In addition to its ability to read analog voltages from the LabJack, Matlab can also set the output voltage of digital ports. We will use this capability to control the rotary motion of optical components to test Snell's Law of Refraction. In addition to the laser and photodiode from Lab 0, we will use:

Stepper motor

- A stepper motor and controller which converts logic pulses from the LabJack into discrete rotary motion. In other words, depending on the stepper controller settings, a single logic pulse from the LabJack will cause the motor shaft to turn 1/400, 1/1000, 1/2000, or $1/10^4$ rotation.

Translation stage

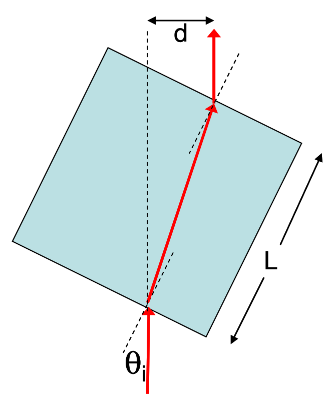
- A translation stage which converts rotary motion into linear motion with a 0.25mm-pitch lead screw.

Place the motor between the laser and photodetector (mounted on the translation stage) so that the rotor is vertical and the sample stage is installed. Close the aperture until the voltage signal is within the measurement range when you align the laser into the detector.

You can send pulses to the motor controller from the LabJack FIO1 output port and through a BNC cable with `lj_step(h)`. What angle does the motor shaft turn per step?

Now place a clear square plastic block on the rotation stage and align the laser beam so that it passes through the longest dimension and is normally incident on the face. [To determine angles with respect to the surfaces, use retro-reflection - adjust the surface so that the reflected light exactly retraces the laser beam. Then you know the beam was normal to the surface.]

Starting with the laser beam aligned into the photodetector, turn the translation stage lead screw several complete revolutions to move the photodiode away from the beam center. Write a script which steps the motor once between photodiode voltage measurements and plots the laser intensity as a function of motor shaft angle. What is the uncertainty in the beam position? How can you minimize this uncertainty?

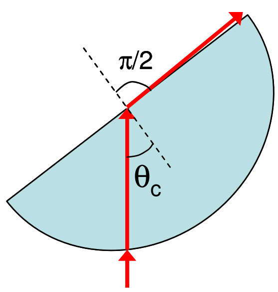


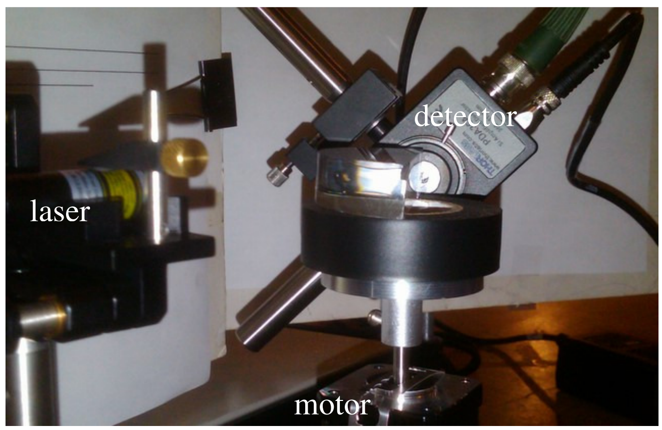
Re-aligning back to normal incidence, use multiple scans starting with different photodetector displacements to determine the index of refraction of the clear block using Snell's law.

Total Internal Reflection: If light is propagating from medium with n_1 to n_2 and $n_1 > n_2$, Snell's Law no longer has a solution for incidence angles greater than the critical angle, where the angle of refraction is 90 deg. For larger angles, no light is transmitted - it is all totally internally reflected. The critical angle is given by

$$\theta_C = \sin^{-1}\frac{n_2}{n_1}.$$

Mount the semicircular optical block so that its outer arc is concentric with the motor shaft/stage axis of rotation. Mount the photodetector on the rotating stage and align it along the flat face of the semicircle (see fig). At grazing incidence along the face, you should see a strong laser signal; upon rotation in the proper direction, you will see another (much weaker) signal corresponding to an angle just before θ_C. <u>Why use a semi-circle, and not the square block from the previous experiment? What index of refraction does this θ_C correspond to?</u>





Remember: Your full lab report must include all M-files and data (.DAT) files. Follow the format given in this document on the course website.