PHY-134 Lab #10 Geometrical Optics
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In this lab we will investigate some of the properties of mirrors, prisms, and lenses. More specifically we will be investigate the reflecting, refracting, dispersing, and focusing properties of some of these components.

1 Reflection

Using a ray box, mirror and protractor show that the property of plane mirrors

$$\theta_{incident} = \theta_{reflected} \tag{1}$$

holds for atleast 3 different incident angles.

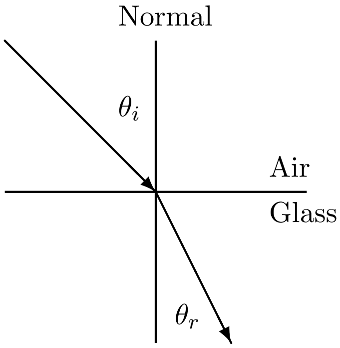
2 Refraction

2.1 Snell's Law

Using a ray box, prism, and protractor test Snell's Law

$$n_i \sin\theta_i = n_r \sin\theta_r \tag{2}$$

where n_i and n_r are the indices of refraction of the incident and refracting media.
$n_{air} = 1, n_{glass} \approx 1.5$.



Q1. *Plot* $\sin\theta_i$ *vs.* $\sin\theta_r$ *for 3 different angles* θ_i*. How can you use this plot to determine the index of refraction of the glass?*
Note: This is the same type of thing we have done all semester. Just take Snell's law make it a "line" equation like $y = mx + b$ and use the slope of your graph, find n_{glass} and compare it to the given value.

2.2 Critical Angle

If light is going from a media with a higher index of refraction into a media with a lower index of refraction, such as from glass to air, we can rewrite (2) with the values of n_{glass} and n_{air} substituted as:

$$\frac{\sin\theta_i}{\sin\theta_r} = \frac{1}{1.5} \approx 0.67 \tag{3}$$

Now, since the left hand side of (3) is maximum when $\theta_r = \frac{\pi}{2}$, i.e. $\sin\theta_r = 1$, there exists a maximum incident angle called the critical angle such that

$$\sin\theta_{crit} = 0.67 \tag{4}$$

Since Snell's Law talks about light passing from one medium into another, (4) means that if an incident angle is larger than θ_{crit} then it will *not* pass from the glass to the air but instead will be trapped inside the glass. This phenomena is called **internal reflection**[1]

Q2. *Use your prism to determine θ_{crit} and compare it with what it should be based on (3) using* your *value of n_{glass} determined from the previous subsection's graph.*

2.3 Dispersion

Use the prism to observe light dispersion - the variation of the index of refraction as a function of frequency[2]. This is goverened by

$$n = \frac{c}{v} = \frac{\lambda f_o}{\lambda f} = \frac{f_o}{f} \tag{5}$$

where v is the speed of the material in the medium, f_o is the frequency of the light in vacuum, and f is the frequency of the light in the medium.

Q3. *Which colors are bent most?*

Note: Don't worry about trying to find n_{blue}, n_{red}.

3 Lenses

This portion of the lab will use the optical bench and several lenses to determine the focal length of 2 converging lenses and 1 diverging lense. Recall that a converging lense(physically thicker at its center) creates a *real* image with focal length $f > 0$; a diverging lense(physically thinner at its center) creates a *virtual* image with a focal length $f < 0$. Also recall

$$\frac{1}{f} = \frac{1}{O} + \frac{1}{i} \tag{6}$$

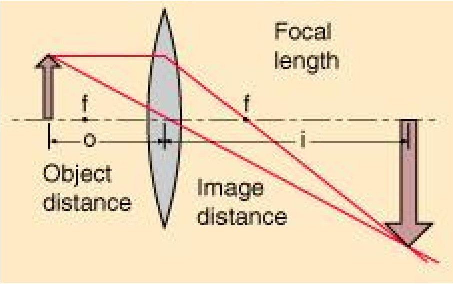


Figure 1: Ray Trace, http://hyperphysics.phy-astr.gsu.edu/Hbase/geoopt/lenseq.html

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[1] This is fiberoptics work. Light is sent down long cables of fiberoptic by being *totally* internally reflected along the walls of the fiber.

[2] Can also be done by looking at the speed of light in the prism. It is interesting to note that if something is travelling faster than the speed of light *in* a medium, it emits a blue to UV light called Cherenkov radiation. This is the method of detecting neutrinos and is what gives water in nuclear reactors a bluish glow.