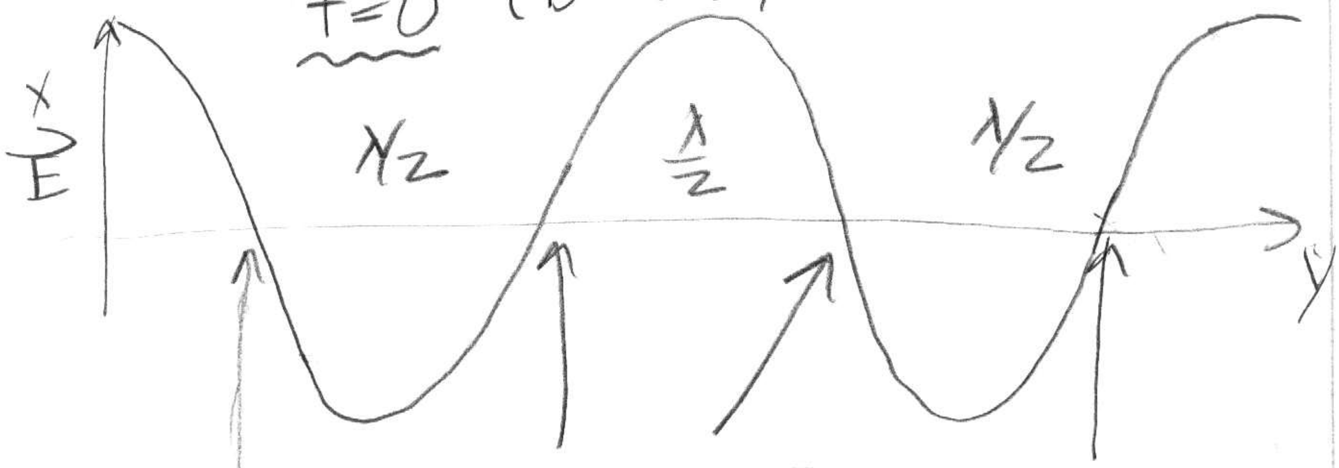
$t=0$ ($\vec{B}=0$!)

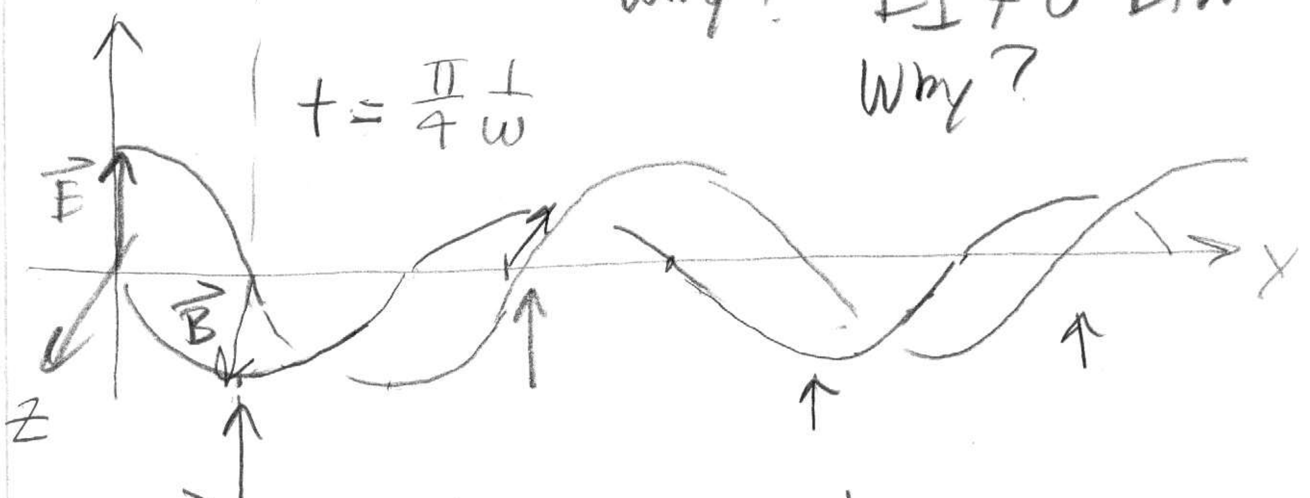


could put mirror here... $\boxed{\vec{E}_{\parallel} \text{ must be } 0 \text{ at conductor}}$

why? $\vec{E}_{\perp} \neq 0$ BTW

why?

$t = \frac{\pi}{4}\frac{1}{\omega}$



$\vec{E}_{\parallel}=0$ at mirror always

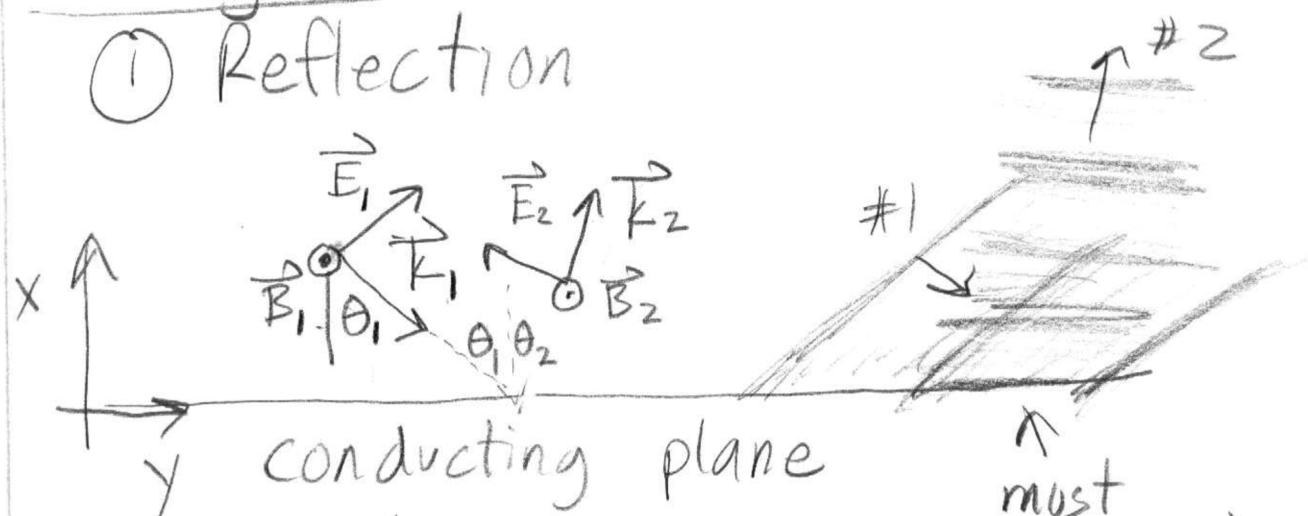
$\vec{B}_{\perp}$? usually not zero!!!

why? $\exists$ a sheet current in the mirror!! caused by $\frac{\partial \vec{B}}{\partial t}$, not $\vec{E}$!

But wait, there is more!

Waveguide !

① Reflection



must conspire to get $\vec{E}_{\parallel}=0$ there !

NOT EASY TO VISUALIZE .

$$\vec{k}_1 = \frac{2\pi}{\lambda_1}\left(-\hat{x}\cos\theta_1 + \hat{y}\sin\theta_1\right)$$

$$\vec{r} = x\hat{x} + y\hat{y}$$

$$\left.\begin{aligned} \vec{k}_1\cdot\vec{r} &= \frac{2\pi}{\lambda_1}\left(-x\cos\theta_1 + y\sin\theta_1\right) \\ \vec{k}_2\cdot\vec{r} &= \frac{2\pi}{\lambda_2}\left(+x\cos\theta_2 + y\sin\theta_1\right) \end{aligned}\right\} \begin{array}{l}\text{want} \\ \vec{E}_{\parallel}=0 \\ @\ x=0\end{array}$$

or

$$\underbrace{E_1\cos\theta_1}_{E_{\parallel,1}}\, e^{i\frac{2\pi}{\lambda_1}y\sin\theta_1 - i\omega_1 t} - \underbrace{E_2\cos\theta_2}_{E_{\parallel,2}}\, e^{i\frac{2\pi}{\lambda_2}y\sin\theta_2 - i\omega_2 t} = 0$$

must work for all y, t !

$\underbrace{E_1 = E_2}_{E}$ $\underbrace{\theta_1 = \theta_2}_{\text{law of reflection, } \theta}$ $\lambda_1 = \lambda_2$ $\omega_1 = \omega_2$

λ ω

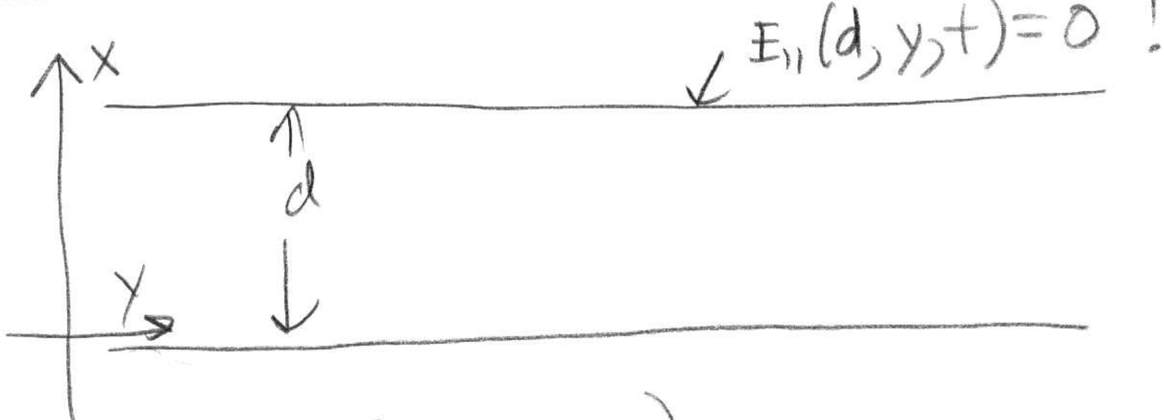
Note: $E_\perp \neq 0$! (charge on surface!)

$$E_\parallel(x,y,t) = E\cos\theta\, e^{i\frac{2\pi}{\lambda}y\sin\theta - i\omega t}\underbrace{\left(e^{-i\frac{2\pi}{\lambda}x\cos\theta} - e^{i\frac{2\pi}{\lambda}x\cos\theta}\right)}_{-2i\sin\left(\frac{2\pi}{\lambda}x\cos\theta\right)}$$

need $i\sin\left(\frac{2\pi}{\lambda}y\sin\theta - \omega t\right)$

$$= 2E\cos\theta\,\sin\left(\frac{2\pi}{\lambda}y\sin\theta - \omega t\right)\sin\left(\frac{2\pi}{\lambda}x\cos\theta\right)$$

Put in second conductor



$$\therefore \quad \sin\left(\frac{2\pi}{\lambda}d\cos\theta\right) = 0$$

$$\frac{2\cancel{\pi}}{\lambda}d\cos\theta = n\cancel{\pi}$$

$$\boxed{\lambda = \frac{2d}{n}\cos\theta}$$

largest λ that "propagates" $= 2d$

shine radiation

$\lambda > 2d$ in $\longrightarrow$

"wave guide"

(Too big to fit in!)

$\Rightarrow$ what happens?

need $(\lambda > 2d) = 2d \underbrace{\cos\theta}_{\text{must exceed } 1\,!}$

θ must be... imaginary!

$\sin\theta$ ... imaginary too

$$e^{i\frac{2\pi}{\lambda} y \underbrace{\sin\theta}_{\text{imaginary}}} \rightarrow \underbrace{e^{-ky}}_{\text{exponential decay}}$$

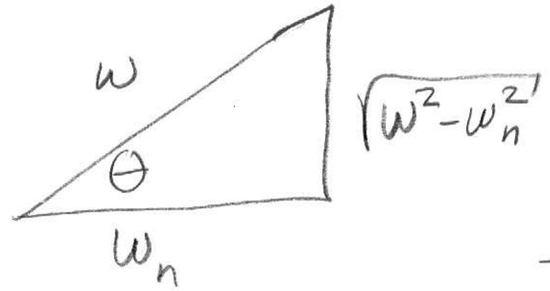
But, now suppose $\lambda < 2d$

<u>DEFINE</u> $\lambda_n \equiv \frac{2d}{n}$ recall $\frac{2\pi}{\lambda} = \frac{\omega}{c}$

$\frac{2\pi}{\lambda_n} \equiv \frac{\omega_n}{c}$ definition

note $\frac{\lambda_n}{\lambda} = \frac{\omega}{\omega_n}$

Then $\lambda = \lambda_n \cos\theta$, $\cos\theta = \dfrac{\lambda}{\lambda_n} = \dfrac{\omega_n}{\omega}$



$\sin\theta = \dfrac{\sqrt{\omega^2-\omega_n^2}}{\omega}$

$\tan\theta = \dfrac{\sqrt{\omega^2-\omega_n^2}}{\omega_n}$

$$E_{11}(x,y,t) = 2E\cos\theta \sin\left(\frac{2\pi \sin\theta}{\lambda_n \cos\theta} y - \omega t\right) \sin\left(\frac{2\pi}{\lambda} x\cos\theta\right)$$

$$= 2E\cos\theta \sin\left(\frac{\omega_n}{c}\frac{\sqrt{\omega^2-\omega_n^2}}{\omega_n} y - \omega t\right) \sin\left(\frac{2\pi}{\lambda_n \cancel{\cos\theta}} x \cancel{\cos\theta}\right)$$

$$\boxed{E_{11}(x,y,t) = 2E\cos\theta \sin\left(\frac{\sqrt{\omega^2-\omega_n^2}}{c} y - \omega t\right) \sin\left(\frac{2\pi x}{\lambda_n}\right)}$$

<u>not</u> $\sin\left(\frac{\omega}{c} y - \omega t\right)$

normal k