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Index of Refraction Using Total Internal Reflection

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Here is a quick way to measure the index of refraction of water using the phenomenon of total internal reflection.

A cell is constructed using two thin glass plates held a millimeter or two apart by a thin strip of window glazing compound run around their edges, forming, in effect, a tiny thermo pane window. A cross section is shown in Fig. 1. The sandwich is submerged in a small fish tank filled with water and suspended from a shaft with a protractor attached to it to measure angle $\theta_1$.

A laser beam is directed toward the cell, and at a certain angle of the plates, relative to the light beam, the beam is abruptly cut off. Snell's law at the first interface is $n_1 \sin \theta_1 = n_2 \sin \theta_2$, and at the second interface is $n_2 \sin \theta_2 = n_3 \sin \theta_3$, showing that $n_1 \sin \theta_1 = n_3 \sin \theta_3$. When $\theta_3$ is 90° and $n_3 = 1.000$, we have the standard condition for total internal reflection: $n_1 = 1/\sin \theta_C$, where $\theta_C$ is now the angle between the incoming beam and the normal to the plates.

This was used for many years in the introductory laboratory at Kenyon College in a potpourri experiment on the reflection and refraction of light. At the time we thought that we had invented a new technique, but later I found it in Preston¹ and traced it to a publication in 1875! I suspect that others have independently invented this experiment, but I have found no recent published record of it.

Reference

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