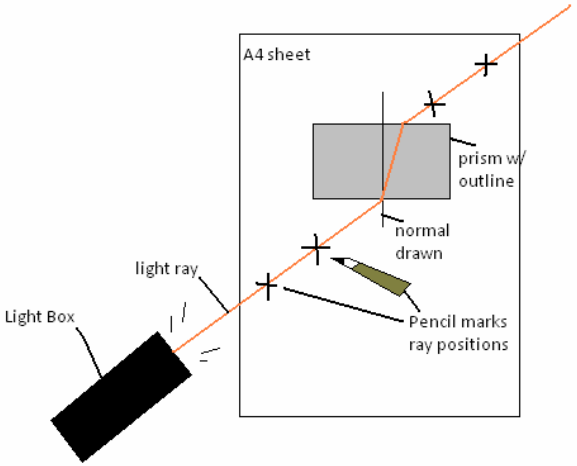
Asaki Tay, C10

Light Refraction Investigation

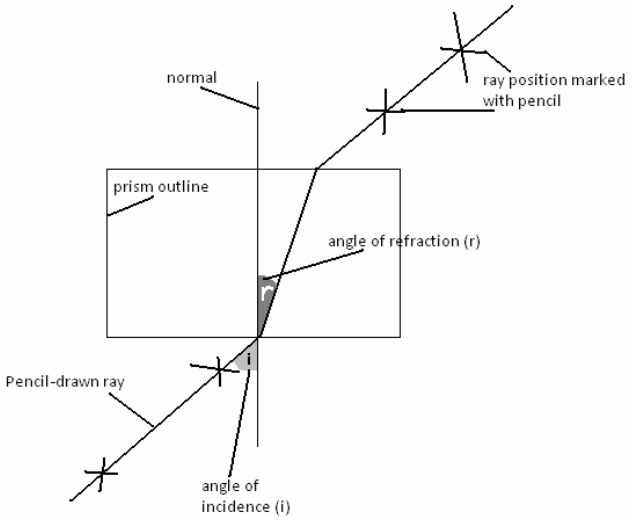
Introduction

The aim of this investigation was to find out the refractive index of light by shining light rays through a rectangular prism.
My hypothesis and prediction is that the refractive index obtained from this practical will be approximately 1.5, the textbook index of light through a glass. The refractive index will be given by dividing the sine of the angle of incidence divided by sine of the angle of refraction. In other words: $\sin i \ / \ \sin r$. For this experiment, a sin r x sin i scatter graph will be plotted after gathering the necessary data, with the gradient of its trendline being the refractive index.
The independent variables include the angle the light ray hits the medium at, while dependent variables are the angles of refraction. As for the controlled variables, these include the position of the light box, as well as that of the prism.



Materials and Method

Apparatus:
- Light box kit
- Rectangular prism
- Paper
- Ruler
- Pencil
- Protractor

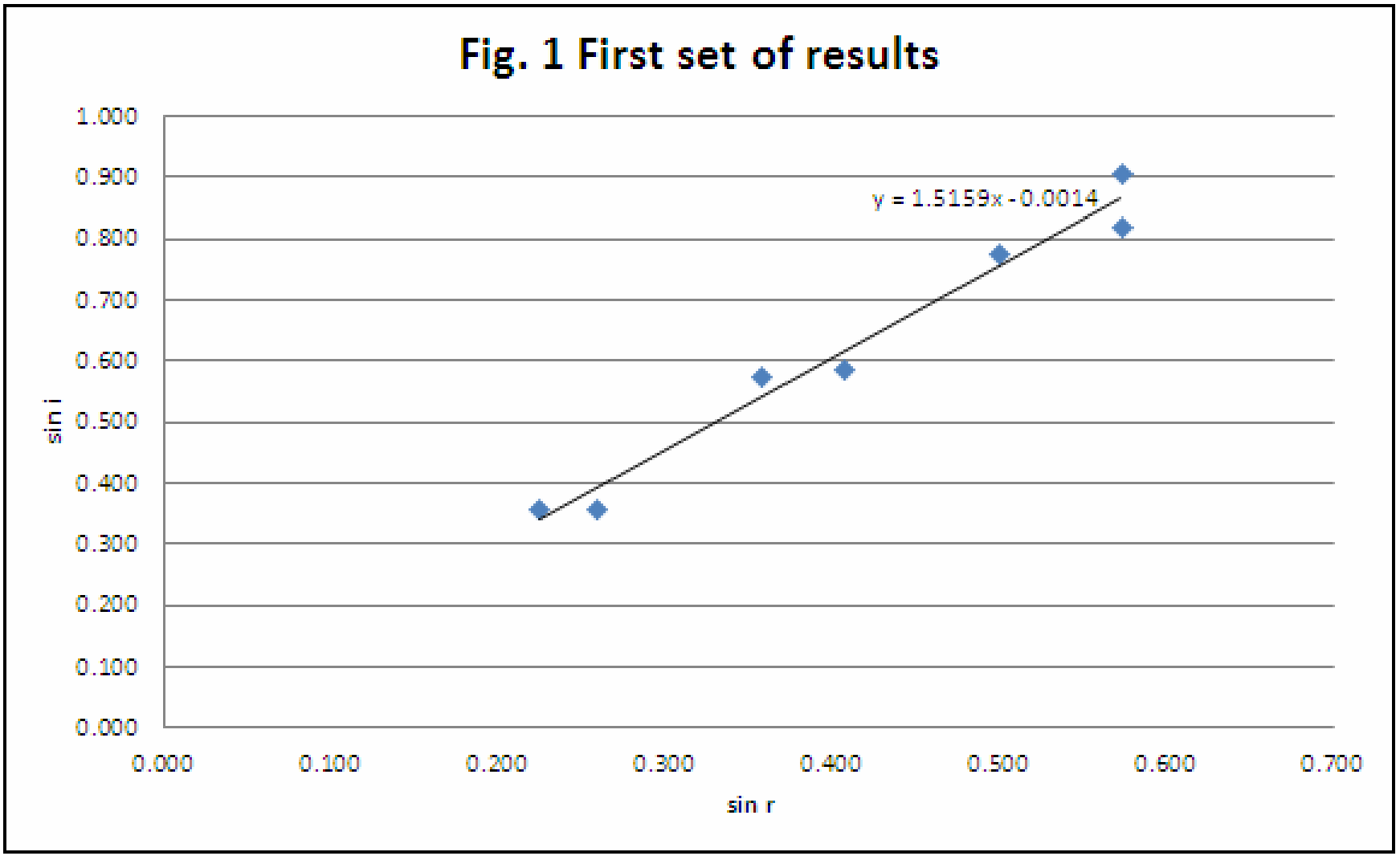


Observe the diagrams to the right. We first set up the light box so that it shone a single thin ray of light through a piece of black plastic with a slit. Then, we took the prism and placed it in the centre of the sheet of paper. To control the position of the prism, we drew an outline of it with a pencil so that we could shift it back into its original position in case it moved (1). Then, a normal was drawn through the middle of the outline with a ruler (2). Afterwards, we began to introduce the light ray at an angle, but always touching the point where the normal met the medium (3). Now, we marked where the ray was before and after it went through with a pencil (4). Now the prism was removed so that we could draw the light ray positions with a ruler through the points (5). We now had a zigzagged line. The incident and refracted angles were measured with a protractor and recorded (6). This was done another six times for the first set of results. A repeat set of results was then done to increase our chances of getting an accurate result.

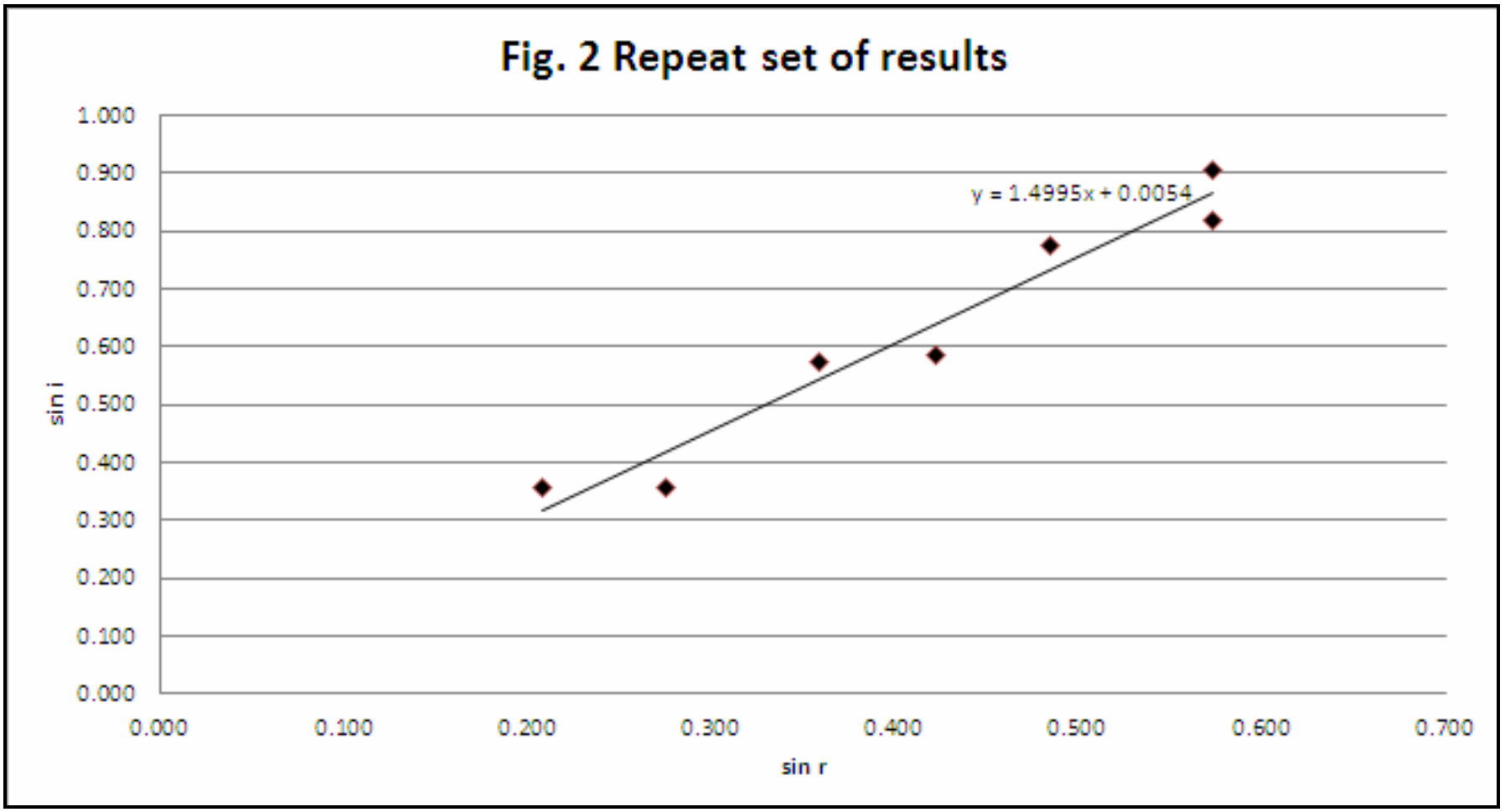
	A	B	C	D	E	F	G	H
1	angle of incidence	uncertainty (+/-)	angle of refraction	uncertainty (+/-)	sin i	sin r	sin i uncertainty (+/-)	sin r uncertainty (+/-)
2	21	1	15	1	0.358	0.259	0.016	0.017
3	21	1	13	1	0.358	0.225	0.016	0.017
4	35	1	21	1	0.574	0.358	0.007	0.016
5	36	1	24	1	0.588	0.407	0.014	0.016
6	51	1	30	1	0.777	0.500	0.011	0.015
7	55	1	35	1	0.819	0.574	0.010	0.014
8	65	1	35	1	0.906	0.574	0.007	0.014
9								
10	21	1	16	1	0.358	0.276	0.016	0.017
11	21	1	12	1	0.358	0.208	0.016	0.017
12	35	1	21	1	0.574	0.358	0.007	0.016
13	36	1	25	1	0.588	0.423	0.014	0.016
14	51	1	29	1	0.777	0.485	0.011	0.015
15	55	1	35	1	0.819	0.574	0.010	0.014
16	65	1	35	1	0.906	0.574	0.007	0.014

	A	B	C	D	E	F	G	H
1	angle of incidence	uncertainty (+/-)	angle of refra	uncertainty (+/-)	sin i	sin r	sin i uncertainty (+/-)	sin r uncertainty (+/-)
2	21	1	15	=((C2+1)-(C2-1))/2	=SIN(A2*PI()/180)	=SIN(C2*PI()/180)	=((SIN(22*PI()/180))-(SIN(20*PI()/180)))/2	=((SIN(16*PI()/180))-(SIN(14*PI()/180)))/2
3	21	1	13	=((C3+1)-(C3-1))/2	=SIN(A3*PI()/180)	=SIN(C3*PI()/180)	=((SIN(22*PI()/180))-(SIN(20*PI()/180)))/2	=((SIN(14*PI()/180))-(SIN(12*PI()/180)))/2
4	35	1	21	=((C4+1)-(C4-1))/2	=SIN(A4*PI()/180)	=SIN(C4*PI()/180)	=((SIN(36*PI()/180))-(SIN(35*PI()/180)))/2	=((SIN(22*PI()/180))-(SIN(20*PI()/180)))/2
5	36	1	24	=((C5+1)-(C5-1))/2	=SIN(A5*PI()/180)	=SIN(C5*PI()/180)	=((SIN(37*PI()/180))-(SIN(35*PI()/180)))/2	=((SIN(25*PI()/180))-(SIN(23*PI()/180)))/2
6	51	1	30	=((C6+1)-(C6-1))/2	=SIN(A6*PI()/180)	=SIN(C6*PI()/180)	=((SIN(52*PI()/180))-(SIN(50*PI()/180)))/2	=((SIN(31*PI()/180))-(SIN(29*PI()/180)))/2
7	55	1	35	=((C7+1)-(C7-1))/2	=SIN(A7*PI()/180)	=SIN(C7*PI()/180)	=((SIN(56*PI()/180))-(SIN(54*PI()/180)))/2	=((SIN(36*PI()/180))-(SIN(34*PI()/180)))/2
8	65	1	35	=((C8+1)-(C8-1))/2	=SIN(A8*PI()/180)	=SIN(C8*PI()/180)	=((SIN(66*PI()/180))-(SIN(64*PI()/180)))/2	=((SIN(36*PI()/180))-(SIN(34*PI()/180)))/2
9								
10	21	1	16	=((C10+1)-(C10-1))/2	=SIN(A10*PI()/180)	=SIN(C10*PI()/180)	=((SIN(22*PI()/180))-(SIN(20*PI()/180)))/2	=((SIN(17*PI()/180))-(SIN(15*PI()/180)))/2
11	21	1	12	=((C11+1)-(C11-1))/2	=SIN(A11*PI()/180)	=SIN(C11*PI()/180)	=((SIN(22*PI()/180))-(SIN(20*PI()/180)))/2	=((SIN(13*PI()/180))-(SIN(11*PI()/180)))/2
12	35	1	21	=((C12+1)-(C12-1))/2	=SIN(A12*PI()/180)	=SIN(C12*PI()/180)	=((SIN(36*PI()/180))-(SIN(35*PI()/180)))/2	=((SIN(22*PI()/180))-(SIN(20*PI()/180)))/2
13	36	1	25	=((C13+1)-(C13-1))/2	=SIN(A13*PI()/180)	=SIN(C13*PI()/180)	=((SIN(37*PI()/180))-(SIN(35*PI()/180)))/2	=((SIN(26*PI()/180))-(SIN(24*PI()/180)))/2
14	51	1	29	=((C14+1)-(C14-1))/2	=SIN(A14*PI()/180)	=SIN(C14*PI()/180)	=((SIN(52*PI()/180))-(SIN(50*PI()/180)))/2	=((SIN(30*PI()/180))-(SIN(28*PI()/180)))/2
15	55	1	35	=((C15+1)-(C15-1))/2	=SIN(A15*PI()/180)	=SIN(C15*PI()/180)	=((SIN(56*PI()/180))-(SIN(54*PI()/180)))/2	=((SIN(36*PI()/180))-(SIN(34*PI()/180)))/2
16	65	1	35	=((C16+1)-(C16-1))/2	=SIN(A16*PI()/180)	=SIN(C16*PI()/180)	=((SIN(66*PI()/180))-(SIN(64*PI()/180)))/2	=((SIN(36*PI()/180))-(SIN(34*PI()/180)))/2

Here are the two sets of results from the practical, shown in the first Excel table. The table below it shows the formulae used to calculate the sine values and uncertainties. The general trend of the sine results is that the sine of I is proportional to the sine of r. In other words, the larger the angle of incidence, the larger the angle of refraction, apart from some anomalies. For example, in the first set of results, an incident angle of 21° first gave a sine refractive angle of 15°. The second time using the same incident angle gave 13°. There was also some measurement error because the angle of refraction from the incident angles 55° and 65° were both 35°



Above is the graph obtained from the first set of results. The trendline shows a gradient of 1.5159, which means that the refractive index for these results was roughly 1.5, which is what I predicted and aimed for. Error bars using the uncertainties are



Above is the graph obtained from the repeat set of results. Again, the trendline's gradient roughly gives a refractive index of 1.5, though it is slightly less than what I predicted. Error bars are also shown here.

Conclusion

The results gathered and plotted on the scatter graphs in Excel suggest that my prediction was correct – the refractive index of the light ray passing through our prism was on average 1.5. This matches the textbook values (1.5, 1.52, etc). However, we did make some mistakes that made our values slightly inaccurate. Some of the angles may have been read incorrectly, giving the same refractive angles for two different incident angles, for instance. Sources of error may include the protractor we used, as they might not have been precise enough. Also, the way we marked where the rays were at each refraction could have been erroneous, because the 'X' marks may not exactly mark where the centre of the ray was, so when we traced the overall line through them, the line could have shifted one degree less or more.
Improvements can be made, such as simply increasing our concentration and precision while measuring the angles and marking the ray locations. Perhaps a more precise protractor could be used, if accessible.
This investigation poses more questions, such as finding out the refractive indexes of light rays through a plethora of media, such as water, alcohol and lead.

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http://www.rpi.edu/dept/phys/Dept2/APPhys1/optics/optics/node4.html
http://goto.glocalnet.net/ibweb/homepagelink.htm