Data Analysis and Using Excel

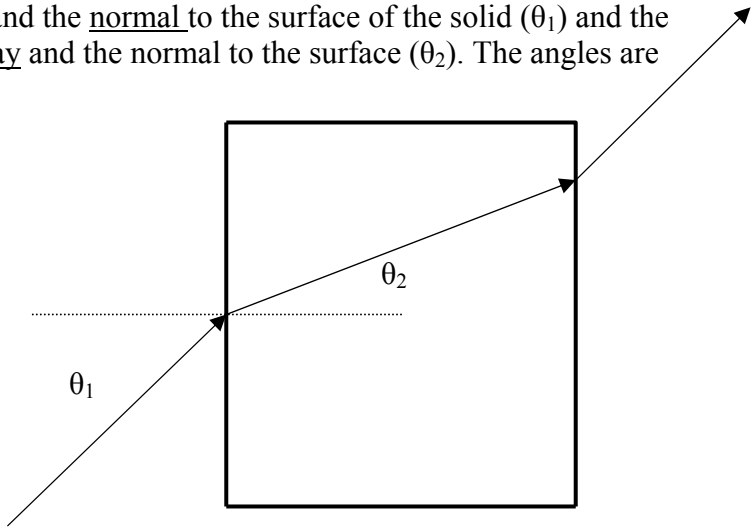
Purpose of Experiment:

In this week's lab your team will perform a simple set of measurements and then use Excel to analyze the data. The phenomenon is relatively simple – the refraction or change of direction of a light beam as it passes from air to a plastic plate. Your teaching assistant will demonstrate the setup. The equipment you will use is a source of light (a laser), a plastic rectangle, and a protractor.

More importantly, in this lab you will learn about the spreadsheet tool, Excel, and how it can be used to display and analyze data. Again, your teaching assistant will provide a demonstration.

Refraction of Light:

When a light ray passes from air into a transparent solid the direction of the ray changes, i.e., the ray is bent. The usual variables used to describe the process are the angle between the incident ray and the normal to the surface of the solid (θ_1) and the angle between the transmitted ray and the normal to the surface (θ_2). The angles are defined in the sketch.



It will be obvious as soon as you start to accumulate data that as θ_1 increases θ_2 also increases. There are many mathematical relations that have this property. For example, one might say that the angles are proportional to each other or, more generally, the angles are linear functions of each other. But many other functions of the angles would describe a situation where one angle increases if the other does. For example, if the sines or the tangents of the angles were linearly related one angle would increase if the other does.

Your task is make enough measurements to distinguish, if possible, among three possible relationships:

a) $\theta_2 = a_0 + a_1 \theta_1$, b) $\sin\theta_2 = a_0 + a_1 \sin\theta_1$, c) $\tan\theta_2 = a_0 + a_1 \tan\theta_1$,

where a_0 and a_1 are constants. The values of the constants are of no concern in this experiment.

Here is a suggestion as to how to proceed. Measure the angles for the largest practical range of incident angles. Compute the sines and tangents and enter everything into adjacent columns in your spreadsheet. Use the software to plot the angles, the sines of the angles, etc., against each other and decide which relationship best represents the data. It is interesting to divide the data sets into parts, say the lower half and upper half and then test these separately.

For each data set, or partial data set, decide which of the proposed relations are consistent with the data. Include error bars in the plots involving angles but not in the others.

Restricting the fits because of additional information.

One thing is clear – if one angle is zero then the other is also. In other words, an incident beam that is perpendicular to the interface enters the second medium without changing direction. This means the a proposed equation involving the constant term, a_0 , makes no sense. Your teaching assistant will show you how to fit the data to a straight line with the constant term equal to zero, i.e., a line that passes through the origin.

Repeat the fits in this way. Of the six proposed formulas which one is most consistent with the data? Which can be excluded?