03/02

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \times \vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{J}$$

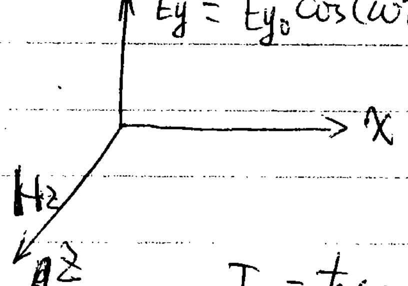
$$\nabla \cdot \vec{D} = \rho_{net}, \quad \nabla \cdot \vec{B} = 0$$

$$\vec{D} = \varepsilon \vec{E}, \quad \vec{J} = \sigma \vec{E}, \quad \vec{B} = \mu \vec{H}$$

ε = const spatially

$$\nabla^2 \vec{E} = \frac{\partial^2 \vec{E}}{\partial t^2} \cdot \mu\varepsilon$$

$$E_y = E_{y_0} \cos(\omega t - kx)$$



$$k^2 = \varepsilon \mu \omega^2$$

$$k = \frac{\omega}{\sqrt{\frac{1}{\mu\varepsilon}}} = \frac{\omega}{c}$$

$$E = \hbar\omega, \quad P = \hbar k, \quad n = c_0/c = \sqrt{\frac{\varepsilon}{\varepsilon_0}\frac{\mu}{\mu_0}} = \sqrt{\varepsilon_r}$$

$$\vec{E} \perp \vec{H} \perp \vec{k}! \quad E_y = E_{y_0} e^{-i(\omega t - kx)}$$

$$\vec{E} = Re(\vec{E}_c)$$

$$\vec{k} = k_x \hat{x} + k_y \hat{y} + k_z \hat{z}, \quad |\vec{k}| = \frac{2\pi}{\lambda}$$

$$\vec{E}_c = \vec{E}_0 \exp[-i(\omega t - \vec{k}\cdot\vec{r})], \quad |k|^2 = \frac{\omega^2}{c^2}$$

If $\sigma \neq 0$

$$+\vec{k}\cdot\vec{k} = +\mu\varepsilon\omega^2 + i\sigma\omega\mu$$

$$\vec{k}\cdot\vec{k} = \mu\omega^2 \underbrace{\left[\varepsilon_0(1+\chi) + i\frac{\sigma}{\omega}\right]}_{\tilde{\varepsilon}}$$

$$N = \sqrt{\tilde{\varepsilon}_r} = n + ik$$

N ↑ complex refractive index

n ↑ refractive index

k ↑ distinction coefficient

$$E_y = E_{y_0} \exp\left[-i\left(\omega t - \frac{N\omega}{c_0}x\right)\right]$$

$$= E_{y_0} \exp\left[-i\omega\left(t - \frac{n+ik}{c_0}x\right)\right]$$

$$= E_{y_0}\, e^{-\frac{\omega k}{c_0}x} \exp\left[-i\omega\left(t - \frac{n}{c_0}x\right)\right]$$

$$\Rightarrow \quad H_z = H_{z_0} \exp\left[-i\omega\left(t - \frac{N}{c_0}x\right)\right]$$

$$H_{z_0} = \frac{N}{\mu c_0} E_{y_0} \quad (\text{positive progation})$$

$$- \frac{N}{\mu c_0} E_{y_0} \quad (\text{Negative progation})$$

~~Poy~~

$$-\nabla\cdot(\vec{E}\times\vec{H}) = \frac{1}{2}\varepsilon\frac{\partial(\vec{E}\cdot\vec{E})}{\partial t} + \frac{1}{2}\mu\frac{\partial(\vec{H}\cdot\vec{H})}{\partial t} + \vec{E}\cdot\vec{J}$$

$$\int_v dv \left\{-\nabla\cdot(\vec{E}\times\vec{H})\right\} = \int_v \left\{\frac{1}{2}\varepsilon\frac{\partial(\vec{E}\cdot\vec{E})}{\partial t} + \frac{1}{2}\mu\frac{\partial(\vec{H}\cdot\vec{H})}{\partial t} + \vec{E}\cdot\vec{J}\right\} dv$$

Poynting Vector

$$\vec{S} = \vec{E}\times\vec{H} = \mathrm{Re}(\vec{E}_c)\times\mathrm{Re}(\vec{H}_c)$$

$$\langle\vec{S}\rangle = \frac{1}{T}\int_0^T (\vec{E}\times\vec{H})dt = \frac{1}{2}\mathrm{Re}(\vec{E}_c\times\vec{H}_c^*)$$

$$\langle\vec{S}\rangle = \frac{1}{2}\mathrm{Re}(\vec{E}_c\times\vec{H}_c^*) = \frac{1}{2}\mathrm{Re}\begin{vmatrix}\hat{x} & \hat{y} & \hat{z}\\ 0 & E_y & 0\\ 0 & 0 & H_z\end{vmatrix}$$

$$\Rightarrow \quad S_x = \frac{1}{2}\mathrm{Re}(E_y H_z^*)$$

$$= \frac{1}{2}\mathrm{Re}\left\{E_{y_0}\exp\left(i\frac{\omega N x}{c_0}\right)\frac{N^*}{\mu c_0}E_{y_0}^*\exp\left(-i\frac{\omega N^* x}{c_0}\right)\right\}$$

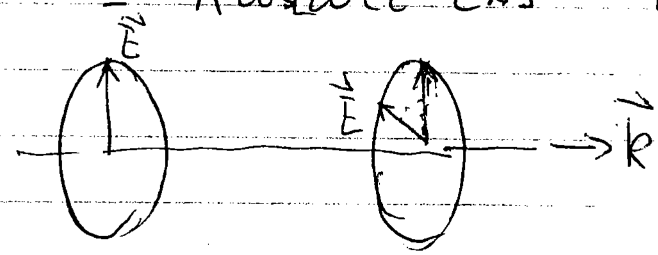
$$= \frac{1}{2}\frac{|E_{y0}|^2}{\mu c_0}\exp\left(-\frac{2\omega k}{c_0}x\right)$$

$$-\alpha x \qquad \alpha = \frac{4\pi k}{\lambda}$$

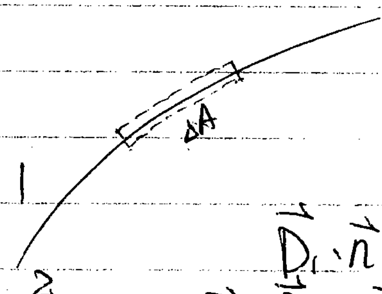
$$\delta = \frac{1}{\alpha} = \frac{\lambda_0}{4\pi k}$$ — skin depth

$$S = S_0 e^{-\alpha x}, \quad \dot{q} = -\frac{dS_x}{dx}\ (-\nabla\cdot\vec{S}) = \alpha S_0 e^{-\alpha x}$$

$$\vec{E} = Re(\vec{E}_c) = Re\{(\vec{A}-\vec{B}i)e^{-i\omega(t-\frac{N}{c}x)}\}$$
$$= \vec{A}\cos[\omega(t-\tfrac{N}{c}x)] - \vec{B}\sin[\omega(t-\tfrac{N}{c}x)]$$



Interface conditions



$$\int(\nabla\cdot\vec{D})dV = \int\rho_{net}\,dV$$

$$\oint\vec{D}\cdot d\vec{A} = \int\rho_{net}\,dV = \rho_s\cdot\Delta A$$

$$\vec{D}_1\cdot\vec{n} - \vec{D}_2\cdot\vec{n} = \rho_s$$ (ideal conductor/battery electrode (charge on electrode)

$$\vec{n}_1\cdot\vec{B}_{1} = \vec{n}_2\cdot\vec{B}_2$$

$$(\vec{E}_1-\vec{E}_2)\times\vec{n} = 0, \qquad (\vec{H}_1-\vec{H}_2)\times\vec{n} = J_s$$