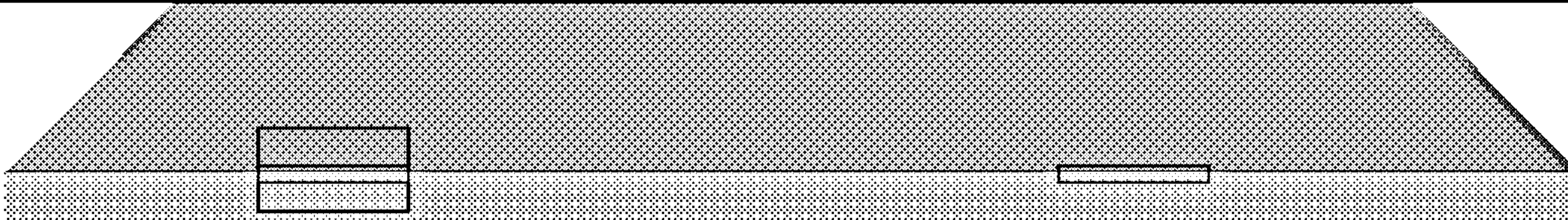


$$\oint_C \vec{\mathbf{E}}\cdot d\vec{l} = -\frac{\partial}{\partial t}\int_S \vec{\mathbf{B}}\cdot d\vec{a} \qquad \oint_C \vec{\mathbf{B}}\cdot d\vec{l} = \int_S \left(\varepsilon_0\mu_0 \frac{\partial}{\partial t}\vec{\mathbf{E}} + \mu_0 \frac{\partial}{\partial t}\vec{\mathbf{P}}\right)\cdot d\vec{a}$$

$$E_{\substack{\text{outside}\\ \text{tangential}}}\, l - E_{\substack{\text{inside}\\ \text{tangential}}}\, l = 0 \qquad B_{\substack{\text{outside}\\ \text{tangential}}}\, l - B_{\substack{\text{inside}\\ \text{tangential}}}\, l = 0$$

$$E_{\substack{\text{outside}\\ \text{tangential}}} = E_{\substack{\text{inside}\\ \text{tangential}}} \qquad B_{\substack{\text{outside}\\ \text{tangential}}} = B_{\substack{\text{inside}\\ \text{tangential}}}$$

Tangential components of both E and B are continuous at the boundary.

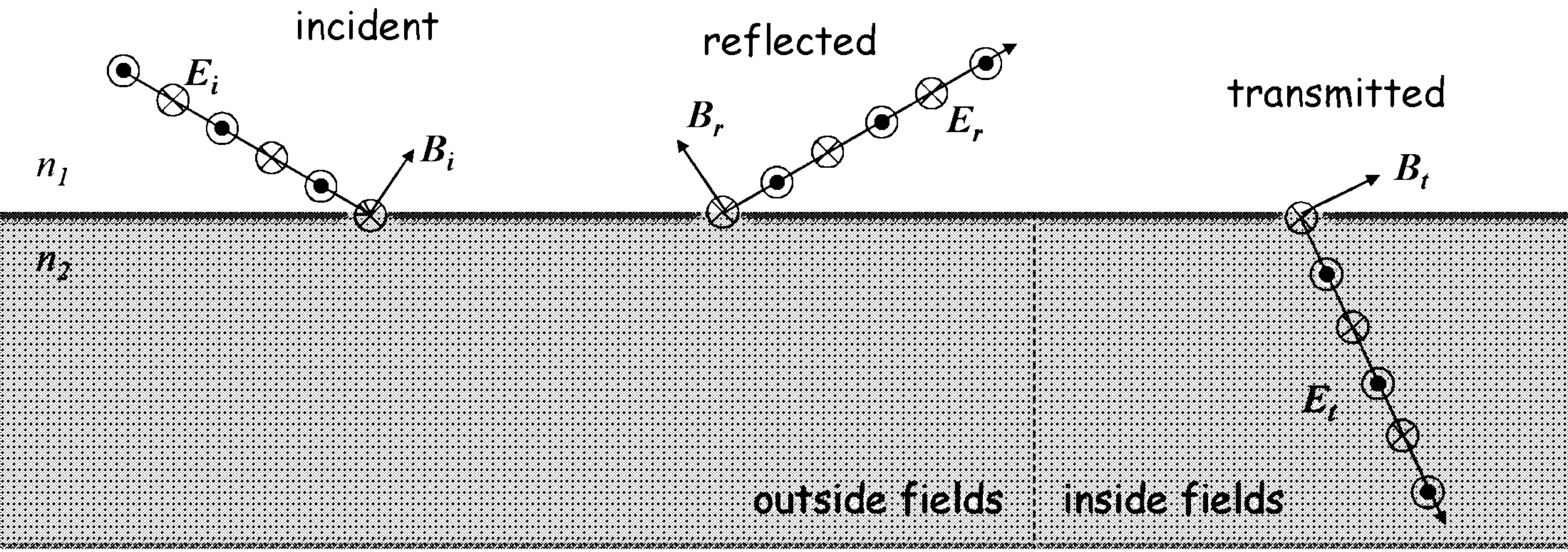
Therefore, for all points on the boundary at all times:

$$\vec{E}_{oi} e^{j\varphi_i} e^{j\left(\vec{k}_i\cdot\vec{r}-\omega_i t\right)} + \vec{E}_{or} e^{j\varphi_r} e^{j\left(\vec{k}_r\cdot\vec{r}-\omega_r t\right)} = \vec{E}_{ot} e^{j\varphi_t} e^{j\left(\vec{k}_t\cdot\vec{r}-\omega_t t\right)}$$

(Tangential components)

Now for the relative amplitudes: TE reflection

$$r_{TE} = \frac{E_r}{E_i}$$



Tangential fields must be continuous:

$$E_i + E_r = E_t$$

$$B_i \cos\theta_i - B_r \cos\theta_r = B_t \cos\theta_t$$

The amplitudes are related by the velocity in the medium:

$$E = vB = \left(\tfrac{c}{n}\right)B$$

$$E_i = \left(\tfrac{c}{n_1}\right)B_i \qquad E_r = \left(\tfrac{c}{n_1}\right)B_r \qquad E_t = \left(\tfrac{c}{n_2}\right)B_t$$

Re-write the B continuity equation in terms of E (the c's cancel and $\theta_i = \theta_r$):

$$n_1 E_i \cos\theta_i - n_1 E_r \cos\theta_i = n_2 E_t \cos\theta_t$$

Combine this version of the B continuity and E continuity to eliminate E_t:

$$n_1 E_i \cos\theta_i - n_1 E_r \cos\theta_i = n_2 \left(E_i + E_r\right)\cos\theta_t$$

Solve this for E_r / E_i to get the reflection coefficient:

$$E_i\left(n_1 \cos\theta_i - n_2 \cos\theta_t\right) = E_r\left(n_2 \cos\theta_t + n_1 \cos\theta_i\right)$$

$$r_{TE} = \frac{E_r}{E_i} = \frac{(n_1 \cos\theta_i - n_2 \cos\theta_t)}{(n_2 \cos\theta_t + n_1 \cos\theta_i)}$$

Combine n_1 and n_2 into the relative index $n = n_2/n_1$

$$r_{TE} = \frac{(\cos\theta_i - n\cos\theta_t)}{(\cos\theta_i + n\cos\theta_t)}$$

Convert $\cos(\theta_t)$ to sine and use Snell's law to get rid of θ_t:

$$r_{TE} = \frac{\cos\theta_i - n\sqrt{1-\sin^2\theta_t}}{\cos\theta_i + n\sqrt{1-\sin^2\theta_t}} = \frac{\cos\theta_i - n\sqrt{1-\frac{1}{n^2}\sin^2\theta_i}}{\cos\theta_i + n\sqrt{1-\frac{1}{n^2}\sin^2\theta_i}}$$

$$r_{TE} = \frac{\cos\theta_i - \sqrt{n^2 - \sin^2\theta_i}}{\cos\theta_i + \sqrt{n^2 - \sin^2\theta_i}}$$