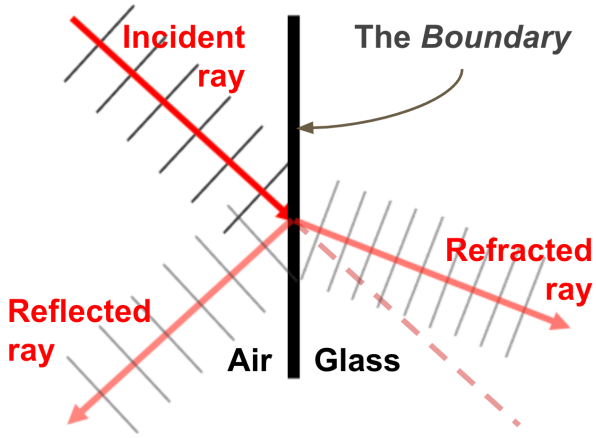


Reflection and Refraction

The **Ray Model of Light** utilizes **ray diagrams** consisting of rays drawn perpendicular to the wavefronts.

At a boundary between two transparent materials, an incident ray will typically undergo both reflection (following the Law of Reflection) and refraction (following Snell's Law).

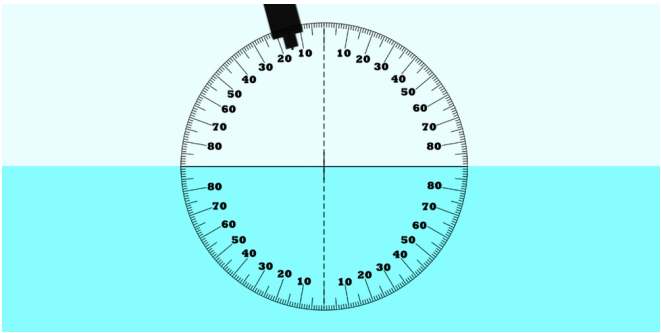
Questions for this video: What variables affect the amount of reflection and refraction? And under what conditions will the incident ray undergo total internal reflection?



Reflection, Refraction and Brightness

One observes from the movie that …

θ_i = 15°: hardly visible reflected ray
θ_i = 30°: very dim reflected ray
θ_i = 45°: dim reflected ray
θ_i = 60°: much brighter reflected ray
θ_i = 75°: brightest reflected ray

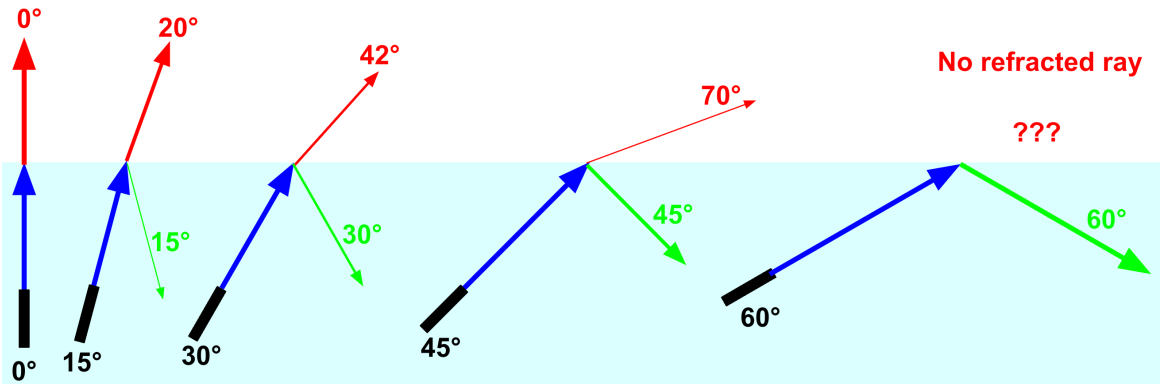


For light in air crossing the boundary into water, one notices …

- As θ_i increases, $\theta_{reflection}$ increases
- As θ_i increases, $\theta_{refraction}$ increases
- As θ_i increases, the reflected ray becomes brighter
- As θ_i increases, the refracted ray becomes dimmer

For Light Passing From Water to Air

Consider light traveling from water to air with varying angles of incidence:



As the angle of incidence is increased from 0° to larger angles, the angle of refraction approaches 90° until finally a refracted ray is no longer seen. The light undergoes reflection ONLY.

Total Internal Reflection (TIR)

Total internal reflection is the phenomenon that occurs when all of the light approaching the boundary undergoes reflection and stays inside the original incident medium.

Two Requirements for TIR:

1. Light must be in the more dense medium and heading towards the less dense medium - e.g., from water (n=1.33) to air (n=1.00) OR from glass (n=1.52) to water (n=1.33).
2. Light must be approaching the boundary at sufficiently large angles of incidence (an angle of incidence greater than the **critical angle**).

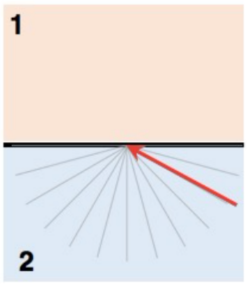
Critical Angles

H_2O-Air: 48.8°
Glass-Air: 41.1°
Diamond-Air: 24.4°
Glass-H_2O: 61.0°

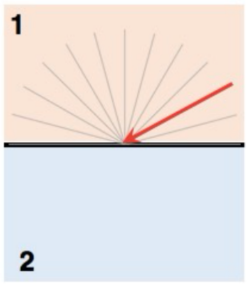
Practice: To TIR or R and R?

Medium 1 is less dense than medium 2. The critical angle for the boundary is 40°. In which case(s) are the two criteria for total internal reflection met?

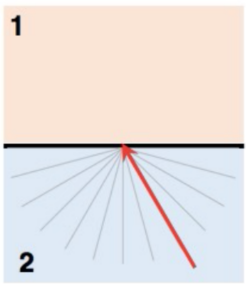
Case A



Case B



Case C



Answer: Case **A** only.
The light must be in the more dense medium (2, not 1) and have an angle of incidence greater than (not less than) 40°.