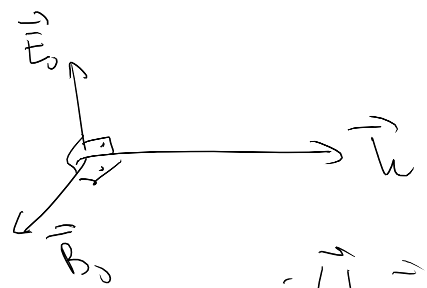
Hand in your HW!



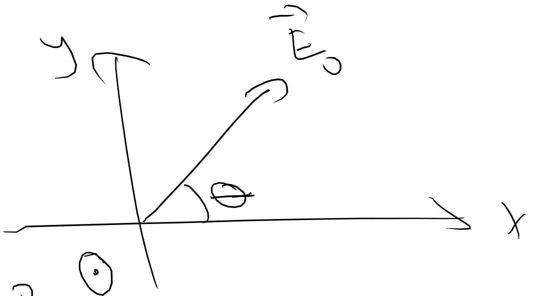
$E_0 = cB_0$

$$\vec{E} = \vec{E}_0 e^{i(\vec{k}\cdot\vec{r} - \omega t)}$$

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

$$\vec{B} = \vec{B}_0 e^{i(\vec{k}\cdot\vec{r} - \omega t)}$$

$$\vec{E} = \vec{E}_0 e^{i(\vec{k}\cdot\vec{r} - \omega t)} \qquad \vec{k} = k\hat{z}$$



angle of polarization

$$\vec{E}_0 = E_0 \cos\theta\, \hat{x} + E_0 \sin\theta\, \hat{y}$$

linearly polarized.

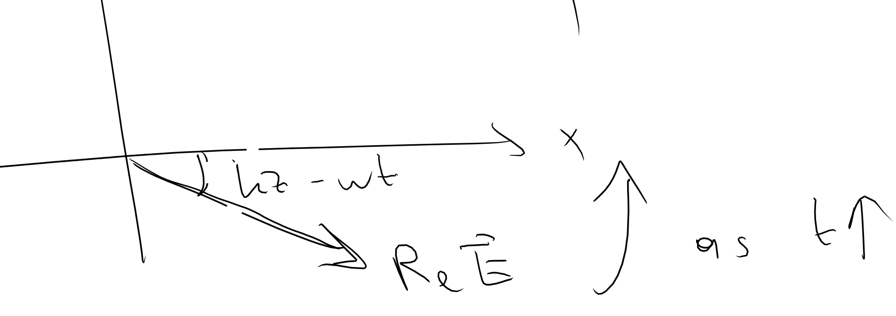
$$\vec{E} = E_0 e^{i(kz - \omega t)}\hat{x} + i E_0 e^{i(kz - \omega t)}\hat{y}$$

$$= E_0 e^{i(kz - \omega t)}\hat{x} + E_0 e^{i(kz - \omega t + \frac{\pi}{2})}\hat{y}$$

$$\mathrm{Re}\,\vec{E} = E_0 \cos(kz - \omega t)\hat{x} - E_0 \sin(kz - \omega t)\hat{y}$$

$$\cos(kz - \omega t + \tfrac{\pi}{2}) = -\sin(kz - \omega t)$$

circularly polarized wave



$$\vec{E} = E_0 e^{i(kz-\omega t)}\hat{x} + E_0 e^{i(kz-\omega t+\frac{\pi}{2})}\hat{y}$$

$$= \underbrace{E_0(\hat{x} + i\hat{y})} e^{i(kz-\omega t)}$$

$$\vec{E} = \vec{E}_0 e^{i(kz-\omega t)} \qquad E_{0x}, E_{0y} \in \mathbb{R}$$

$$\mathrm{Re}\,\vec{E} = (\mathrm{Re}\,\vec{E}_0)\cos(kz-\omega t)$$

$$\vec{E} = E_0(\hat{x} - i\hat{y})e^{i(kz-\omega t)}$$

as t increases

$\vec{E}_0 \quad E_0\hat{x} + iE_0'\hat{y}$: elliptically polarized.

$\vec{E}_0 = E_0(i\hat{x} + i\hat{y})$: linearly polarized

$\vec{E}_0 = E_0(i\hat{x} - i\hat{y})$: linearly polarized

$\vec{E}_0 = E_0(\hat{x} + i\hat{y})$: <u>not</u> linearly polarized

$\vec{E}_0 = E_0\left(\frac{1-i}{\sqrt{2}}\hat{x} + \frac{1+i}{\sqrt{2}}\hat{y}\right)$:

$= E_0\left(e^{-i\frac{\pi}{4}}\hat{x} + e^{i\frac{\pi}{4}}\hat{y}\right)$ <u>not</u> linearly polarized)

$$\hat{X} = \hat{x}\,\frac{1+i}{2} + \hat{x}\,\frac{1-i}{2}$$

$$u = \frac{1}{2}\varepsilon_0 \vec{E}^2 + \frac{1}{2\mu_0}\vec{B}^2$$

$$\left\{\begin{aligned} \vec{E} &= \vec{E}_0 \cos(kz-\omega t) \\ \vec{B} &= \vec{B}_0 \cos(kz-\omega t) \end{aligned}\right\}$$

$$u = \left(\frac{1}{2}\varepsilon_0 \vec{E}_0^2 + \frac{1}{2\mu_0}\vec{B}_0^2\right)\cos^2(kz-\omega t)$$

$$E_0 = cB_0 \qquad \vec{F} = q(\vec{E} + \vec{v}\times\vec{B})$$

$$B_0 = \frac{1}{c}E_0$$

$$u = \left(\frac{1}{2}\varepsilon_0 \vec{E}_0^2 + \frac{1}{2\mu_0}\frac{1}{c^2}\vec{E}_0^2\right)\cos^2(kz-\omega t)$$

$$\frac{1}{c^2} = \mu_0\varepsilon_0$$

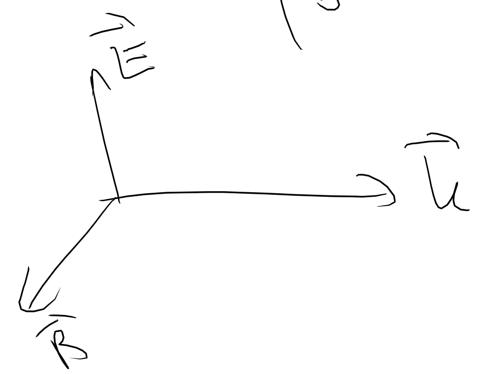
$$u = \left(\frac{1}{2}\varepsilon_0 \vec{E}_0^2 + \frac{1}{2}\varepsilon_0 \vec{E}_0^2\right)\cos^2(kz-\omega t)$$

$$\boxed{u = \varepsilon_0 \vec{E}_0^2 \cos^2(kz-\omega t)}$$

$$\langle u \rangle = \frac{1}{T}\int_0^T u(\vec{r},t)\,dt$$

$$\langle u \rangle = \frac{1}{2}\varepsilon_0 \vec{E}_0^2$$

$$\vec S = \frac{1}{\mu_0}\vec E \times \vec B = \frac{1}{\mu_0} E B \hat k$$



$$\vec S = \frac{1}{\mu_0} E_0 B_0 \cos^2(kz-\omega t)\hat k$$

$$B_0 = \frac{E_0}{c}$$

$$\vec S = \frac{1}{\mu_0 c} E_0^2 \cos^2(kz-\omega t)\hat k$$

$$= \frac{1}{\mu_0 c}\vec E_0^2 \cos^2(kz-\omega t)\hat k$$

$$= \frac{1}{\mu_0 c}\frac{1}{\varepsilon_0}\left[\varepsilon_0 \vec E_0^2 \cos^2(kz-\omega t)\hat k\right]$$

$$\vec S = \frac{c^2}{c} u \hat k = u(c\hat k) = u c \frac{\vec k}{k}$$

$E_0 = |\vec E_0|$

$\vec p$: momentum density

$$\vec p = \mu_0 \varepsilon_0 \vec S = \frac{1}{c^2} u c \hat k = \boxed{\frac{u}{c}\hat k = \vec p}$$

$$m_{eff} = \frac{E}{c^2}$$

mass density

$$\rho_{eff} = \frac{(\text{energy density})}{c^2}$$

$$\begin{pmatrix}\text{momentum} \\ \text{density}\end{pmatrix} = \rho_{eff}\,(\text{velocity}) = \frac{u}{c^2}\,c\,\hat{k}$$

$$\frac{\partial u}{\partial t} + \vec{\nabla}\cdot\vec{S} \stackrel{?}{=} 0$$

$$u = \varepsilon_0 \vec{E}_0^2 \cos(kz - \omega t)$$

$$\vec{S} = u c \hat{k}$$

$$\vec{S}(\vec{r}, t) = u(kz - \omega t)\, c\, \hat{k}$$

$$\frac{\partial \vec{S}}{\partial x} = 0 = \frac{\partial \vec{S}}{\partial y} \qquad u' = \left.\frac{d u(\alpha)}{d\alpha}\right|_{\alpha = kz - \omega t}$$

$$\frac{\partial \vec{S}}{\partial z} = u'(kz - \omega t)\, k\, c\, \hat{z}$$

$$\vec{\nabla}\cdot\vec{S} = \underbrace{\cancel{\frac{\partial S_x}{\partial x}}}_{0} + \underbrace{\cancel{\frac{\partial S_y}{\partial y}}}_{0} + \frac{\partial S_z}{\partial z} = u'(kz - \omega t)\, kc$$

$$\frac{\partial u}{\partial t} = u'(kz - \omega t)(-\omega) = -u'(kz - \omega t)\, kc$$

$$\frac{\partial u}{\partial t} = -\vec{\nabla}\cdot\vec{S} \Rightarrow \boxed{\frac{\partial u}{\partial t} + \vec{\nabla}\cdot\vec{S} = 0}$$

Waves In Medium

$$\vec{\nabla}\cdot\vec{D} = \rho \qquad \vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$$

$$\vec{\nabla}\cdot\vec{B} = 0 \qquad \vec{\nabla}\times\vec{H} = \vec{J} + \frac{\partial\vec{D}}{\partial t}$$

$$\vec{D} = \varepsilon\vec{E}$$

$$\vec{B} = \mu H \Rightarrow \vec{H} = \frac{\vec{B}}{\mu}$$

$$\vec{\nabla}\cdot\vec{E} = \frac{\rho}{\varepsilon} \qquad \vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$$

$$\vec{\nabla}\cdot\vec{B} = 0 \qquad \vec{\nabla}\times\vec{B} = \mu\vec{J} + \mu\varepsilon\frac{\partial\vec{E}}{\partial t}$$

$$\varepsilon_0 \longrightarrow \varepsilon$$

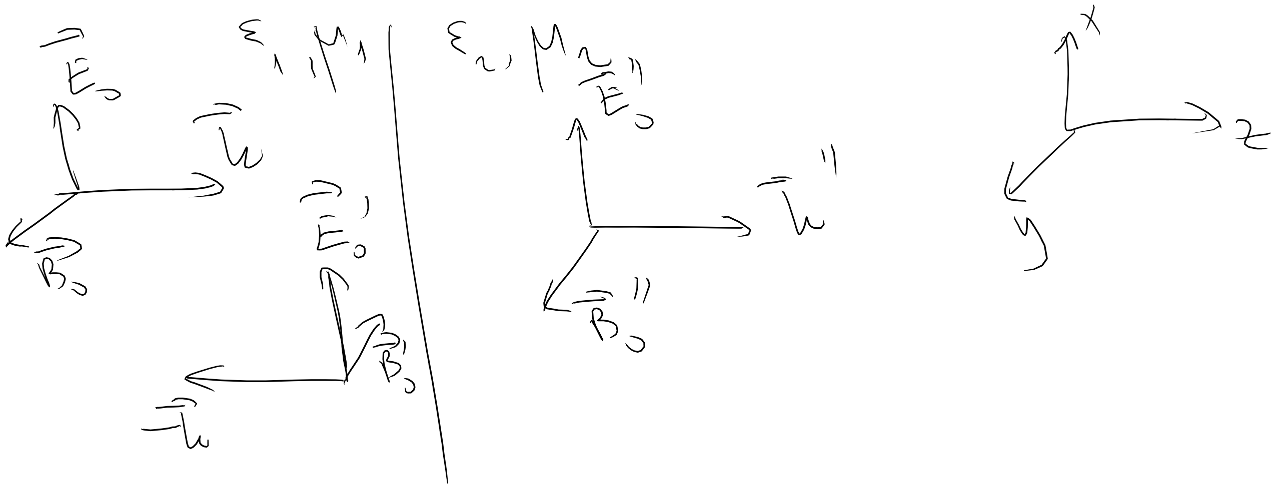
$$\mu_0 \longrightarrow \mu$$

$$v^2 = \frac{1}{\varepsilon\mu} = \frac{\varepsilon_0\mu_0}{\varepsilon\mu}c^2.$$

$$\boxed{v = \frac{c}{n}} \qquad n \equiv \sqrt{\frac{\varepsilon\mu}{\varepsilon_0\mu_0}} \simeq \sqrt{\frac{\varepsilon}{\varepsilon_0}}$$

index of refraction.

Reflection



$$\vec{E}_0 = E_0 \hat{x} \qquad \vec{E}_0' = E_0' \hat{x} \qquad \vec{E}_0'' = E_0'' \hat{x}$$

$$\vec{B}_0 = B_0 \hat{y} \qquad \vec{B}_0' = -B_0' \hat{y} \qquad \vec{B}_0'' = B_0'' \hat{y}$$