TRANSMISSION COEFFICIENTS FROM WATER THROUGH GLASS INTO AIR

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References: Griffiths, David J. (2007), Introduction to Electrodynamics, 3rd Edition; Pearson Education - Problem 9.36.

Here's another simple example of the transmission coefficient for waves passing from medium 1 through medium 2 into medium 3. Suppose we have an aquarium filled with water (index of refraction $n_1 = \frac{4}{3}$). Light from the aquarium passes (at normal incidence) through a sheet of glass ($n_2 = \frac{3}{2}$) and into air ($n_3 = 1$).

The transmission coefficient is given by

$$T^{-1} = \frac{1}{4n_1n_3}\left[(n_1+n_3)^2 + \sin^2\left(\frac{n_2\omega d}{c}\right)\frac{\left(n_1^2-n_2^2\right)\left(n_3^2-n_2^2\right)}{n_2^2}\right] \tag{1}$$

The minimum value of T occurs when the sine is 1:

$$\begin{aligned} T_{min}^{-1} &= \frac{1}{4n_1n_3}\left[(n_1+n_3)^2 + \frac{\left(n_1^2-n_2^2\right)\left(n_3^2-n_2^2\right)}{n_2^2}\right] &(2)\\ T_{min} &= 0.935 &(3)\end{aligned}$$

The maximum is when the sine is zero:

$$\begin{aligned} T_{max} &= \frac{4n_1n_3}{(n_1+n_3)^2} &(4)\\ &= 0.980 &(5)\end{aligned}$$

It doesn't matter much what the frequency of the light is or how thick the glass is; most of the light makes it through in any case. Since 1 is symmetric in n_1 and n_3 a fish inside the aquarium can see out as easily as we can see in.