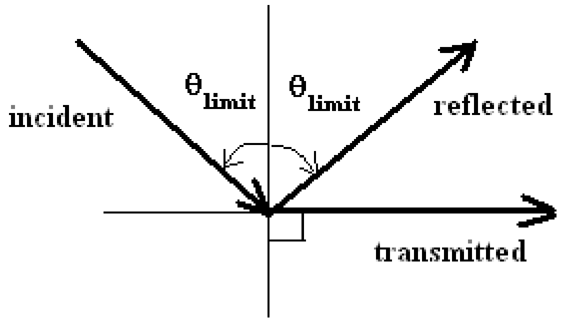
Total reflection

Let's go back to the phenomenon of *total reflection*, as in the figure



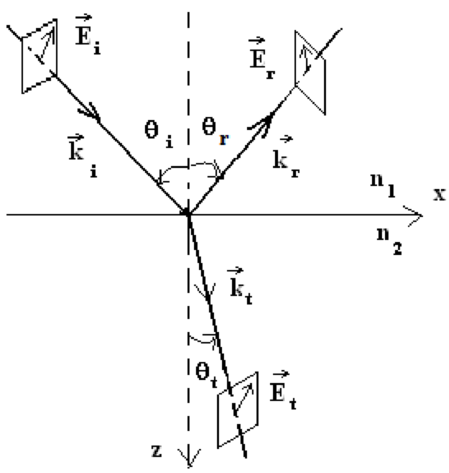
The condition for total reflection is:

$$\sin\theta_l = \frac{n_2}{n_1} \qquad \text{(EM52)}$$

and can be fulfilled only if $n_2 < n_1$. What happens if $\theta_i > \theta_l$? The refraction condition gives

$$n_2 \sin\theta_t = n_1 \sin\theta_i > n_1 \times \frac{n_2}{n_1} = n_2$$

hence $\sin\theta_t > 1$. The transmission angle becomes imaginary. We have to use in our computations only real angles, therefore we replace θ_t with some function of θ_i, which is definitely a real angle. Consider the figure used for Snell laws:



The electric field in the 2nd material is

$$\vec{E}_t = \vec{E}_{0t} \exp\left[i\left(\omega t - \vec{k}_t \vec{r}\right)\right]$$

Here $\vec{k}_t \cdot \vec{r} = k_t x \sin\theta_t + k_t z \cos\theta_t$ and $k_t = \frac{n_2 \omega}{c}$. Replace θ_t by θ_i:

$$\sin\theta_t = \frac{n_1}{n_2}\sin\theta_i, \qquad \cos\theta_t = \pm\sqrt{1 - \left(\frac{n_1}{n_2}\sin\theta_i\right)^2} = \pm i\sqrt{\left(\frac{n_1}{n_2}\sin\theta_i\right)^2 - 1}$$

where the square root is real. The electric field of the transmitted wave is

$$\vec{E}_t = \vec{E}_{0t} \exp\left[i\left(\omega t - \frac{n_1 \omega}{c} x \sin\theta_i\right)\right] \exp\left[\mp \frac{n_2 \omega}{c} z \sqrt{\left(\frac{n_1}{n_2}\sin\theta_i\right)^2 - 1}\right]$$

Discussion during the lectures:

- the signs $\pm$
- attenuation and propagation