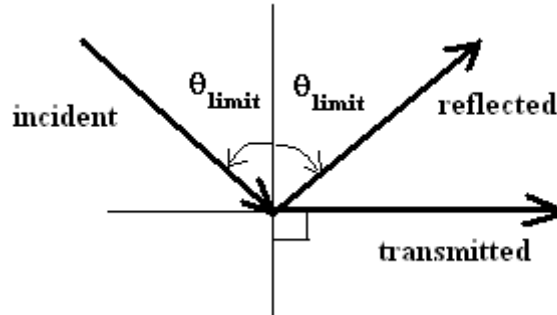


## Total reflection

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



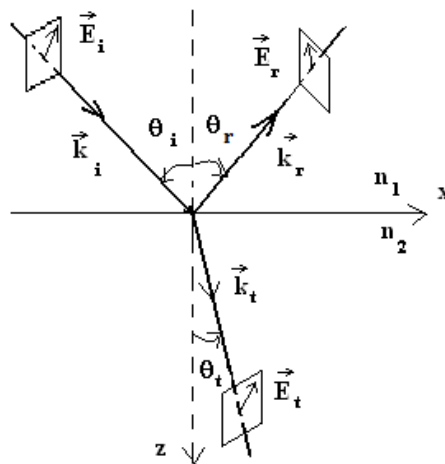
The condition for total reflection is:

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

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  $\theta_t$  with some function of  $\theta_i$ , which is definitely a real angle. Consider the figure used for Snell laws:



The electric field in the 2<sup>nd</sup> material is

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

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  $\theta_t$  by  $\theta_i$ :

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

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.