An experimental study on Refraction

Aim

The aims of this experiment are to verify Snell's law, being able to measure and calculate the refractive index of a glass and finding its critical angle.

Background information

Refraction and Snell's law are strictly related as refraction is the travel of light from one medium into another in which there is a change in speed, and Snell's law is a formula used to describe the relationship between the angles of incidence and refraction. The formula for Snell's law is " $n_1 * \sin \theta_1 = n_2 * \sin \theta_2$ ". The refractive index depends on the wavelength of the light, and the ray will also be reflected beyond being refracted.

Instruments and materials

Instruments:
- Protractor —> sensitivity ± 1°; range 360°

Materials:
- Semicylinder of plexiglass
- Laser ray box

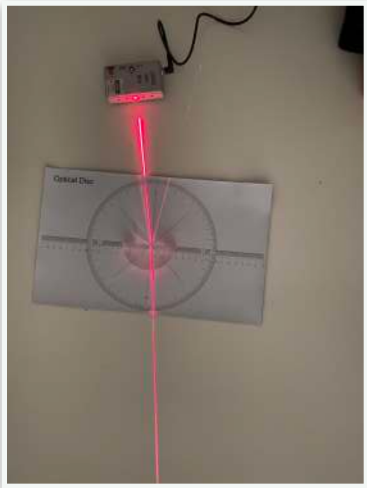


Fig. 1 —> Protractor with laser beam

Safety issues

- Avoid direct eye contact with laser ray because of laser radiation

Procedure

- Place the glass semicylinder on top of the protractor and check accurately that it is as centred as possible. Help your self to place the semicylinder in the correct central position by aligning it on the line labelled side of the protractor, in this way you can just count if the lines on the right and the lines on the left are the same amount.
- Check that the laser ray box is off and then plug it into the socket.
- Set the number of laser beams to one as no more than one is needed for this experiment
- Place the laser ray box facing the flat side of the semicylinder and turn it on.
- Align the laser beam with the center of the protractor, which should also be the center of the flat face of the semicylinder, and try to be as perpendicular as possibile to the face. To help yourself, try and look to the reflected ray. When the projected beam and the reflected beam are aligned, the equipment is correctly positioned.
- Annotate the angle of refraction every 10° starting from 0° to -80° and from 0° to 80°
- To calculate the critical angle of the glass, look at the angle at which the incident ray impacted on the rounded part of the semicylinder has total internal reflection.

Results

	î	r̂
	(° ; ± 1°)	(° ; ± 1°)
1	+ 10°	+ 7°
2	+ 20°	+ 13°
3	+ 30°	+ 20°
4	+ 40°	+ 26°
5	+ 50°	+ 31°
6	+ 60°	+ 36°
7	+ 70°	+ 40°
8	+ 80°	+ 42°

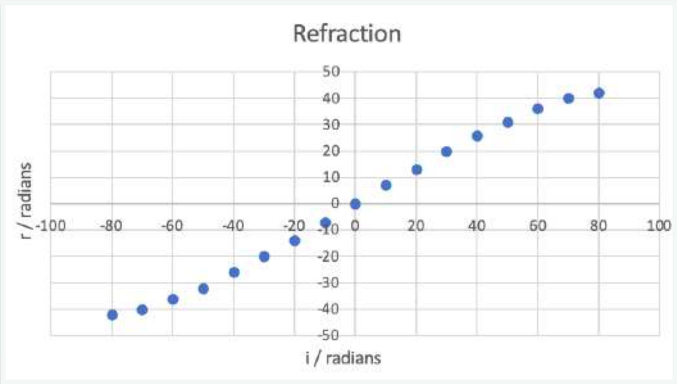
	î	r̂
	(° ; ± 1°)	(° ; ± 1°)
1	- 10°	- 7°
2	- 20°	- 14°
3	- 30°	- 20°
4	- 40°	- 26°
5	- 50°	- 32°
6	- 60°	- 36°
7	- 70°	- 40°
8	- 80°	- 42°

Analysis

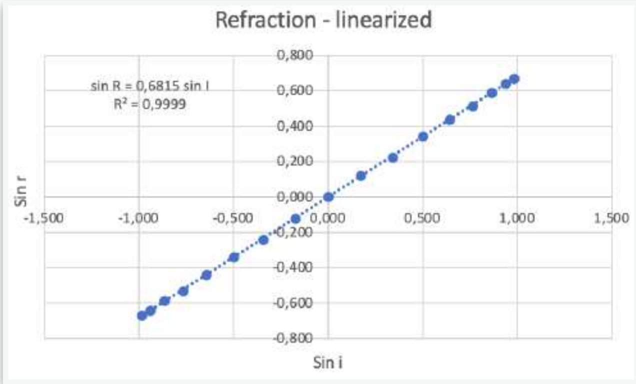
0° to 80°	Sin î	Sin r̂
+ 0°	0,000	0,000
+ 10°	0,174	0,122
+ 20°	0,342	0,225
+ 30°	0,500	0,342
+ 40°	0,643	0,438
+ 50°	0,766	0,515
+ 60°	0,866	0,588
+ 70°	0,940	0,643
+ 80°	0,985	0,669

-80° to 0°	Sin î	Sin r̂
- 80°	-0,985	-0,669
- 70°	-0,940	-0,643
- 60°	-0,866	-0,588
- 50°	-0,766	-0,530
- 40°	-0,643	-0,438
- 30°	-0,500	-0,342
- 20°	-0,342	-0,242
- 10°	-0,174	-0,122
+ 0°	0,000	0,000

- Critical angle = (43°; ± 1°)
- sin (r) = 1/n sin (i) so n = 1.466 and it has an uncertainty of 0.009 and relative uncertainty of 0.0058
- R^2 = 0.999 which means the relation between Sin î and Sin r̂ is almost absolute



Graph 1 —> Refraction



Graph 2 —> Refraction Linearized

Conclusion

In conclusion Snell's law was verified as the relationship between the angles of incidence and the angles of refraction had a Pearson correlation very near to 1, which represents an absolute relation between the two variables. The refractive index calculated is of 1.466 with a critical angle of approximately 43°. This last measure is just one of the approximated measurements taken as the instrument used had just a sensitivity of just ± 1° which for this type of experiment is enough, but to have a higher degree of precision, it would be better to have a more sensitive instrument.

Bibliography

- Physics for the IB diploma, sixth edition
- Figure 1 —> by Giorgio Dal Pont —> Protractor with laser beam
- Graph 1 —> by Giorgio Dal Pont —> Refraction
- Graph 2 —> by Giorgio Dal Pont —> Refraction Linearized