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Optical Micrometer:

Procedure:

We were to measure the index of refraction and the lateral displacement of light through a lens using the optical micrometer. That lens was one of two things, either a semicircle oriented with the straight edge facing the incoming light or the curved section facing the incoming light, or a rectangular plate. The semicircle was used to measure the index of refraction using Snell's Law along with our measurements, noting the average index of refraction and standard deviation and standard deviation of the mean with any uncertainties accounted for. The rectangular block was used to determine the lateral displacement of the incoming light. Measurements were made in ten degree increments after precise collimation and alignment of the optical micrometer.

2. It is important to note that the beam is positioned in the center of the semicircular lens because if it is not, then the starting point, zero degrees, will have a refracted ray of light with more or less intensity than if it were perfectly aligned in the center of the semicircle.

3. The first step is to orient the lens such that the incident ray is going through the flat surface of the semicircle. I then recorded the position of the refracted laser beam for ten separate measurements in increments of ten degrees, starting with zero, then ten, twenty, and so on so forth. The measurements are in a table in my lab notebook under number three. Qualitatively observing the intensity of the light leads one to ascertain that as the incident angle increases, the intensity of the refracted light ~~increases~~ decreases. The intensity of the reflected light follows the same pattern in that as the incident angle increases, the intensity of the reflected light increases.

intensity of reflected light increases

=> you had it right in your lab book

4. This step asked for the index of refraction of each of the measurements separately. Using Snell's Law, n(i)*sin(theta(i)) = n(r)*sin(theta(r)), where i and r correspond to incident and refracted light, I was able to calculate the index of refraction. This is a simple calculation so I feel there is no need to show those calculations for each value, thus it is only noted in the lab notebook in my table for number three under the column heading "Index of Refraction" with the number four above to indicate the values correspond to procedure step number four. I then found the mean value for index of refraction, which came out to be 1.575. The calculations for the mean are on the back side of the first sheet of my lab notebook. I then calculated the standard deviation, +/- .024, and the standard deviation of the mean, +/- .008, using the formulas on page 100 and 102 of Taylor. Both are a unit-less number because the index of refraction has no unit, therefore both the standard deviation and standard

deviation of the mean of the index of refraction should have no unit as well. The calculations for both are also on the back side of the first sheet of my lab notebook under the calculations for mean. Thus, my final value for index of refraction including error is...

1.575 +/- .008

5. Step five wanted the same measurements as number four, but this time with the semicircle oriented the other way, with the curved region facing the incident light. Once again I collimated the beam to keep the procedure uniform. It suffices to note that when the semicircle is oriented this way, there is a critical angle where total internal reflection occurs. I measured the incident angle degree measure where this occurs to be 43.5 degrees. I assigned an error of +/- 1 degree to my calculation of the critical angle taking into account poor eyesight in the morning along with other factors influencing that value and how I measured it. Another issue worth noting is that when theta(i) is greater than theta(c), with i and c corresponding to incident and critical angle, there is only reflection. So in the table of values I made for this problem in my lab notebook under number five, I noted this and explained why I still put a value in the table for an incident angle of 50 degrees even though there is no such refraction at this degree measure. After calculating the index of refraction using Snell's Law for each measurement I found the mean value for index of refraction to be 1.370. I then calculated the standard deviation, +/- .039, and the standard deviation of the mean, +/- .014, of my measurements. I also calculated the index of refraction using my critical angle and the formula, theta(c) = arcsin(n(r)/n(i)), which came out to be 1.453. The error I assigned to my critical angle estimation was +/- 1 degree, so the uncertainty for the index of refraction is equal to one divided by my critical angle, or +/- .023. My calculations for mean, standard deviation, and standard deviation of the mean along with index of refraction from the critical angle can be found on the back side of the first page of my lab notebook under number five. Thus my final values for index of refraction with error are...

1.370 +/- .014 and 1.453 +/- .023

=0 so systematically below part I

Qualitative observation of the light intensity for incident angles greater/less than zero degrees with the normal lead to the conclusion that light intensity decreases for the refracted ray when the incident angle increases. Reflected light follows a different pattern in that as the incident angle increases the intensity of the reflected light increases.

The table comparing my values for number four and number five is on the following page.

Procedure Number	Index of Refraction	Uncertainty
4	1.575	+/- .008
5	1.370	+/- .014
5	1.453	+/- .023

systematic uncertainties obviously larger

6. After collimating the beam and measuring the thickness of the rectangular plate, D, with a caliper I recorded the lateral displacement, d, of the beam for incident angle measurements in ten degree increments. I did this at a far point and a near point with the difference in length between the two, L, to be 39.8 cm. I measured the thickness of my rectangular plate, D, to be 2.618 cm with the vernier caliper. The table with all of my lateral displacements for each incidence angle for both the near and far point measurements is in my lab notebook under number six. It can be noted that my estimation for error in my measurement of lateral displacement is going to be quite large because the precision and accuracy of my pencil markings on the white sheet of paper is not very good. My estimation for error in my measurement of d, lateral displacement, is +/- .05 cm because my pencil markings were hard to come by and it is hard to tell exactly where I was supposed to measure from using them. My estimation for error in my measurement of D, thickness of rectangular plate, is +/- .005 cm because the vernier caliper measures to very small values in millimeters. In my measurement of L I will assign an error/uncertainty of +/- .05 cm because I was using the meter stick whose smallest measure is of the order of millimeters. The table of values for my measurements of lateral displacement for both far point and near point is in my lab notebook on the second page under number six. The column labeled d with 43.5 cm in parentheses corresponds to far point and the column labeled d with 3.7 cm in parentheses corresponds to near point. To compare my calculated values with my measured values shows that the values I measured were significantly greater than the values I calculated. The reason for this is that it was very difficult to put accurate pencil markings on the white sheet of paper. I had to keep my arm elevated so it did not block the refracted light which in turn made my hand very unsteady so my markings are curved and slanted. There was no way to prevent this from happening because the apparatus did not allow for me to make precise marks from which to measure the lateral displacement. This is both a systematic and a random error in that I made the same mistake over again but it varied in the intensity or severity of the mistake. So my measured values should have a very large uncertainty compared to the uncertainty of my calculated values to account for this error.

7. The angle of deviation is defined to be the displacement of the laser beam with respect to the incident path. The table of values with my angle of deviation is in my lab notebook on the back side of the second page under number eight. The formula for the uncertainty that I obtained for both the measured and calculated angle of deviation sets is also found on the very same page. The uncertainty I found for the angle of deviation for the measured set of values for lateral displacement is +/- .106 degrees. The uncertainty I found for the angle of deviation for the calculated set of values for lateral displacement is +/- .279 degrees. What I can conclude about the angle of deviation is that I had a greater uncertainty with my calculated values for lateral displacement, but on average the values I got for the angle of deviation of my calculated lateral displacement are much smaller than those for the angle of deviation of my measured lateral displacement.

good

Conclusions:

I did the lab on my own but I did collaborate a little bit with the people around me. I had no trouble setting up the experiment, it was just tedious to write tables and record lots of values. I do not think the lab needs to be improved/changed very much because everything seemed to work fine for me. The only problem I did have was making pencil marks on the white sheet of paper for part six, but I adjusted my uncertainty and error to account for it. I feel that I learned a lot conceptually about refraction and reflection and how the angle of incidence and certain lenses affect my findings. I did find that I had a lot of uncertainty with my estimations for lateral displacement. Although I explained them in the appropriate procedure number, I feel they need to be addressed again. As you will see on the white sheet of paper with which I made my measurements, the markings are rather slanted and wide. With the marks being both slanted and wide it is hard to get a precise measurement using them because I do not know where the actual mark should have been, just approximately. Another dilemma I faced while doing the lab was that my eyesight was very poor in the morning. I tried to account for these random and systematic errors as much as possible but I am afraid I may not have done enough. I had a hard time assigning an error to my measurements because I have no idea how large/small my mistakes contributed to the end results. The best I could do was use the error in the measuring devices, which was assigned to me back in PHY 191, to come up with some logical way of assigning the uncertainty. So, if my results are a little skewed, I feel as though I have provided ample explanation of why that is.