Lab: Refractive Index and Dispersion

If a ray of light (by definition normal to a wave front) is refracted at an interface of two media with refractive indices n_i (incident medium) and n_t (transmitting medium), then the angles with the interface normal, θ_i and θ_t, follow Snell's law:

$$n_i \sin \theta_i = n_t \sin \theta_t$$

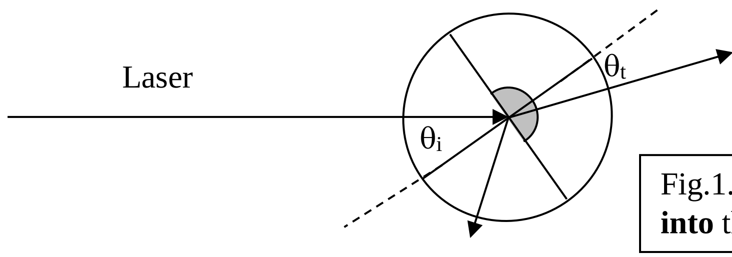

Fig.1. set-up for beam going **into** the denser medium

Set-up

1. Use the red laser for one trial, then repeat this entire exercise with the green laser.
2. Put the rotation stage (as illustrated above) approximately 1-2 m away on optical bench. Align it so that the beam goes through the center of the rotation table.

Measurement 1: **Into** the denser medium: $n_i = 1$

1. Place the half-cylinder as shown in Fig 1 on the rotation table. *Why is it important to center the half-cylinder on the axis of rotation?*
2. Rotate the table in increments of 10 degrees for the incoming beam and measure the angle of the refracted beam.
3. Put as much data as you can in a table (example below), calculating the index of refraction at each angle as well as the average refractive index for the material.
4. Give a relative permittivity ($\varepsilon_r = \varepsilon/\varepsilon_o$) of 1.77, determine the relative permeability ($\mu_r = \mu/\mu_o$) based on the average measured index of refraction. *What material properties can be inferred based in the relative permeability?*
5. Repeat using the green laser. *Should the index of refraction be higher or lower for the green laser?*

Example Table

Incoming angle, θ_i	Transmitted angle, θ_t	Index of refraction, n
0		
10		
20		
30		
40		
50		
60		
70		
80		
90		
		Average:

Measurement 2: **Out of** the denser medium into air: $n_t = 1$

1. Place the half-cylinder as shown in Fig 2 on the rotation table. *Why does this orientation accurately represent the ray refracting from a higher index, to a lower index?*
2. Rotate the table in increments of 10 degrees for the incoming beam and measure the angle of the refracted beam. *Do you expect an upper limit on the rotation angle? Why or why not?*
3. Put as much data as you can in a table, and calculate the refractive index n.

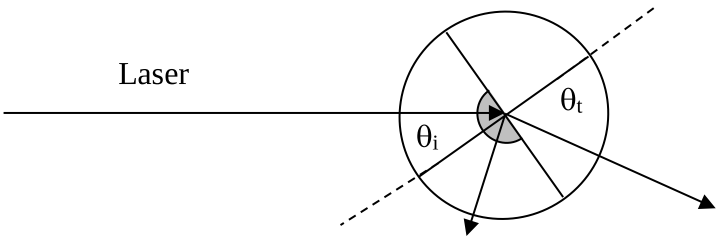

Fig.2. set-up for beam going **out of** the denser medium

Measurement 2: **Dispersion**

1. Reset the stage as in figure 1. Only this time you will use a H and He gas lamp with a lens at a distance of roughly 10 cm away from the slit, so that the light forms a sharp image in the far field, 3-4 m away on the wall. Make sure the light travels to the wall at normal incidence--be precise!
2. Rotate the stage in 20^o increments and measure the transmission angle for the following gas emission lines H 486.13nm (F) He 587.56nm (d) H 656.27nm (C).
3. Put as much data as you can in a table, and calculate the refractive index n.
4. Using this data calculate the index of refraction at each wavelength and the abbe number (v_d) for the material. *What material properties can be inferred based in the abbe number?*

$$v_d = \frac{n_d - 1}{n_F - n_C}$$