Light Paper

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Physics – A

Plane Mirrors

Pin, Pin, Picture of a Pin

In this section, reflection of pins was explored by using more pins to determine where the virtual image of the pin was. Using these pictures (attached), angles of incidence and reflection and the distance from the object to the mirror (Di) and the distance from the mirror to the virtual image (Do) was found. It was found that the angle of incidence and the angle of reflection are equal, as well was Di and Do. Also, with three pins, the areas of the triangles formed are equal. In conclusion, the virtual image reflected is related to mirror in the same ways as the object itself. As for perpendicular mirrors, a virtual image is reflected in each surface of the mirror in the same fashion as the other trials; however, there is a third image (*). Because of the third image has percent errors so high, the third middle image does not act like the other reflections. My data is as follows:

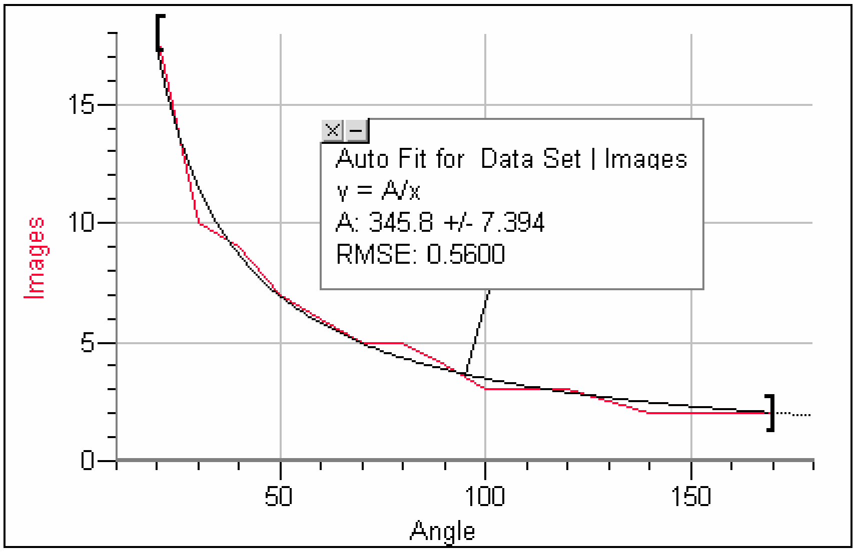
		Θ I	Θ R	% error	Do	Di	% error
1 pin	Trial A	11	17	0.352941	5.1	4.7	0.078431
		17	22	0.227273			
	Trial B	11	16	0.3125	3.3	3.1	0.060606
		22	27	0.185185			
	Trial C	15	16	0.0625	9.9	8.6	0.131313
		10	14	0.285714			
3 pins	Pin Red	12	16	0.25	3.9	2.5	0.358974
		11	14	0.214286			
	Pin Orange	7	7	0	5.6	4.7	0.160714
		9	12	0.25			
	Pin Purple	20	24	0.166667	2.8	2.6	0.071429
		22	23	0.043478			
⊥ mirrors	Blue	27	29	0.068966	7.2	5.8	0.194444
		15	16	0.0625			
	Green	9	9	0	7.7	6	0.220779
		22	22	0			
	*Purple	40	59	0.322034	10.2	2.8	0.72549
		33	56	0.410714			

Area O :	8.71
Area I:	7.37
% error:	0.15384

Multi Images

In this section, one pin was placed within and angle formed by two mirrors. The number of images of the pin was counted as the angle of the mirrors was made narrower. The data is following. The fit line given to me by Logger Pro was 345.8/angle. I looked at this and tried to figure out why this would be. Then I noticed that it was close to 360 and did some math to prove this. Also shown in the data table is 360/angle.

Angle	Images	$\frac{360}{angle}$
170	2	2.117647
160	2	2.25
150	2	2.4
140	2	2.571429
120	3	3
100	3	3.6
90	4	4
80	5	4.5
70	5	5.142857
60	6	6
50	7	7.2
40	9	9
30	11	12



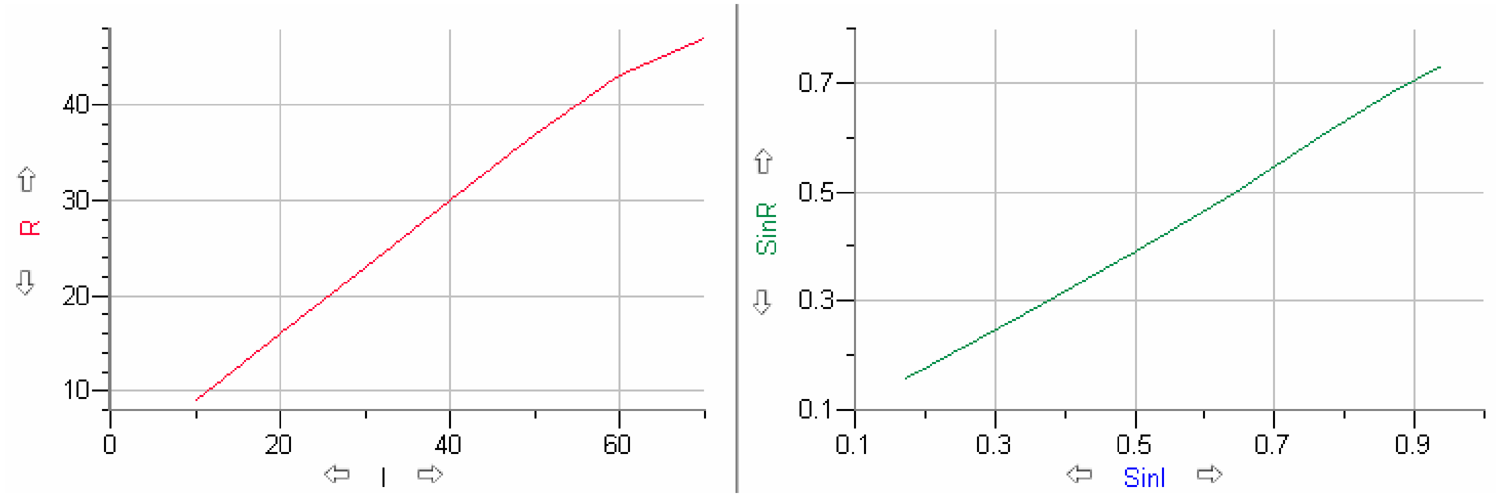
Refraction

Liquids

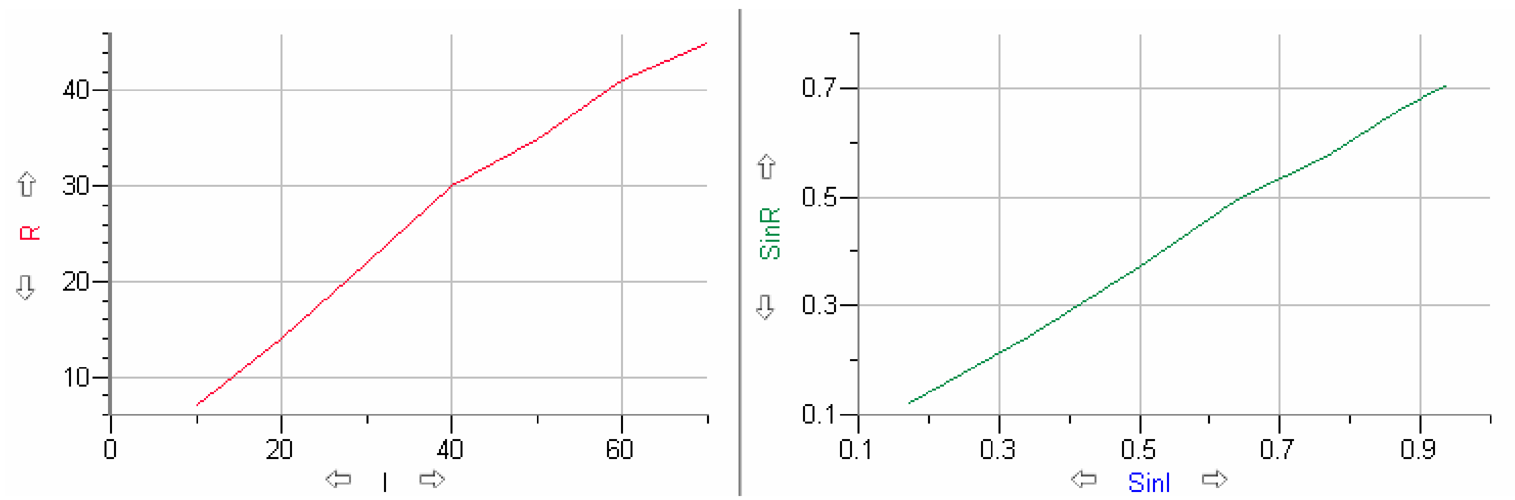
To investigate refraction of liquids, a semi-circular container of a liquid was placed with its center on the center of polar graph paper. Then, I found the angle at which the liquid was refracted through the liquid at each angle of incidence. With this data I was able to find the index of refraction (n) by using $n_1 Sin\theta_1 = n_2 Sin\theta_2$, Snell's Law, and the critical angle by using the formula $Sin\theta_c = n_2/n_1$ (using 1 was n_{air}). My data is below along with graphs of the angle of incidence verse angle of refraction and sine of the angle of incidence verse sine of the angle of refraction. As you can see, both relationships were linear.

	Θ I	Θ R	n	Average n	Critical Angle
Water	10	9	1.11004	1.249099	53.185243
	20	16	1.240835		
	30	23	1.279653		
	40	30	1.285576		
	50	37	1.27289		
	60	43	1.269835		
	70	47	1.284868		
Alcohol	10	7	1.424874	1.349067	47.838264
	20	14	1.413761		
	30	22	1.334732		
	40	30	1.285576		
	50	35	1.335558		
	60	41	1.320041		
	70	45	1.328926		
Oil	10	6	1.661258	1.488268	42.215579
	20	14	1.413761		
	30	20	1.461903		
	40	26	1.46631		
	50	31	1.487354		
	60	37	1.439022		
Corn Syrup	10	7	1.424874	1.466677	42.985509
	20	13	1.52042		
	30	20	1.461903		
	40	25	1.520967		
	50	31	1.487354		
	60	36	1.47337		
	70	43	1.377853		

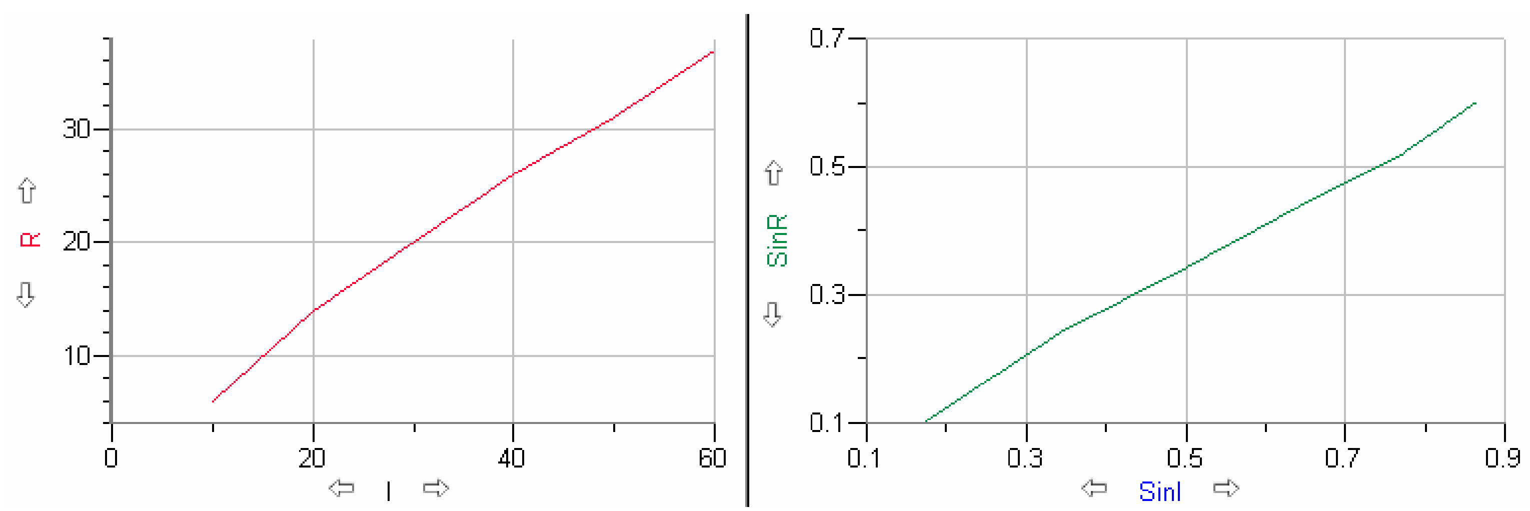
Water



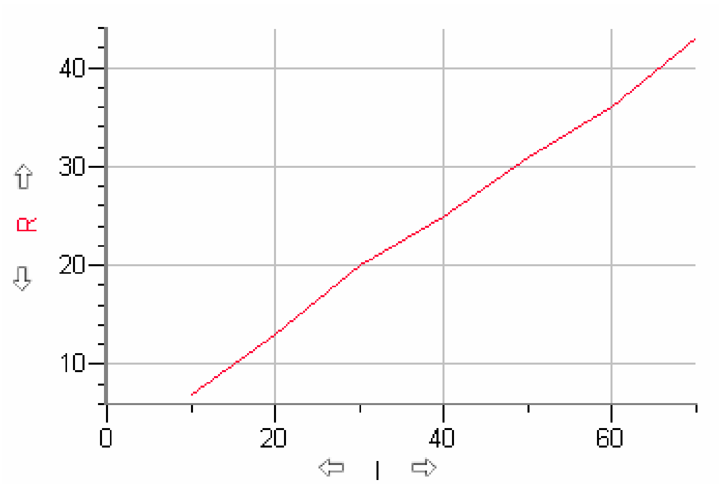
Alcohol

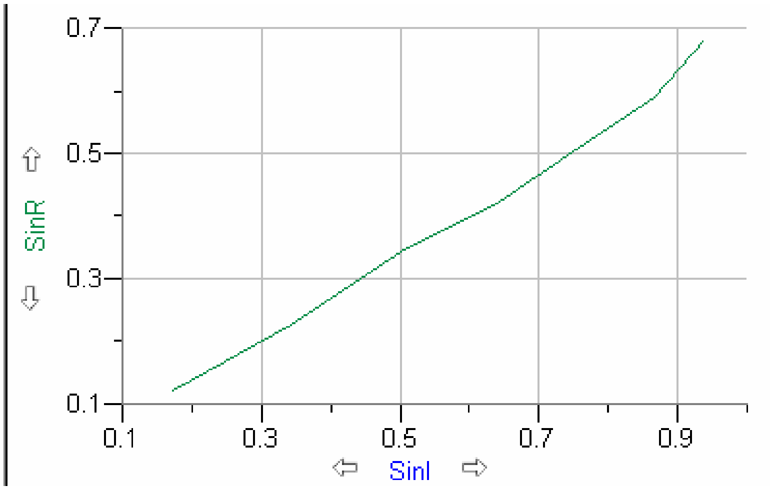


Oil



Corn Syrup





Solids

In this part, the refraction of light through glass and plastic plates was investigated. Using pins again, the path of the light was draw as you can see in the attached pictures. Using the angle of incidence and refraction, the index of refraction (n) was found using $n_1 Sin\theta_1 = n_2 Sin\theta_2$, Snell's Law, and the critical angle was found by using the formula $Sin\theta_c = n_2/n_1$ (using 1 was n_{air}). My data is on the table below. I found that the angle at which the light entered the glass or plastic was equal to the angle that it exited, although they were not on the same line.

	θ_{i1}	θ_{r1}	θ_{i2}	θ_{r2}	n	Average n	Critical Angle
Glass	25	17	17	24	1.47242	1.529876	40.817194
	16	10	10	16	1.587332		
Plastic	45	30	30	46	1.426446	1.442154	43.900428
	26	18	17	26	1.457862		

Lasers

In this part the index of refraction was found by first finding the critical angle. The critical angle was found by shining a laser into the glass and changing the angle of incidence. When the light was internally reflected, I had reached the critical angle. The using the same formula $Sin\theta_c = n_2/n_1$, I was able to solve for the glass's refractive index using 1 was n_{air}.

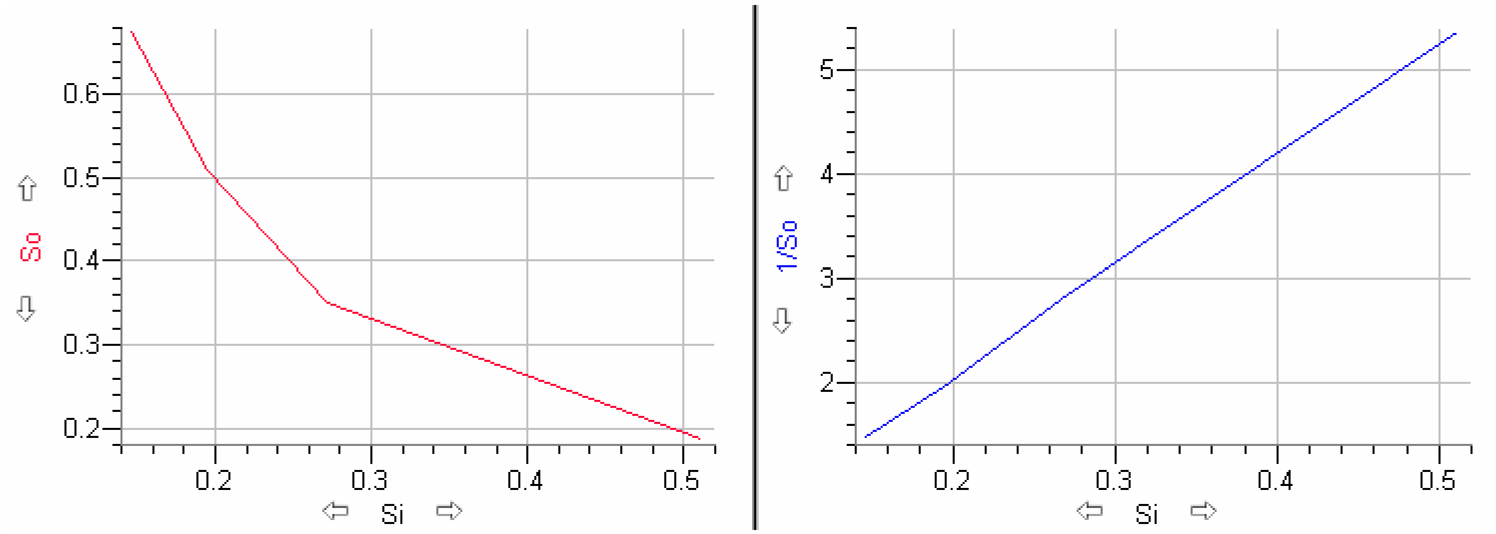
	Critical Angle	n
Glass	43	1.466279

Lenses

Converging

We also investigated refraction using converging lenses where the lens is thickest in the middle making parallel waves of light angle in towards each other at a focal point. First we determined the focal length (f) of our lens by moving the lens up and down under a florescent light until an image of the light because focused on the ground. Our distance of .33 m from the lens to the ground is our focal length. Once we have the focal length we can begin measuring Di and Do and Hi and Ho at various distances. The data is on the table below. Next, f can be found by using the formula 1/f=1/di+1/do. Finally Si and So can be found by subtracting the focal length from Di and Do respectively. The last two rows of data cannot contain f, Si, or So, because the lens was held at a point less than or equal to the focal point. For a graphical solution, see the attached pages. The graph shown below of Si verses So shows a curve. Because of the curves orientation it appears to be a reciprocal function. This is proven by the second graph containing Si verses 1/So, because it has a perfect linear relationship. Also, I have found that when the lens is held at a distance less than or equal to the focal length, the image is virtual and right-side-up, but when it is greater than the focal length, the image is real and upside-down.

Di	Do	Hi	Ho	f	Si	So	Di/Do	Hi/Ho	% error
0.46	0.99	0.003	0.008	0.314069	0.145931	0.675931	0.464646	0.375	0.192935
0.51	0.825	0.004	0.008	0.315169	0.194831	0.509831	0.618182	0.5	0.191176
0.58	0.66	0.005	0.008	0.30871	0.27129	0.35129	0.878788	0.625	0.288793
0.82	0.495	0.01	0.008	0.308669	0.511331	0.186331	1.656566	1.25	0.245427
no image	0.33	N/A	no image	N/A	N/A	N/A	N/A	N/A	N/A
no image	0.165	N/A	no image	N/A	N/A	N/A	N/A	N/A	N/A



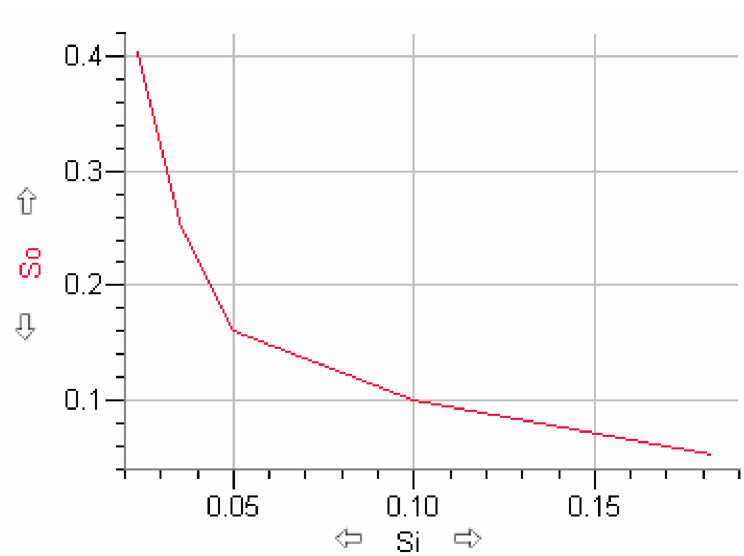
0.6
0.5
0.4
0.3
0.2
So
0.2
0.3
0.4
0.5
Si
5
4
3
2
1/So
0.2
0.3
0.4
0.5
Si

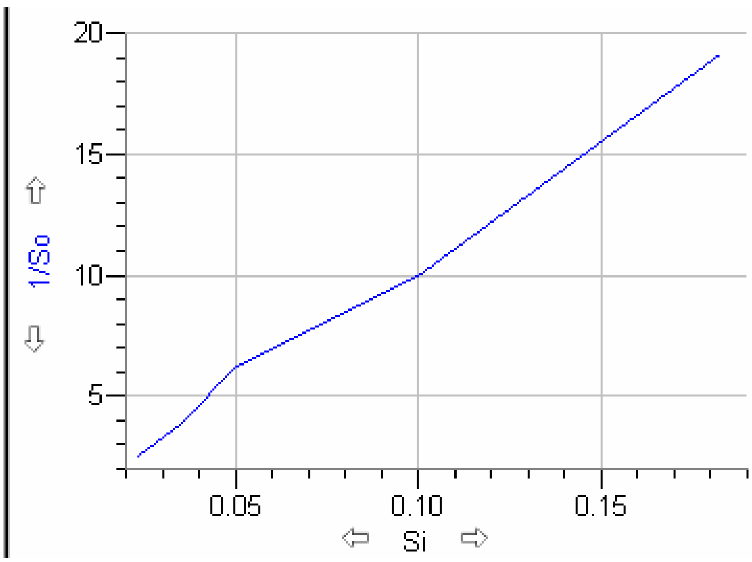
Curved Mirrors

Concave

The experimental design for curved mirrors is very similar to that for converging lenses. The image is reflected off of the mirror and projected onto a piece of paper. The Di is the distance from the image to the mirror and Do is the distance from the candle to the mirror. At various Dos, Di, Di, Hi, and Ho were measured. From that data, f can be found by using the formula 1/f=1/di+1/do. For a graphical solution see the attached pages. Lastly, Si and So can be found by subtracting the focal length from Di and Do respectively. Si verse So and Si verse 1/So are both graphed below. They show the same trends as the converging lenses. Also, when the Do was at or less than the image was virtual, while it was real when Do was greater than the focal length.

Di	Do	Hi	Ho	f	Si	So	Di/Do	Hi/Ho	% error
0.12	0.5	0.002	0.0075	0.096774	0.023226	0.403226	0.24	0.266667	0.1
0.13	0.35	0.005	0.0075	0.094792	0.035208	0.255208	0.371429	0.666667	0.442857
0.14	0.25	0.002	0.005	0.089744	0.050256	0.160256	0.56	0.4	0.285714
0.2	0.2	0.004	0.0075	0.1	0.1	0.1	1	0.533333	0.466667
0.28	0.15	0.01	0.005	0.097674	0.182326	0.052326	1.866667	2	0.066667
no image	0.1	no image	0.005	N/A	N/A	N/A	N/A	N/A	N/A





Diffraction

Finding wavelengths: Lamps

Using the diffraction glasses, three different types of lights were examined—two tube lights, one pink and one yellow, and a black light. The colors in the light separated and the distance from the source to each color was measured. To find the wave length of each color in the light, the formula d(x/l) = nλ was used. The variable n was the node, which was equal to 1 for all cases and the variable l was the distance from the glasses to the light, which was also 1 throughout this experiment. Therefore the equation for wavelength could be rewritten for this section as λ= dx, where d is the distance between slits on the glasses ($4.82x10^{-6}$, as found in the next section) and x is the distance measured from the light source to the diffracted light. My data and calculations are as follows:

		x	λ
Black Light	Green	0.13	$3.71x10^{-7}$
	Blue	0.125	$3.86x10^{-7}$
	Purple	0.15	$3.21x10^{-7}$
Pink Tube	Red	0.125	$3.86x10^{-7}$
	Yellow	0.12	$4.02x10^{-7}$
	Green	0.1	$4.82x10^{-7}$
	Purple	0.09	$5.36x10^{-7}$
Yellow Tube	Red	0.13	$3.71x10^{-7}$
	Yellow	0.11	$4.38x10^{-7}$
	Green	0.095	$4.07x10^{-7}$
	Blue	0.085	$5.67x10^{-7}$

Finding the distance between slits: Lasers

Next, we diffracted lasers off of various ridged surfaces to determine the distance between slits. We used the diffraction glasses, a grating, a CD, a DVD, and a big ole fashioned record. To determine the length between slits the same formula as used in the previous section, d(x/l) = nλ, will be used again. Like previously, l is equal to one, but we do have various nodes in this section. Also, the wavelength of the laser is equal to 650nm throughout this section. Therefore, the equation can be changed to d=650n/x, where d is the distance between slits and x is the distance from the center to the light at the given node (n). My data and calculations are below. Looking at the distance between slits for the record, CD, and DVD, I noticed that there seemed to be a correlation between the amount of data a disk holds and the distance between slits on that disk—the smaller the distance between slits the more data the disk can hold.

	n	x	d	Average d
Glasses	1	0.13	$5x10^{-6}$	$4.82x10^{-6}$
	2	0.27	$4.81x10^{-6}$	
	3	0.42	$4.64x10^{-6}$	
Grating	1	0.15	$4.33x10^{-6}$	$4.49x10^{-6}$
	2	0.28	$4.64x10^{-6}$	
Record	1	0.02	$3.25x10^{-5}$	$3.25x10^{-5}$
CD	1	0.495	$1.31x10^{-6}$	$1.26 x10^{-6}$
	2	1.085	$1.2x10^{-6}$	
DVD	1	1.04	$6.25x10^{-7}$	$6.25x10^{-7}$

Color Filters

Using a regular, white light, the diffraction of the light was viewed with several color filters over the light source. The unfiltered source emitted all colors: red, orange, yellow, green, blue, and purple. First, the red filter blocked out green and made the orange blend with the red more. The orange filter blocked out the blue light. The yellow filter blocked out the purple. The green blocked out the red. The blue and purple each blocked out both yellow and orange. With the exception of blue and purple, I found that the colors came in pairs. Blue should have blocked out orange and purple should have blocked out yellow, but because the colors were so similar, it was difficult to see which color was blocked out. With this in mind, I made the conclusion that a colored filter will block out its opposite color.

Specifically, red and green blocked out each other, orange and blue blocked out each other, and finally yellow and purple blocked out each other.