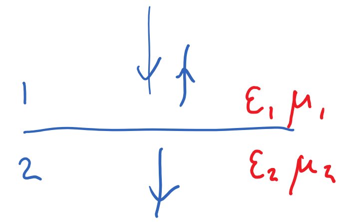
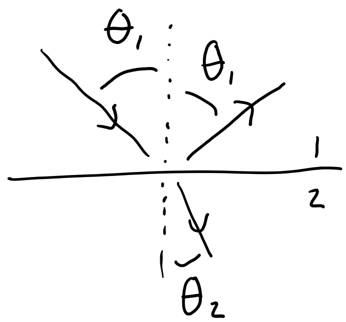


$$\Gamma = \frac{E_{r_0}}{E_{i_0}} = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$$

$$\eta_2 = \sqrt{\frac{\mu_2}{\varepsilon_2}}$$

$$\eta_1 = \sqrt{\frac{\mu_1}{\varepsilon_1}}$$



$$k_1 = \omega\sqrt{\mu_1 \varepsilon_1}$$

$$k_2 = \omega\sqrt{\mu_2 \varepsilon_2}$$

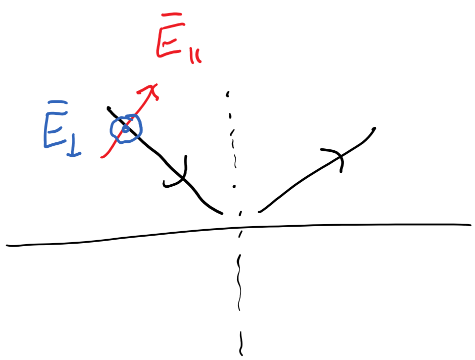
$$k_1 \sin\theta_1 = k_2 \sin\theta_2$$

$$\sqrt{\mu_1 \varepsilon_1}\, \sin\theta_1 = \sqrt{\mu_2 \varepsilon_2}\, \sin\theta_2$$

$$\underbrace{\sqrt{\mu_{r_1} \varepsilon_{r_1}}}_{n_1} \sin\theta_1 = \underbrace{\sqrt{\mu_{r_2} \varepsilon_{r_2}}}_{n_2} \sin\theta_2$$

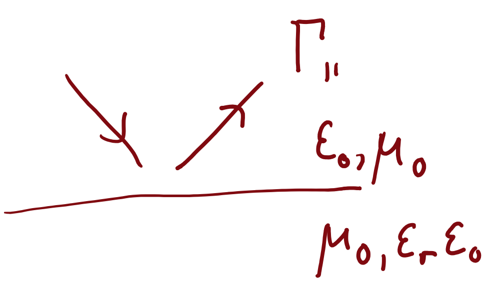
$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$$

$$\mu_r = \frac{\mu}{\mu_0}$$



$$\Gamma_\parallel = \frac{\eta_2 \cos\theta_2 - \eta_1 \cos\theta_1}{\eta_2 \cos\theta_2 + \eta_1 \cos\theta_1}$$

$$\Gamma_\perp = \frac{\eta_2/\cos\theta_2 - \eta_1/\cos\theta_1}{\eta_2/\cos\theta_2 + \eta_1/\cos\theta_1}$$



$$\eta_1 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = \eta_0$$

$$\eta_2 = \sqrt{\frac{\mu_0}{\varepsilon_r \varepsilon_0}} = \frac{\eta_0}{\sqrt{\varepsilon_r}}$$

$$\Gamma_\parallel = \frac{\overset{\eta_0/n}{\eta_2} \cos\theta_2 - \overset{\eta_0}{\eta_1} \cos\theta_1}{\eta_2 \cos\theta_2 + \eta_1 \cos\theta_1}$$

$$\Gamma_\parallel = \frac{\cos\theta_2 - n\cos\theta_1}{\cos\theta_2 + n\cos\theta_1}$$

$$\sin(2\alpha) = 2\sin\alpha\cos\alpha$$

$$\eta_2 = \sqrt{\frac{\mu_0}{\varepsilon_r \varepsilon_0}} = \frac{\eta_0}{\underbrace{\sqrt{\varepsilon_r}}_{n}}$$

$$\sin(2\alpha) = 2\sin\alpha\cos\alpha$$

$$\Gamma_{\parallel} = 0 \longrightarrow \begin{aligned} \cos\theta_2 &= n\cos\theta_1 \\ n\sin\theta_2 &= \sin\theta_1 \end{aligned} \quad \text{(SNELL)}$$

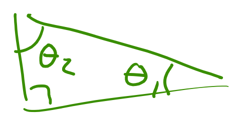
$$2\cancel{n}\sin\theta_2\cos\theta_2 = 2\cancel{n}\sin\theta_1\cos\theta_1$$

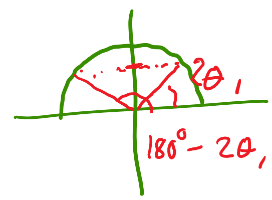
$$\sin 2\theta_1 = \sin 2\theta_2$$

$\sin 30^\circ =$
$\sin 150^\circ =$

$$2\theta_1 = 180^\circ - 2\theta_2$$

$$\theta_1 = 90^\circ - \theta_2$$

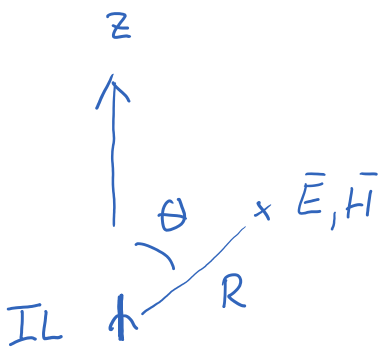




$$\sin\theta_1 = \cos\theta_2$$

$$\underbrace{\cos\theta_2}_{\sin\theta_1} = n\cos\theta_1$$

$$n = \frac{\sin\theta_1}{\cos\theta_1} = \tan\theta_1 \leftarrow \theta_{Br}$$



$$\bar{J} \to \bar{A} \to \bar{B} \to \bar{H} \to \bar{E}$$

$$\nabla^2 \bar{E} + \underbrace{\omega^2 \mu_0 \varepsilon_0}_{k^2} \bar{E} = 0$$

PLANE WAVE

$$\bar{E}(\bar{R}) = \bar{E}(z)$$

$$E''(z) + k^2 E(z) = 0$$

SPHERICAL WAVE: $\bar{E}(\bar{R}) = \bar{E}(R)$

$$\nabla^2 E(R) + k^2 E(R) = 0$$

$$\frac{1}{R^2} \frac{\partial}{\partial R}\left(R^2 \underbrace{\frac{\partial E}{\partial R}}_{E'}\right)$$

$$= \frac{1}{R^2} \frac{d}{dR}\left(R^2 E'\right)$$

Spherical coordinates

$$\nabla f = \bar{a}_R \frac{\partial}{\partial R} f + \bar{a}_\theta \frac{1}{R} \frac{\partial}{\partial \theta} f + \bar{a}_\phi \frac{1}{R \sin\theta} \frac{\partial}{\partial \phi} f$$

$$\nabla \times \bar{f} = \frac{1}{R^2 \sin\theta} \begin{vmatrix} \bar{a}_R & R\bar{a}_\theta & R\sin\theta \bar{a}_\phi \\ \frac{\partial}{\partial R} & \frac{\partial}{\partial \theta} & \frac{\partial}{\partial \phi} \\ f_R & R f_\theta & R \sin\theta f_\phi \end{vmatrix}$$

$$\nabla \cdot \bar{f} = \frac{1}{R^2} \frac{\partial}{\partial R}(R^2 f_R) + \frac{1}{R \sin\theta} \frac{\partial}{\partial \theta}(\sin\theta f_\theta) + \frac{1}{R \sin\theta} \frac{\partial}{\partial \phi} f_\phi$$

$$\nabla^2 f = \frac{1}{R^2} \frac{\partial}{\partial R}\left(R^2 \frac{\partial f}{\partial R}\right) + \cancel{\frac{1}{R^2 \sin\theta} \frac{\partial}{\partial \theta}\left(\sin\theta \frac{\partial f}{\partial \theta}\right)} + \cancel{\frac{1}{R^2 \sin^2\theta} \frac{\partial^2 f}{\partial \phi^2}}$$

$$= \frac{1}{R^2}\left(2RE' + R^2E''\right) = E'' + \frac{2}{R}E'$$

$$\frac{1}{R}(RE)'' = \frac{1}{R}(E + RE')' = \frac{1}{R}\left(E' + E' + RE''\right) = E'' + \frac{2}{R}E'$$

$$\nabla^2 E + k^2 E = \frac{1}{R}(RE(R))'' + k^2 E(R) = 0$$

$$(RE(R))'' + k^2 (RE(R)) = 0$$

$$RE(R) = e^{\pm jkR}$$

$$E(R) = E_+ \frac{e^{-jkR}}{R} + E_- \frac{e^{+jkR}}{R}$$

$$\nabla \cdot \bar{B} = 0 \quad \Rightarrow \quad \bar{B} = \nabla \times \bar{A}$$

$$\nabla \times \bar{E} = -j\omega \bar{B} = -j\omega \nabla \times \bar{A}$$

$$\nabla \times (\underbrace{\bar{E} + j\omega \bar{A}}_{-\nabla V}) = 0$$

$$-\nabla V - j\omega \bar{A}$$

$$\nabla \times \underbrace{\mu \bar{H}}_{\bar{B} = \nabla \times \bar{A}} = \mu \bar{J} + j\omega\varepsilon\mu \bar{E}$$

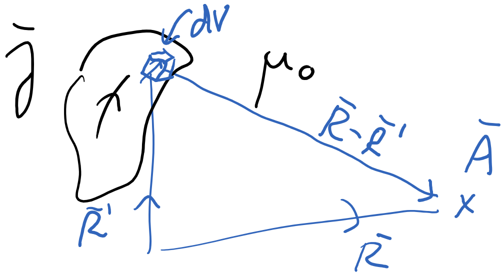
$$\nabla(\underbrace{\nabla \cdot \bar{A}}_{-j\omega\varepsilon\mu V}) - \nabla^2 \bar{A} = \mu \bar{J} - j\omega\varepsilon\mu \nabla V + \omega^2 \mu\varepsilon \bar{A}$$

$$\nabla^2 \bar{A}(\bar{R}) + \overbrace{\omega^2 \mu\varepsilon}^{k^2} \bar{A}(\bar{R}) = -\mu \bar{J}$$

MAGNETOSTATICS : $\omega = 0$

$$\nabla^2 \bar{A} = -\mu_0 \bar{J}$$

$$\bar{A}(\bar{R}) = \int \frac{\mu_0 \bar{J}(\bar{R}')\, dV'}{4\pi |\bar{R} - \bar{R}'|}$$



DYNAMICS

$$\nabla^2 \bar{A} + k^2 \bar{A} = -\mu_0 \bar{J} \quad \Rightarrow \quad \bar{A}(\bar{R}) = \int \frac{\mu_0 \bar{J}(\bar{R}')\, e^{-jk|\bar{R} - \bar{R}'|}}{4\pi |\bar{R} - \bar{R}'|} dV'$$