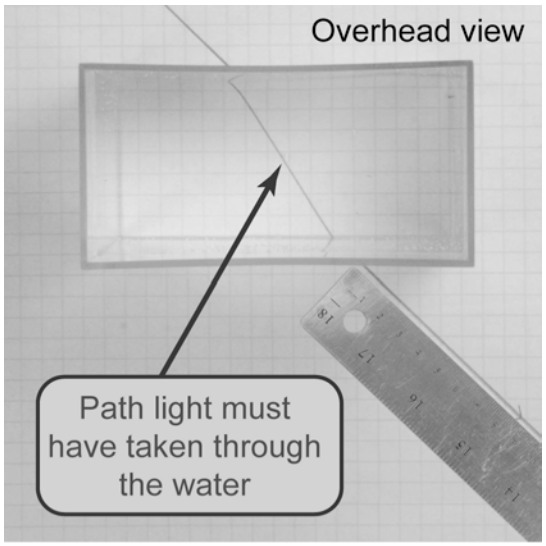
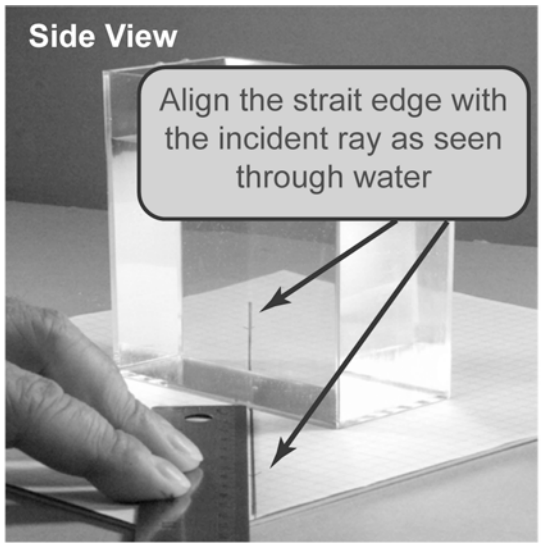
Sample refraction experiment

Essential question: How does light refract at a boundary?
What is the index of refraction of water?

Refraction may change the direction of light rays passing from one medium to another. The differences in *index of refraction* between the two media determine how much refraction occurs. In this investigation, you will analyze light rays passing through air and water, and determine the index of refraction of water.





Part 1: Trace the path of light through air and water

1. Place the container in the middle of a piece of graph paper and trace its outline.
2. Remove the container. Use a straight edge to draw an incident ray that intersects the left side of the container outline at an incident angle of about 45 to 50°.
3. Fill the container with water and replace it.
4. On the far side of the container, look through the water to view the incident ray. Align a straight edge with the incident ray as seen through the water. Use the straight edge to draw the refracted ray.
5. Empty and replace the container. Align a straight edge with the incident ray as seen through the empty container. Draw and label the "refracted" ray.
6. Remove the container. Connect the path of the light rays through both the full and empty container.

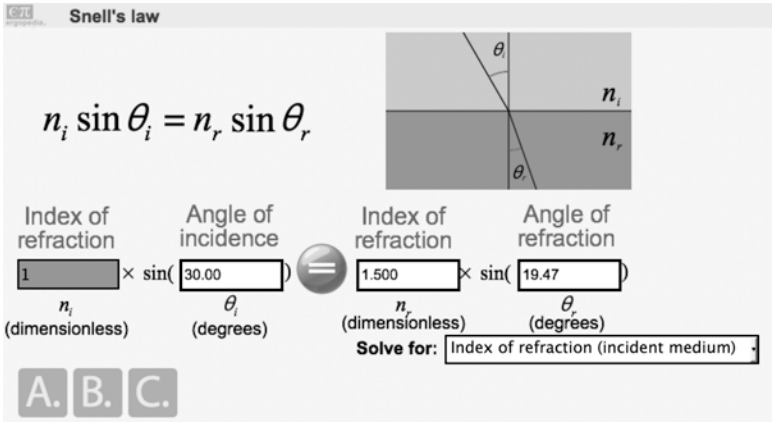
Questions

a. Did the light bend through the empty container? Through the water? Why or why not?

b. When the light bent, in how many places did it bend?

c. Construct the normals for both boundaries using dashed lines. With a protractor, measure the angles of incidence and refraction and record them in the table below.

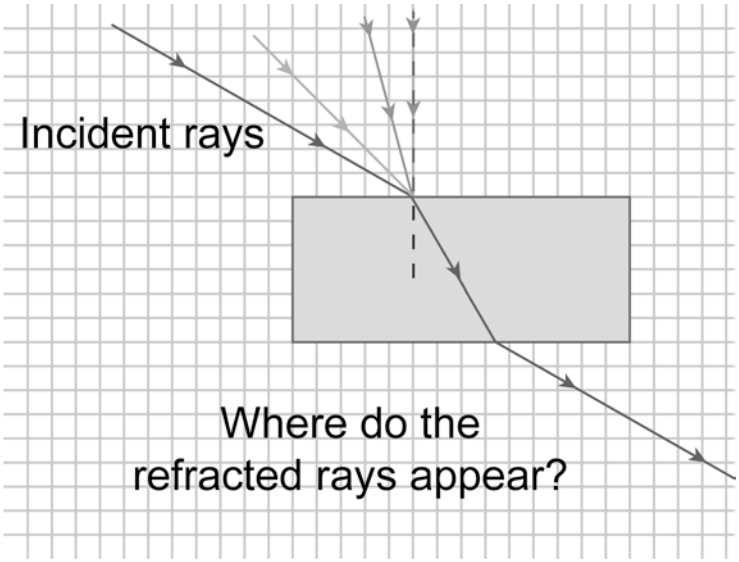
d. Use the Snell's law calculator to calculate the index of refraction of water for each boundary. The index of refraction of air is approximately 1 (1.003).



Data Table

Mediums	Angle of incidence	Angle of refraction	Did the light bend?	Index of refraction of water
Air to water				
Water to air				
Air to air				NA

Part 2: Investigate the effect of angle



1. Construct three more incident rays at angles smaller than 45°, including one ray with an angle of incidence of 0°. These rays should intersect the container outline at the same point as the original ray. Use colored pencils to differentiate the rays.
2. Refill and replace the container of water.
3. Look through the container to view the incident rays. Draw the refracted rays with a straight edge.
4. Remove the container of water and connect the path of the light rays. Then replace the container and view the complete set of rays.

Questions

a. Did all rays through the water refract? Which rays refracted the most? The least?

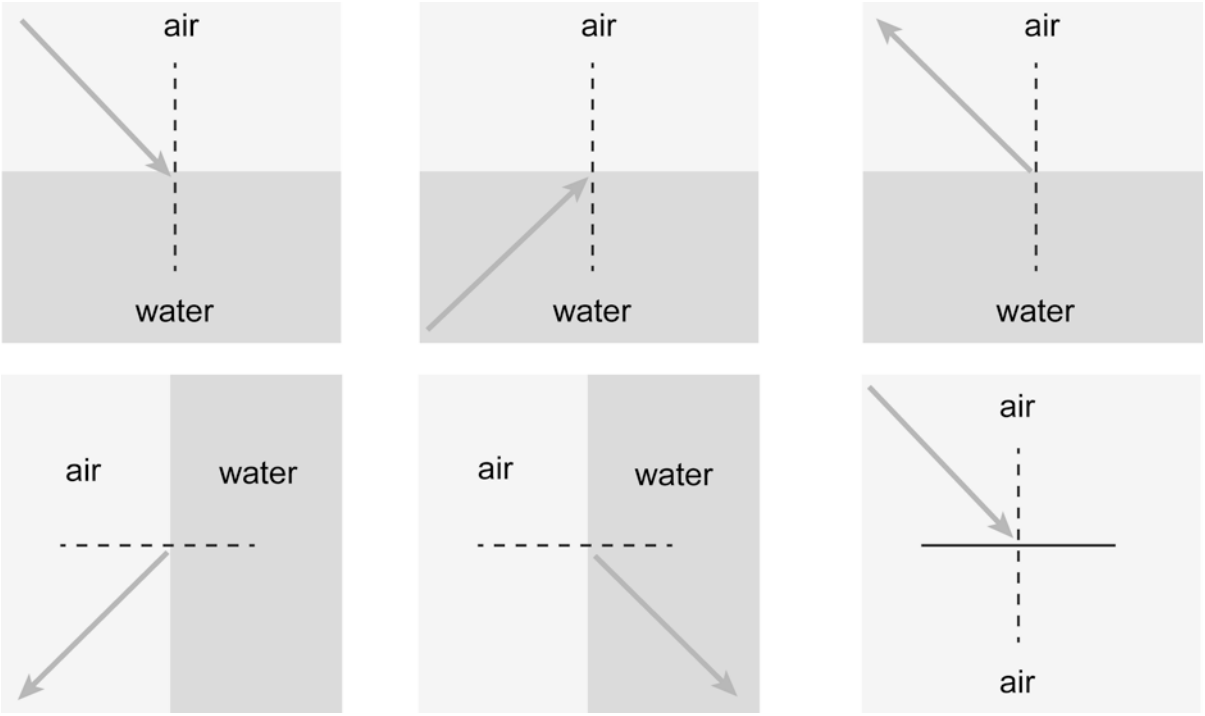
b. What two factors determine how much a light ray will bend?

c. Reverse position and look through the water to view the refracted rays. What do you notice?

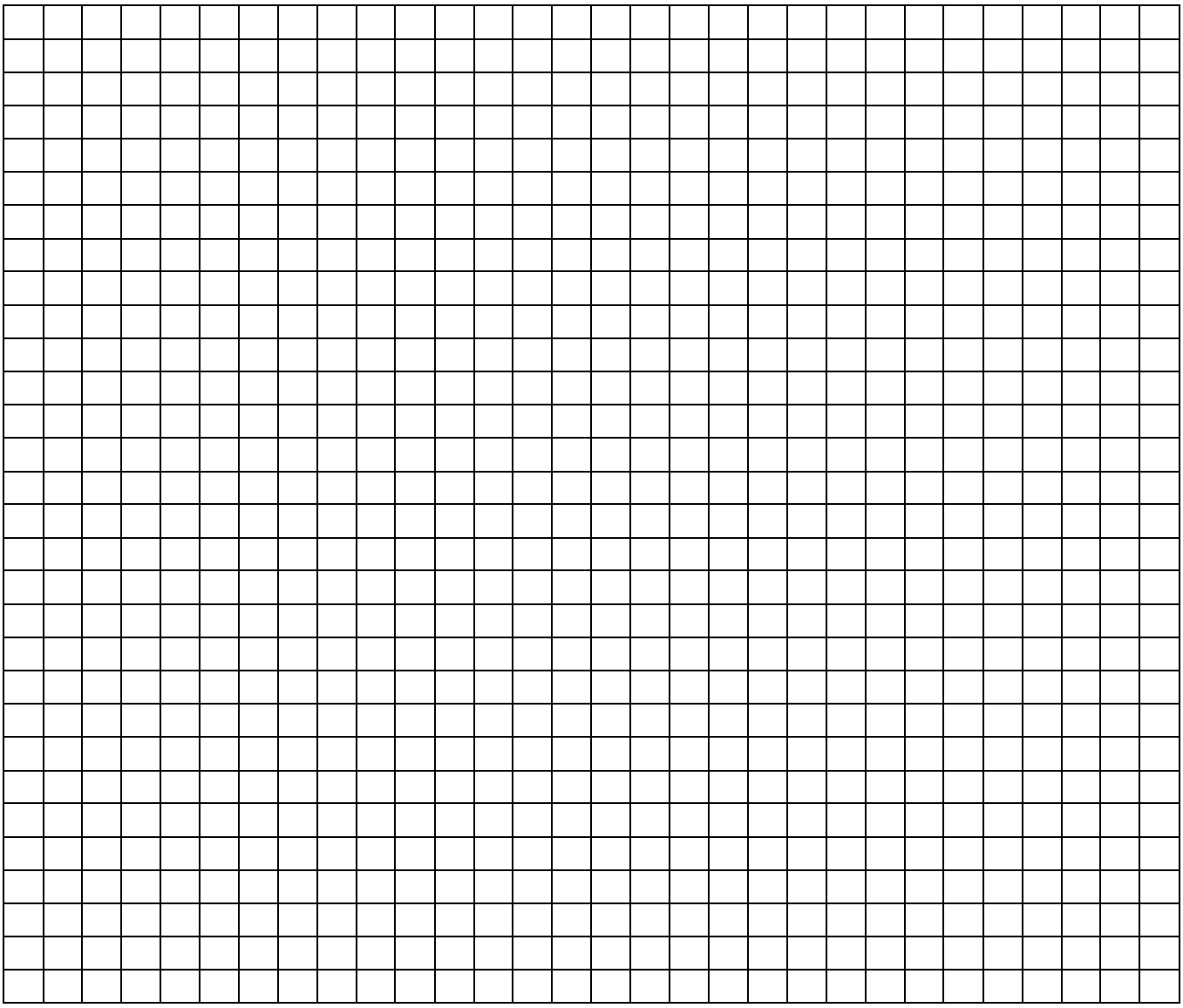
d. Compare a ray before entering and after exiting the container. Describe how these two segments are related to each other geometrically.

e. Draw a sketch of the *wave fronts* of light as they refract from air into water. Does the light bend toward or away from the normal?

f. Complete each diagram below by sketching the missing ray. Your sketch should clearly show the direction of refraction (toward or away from the normal).



g. Write a multiple-choice question that requires the reader to demonstrate an understanding of the effect of the index of refraction on the amount or direction of bending of light between two mediums.



Applying new knowledge

1. For each of the following, determine whether the phenomenon described involves refraction or reflection.
   a. Objects look larger when viewed through a magnifying glass.
   b. You view your image in a mirror.
   c. Objects look broken when semi-submerged in water.
   d. A room looks unusual when viewed through a prism.
   e. When you look out of your house through a window at night, you can see an image of the room you are standing in.
   f. You examine objects while wearing someone else's prescription glasses.

2. A beam of light shines from water into two mystery materials A and B. Material B deflects the light beam more. Which of the following *must* be true?
   A. material B has a higher index of refraction than material A
   B. material B has a lower index of refraction than material A
   C. material B is diamond
   D. none of the above

3. A light beam passes from water (n = 1.33) into glass (n = 1.5). The angle of incidence is 55º. Use the interactive calculator to find the angle of refraction.
   A. 33.1º B. 46.6º C. 55.0º D. 67.5º

4. A student shines a light ray from material A into material B. The angle of incidence is 30º and the angle of refraction is 20º. When a light ray shines from material B into material A, does the ray deflect towards the normal or away from it?

5. A beam of light shines from diamond (n = 2.4) into water (n = 1.33) or glass (n = 1.5). Which combination of materials bends the beam more?

6. A beam of light shines from water (n = 1.33) into air (n = 1) or glass (n = 1.5). Which combination of materials bends the beam more?

7. How much is the light ray in the diagram *deflected*, and in which direction?
   A. 10.5 degrees away from the normal
   B. 10.5 degrees towards the normal
   C. 30 degrees away from the normal
   D. 30 degrees towards the normal