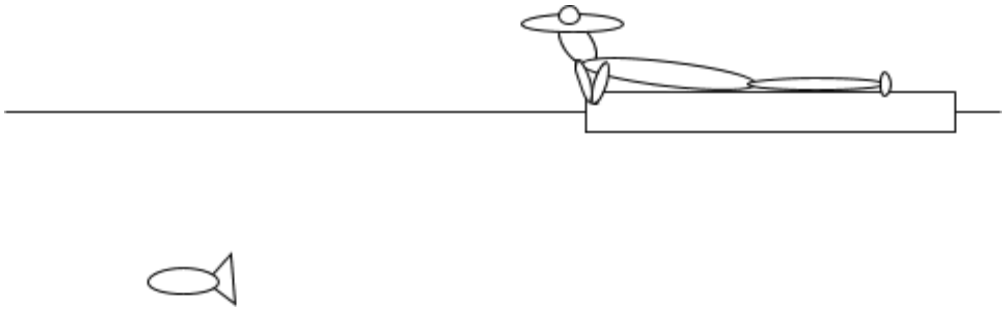
Refraction

1. Debbie is relaxing on a raft on a lake when she spots a fish in the water. Draw the path the light took to reach her eyes. Also identify the fish's apparent location.

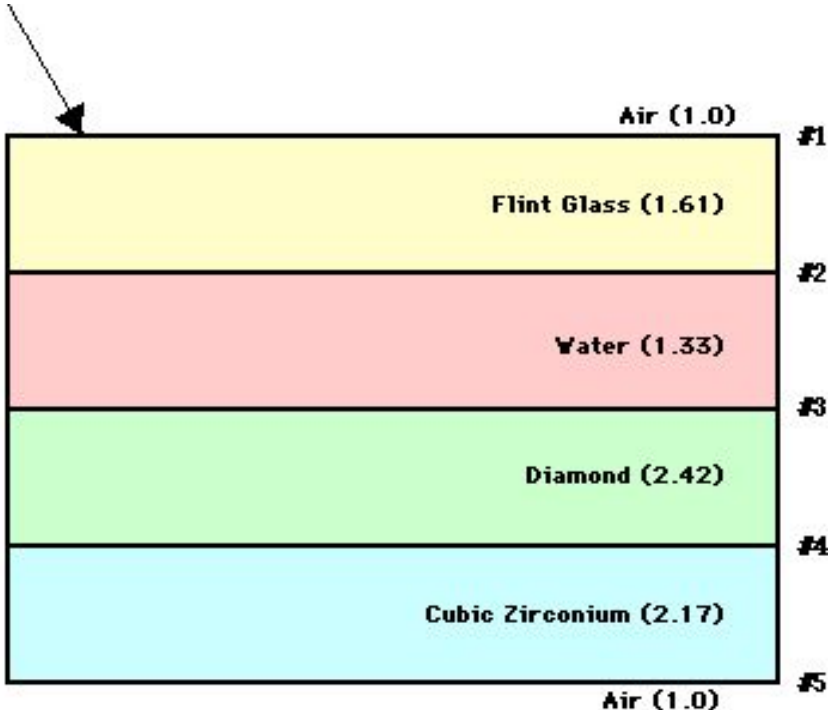


2. Suppose that you have a piece of polished plexiglass. Sketch the orientation of the plexiglass that would produce each of the following paths if the light starts on the left.

a.

b.

3. Trace the path of the light ray through the following series of layers. The angle of incidence is 30°. Show your work and label all angles.



4. A ray of light in crown glass (n=1.52) exits into air at an angle of 25.0 degrees. Determine the angle at which the light approached the glass-air boundary.

5. A penny is at the bottom of a 50 cm fountain. The light that gets to the observer whose eyes are out of the water approaches the water-air boundary at a 15 degree angle (n_{water}=1.33). Determine the apparent depth of the penny. Include a diagram to show the location of the image.

6. Calculate the critical angle for total internal reflection for light at the interface of water (n=1.33) and air. Explain why you can only see a reflection off the surface of the water if you look too far out into the water.

7. A diamond (n=2.42) is cut to maximize the brilliance.
    a. Calculate the critical angle for a diamond-air surface.
    b. Draw a diagram that explains how diamonds are cut to maximize brilliance.
    c. Cubic zirconia is often used in place of a diamond. It's index of refraction is approximately 2.15. Explain how this will impact the brilliance of the stone.

8. Calculate the critical angle for a plexiglass-air boundary. ($n_{plexiglass}$ = 1.51). Explain what this means for the design of the "light-pipe" we have in class to demonstrate total internal reflection.