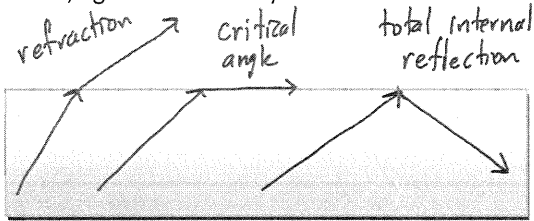


Total Internal Reflection

When passing from a more dense to a less dense medium, light refracts away from the normal.



If the angle is large enough then the angle of refraction will be parallel to the medium boundary. (i.e. $\theta_r = 90^\circ$)

Critical angle: θ_c ; that results in $\theta_r = 90^\circ$

Total Internal Reflection: occurs when $\theta_i > \theta_c$

Ex: Find the critical angle for light traveling from water into air. Draw a diagram.

Diagram: A ray in water at angle θ_c to the normal hits the water-air boundary at 90° .

$$n_i \sin \theta_c = n_r \sin \theta_r$$

$$\sin \theta_c = \frac{n_r \sin \theta_r}{n_i} = \frac{1.0003 \sin 90^\circ}{1.33}$$

$$\sin \theta_c = 0.7521 \quad \theta_c = 48.8^\circ$$

Snell's Law

1) Light travels at 2.62×10^8 m/s in a new clear type of plastic. What is this new product's index of refraction?

$$n = \frac{c}{v} = \frac{3 \times 10^8}{2.62 \times 10^8} \quad n = 1.14$$

2) How fast does light travel in zircon ($n = 1.92$)?

$$n = \frac{c}{v} \quad v = \frac{c}{n} = \frac{3 \times 10^8}{1.92}$$

$$v = 1.56 \times 10^8$$

3) Light traveling in air hits a diamond surface at 42° to the normal. To what angle is it refracted in the diamond?

$$n_i \sin \theta_i = n_r \sin \theta_r$$

$$1.0003 \sin 42 = 2.42 \sin(\theta)$$

$$\sin^{-1}(0.27) = 16^\circ$$

4) Light leaves a ruby and enters water. If the angle of refraction is 60° , what was the incident angle inside the ruby? The index of refraction for ruby is 1.55.

$$n_i \sin \theta_i = n_r \sin \theta_r$$

$$1.55 \sin \theta_i = 1.33 \sin 60$$

$$\sin^{-1}(0.74) = 48^\circ$$

5) An experiment is done with an unknown substance. Light entering the substance from air at 38° to the normal is refracted to 23.6° .

What is the sample's index of refraction?
What might the sample be made of?
How fast does light travel in the sample?

A) $1.0003 \sin 38 = n \sin 23.6 \quad n = 1.54$
B) Quartz
C) $v = \frac{c}{n} = 1.95 \times 10^8$

6) What is the critical angle for light leaving zircon and entering glass of the flint variety?

$$1.925 \sin(\theta) = 1.615 \sin(90) = 57^\circ$$

7) What is the critical angle for light leaving diamond and entering air?

$$2.42 \sin \theta = 1.0003 \sin(90)$$

$$2.42$$

$$= 24^\circ$$

8) A killer whale in its pool observes total internal reflection when it looks at the glass wall at a certain angle (it sees the reflection of the pool, and things in it). At what boundary does this reflection occur, water to glass or glass to air?

Must be higher to lower
 \therefore Glass to air.

- 1) 1.15 2) 1.56×10^8 m/s 3) 16° 4) 48° 5) 1.54, quartz, 1.95×10^8 m/s 6) 59° 7) 24° 8) Glass to air