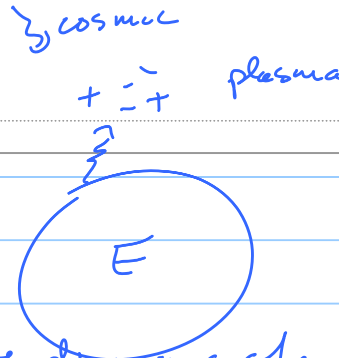
Note Title 7/24/2006

Fowles

ionosphere:



microscopic model EM wave driving a charge particle

(Newton's 2nd $\Rightarrow v \Rightarrow J = \rho v \Rightarrow$ ME or wave eqn

damping & inertial

from wave eq get dispersion relation: $K^2 = \frac{\omega^2}{c^2} + \frac{i\omega\mu_0 \frac{\sigma_0}{\tau}}{\frac{1}{\tau} - i\omega}$

τ damping :)

atmosphere damping negligible $\frac{1}{\tau} \to 0$

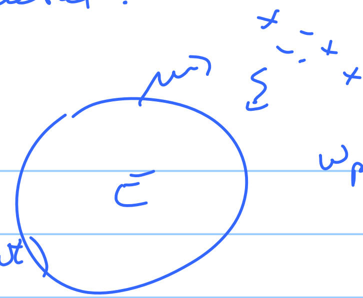
dc conductivity electron density

$$\sigma = \frac{\sigma_0/\tau}{\frac{1}{\tau} - i\omega} \xrightarrow[\text{damping}]{\text{little}} = \frac{iNfe^2}{m\omega}$$

mass of electron driving freq

$$\Rightarrow \quad K^2 = \frac{1}{c^2}\left(\omega^2 - \omega_p^2\right)$$

for $\omega < \omega_p$ K is imaginary & damping into plasma like reflection from a metal.



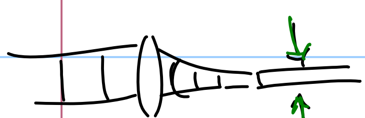
$\omega_p \simeq 2\pi\, 3$ MHz

for $\omega > \omega_p$ transmission

because k is real $\Rightarrow e^{i(kx-\omega t)}$

← travelling wave

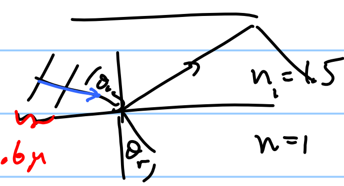
Waveguides:



$\lambda = .6\mu$

$\frac{2\mu}{200\mu}$ $2\mu = 2\times10^{-6}$ m

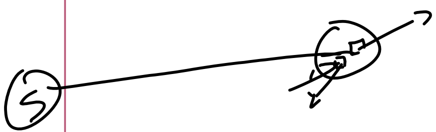
$1.5 \sin\theta_i = 1.0 \sin\theta_r$



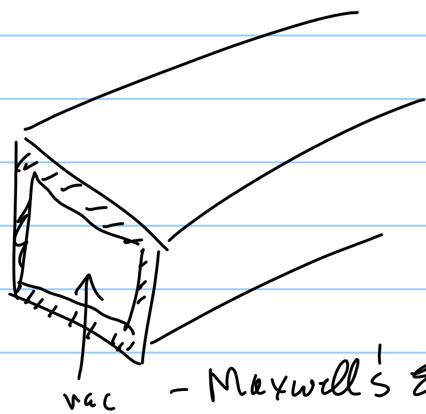
$\sin\theta_r = \frac{1.5}{1.0}\sin 80°$

1.3

← if surface roughness << λ angle inc = angle reflect

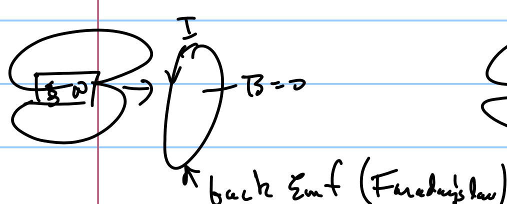


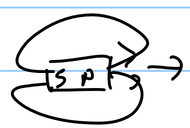
E

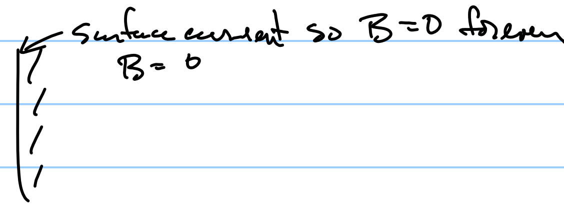


- Maxwell's Equation in vac
- Bndry conditions (metal loss Grad level class)

assume perfect conductor with E & B inside 0
to start with & there 0 when we launch wave into waveguide

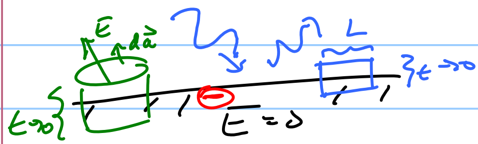






$$\vec{\nabla}\times\vec{E} = -\frac{\partial \vec{B}}{\partial t} \qquad \vec{\nabla}\times\vec{B} = \mu_0\vec{J} + \mu_0\epsilon_0\frac{\partial\vec{E}}{\partial t}$$

$$\vec{\nabla}\cdot\vec{E} = \rho/\epsilon_0 \qquad \vec{\nabla}\cdot\vec{B} = 0$$



$$\int \vec{\nabla}\times\vec{E}\cdot d\vec{a} = -\frac{\partial}{\partial t}\int\vec{B}\cdot d\vec{a}$$

$$\oint \vec{E}\cdot d\vec{l} = -\frac{\partial}{\partial t}\Phi_B \overset{=0}{} \quad \text{area goes to zero}$$

$$\oint \vec{E}\cdot d\vec{a} = \int \vec{E} + \int\limits_{\text{body}}^{0} + \int$$

$$E^{\parallel}_{vac}L - E^{\parallel}_{metal}L = 0$$

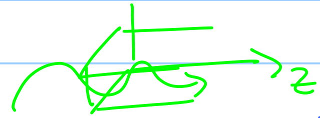
$E_{\perp}$

$$\boxed{E^{\parallel}_{vac} = 0}$$

$$E^{\parallel}_{in} + E^{\parallel}_{reflec} = 0$$

$$\vec{F}_{net} = q\vec{E}^{\parallel} + \cancel{\vec{F}_{damping}}^{\,0} = m\vec{a}$$

perfect conductor



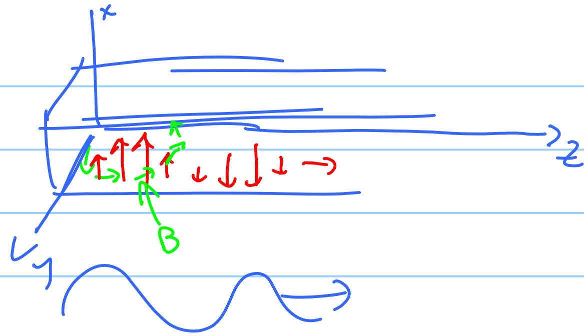
Assumption: $\tilde{E}(x,y,z,t) = \underline{\tilde{E}_0(x,y)}\, e^{i(kz-\omega t)}$

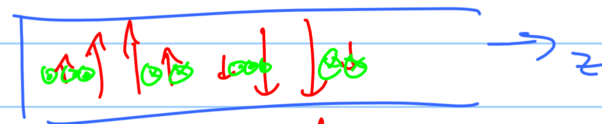
only

$$\tilde{B}(x,y,z,t) = \tilde{B}_0(x,y)e^{i(kz-\omega t)}$$
$$= B_0(x,y)\,K(z)\,\phi(t)$$

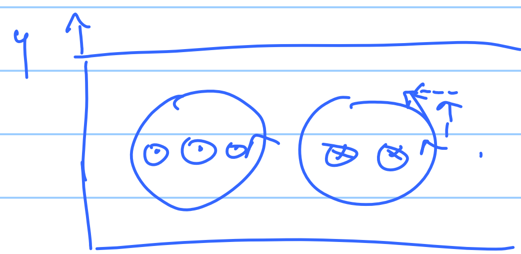
Sep. of variables

$\tilde{E}_0 = E_x \hat{x} + E_y \hat{y} + E_z \hat{z}$ $\qquad$ $\vec{B}_0 = B_x \hat{x} + E_y \hat{y} + E_z \hat{z}$





side



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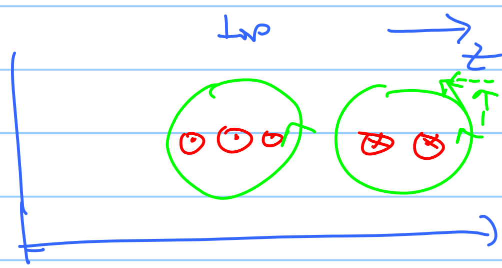
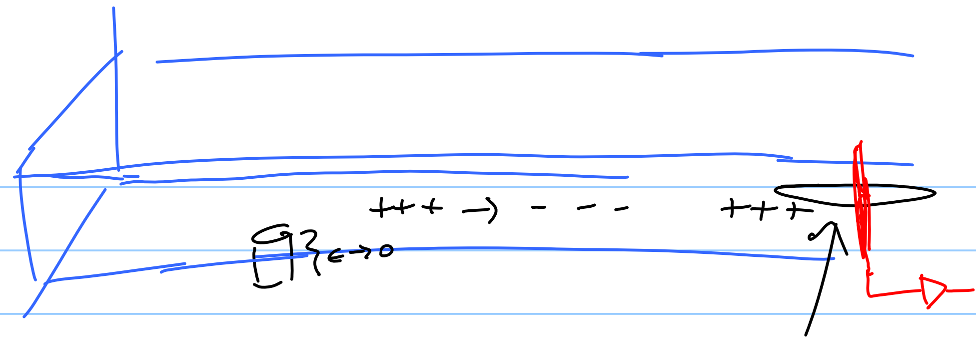


$\lambda \nu = c$

$\omega = kc$

$$e^{i(kz - \omega t)}$$
$$= e^{i(\frac{\omega}{c} z - \omega t)}$$
$$= e^{i\omega(\frac{z}{c} - t)}$$
$$= e^{i\omega(\frac{z - tc}{c})}$$
$$e^{i\frac{\omega}{c}(z - ct)}$$



$\vec{\nabla}\cdot\vec{E} = \frac{\rho}{\epsilon_0}$

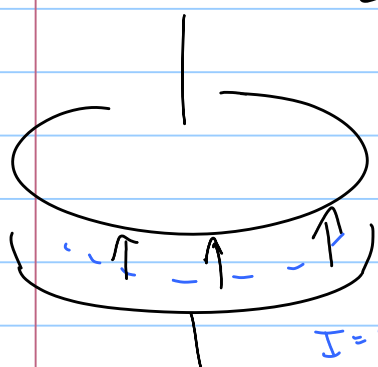
$\downarrow$

$\oint \vec{E}\cdot d\vec{a} = \frac{Q_{encl}}{\epsilon_0}$

$E_\perp^{vac} \cancel{A} - \cancel{E_\perp^{metal} A} = \frac{\sigma \cancel{A}}{\epsilon_0}$, $E_\perp^{metal} \to 0$

$E_\perp = \frac{\sigma}{\epsilon_0}$

$\hat{E}_0(x,y)\, e^{i(kz-\omega t)} = \frac{\sigma}{\epsilon_0}$

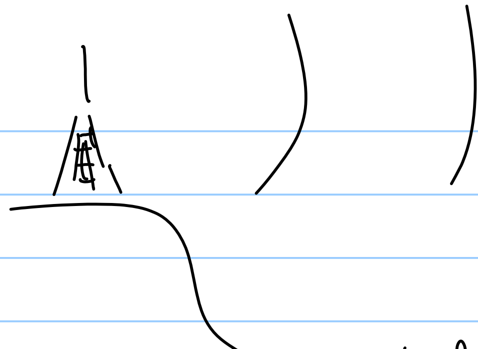


$\vec{\nabla}\times\vec{B} = \mu_0\epsilon_0 \frac{\partial \vec{E}}{\partial t}$ $\;\; \cdot d\vec{a}$ $\longrightarrow$ $\oint \vec{B}\cdot d\vec{l} = \mu_0\epsilon_0 \frac{\partial \int \vec{E}\cdot d\vec{a}}{\partial t}$

$\vec{\nabla}\times\vec{E} = -\frac{\partial \vec{B}}{\partial t}$ $\qquad B\, 2\pi r = \mu_0\epsilon_0 \frac{\partial}{\partial t} E \pi r^2$

$I = \frac{dQ}{dt}$ $\qquad E_{enc} = \frac{\sigma}{\epsilon_0} = \frac{Q}{A\epsilon_0} = \frac{It}{A\epsilon_0}$

4.)



Cal retarded potentials & find E & B from

$$\vec{B} = \vec{\nabla} \times \vec{A}$$