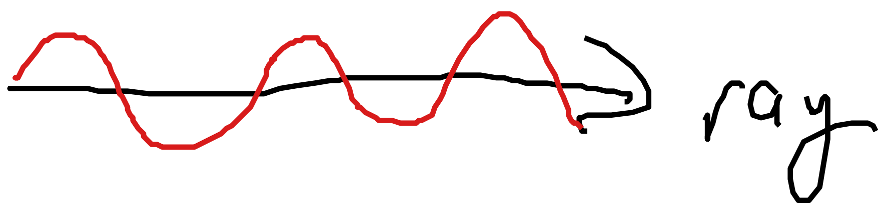
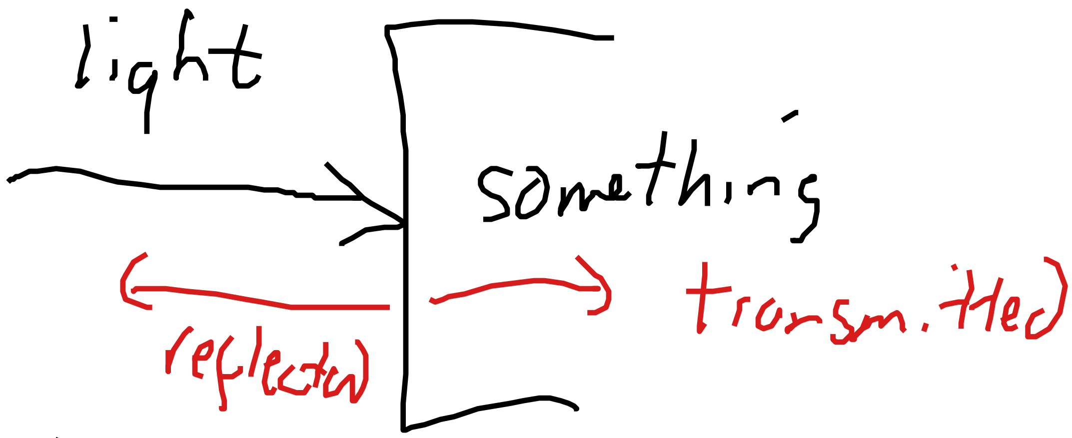
Ray Optics

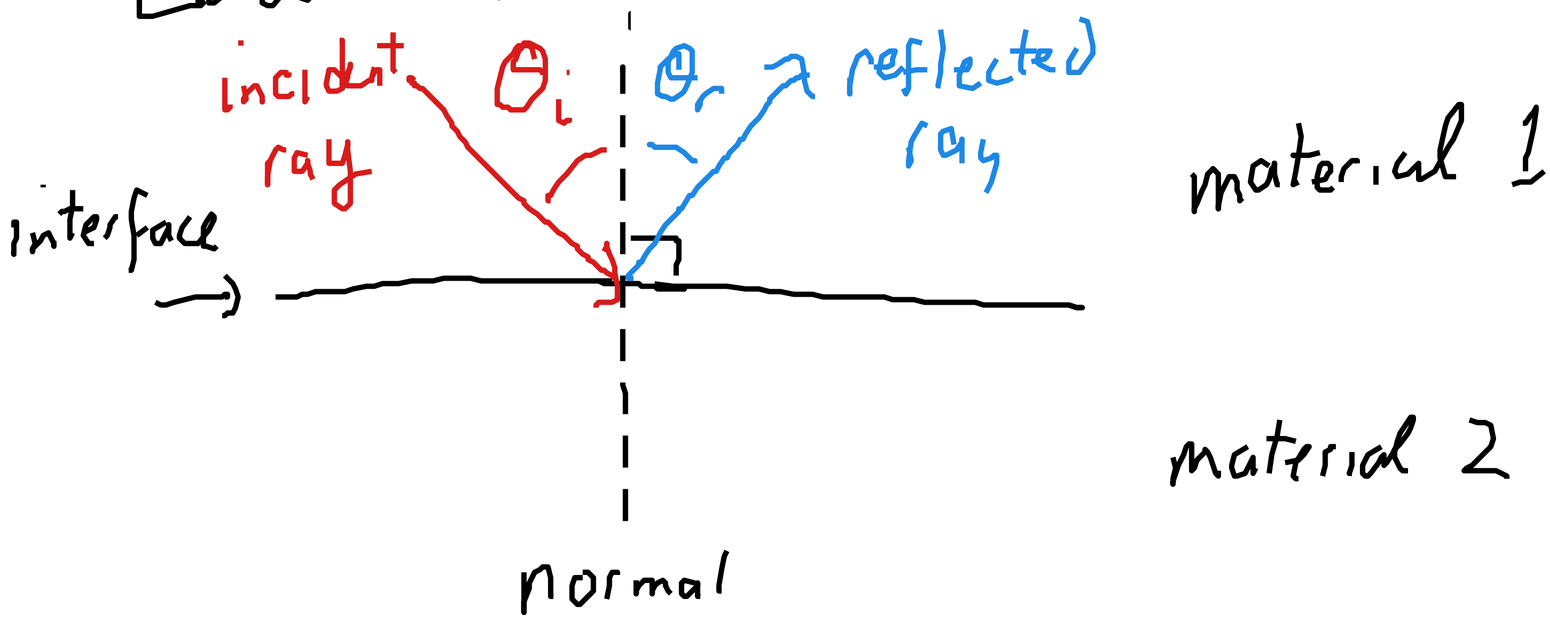


- Light rays travel in a straight line at constant speed until they hit something.



1) absorption
2) reflection
3) transmission

Law of Reflection

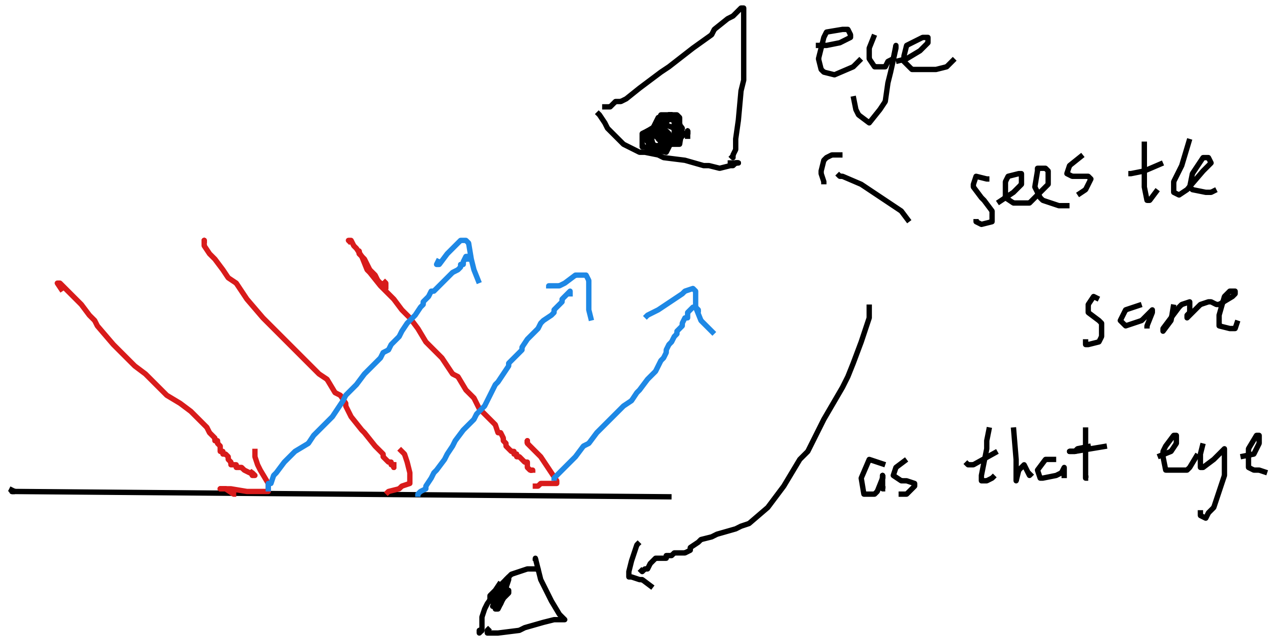


θ_i: angle of incidence with respect to the normal

θ_r: angle of reflection w.r.t. the normal

$$\boxed{\theta_r = \theta_i}$$

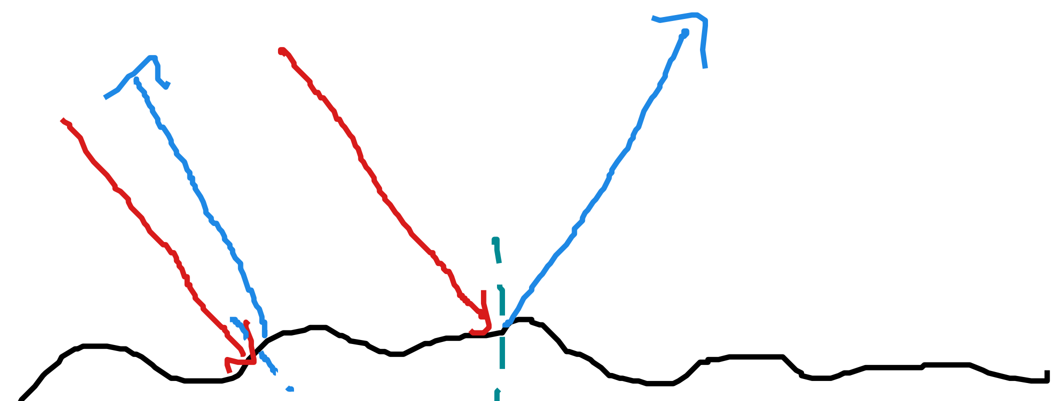
Specular Reflection



very flat surface

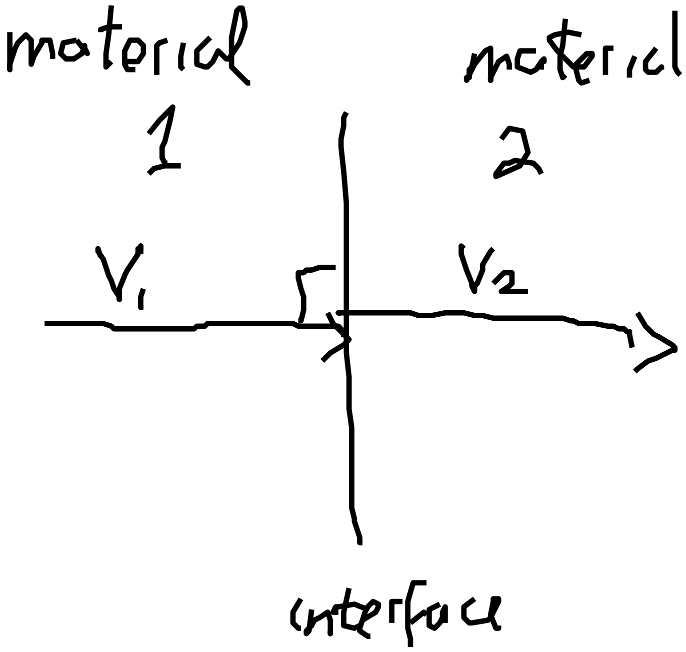
you can see reflections

Diffuse Reflection



reflected rays are scattered in all directions – no reflections seen

Transmission of Light (non-opaque materials)

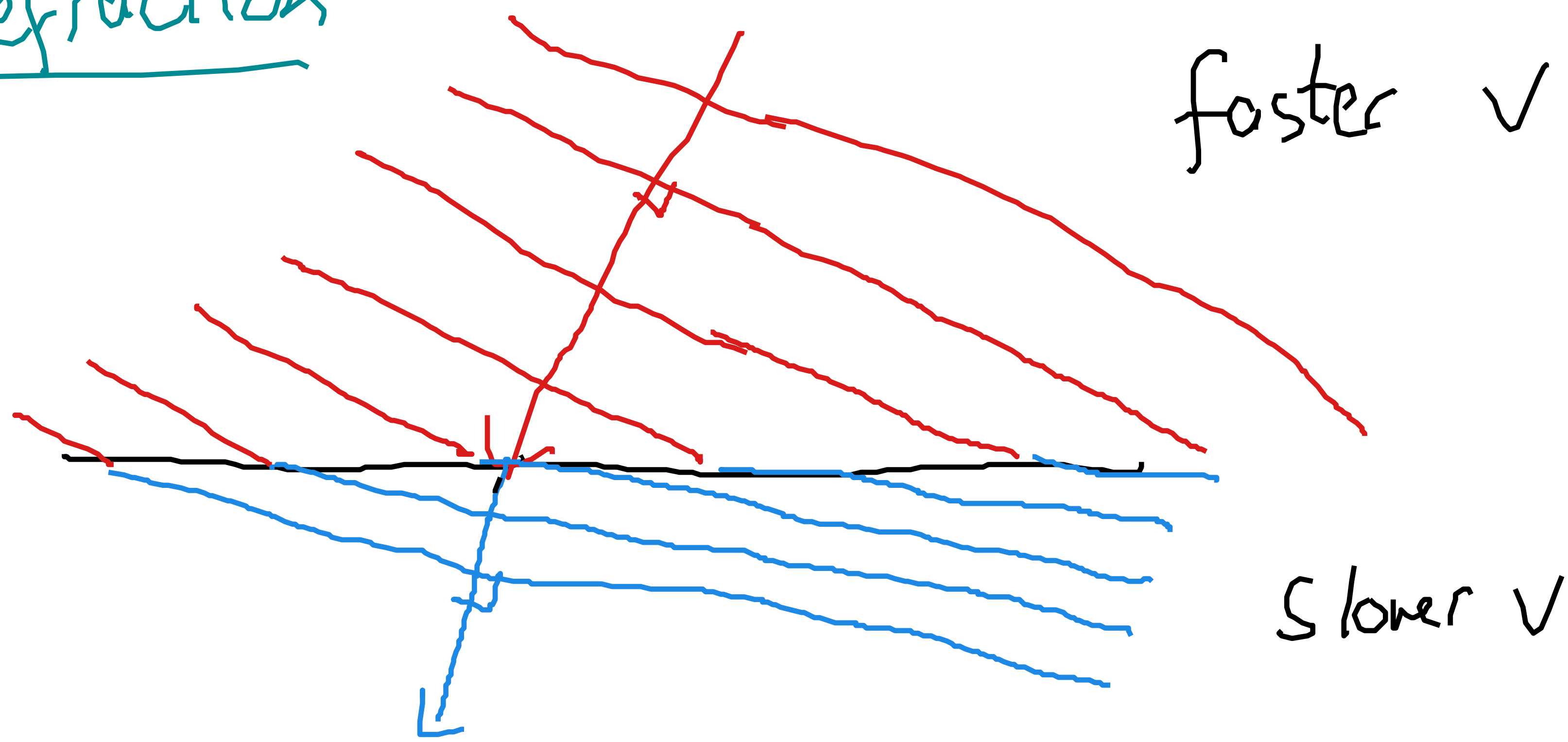


- light changes speed
- index of refraction of a material

$$n = \frac{c}{v} \quad \Longleftrightarrow \quad v = \frac{c}{n}$$

- frequency stays same, but wavelength changes

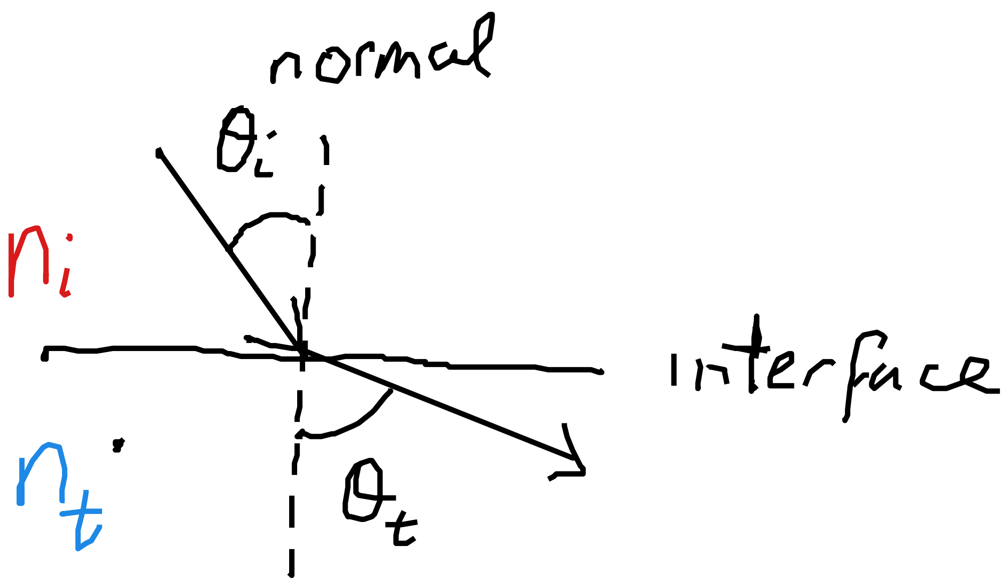
refraction



ray entering a material has to bend so that the wavefronts stay continuous but the wavelength can change

- When light slows down, ray bends toward the normal
- When light speeds up, ray bends away from the normal

Snell's Law



θ_i : incident angle

θ_t : transmitted angle

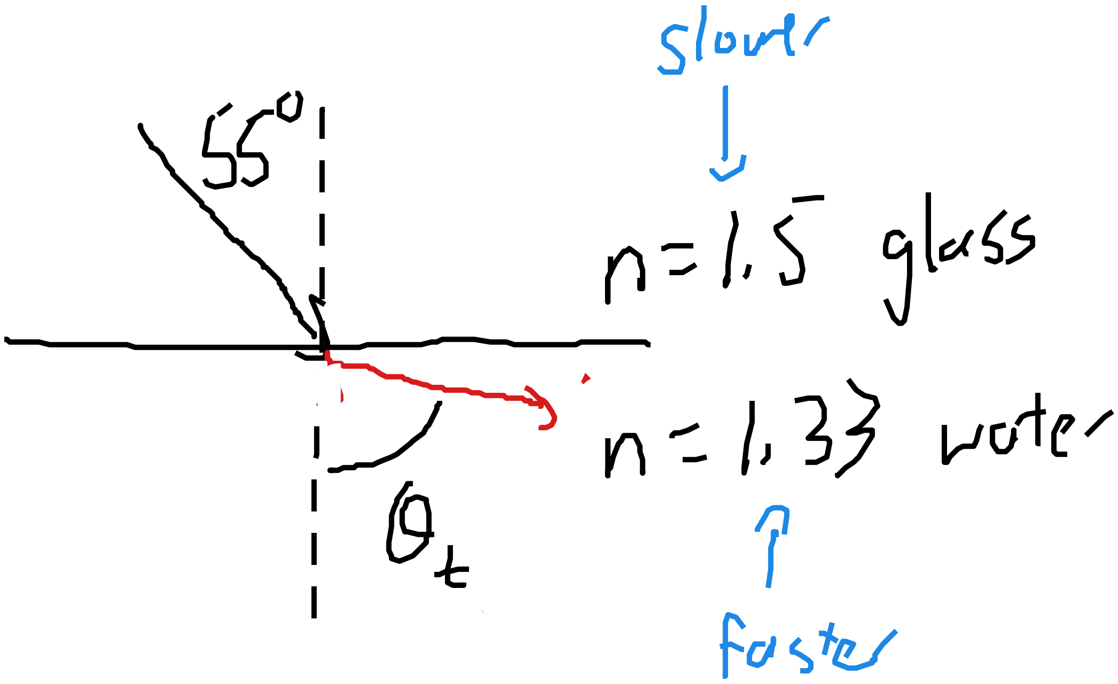
$$\boxed{n_i \sin\theta_i = n_t \sin\theta_t}$$

in this picture,

$$\theta_t > \theta_i \Rightarrow \sin\theta_t > \sin\theta_i$$

$$\Rightarrow n_t < n_i$$

incident material is slower than transmitting material



$$n_i \sin\theta_i = n_t \sin\theta_t$$

$$1.5 \sin 55^\circ = 1.33 \sin\theta_t$$

$$\frac{1.5}{1.33} \sin 55^\circ = \sin\theta_t$$

$$\underbrace{(1.13)(0.819)} = \sin\theta_t$$

$$\theta_t = \sin^{-1} 0.924 = 67.5^\circ$$

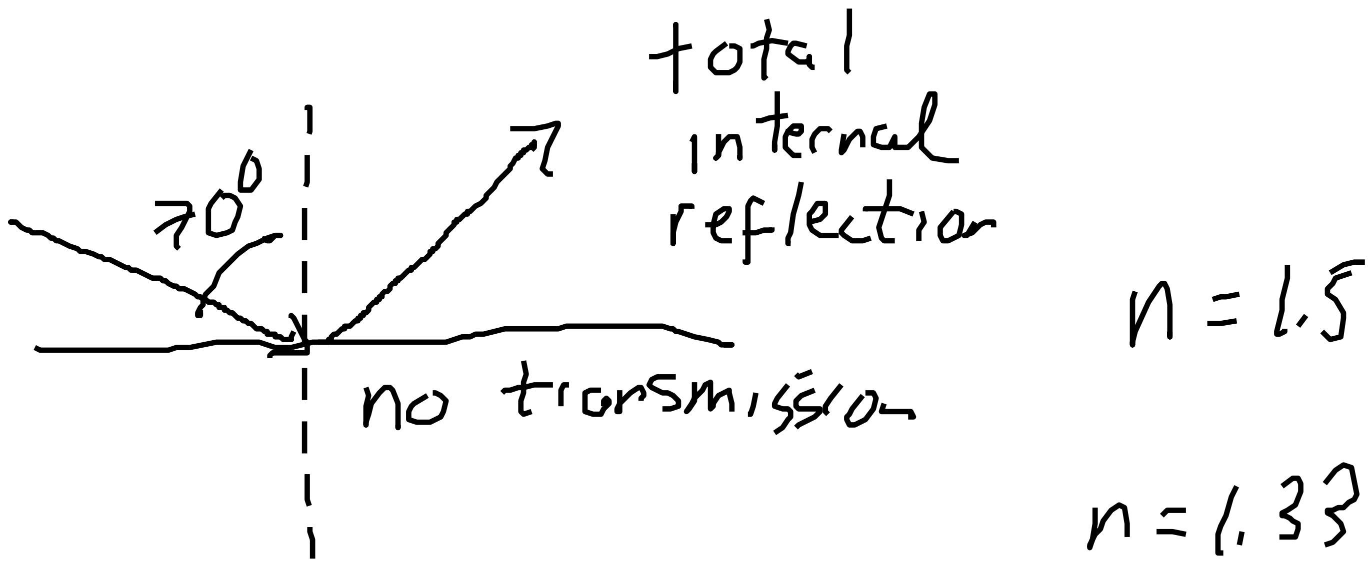
(Be sure $\sin 90 = 1$ on your calculator!)

What if $\theta_i = 70°$?

$$1.5 \sin 70° = 1.33 \sin \theta_t$$

$$\sin \theta_t = 1.06$$

there is no solution!



Can occur when light speeds up

Total Internal Reflection

$$n_i \sin\theta_i = n_t \sin\theta_t$$

$$\sin\theta_t = \frac{n_i}{n_t}\sin\theta_i > 1$$

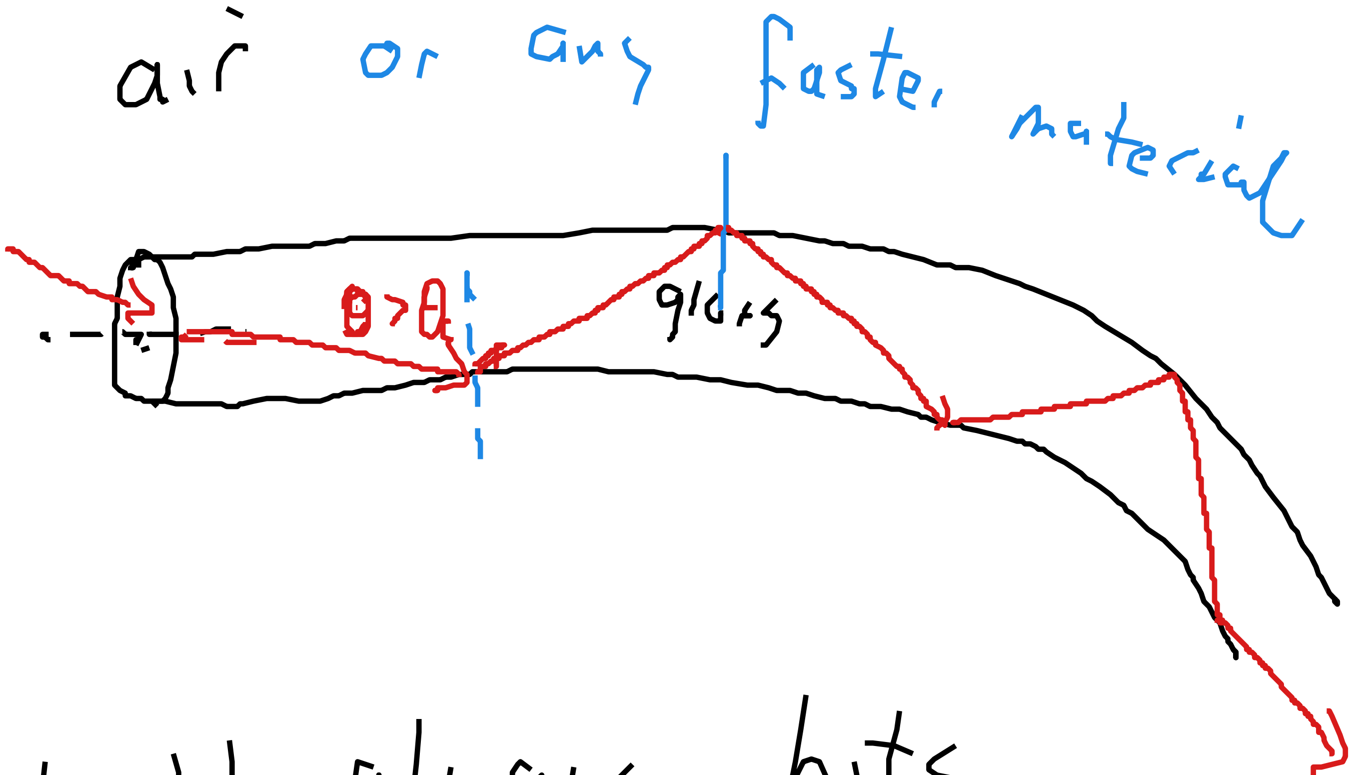
$$\frac{n_i}{n_t}\sin\theta_i > 1 \rightarrow \theta_i > \sin^{-1}\frac{n_t}{n_i}$$

must be $> 1 \Rightarrow n_i > n_t$

$$\theta_c = \sin^{-1} \frac{n_t}{n_i}$$

Critical angle for T. I. R.

Fiber Optics



light always hits surface inside the fiber at an angle $\theta > \theta_c$ so none of it escapes