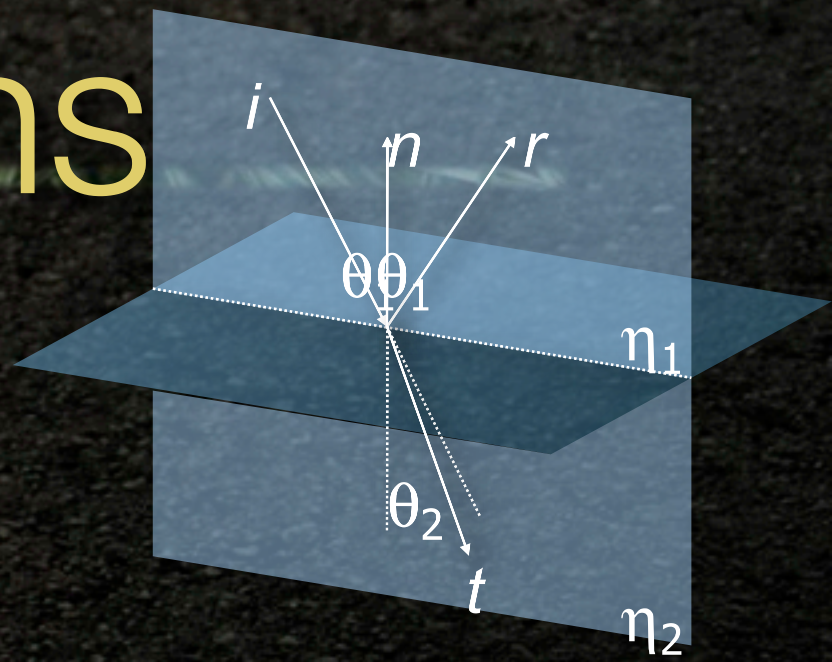
Fresnel Equations

- The fresnel effect is the observation that things get more reflective at grazing angles
- Fresnel equations describe how much energy is reflected at a surface boundary
- Remainder is absorbed as heat

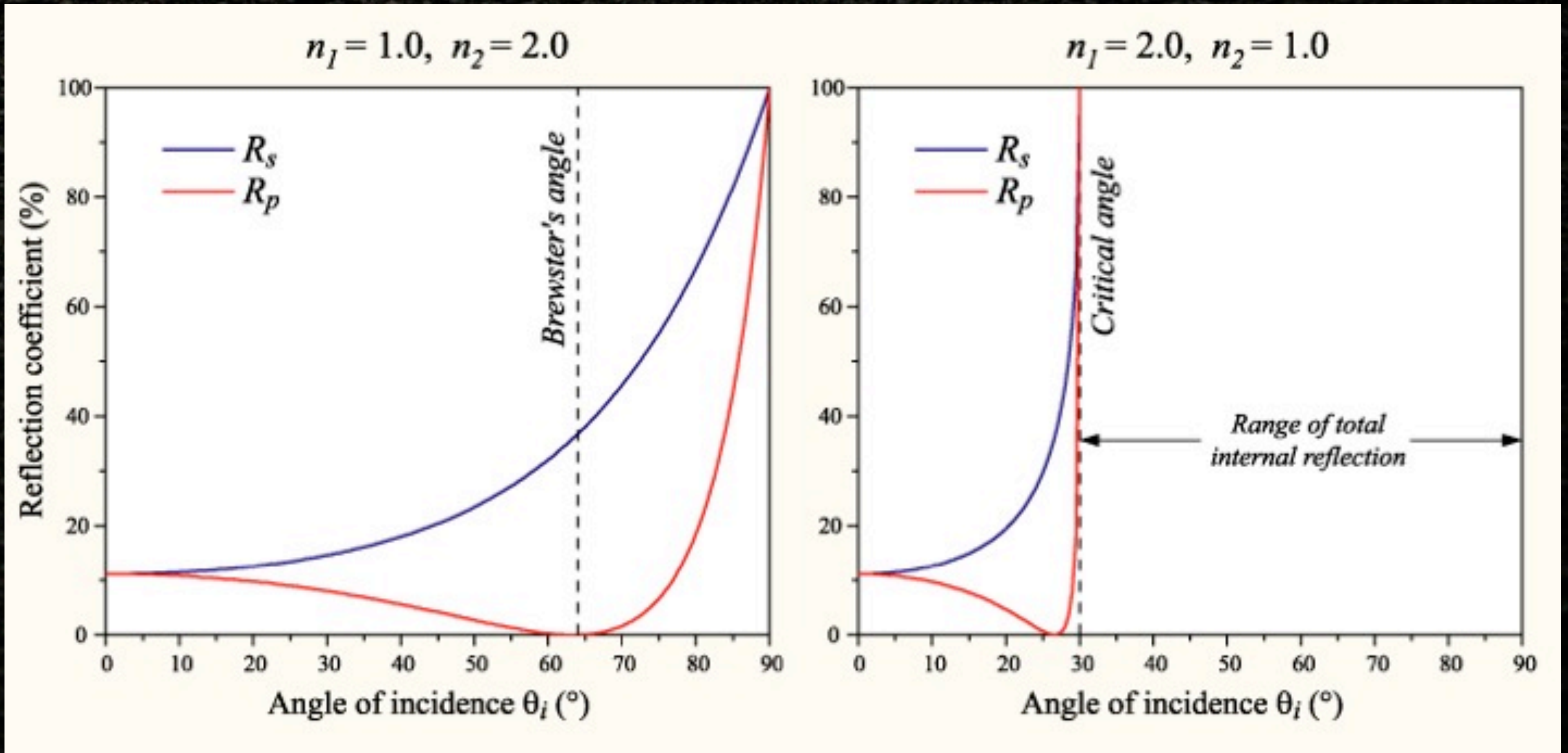
Fresnel Equations



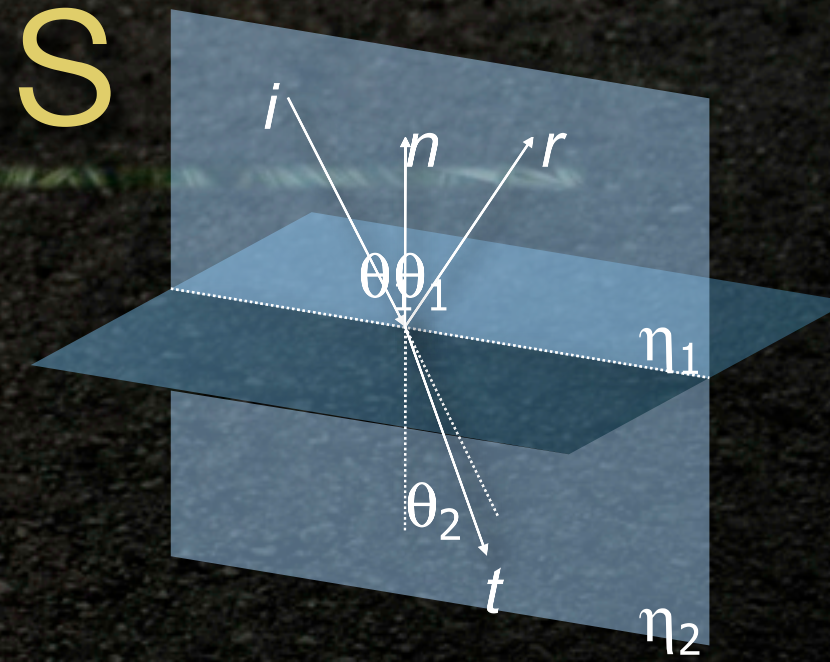
$$r_{\parallel}^2 = \frac{\sin^2(\theta_1 - \theta_2)}{\sin^2(\theta_1 + \theta_2)}$$

$$r_{\perp}^2 = \frac{\tan^2(\theta_1 - \theta_2)}{\tan^2(\theta_1 + \theta_2)}$$

Fresnel equation for conductors



Fresnel Equations



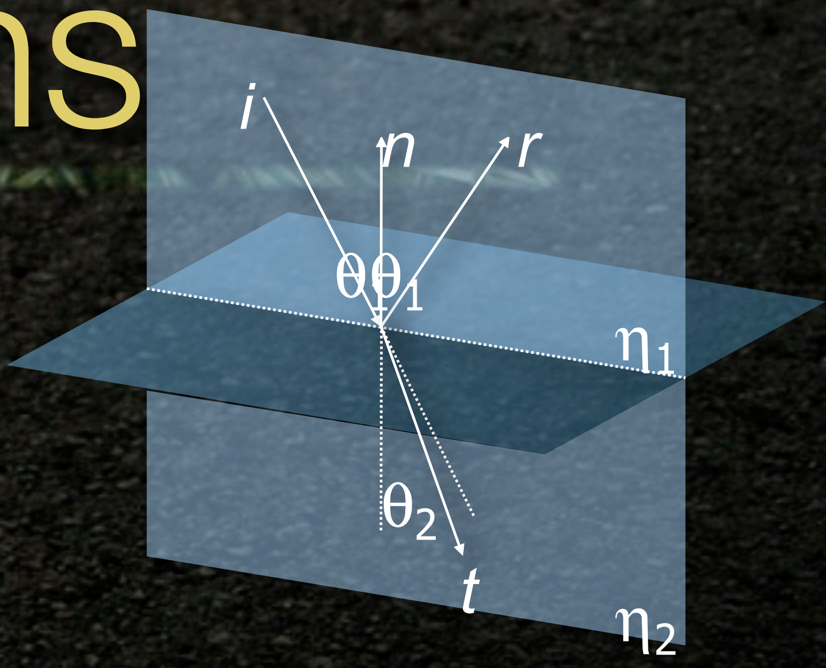
Fresnel equation for conductors

$$r_{\parallel}^2 = \frac{\sin^2(\theta_1 - \theta_2)}{\sin^2(\theta_1 + \theta_2)}$$

$$r_{\perp}^2 = \frac{\tan^2(\theta_1 - \theta_2)}{\tan^2(\theta_1 + \theta_2)}$$

$$F_r = \frac{1}{2}\left(r_{\parallel}^2 + r_{\perp}^2\right)$$

Fresnel Equations



$$r_{\parallel}^2 = \frac{\sin^2(\theta_1 - \theta_2)}{\sin^2(\theta_1 + \theta_2)}$$

$$r_{\perp}^2 = \frac{\tan^2(\theta_1 - \theta_2)}{\tan^2(\theta_1 + \theta_2)}$$

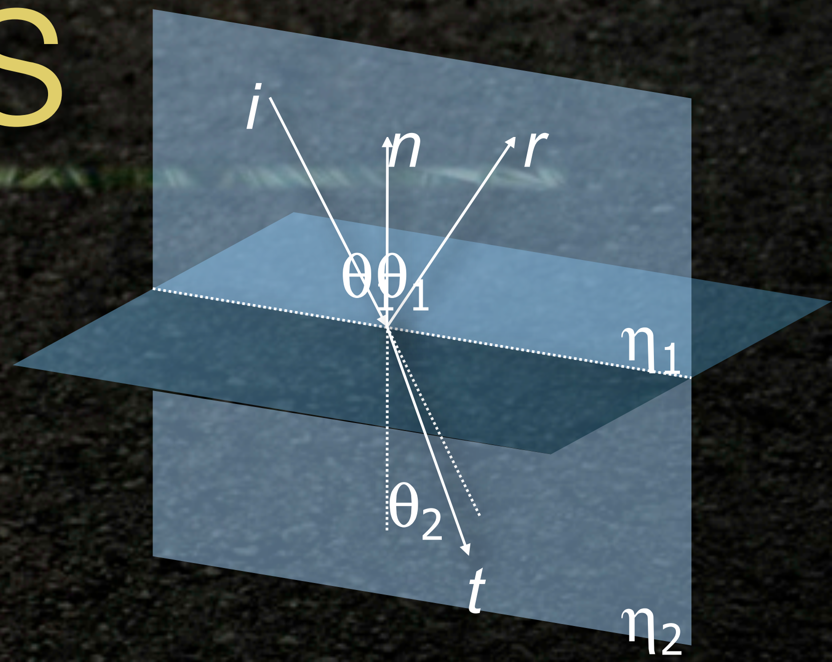
$$F_r = \frac{1}{2}\left(r_{\parallel}^2 + r_{\perp}^2\right)$$

For $\theta_1 = \theta_2 = 0$:

$$\mathrm{F_r} = \frac{(\eta_1 - \eta_2)^2}{(\eta_1 + \eta_2)^2}$$

$$\eta = \frac{1 + \sqrt{F_r}}{1 - \sqrt{F_r}}$$

Fresnel Equations



Schlick approximation:

$$F_r \approx R_0 + \left(1 - R_0\right)\left(1 - \cos\theta_1\right)^5$$

$$R_0 = \left(\frac{\eta - 1}{\eta + 1}\right)^2$$

Metal shading

Compute hit position ($\vec{P} = \vec{O} + t\vec{V}$)

Call primitive to get normal ($\vec{N}$) (normalized)

$costheta = \vec{N} \cdot \vec{V}$

$if\,(costheta > 0)$

normal =-normal

else

costheta = -costheta

foreach light source

compute phong term, just like Phong material

result=speclight*R_0

if depth of ray <maximum depth:

$F_r = R_0 + (1 - R_0)(1 - costheta)^5$

reflection direction = $\vec{V}$+2costheta$\vec{N}$

refl color = trace/shade ray(hitpos, reflection direction)

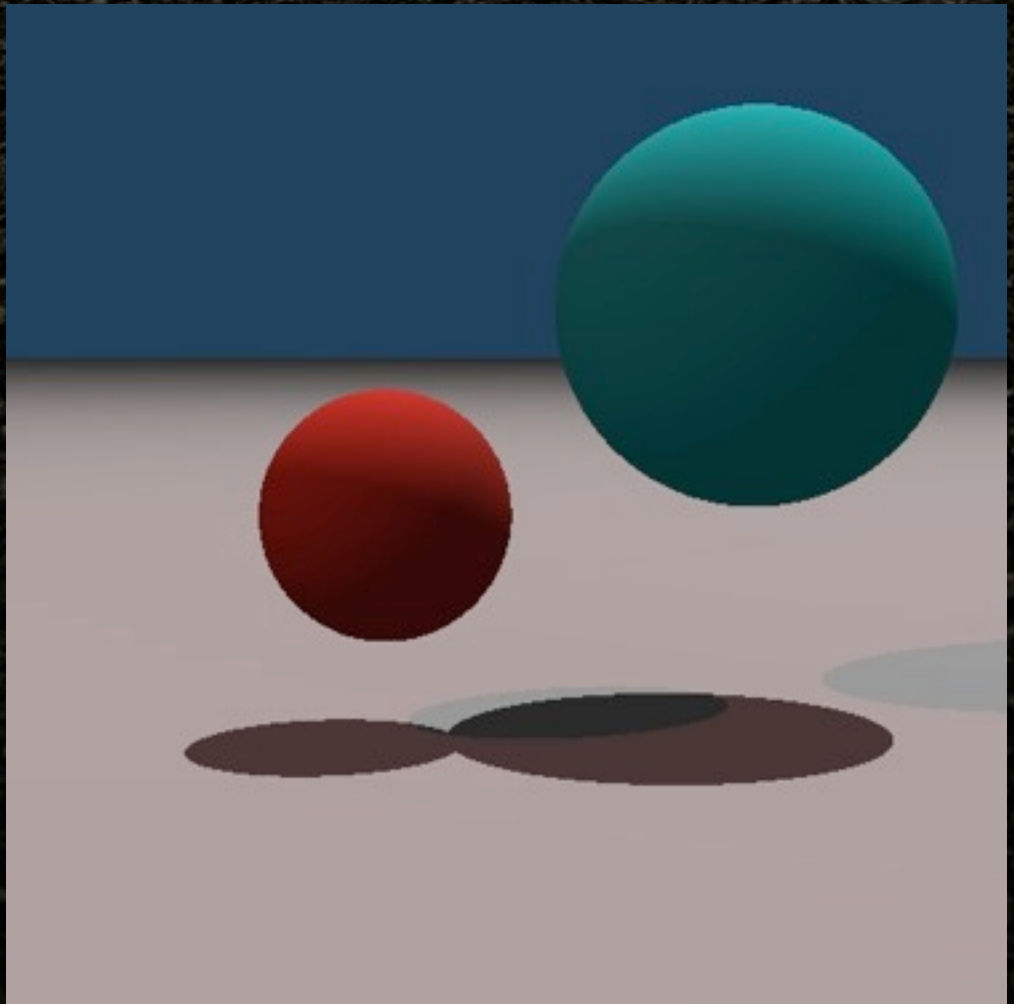
result += F_r * refl color

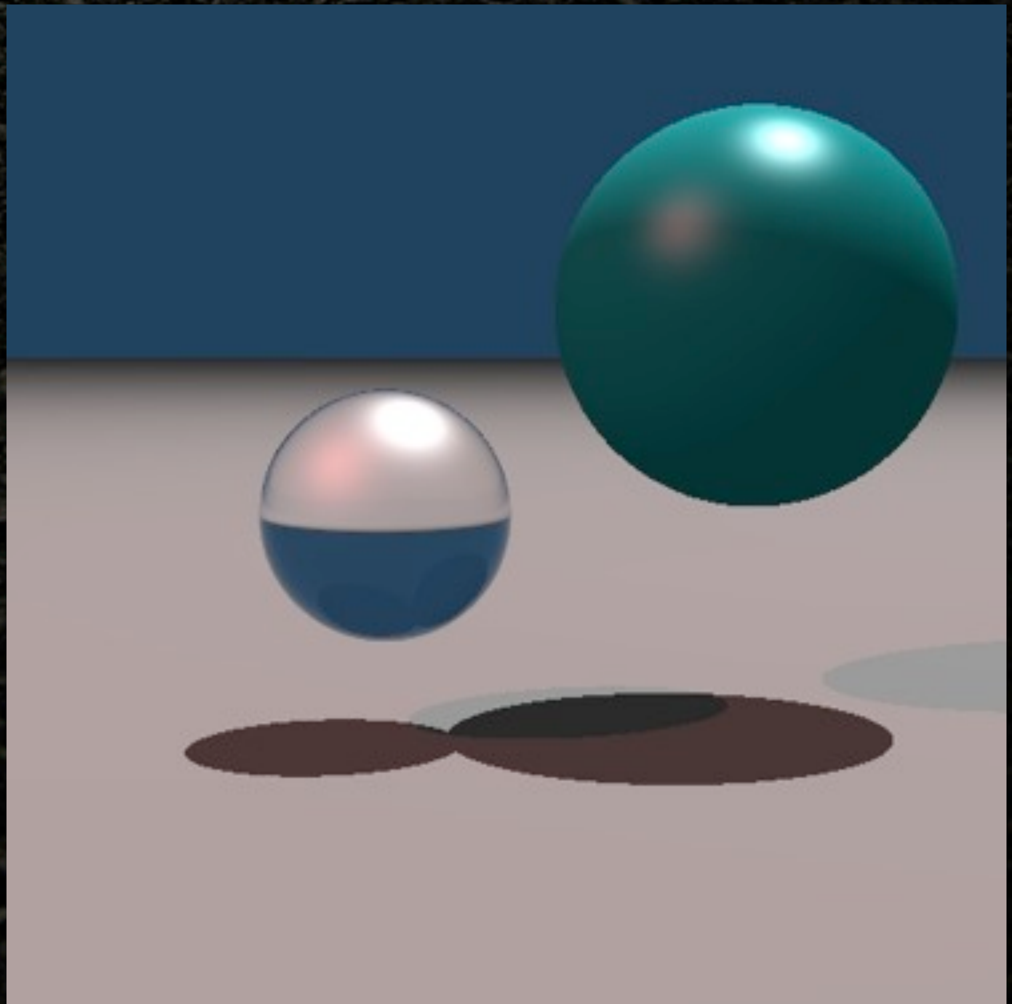
Implementation tips

- Make sure the magnitude of your reflection direction == 1 (print it out)
- Scene now contains max ray depth
- Start with max ray depth==2

Dielectric shading

	From light sources	From other surfaces
Diffuse reflection	-	-
Specular reflection	Phong term	Fresnel reflection
Diffuse transmission	-	-
Specular transmission	Phong term	Fresnel transmission





Fresnel equations

Fresnel equations for transparency

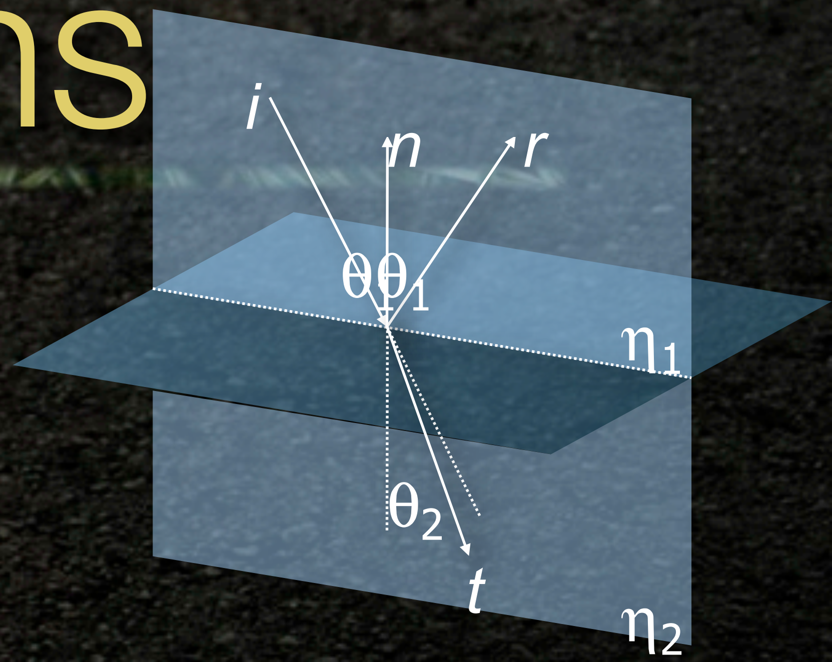
$$r_{\parallel}^2 = \frac{\eta_2 \cos\theta_1 - \eta_1 \cos\theta_2}{\eta_2 \cos\theta_1 + \eta_1 \cos\theta_2}$$

$$r_{\perp}^2 = \frac{\eta_1 \cos\theta_1 - \eta_2 \cos\theta_2}{\eta_2 \cos\theta_2 + \eta_2 \cos\theta_2}$$

$$F_r = \frac{1}{2}\left(r_{\parallel}^2 + r_{\perp}^2\right)$$

$$F_t = 1 - F_r$$

Fresnel Equations



$$r_{\parallel}^2 = \frac{\sin^2(\theta_1 - \theta_2)}{\sin^2(\theta_1 + \theta_2)}$$

$$r_{\perp}^2 = \frac{\tan^2(\theta_1 - \theta_2)}{\tan^2(\theta_1 + \theta_2)}$$

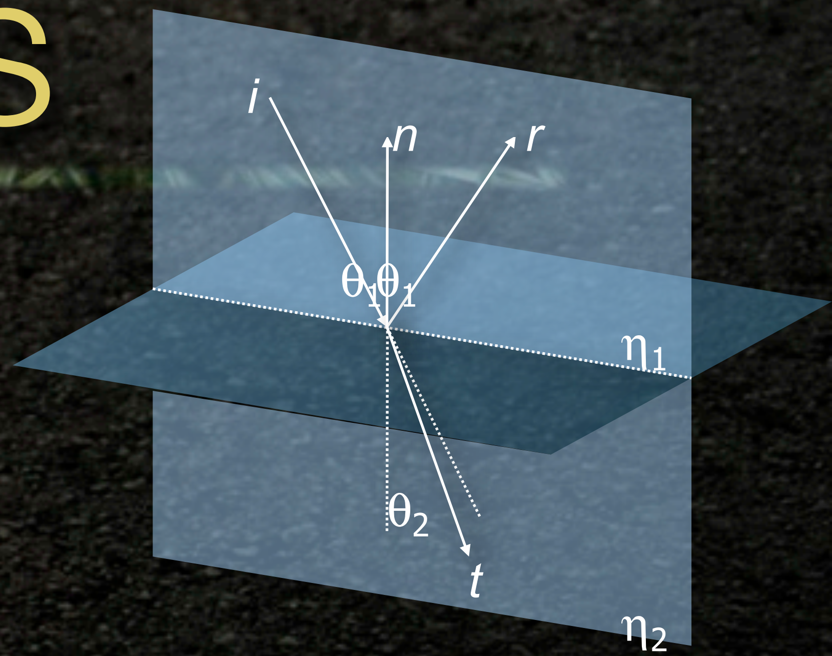
$$F_r = \frac{1}{2}\left(r_{\parallel}^2 + r_{\perp}^2\right)$$

For $\theta_1 = \theta_2 = 0$:

$$\mathrm{F_r} = \frac{(\eta_1 - \eta_2)^2}{(\eta_1 + \eta_2)^2}$$

$$\eta = \frac{1 + \sqrt{F_r}}{1 - \sqrt{F_r}}$$

Fresnel Equations



Schlick approximation:

$$F_r \approx R_0 + (1 - R_0)(1 - \cos\theta_m)^5$$

$$\theta_m = \max(\theta_1, \theta_2)$$

$$F_t = 1 - F_r$$

$$R_0 = \left(\frac{\eta - 1}{\eta + 1}\right)^2$$