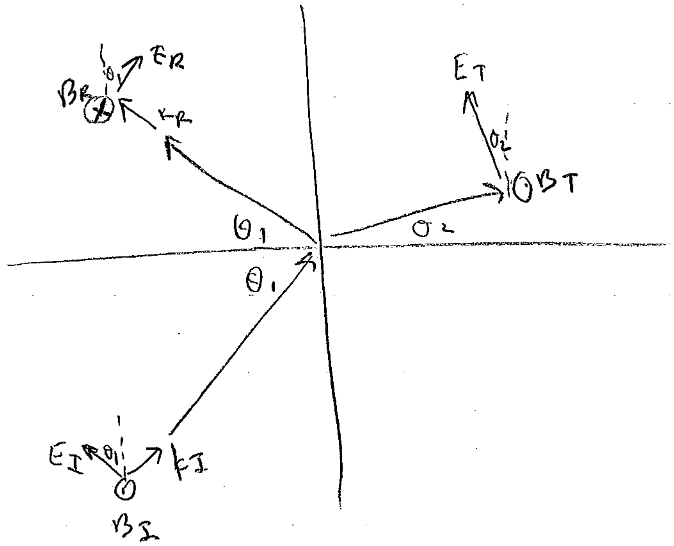
HW 6 p3.1

Do the same thing for p-polarized light → E is ∥ to plane (in plane)

Start w/ picture, ensure that $E \times B$ in K direction



assume a direction for E, if wrong will turn out negative

Do rest for HW!

bndy conds → 2 eqns

→ subst β, α

→ solve for ratios

Result:

$$r = \frac{\alpha - \beta}{\alpha + \beta}$$

$$t = \frac{2}{\alpha + \beta}$$

p-polarization

Summary on Powerpoint

Intensity coefficients: R and T

(already did this for 1D case)

Recall Poynting: $I = \langle S \rangle = \frac{1}{2} n \epsilon_0 c E^2$

$$R = \frac{I_{refl}}{I_{incident}} = \frac{\frac{1}{2} n_1 \epsilon_0 c E_R^2}{\frac{1}{2} n_1 \epsilon_0 c E_I^2}$$

$$\boxed{R = |r|^2}$$

$T = \frac{I_{trans}}{I_{incident}}$? conservation of energy say

$$I_{incident} = I_{reflected} + I_{transmitted}$$

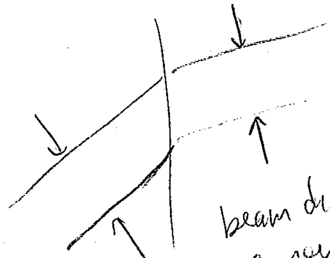
$$1 = R + T$$

$$\boxed{T = 1 - R}$$ (true if no absorption)

alternatively: $T = \frac{\frac{1}{2} n_2 \epsilon_0 c E_T^2}{\frac{1}{2} n_1 \epsilon_0 c E_I^2} \frac{\cos\theta_2}{\cos\theta_1}$

$$\boxed{T = \alpha\beta \cdot |t|^2}$$

☆ Modification needed for beams at angle



beam diameters are now different

area changed by ratio of cosines

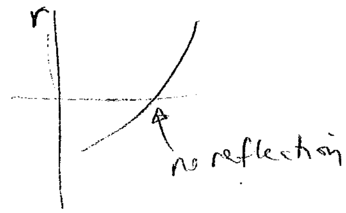
Fresnel Eqns - what do they mean?

Plots for air ($n=1$) to glass ($n=1.5$)

(In powerpoint)

Notice "Brewster angle"

p-polar.



when does $r=0$ for p polar?

Num $=0$

$\alpha=\beta$

$$\frac{\cos\theta_2}{\cos\theta_1}=\frac{n_2}{n_1}$$

$$\rightarrow \frac{\sqrt{1-\sin^2\theta_2}}{\sqrt{1-\sin^2\theta_1}}=\frac{n_2}{n_1}$$

$$\rightarrow \frac{\sqrt{1-\frac{n_1^2}{n_2^2}\sin^2\theta_1}}{\sqrt{1-\sin^2\theta_1}}=\frac{n_2}{n_1} \longrightarrow \sin^2\theta_1=\frac{\beta^2}{\beta^2+1} \quad (\beta=n_2/n_1)$$

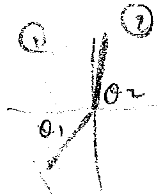
$$\longrightarrow \cos^2\theta_1=\frac{1}{\beta^2+1}$$

$$\longrightarrow \tan^2\theta_1=\beta^2 \longrightarrow \boxed{\tan\theta_1=\beta}$$

day 9 pg 4

Total Internal Reflection

– give reading quizzes (2x)



$n_1 > n_2$

Review

When Snell's Law predicts $\theta_2 = 90°$
it can't bend anymore

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

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

$\theta_1 \geq \sin^{-1}\left(\frac{n_2}{n_1}\right)$ TIR occurs

Proof that it's total reflection

For p polar. $r = \frac{\tilde{E}_{0R}}{\tilde{E}_{0I}} = \frac{\alpha - \beta}{\alpha + \beta}$ $\alpha = \frac{\cos\theta_2}{\cos\theta_1}$ $\beta = \frac{n_2}{n_1}$

α is now imaginary! But that's OK with equations

proof: $\alpha = \frac{\sqrt{1-\sin^2\theta_2}}{\cos\theta_1} = \frac{\sqrt{1-\left(\frac{n_1}{n_2}\right)^2 \sin\theta_1}}{\cos\theta_1}$ → larger than 1

$= \frac{\sqrt{\text{negative}}}{\text{positive}}$

= Imaginary!

$= ix$

What does that do to r?

$r = \frac{ix - \beta}{ix + \beta}$

what is magnitude of r? $|r| = \sqrt{r r^*}$

$= \sqrt{\left(\frac{ix-\beta}{ix+\beta}\right)\left(\frac{-ix-\beta}{-ix+\beta}\right)}$

$= \sqrt{(-1)(-1)}$

$= 1$ ✓

All is reflected!

evanescent field → long eqn, Eqn 3.42 pg 82

Optics animation 1, 2⁴⁶ + animation 5, 1³³ → evanescent waves

~~Reflection consider n now can be complex $N = n + iK$~~
~~– not only is α imaginary (complex?)~~
~~but β is also!~~
~~but aside from that things same~~
~~through~~

Reading quiz

Reflection from conductors

n now complex, $N = n + iK$.

remember $\alpha = n_2/n_1$

$\beta = \frac{\cos\theta_2}{\cos\theta_1}$

α, β both complex.

Snell's law for air - metal

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

$(1)\sin\theta_1 = (n + iK)\sin\theta_2$

θ_2 is complex!

(But that's OK)

But all eqns still hold.

Mathematica + most calculators can handle complex angles.

If yours can't, do $\beta = \frac{\sqrt{1 - \sin^2\theta_2}}{\cos\theta_1}$ ← $\sin\theta_2$ from Snell's law.

Result: r = complex #

Write as $|r| e^{i\phi}$

$|r|$ ↓ what fraction of light reflects (usually fairly close to 100%)

ϕ ↘ phase shift of reflected wave relative to incident wave