EXPERIMENT 6

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INTRODUCTION

In this experiment I sought to learn about the optical properties of light through various plexiglass and glass media. I wanted to determine the index of refraction of plexiglass and use that to calculate its critical angle. I then set out to observe total internal reflection of light through a special 45-45-90-degree prism and the behavior of light through arrangements of 2 prisms adjacent to each other, with and without water at their interface. I set out to investigate the dispersive wave phenomenon of the rainbow by measuring the index of refractions of red and blue light through an equilateral prism.

RESULTS

Behavior of Light Through Plexiglass:

In this section, I shined light through the two parallel faces of a piece of plexiglass. I observed two reflections coming back from the block with some small spacing in between them and changing the position of the block affects the magnitude of this spacing. I could determine the beam was normal on the surface by drawing the trajectory of the beam on the table and comparing this to the normal vector of the surface. I solved for the index of refraction in terms of the block thickness, angle of incidence, and ray spacing as follows.

Using this method and a set of measurements on block thickness, a normal angle of incidence, and the ray spacing, I determined the index of refraction of the plexiglass as follows.

Next, using Snell’s law, I determined the critical angle in terms of the index of refraction, n, to be

, which using the value measured previously put the predicted critical angle at . Then, by adjusting the angle of incidence until no light was transmitted out of the plexiglass, I experimentally determined the critical angle to be . This value agrees with the predicted value within experimental error.

Behavior of Light Through BK-7 Optical Glass:

This glass has index of refraction 1.515, so I determined the critical angle to be 0.721 rad. If light is incident at rad as shown in the lab manual diagram, it will be totally internally reflected since the incident angle from within is greater than the critical angle. Using the labels from the diagram, the top and bottom incident rays switch positions upon exit, so the one initially on top ends up on bottom and vice versa, reversing the image. Two such prisms can be used to “move” an image in periscope fashion to achieve results like a binocular’s lenses being further out than its eyepieces. I then tried to observe the light I saw through the prism in a couple of orientations. Holding the prism in the vertical orientation, I appeared upside down due to the rays reversing relative position in the reflection. Holding the prism in the horizontal orientation, I appeared right side up, but *not* mirrored as I’d have expected, since the left/right relative positions of the rays reverse.

Next, I placed one of the prisms normal to an incident beam and observed a reflection but no refracted (transmitted) light. This is because the angle of incidence exceeds the critical angle for the internal incident beams. I then placed another prism adjacent to it such that collectively the two formed a rectangular prism continuously. There was still a reflection but no refraction. The adjacent prisms behave like two separate objects and therefore the same critical angle issue occurs here. Next, I dripped water to fully wet the adjacent face between the two prisms. Again, shining light through, this time there was a strong refracted beam. There was still a reflected beam, but it became substantially weaker. This is because the water on the boundary causes the two prisms to act as one, in which there is essentially no internal surface to reflect from since the refractive indices of water and glass are much closer than those of air and glass.

Dispersive Phenomena

I now turned my attention to an equilateral prism and first sought to determine its index of refraction using the method of minimum angle of deflection of an incident red light beam. This minimum angle was found to be , and from this I determined the prism’s index of refraction to be . Then, to study dispersion, I shined a white light through the prism, resulting in a familiar rainbow pattern being refracted out of the prism. Based on the rainbow pattern observed, I predicted that blue light has a higher refractive index in the prism than red light because it bends further, appearing to the right of the red light in the rainbow, which appeared to the right of the incident beam. Again using the method of minimum deflection, I determined that blue light is refracted more than red light. The low precision of this result comes from the reliance of the eye to spot the broad, blending bands of color in the rainbow.

SUMMARY

I successfully determined the index of refraction and critical angle of a plexiglass block in this experiment while learning about properties of refracted light. I also succeeded in investigating the critical angle and related properties of a set of 45-45-90-degree prisms made of optical glass, further validating the theoretical predictions about this behavior. I then was able to observe the splitting of refracted light based on frequency, a dispersive phenomenon, in sending white light through an equilateral prism. In doing so, I was able to fulfill each of the objectives outlined in the introduction. A question for a future experiment could be the effect of the magnitude of the discontinuity of index of refraction on the transmitted beams, and whether this effect is linear or not.