free space:

$$\boxed{\begin{aligned} &\nabla\cdot\vec{E} = 0 \\ &\nabla\cdot B = 0 \\ &\nabla\times E = -\frac{\partial B}{\partial t} \\ &\nabla\times B = \mu_0\epsilon_0\frac{\partial E}{\partial t}\end{aligned}}$$

$\Rightarrow$

$$\boxed{\begin{aligned} &\nabla^2 E = \mu_0\epsilon_0\frac{\partial^2 E}{\partial t^2} \\ &\nabla^2 B = \mu_0\epsilon_0\frac{\partial^2 B}{\partial t^2}\end{aligned}}$$

$$\vec{E}(z,t) = \underline{E_0}\, e^{i(kz-\omega t)} \quad \hat{x}$$

$$\vec{B}(z,t) = B_0\, e^{i(kz-\omega t)} \quad \hat{y}$$

$$\boxed{\vec{B} = \frac{\vec{E}}{c}}, \quad \vec{E}\perp\vec{B}$$

$$\boxed{k = \frac{2\pi}{\lambda}}$$

$$c = \frac{1}{\sqrt{\mu_0\epsilon_0}}$$

Matter:

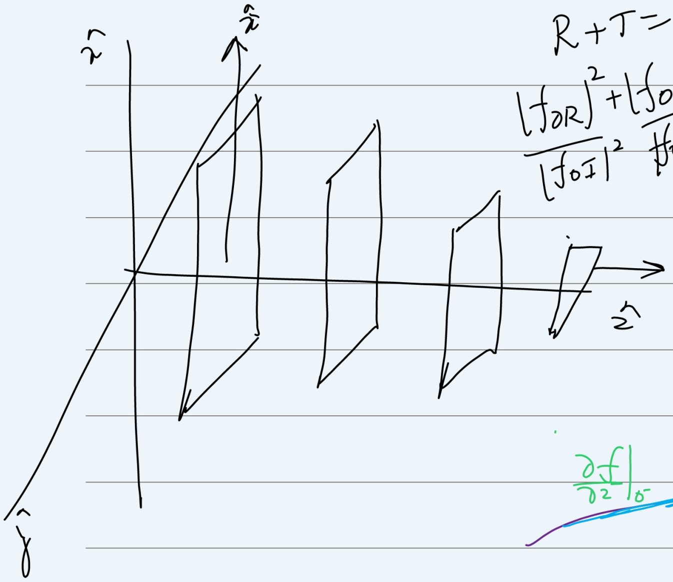
$$v = \frac{1}{\sqrt{\mu\epsilon}}$$

$$v = \frac{\lambda}{T} = \frac{2\pi/k}{\frac{2\pi}{\omega}} = \frac{\omega}{k}$$

$$T = \frac{1}{\nu} = \frac{2\pi}{2\pi\nu}$$

$$\omega T = 2\pi$$

$$\boxed{n = \text{Refractive index} = \frac{c}{v} = \sqrt{\frac{\mu}{\mu_0}\cdot\frac{\epsilon}{\epsilon_0}} \simeq \sqrt{\epsilon_r}}$$



$R + T = 1$

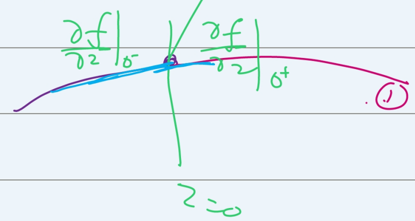
$$\frac{|f_{0R}|^2}{|f_{0I}|^2} + \frac{|f_{0T}|^2}{|f_{0I}|^2} = 1$$

$$\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0} = \frac{\text{Energy}}{\text{Area} \times \text{Time}} \qquad \frac{\partial y}{\partial t}$$

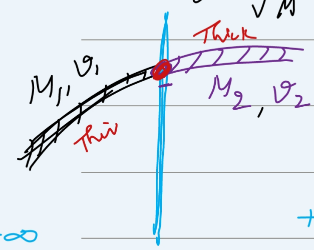
$$\left.\frac{\partial f}{\partial z}\right|_{0^-} + \left.\frac{\partial f}{\partial z}\right|_{0^+} = \frac{E^2}{c\mu_0}$$

$\hat{z}$

$$F = \mu L \frac{\partial^2 y}{\partial t^2}$$



$$v = \sqrt{\frac{T}{M}}$$



Net wave arriving at $z=0$ | = Net wave transmitted at $z=0$.

$$\tilde{f}_I(z,t) = f_{0I}\, e^{i(k_1 z - \omega t)}$$

$z<0$.

$+\infty$

$$\tilde{f}_R(z,t) = f_{0R}\, e^{i(-k_1 z - \omega t)}$$

$$\tilde{f}_T(z,t) = f_{0T}\, e^{i(k_2 z - \omega t)}$$

$$\boxed{R+T=1}$$

$$T = \frac{|f_{0T}|^2}{|f_{0I}|^2}$$

$$R = \frac{|f_{0R}|^2}{|f_{0I}|^2}$$

(1) At $z=0$, $f_{0I} + f_{0R} = f_{0T}$ — (1)

(2) $\left.\frac{\partial f}{\partial z}\right|_{0^-} = \left.\frac{\partial f}{\partial z}\right|_{0^+}$

$$k_1\left[f_{0I} - f_{0R}\right] = k_2 f_{0T} \quad \text{— (2)}$$

$$f_{0I} + f_{0R} = f_{0T}$$

$$f_{0I} - f_{0R} = \frac{k_2}{k_1} f_{0T}$$

$$\frac{f_{0T}}{f_{0I}} = \frac{2k_1}{k_1+k_2} = \frac{2v_2}{v_1+v_2}.$$

$$\boxed{\frac{v_1}{v_2} = \frac{k_2}{k_1}}$$

$$\frac{f_{0R}}{f_{0I}} = \frac{k_1-k_2}{k_1+k_2} = \frac{v_2-v_1}{v_1+v_2}.$$

$v_1 = \sqrt{\frac{T}{M_1}}$

$v_2 = \sqrt{\frac{T}{M_2}}$

$$\frac{f_{0T}}{f_{0I}} = \frac{2v_2}{v_1+v_2} \Big\} +ve.$$

$$\frac{f_{0R}}{f_{0I}} = \frac{v_2 - v_1}{v_2 + v_1}.$$

$v_2 \propto \frac{1}{\sqrt{M_2}}$

$v_1 \propto \frac{1}{\sqrt{M_1}}$.

$$f_I = f_{0I}\, e^{i(kz - \omega t)}$$

① $v_2 > v_1$: +ve.

$M_2 < M_1$

Thin Thick

$$Re \; f_I = f_{0I} \cos(kz - \omega t)$$

② $v_2 < v_1$: -ve.

$$f_{0R} = f_{0R} \cos[-kz - \omega t + \delta], \quad \delta \to \pi$$

$$\frac{\lambda_1}{\lambda_2} = \frac{2\pi}{K_1} \cdot \frac{K_2}{2\pi} = \frac{K_2}{K_1}.$$

$$\vartheta_1 = \frac{\lambda_1}{T_1}.$$

$$\frac{\lambda_1}{\lambda_2} = \frac{\vartheta_1 T_1}{\vartheta_2 T_2} = \frac{K_2}{K_1}$$

$$\boxed{\frac{\vartheta_1}{\vartheta_2} = \frac{K_2}{K_1}}$$

$$\frac{\vartheta_1 = \sqrt{\frac{T}{M_1}}}{\vartheta_2 = \sqrt{\frac{T}{M_2}}}.$$