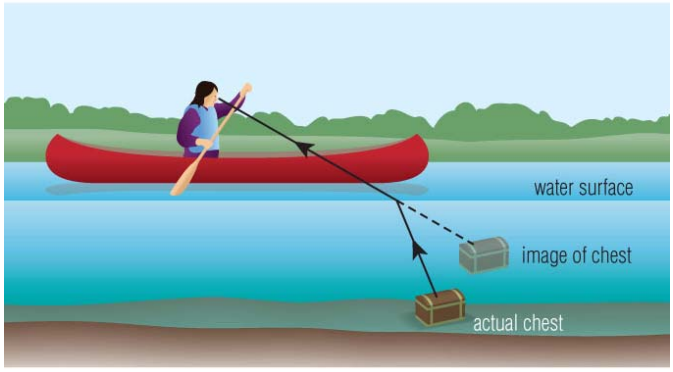
Refraction

- Light travels at different speeds in different materials.
- Refraction is the bending of light as it travels from one medium to another.
- Refraction is due to changes in the speed of light and the angle the light hits the medium. For example, as light moves from air into water it bends.

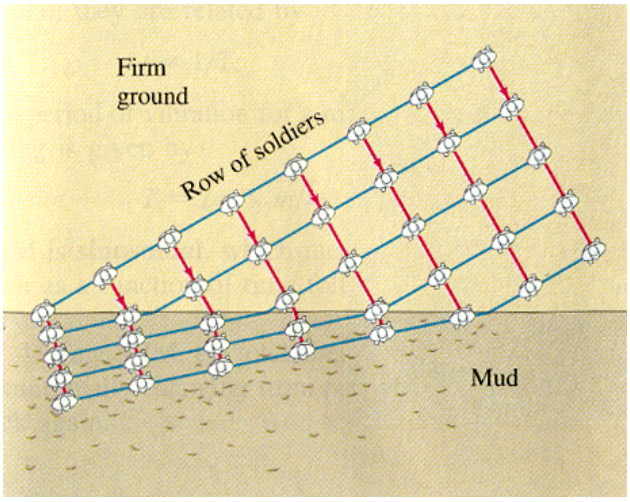


Examples of Refraction in Nature:

- **Dispersion** is the refraction of white light into separate wavelengths, or colours – prisms and rainbows
- **The "Flattened" Sun** – the sun is flatter at sunset close to the horizon
- **Mirages** – pools of water on a highway on a hot day

How light Refracts

Example 1: To visualize what happens when light enters a new media, picture a beam of light as rows of soldiers marching. Each line of soldiers is a light wave front. At first, all the waves are parallel. Then, the soldier rows (light waves) are compressed as they enter the mud and slow down. If the soldiers enter the mud at an angle, that part of the army slows down first. Once all soldiers are in the mud then continue in a straight line again.



Example 2: Driving a car and one wheel goes off road. As one wheel hits the shoulder, it slows down pulling the other wheel into a turn - refraction. Once both wheels are in the new medium it travels in a straight line.

- Different media slow down light by different amounts. The more that light slows down, the more the light is refracted – called index of refraction or refractive index

- Therefore, the larger the refractive index, the more the medium decreases the speed of light. Light travels fastest in a vacuum.

- The refractive index of the speed of light in a vacuum is assigned a value of 1.00 while in diamond; the refractive index is high at 2.42.

$$n = \frac{c}{v}$$

n = index of refraction,

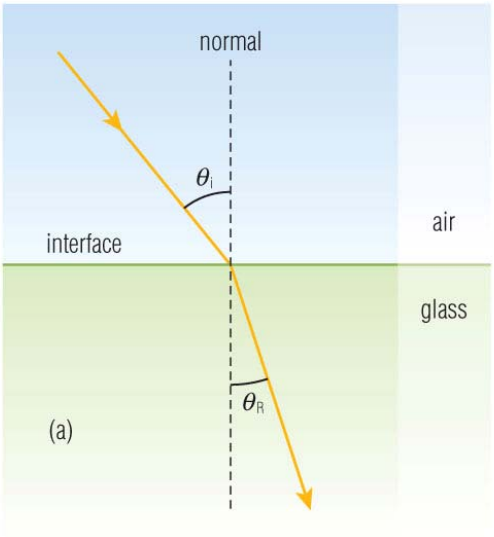
c = speed of light in vacuum,

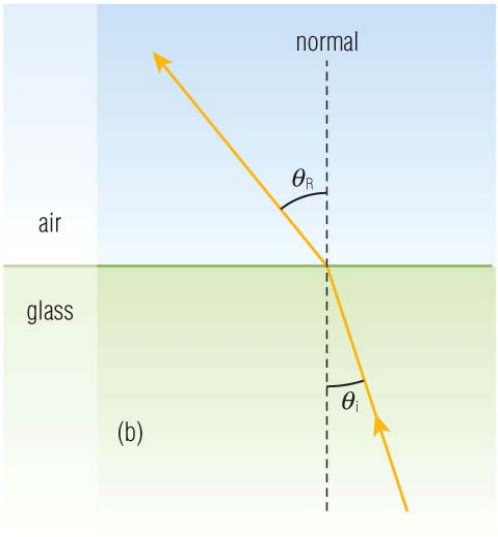
v = speed of light in material

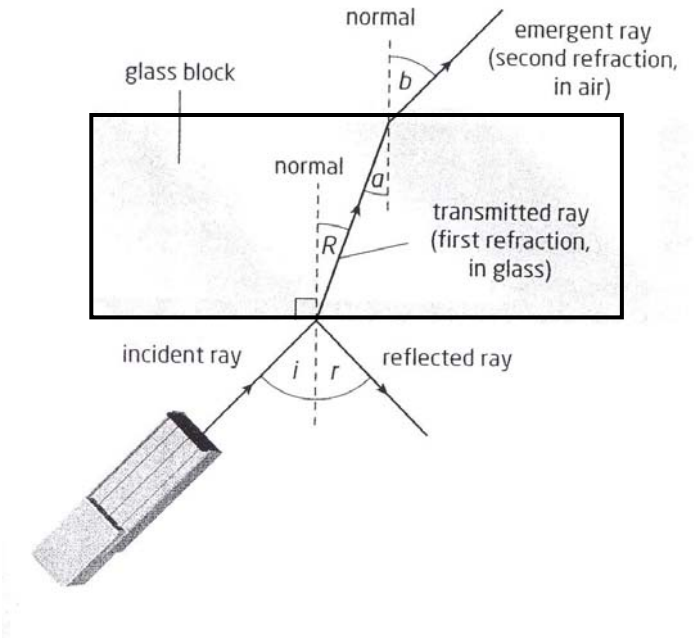
- The angles of the refracted light rays are measured from the normal, drawn at 90° to the surface where the light ray crosses between the two media.

- When light travels from air, with a low refractive index, into water, with a higher refractive index, it bends toward the normal.

- When light travels from a denser (higher refractive index) medium into a less optically dense (lower refractive index) medium, it bends away from the normal.







Investigating Refraction

1. Place the glass block in the center of the sheet of paper. Outline the block.
2. Place a single slit in the ray box and shine the light toward the longest side of the block as shown in the diagram.
3. Make small pencil marks on the incident, reflected, and emergent rays.
4. Remove the block and use a ruler to connect the dots with a solid line to show the path of the light ray. The light ray should change direction at the outline of the block.
5. Draw a normal at the point where the incident ray enters the block. Draw a second normal where the emergent ray leaves the block. Measure the angles of incidence (i), reflection (r), and refraction (R), as well as the angles labeled a and b in the diagram. Record results in the table below. Repeat the procedure a second time for another incident ray at a different angle.

Incident Ray	**Reflected Ray**	**Transmitted Ray**		**Emergent Ray**
		First Refraction, in Glass		**Second Refraction, in Air**
$\angle i$	$\angle r$	$\angle R$	$\angle a$	$\angle b$

D17 *Quick Lab*

Observing Refraction

Purpose

To observe whether the bending of light affects the way we see certain objects

Materials & Equipment

- glass of water
- pencil
- jar lid with opaque rim
- coin

Procedure

1. Insert a pencil into the glass of water. Observe the glass from the side at various angles. Record your observations using labelled diagrams.
2. Place a jar lid with an opaque rim on a desk and put a coin in the middle.
3. Keep watching the coin while you lower the height of your head until the coin just disappears from view behind the rim of the lid (Figure 11.29).
4. Keeping your head at the same level, pour water into the lid, on top of the coin. Observe. Record your observations using labelled diagrams.

Figure 11.29 Step 3

Questions

5. Describe the path of light from the water to the air.
6. Draw a ray diagram of the light rays from the coin to your eye:
   (a) in step 3
   (b) in step 4
7. Compare your drawings in question 6 with those done by classmates.
   (a) How are your drawings similar?
   (b) How are your drawings different?

Demo 1

Figure 11.30 The spoon appears to be broken because light rays change direction as they move from air into water and from water into air.

Answers

To have students observe whether the bending of light affects the way we see certain objects

Activity Notes

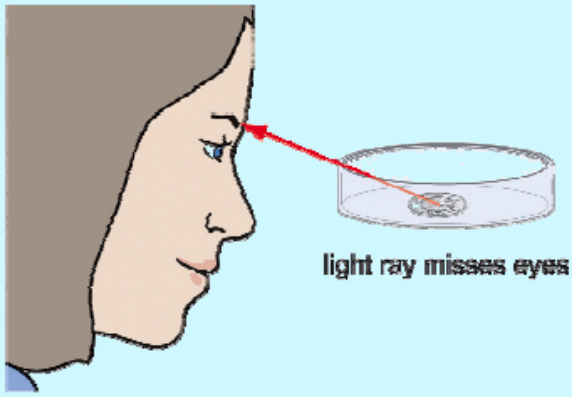
- This activity definitely gets an "oooh" from everyone.
- Deep lids like those from mayonnaise jars work best. Avoid lids from peanut butter jars due to possible allergies.
- Follow up with some easy demonstrations as shown in Figures 11.30 and 11.32.

ANSWERS TO QUESTIONS

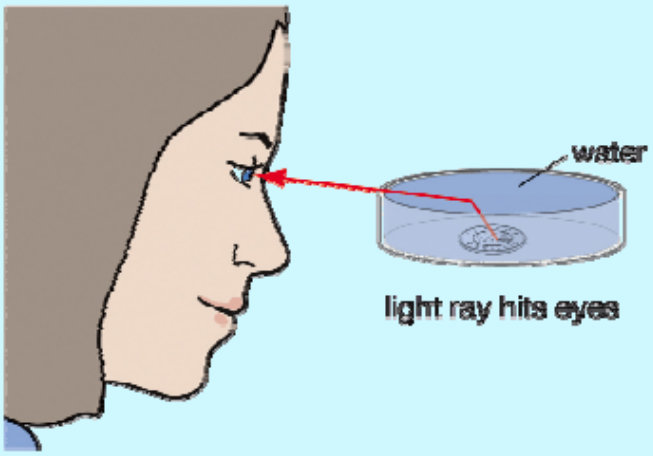
Students' answers may vary but should include the same main points.

5. The light ray had to go almost straight up in the water and then bend toward the edge of the lid and my eye.

6. (a)



(b)



7. (a) Most students showed a straight light ray in step 3 and a light ray with a bend in step 4.

(b) We all drew the light ray from different spots on the coin. We didn't all have the same angles.