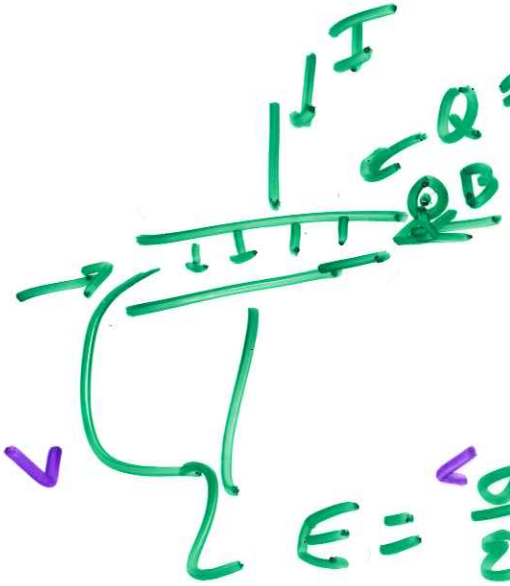
Poynting

$S = E \times H$




$$E = \frac{\sigma}{\varepsilon_0} = \frac{It}{A\,\varepsilon_0}$$

$S = E \times H$

$$\nabla \cdot J + \partial_t \rho = 0$$

$\frac{Q/t}{A}$ $\qquad$ $\frac{Q}{Vol}$ ← Ene

$\underline{\underline{u_E + u_M}}$

Study Day?
Exam 3
Tues 4pm

Maxwell Final

$\nabla\cdot D=\rho$ $\quad \nabla\times E=-\partial_t B$ $\quad \nabla\cdot B=0$ $\quad \nabla\times H=J+\partial_t D$

displacement current density

$D=\varepsilon E$ $\quad B=\mu H$ ← linear material

$\nabla\cdot J+\partial_t\rho=0$ ← conservation of charge $\quad J=gE$

$u_E+u_M=\frac{1}{2}E\cdot D+\frac{1}{2}B\cdot H$ ← $\frac{\text{energy}}{\text{volume}}$

$B=\nabla\times A$ $\quad E=-\nabla\phi-\partial_t A$ $\quad$ potentials

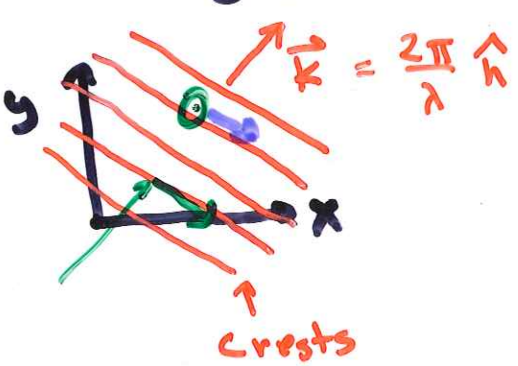
Vector Magic: $\nabla\cdot(E\times H)+\partial_t(u_E+u_M)=-J\cdot E$

$\frac{W}{m^2}$ → Poynting $\quad \frac{J}{m^3}$ $\quad \frac{\text{energy in/out via external}}{\text{volume}}$

wave Eq: $\left(\nabla^2-\varepsilon\mu\,\partial_t^2-g\mu\,\partial_t\right)\begin{matrix}H\\E\end{matrix}=0$

$c=\frac{1}{\sqrt{\varepsilon_0\mu_0}}$ $\quad v=\frac{1}{\sqrt{\varepsilon\mu}}$ $\quad n=\frac{c}{v}=\sqrt{K_E K_M}$

Note: $g\neq 0$ → damped waves (future)




$$e^{i(\vec{k}\cdot\vec{r}-\omega t)}\begin{bmatrix}E_0\\H_0\end{bmatrix}$$

$\vec{\nabla}\to i\vec{k}$ $\quad \partial_t\to -i\omega$

Free space ($\rho=0,\vec{J}=0$) Maxwell

$\vec{k}\cdot\vec{E}_0=0$ $\quad \vec{k}\times\vec{E}_0=\omega\mu\vec{H}_0$ $\quad \vec{k}\cdot\vec{H}_0=0$ $\quad \vec{k}\times\vec{H}_0=-\omega\varepsilon\vec{E}_0$

$\overline{E\times H}=$ $\quad E$

$\frac{\omega}{k}=v_p=\lambda f$ $\quad$ [group velocity $=\frac{d\omega}{dk}$]

$K\,H_0$

$v_p = \frac{\omega}{k}$

$k E_0 = \omega \mu H_0$

$k H_0 = \omega \varepsilon E_0$

$E_0 = v_p \underbrace{\mu H_0}_{B_0}$

$H_0 = v_p \varepsilon E_0$

$E_0 = v_p B_0$

$E_0 = v_p \mu v_p \varepsilon E_0$

$\frac{1}{\mu \varepsilon} = v_p^2$

$S = E \times H = E_0 v_p \overbrace{\varepsilon E_0 \hat{k} \times \frac{\mu}{\mu}}^{\frac{1}{v_p^2}}$

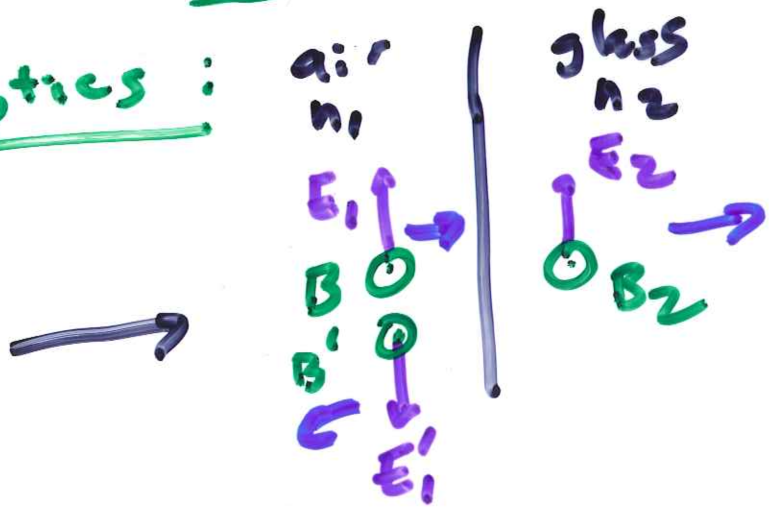
$= \frac{1}{v_p \mu} E_0^2 = \frac{c}{v_p} \frac{1}{c\mu} E_0^2$

$= n \frac{1}{c\mu} E_0^2$

$\langle S \rangle = \frac{n}{c\mu} \frac{1}{2} E_0^2$

Relativity & Light production

## Optics :




$g = 0$

$\mu_0 = $ all

$\Delta E_t = 0$

$\Delta H_t = 0$

$\Delta B_t = 0$

$v_p B = E$

$B = \frac{1}{v_p} E$

$cB = nE$

$E_1 - E_1' = E_2$

$B + B' = B_2$

$n_1 (E_1 + E_1') = n_2 E_2$

$- \quad n_2 ( E_1 - E_1' = E_2 )$

$(n_1 - n_2) E_1 + (n_1 + n_2) E_1' = 0$

$\frac{(n_2 - n_1)}{(n_1 + n_2)} E_1 = E_1'$

$n_2 > n_1$ inversion on reflection

$$\frac{\text{reflected } P}{\text{incident } P} = \frac{n_1 \left[ \left( \frac{n_2 - n_1}{n_1 + n_2} \right) E_1 \right]^2}{n_1 \left[ E_1 \right]^2}$$

$\frac{(n_2 - n_1)^2}{(n_2 + n_1)^2}$ ~

1.5

1

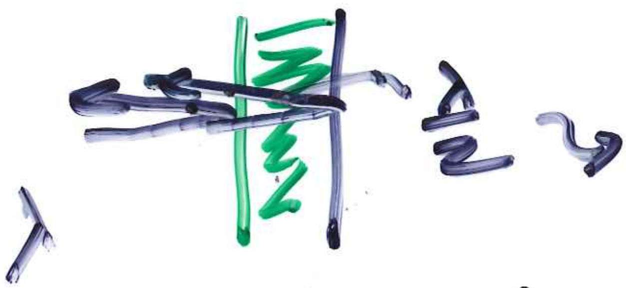
$\left( \frac{.5}{2.5} \right) = \left( \frac{1}{5} \right)^2$

$\frac{1}{25} = 4\%$

anti reflection coating

blue

$$2t = \frac{\lambda/n}{2}$$



conserved

BC!!!!


$e^{ik\cdot r}$

$$f\lambda = \frac{c}{n}$$

$$n_1 \cancel{f_1} \lambda_1 = n_2 \cancel{f_2} \lambda_2$$

$$n_1 \frac{\lambda_1}{n_2} = \lambda_2$$

$n_1 = 1$

Snell

$$n_1 \sin\theta = n_2 \sin\phi$$

$i\bar{k}\cdot\bar{r}$

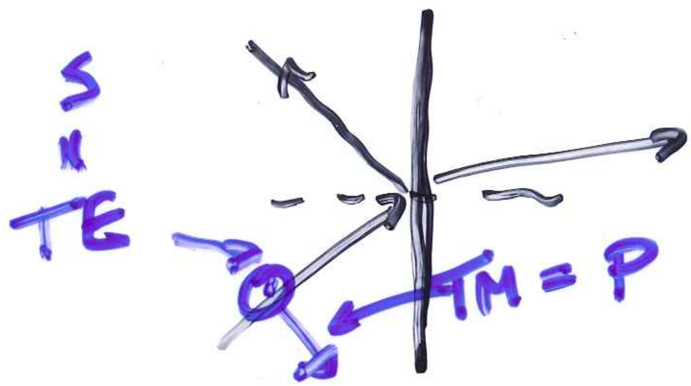
$$k_1 \sin\theta = k_2 \sin\phi$$

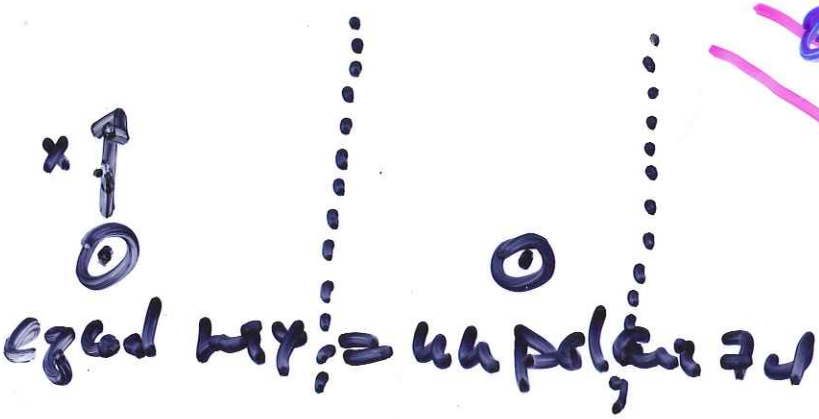
$$n_1 \sin\theta = n_2 \sin\phi$$

$$\frac{\omega}{k} = v_\phi$$

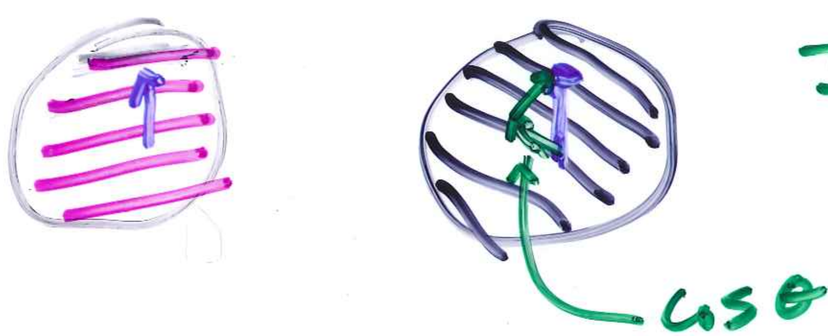
$$k = \frac{\omega}{v_\phi} = \frac{n\omega}{c}$$

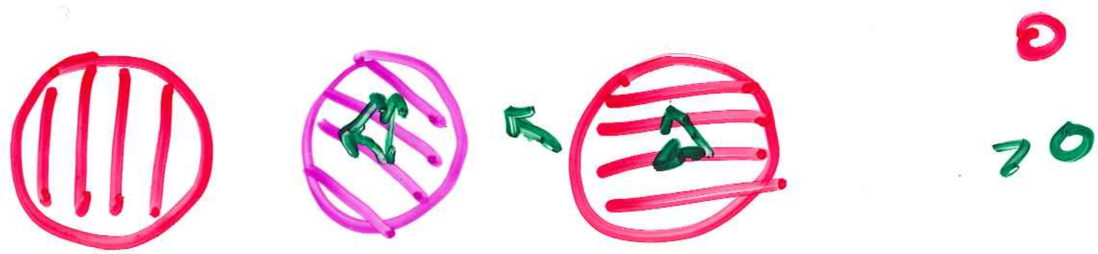
# polarization



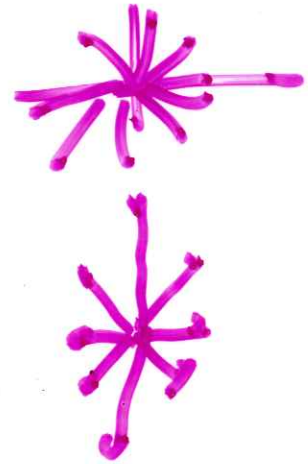

$I = I_0 \cos^2\theta$



Circular polarized light

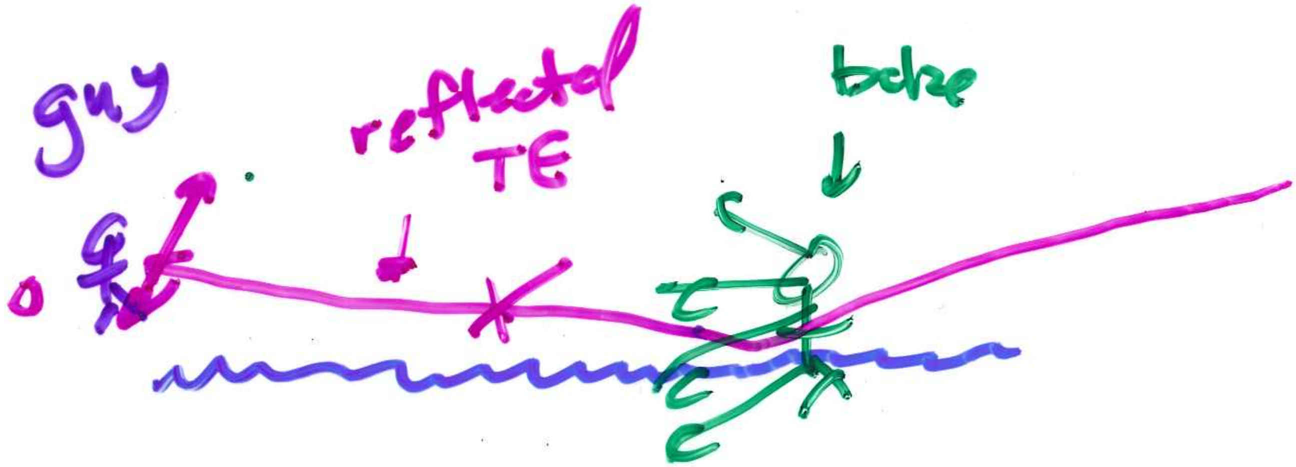
$$E = \hat{x}\cos(\omega t) + \hat{y}\sin(\omega t)$$



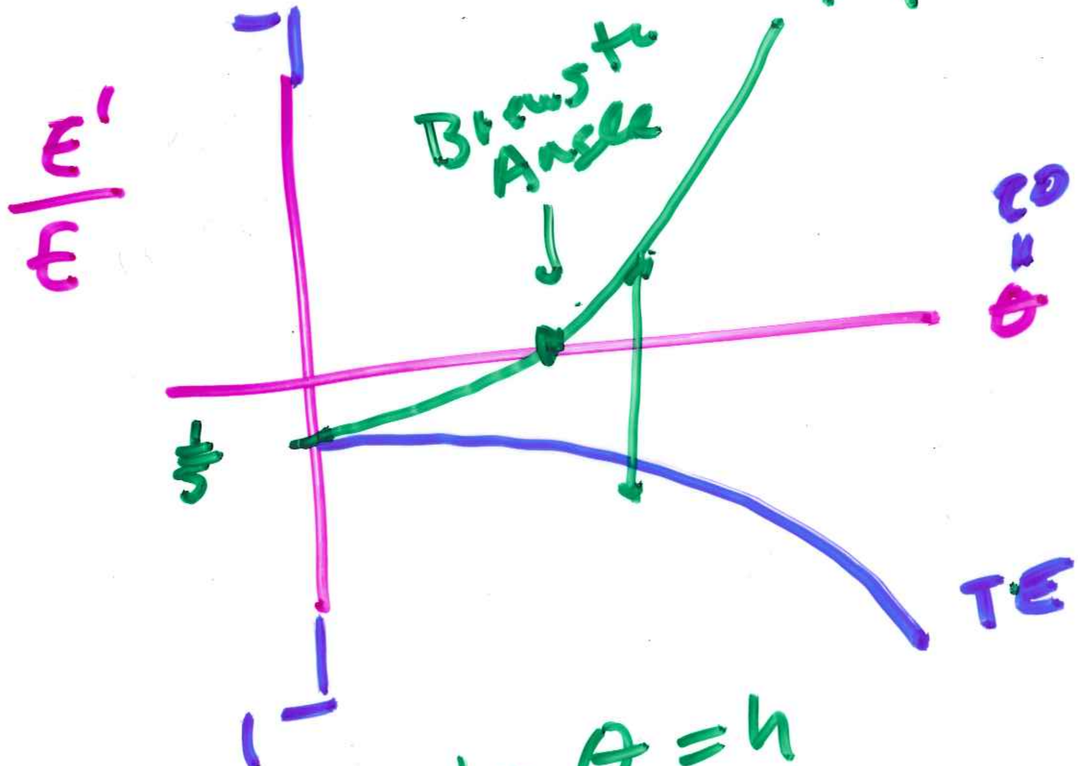
real story

photon $\leftarrow$ $s = 1$

$s = \frac{1}{2}$




Fresnel




$$\tan\theta = n$$

$\uparrow$ 1.33