Phys 1402 2017-11-16 Lec 22

A car stereo produces 96 dB sound at a distance of 10 m from the car. What sound level is heard if a listener moves to 20 m away and half of the speakers die?

$$I = \frac{P}{4\pi R^2}$$ (Spherical Waves from point source)

Power: Cut in half b/c dead speakers

Distance: Doubled

Intensity: 8 times less.

$$Ratio = 10^{x} \qquad x = \log(Ratio)$$

exponent $x = \log_{10}(8) = 0.9$

$10^{0.9} = 8$

Level in dB $\frac{\beta}{10} = x$ $\beta = 9$ dB quieter

New sound level $96\text{ dB} - 9\text{ dB} = \boxed{87\text{ dB}}$

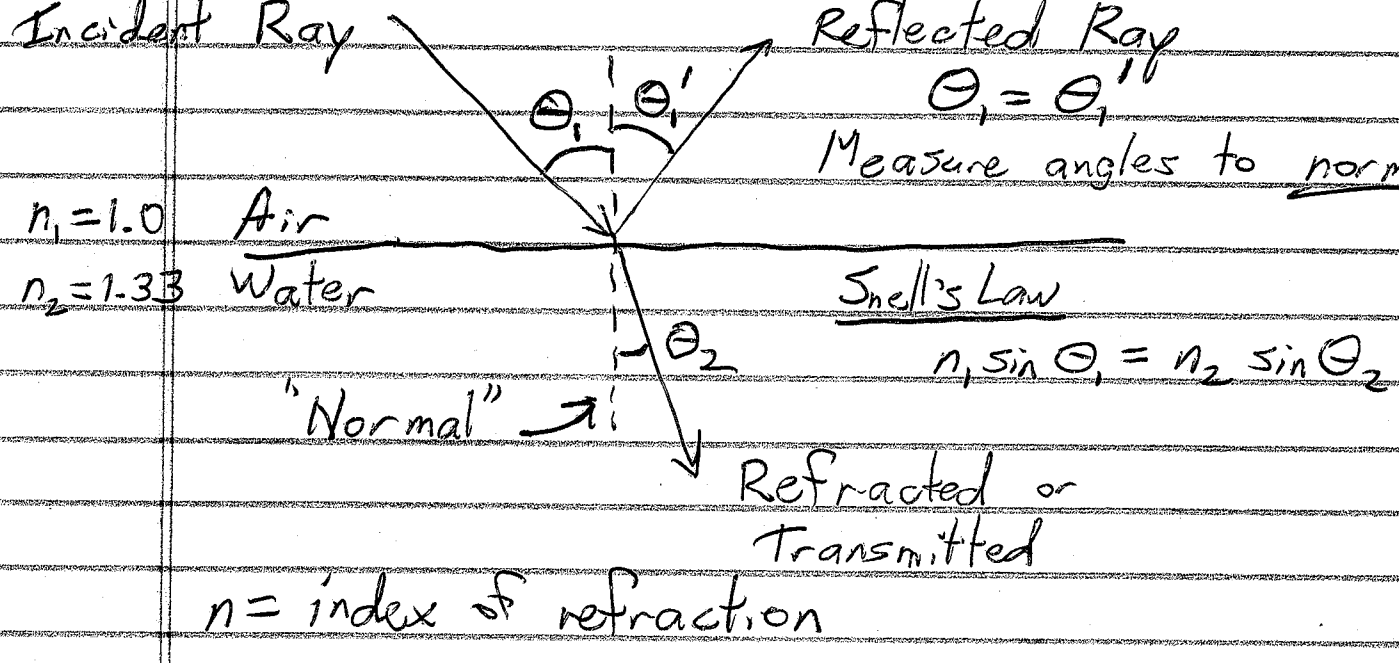
$$Ratio = 10^{\beta/10} \qquad \beta = 10\log(Ratio)$$

Geometric Optics - Bending waves with the shape of the medium.

Two main effects:
- Reflection - Bouncing wave off a surface.
- Refraction - Bending a wave as it crosses a surface.

Types of materials
- "Nothing" - Vacuum and air carry light.
- Transparent - Water, glass, diamond.
  Air is transparent for sound.
- Absorbing - Flat black
- Reflective - Shiny objects
- Scattering - Paper produces diffuse reflection

Reflection + Refraction occur together.



n = index of refraction

Ex: $\theta_1 = 45^\circ$ $n_2 = 1.33$

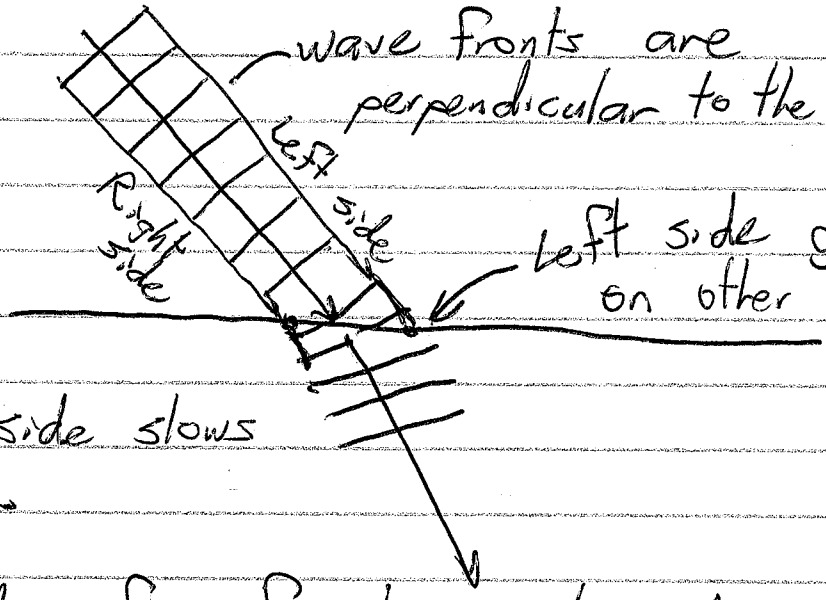
$n_1 = 1$

$(1.0)\sin(45^\circ) = (1.33)\sin\theta_2$

$0.532 = \sin\theta_2$

$\theta_2 = \sin^{-1}(0.532) = 32^\circ$

Why do waves refract?



- Right side slows first.

The index of refraction also describes how a material affects the speed.

$$\text{Actual Speed} = v = \frac{c}{n} = \frac{\text{Speed in vacuum}}{\text{Index of Refraction}}$$

Air	$n = 1.0003 \approx 1$	$v = 3 \times 10^8$ m/s
Water	$n = 1.33$	$v = 2.25 \times 10^8$ m/s
Glass	$n = 1.5$	$v = 2 \times 10^8$ m/s

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

n_1 = water $\quad n_2$ = air

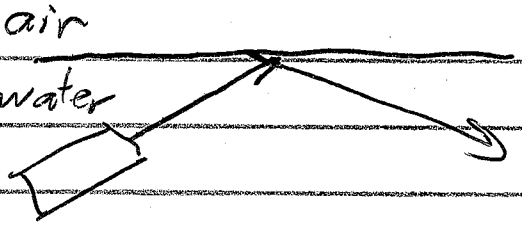
$\theta_1 = 60^\circ$

$1.33 \sin(60^\circ) = (1.0)\sin\theta_2$

$1.15 = \sin\theta_2$

There is no θ_2!

No transmitted light.



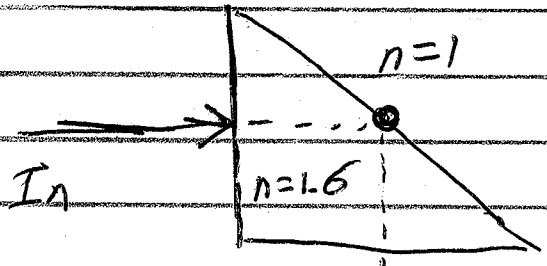
Total Internal Reflection

Ex: Prism reflectors:

$n_1 = 1.6 \quad n_2 = 1$

$\theta_1 = 45^\circ$

$\frac{n_1}{n_2} \sin\theta_1 = 1.13$ no θ_2



At in and out, $\theta = 0^\circ$ Out

Critical angle is when $\sin\theta_2 = 1.0$.

$$\frac{n_1 \sin\theta_1}{n_2} = 1.0$$

$\sin\theta_1 = n_2/n_1$

↑ This θ_1 is the critical angle.

For water → air:

$\sin\theta_1 = 1/1.33 = 0.75$

$\theta_1 = 49^\circ$