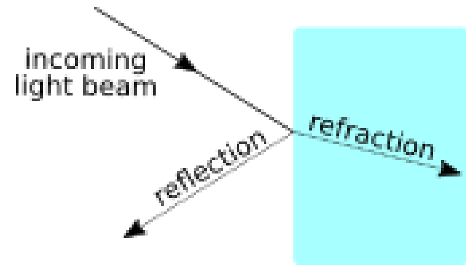
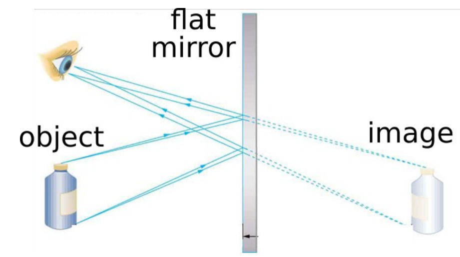
Light Beams: Reflection and Refraction

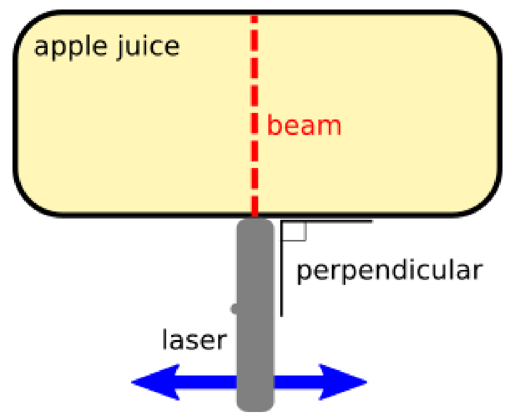
- Light always travels in straight lines (beams) until it interacts with something that makes it bend.
- **Reflection (mirrors)**: bouncing back of a light beam.
- **Refraction (lenses)**: bending of light when it goes from one material to another.
- Reflection and refraction can distort the light beams coming off an object, making the beams **converge** (come together) or **diverge** (split apart). The beams **focus** at a new point to forms an **image** that we see somewhere other than the object itself.





Part 1: Reflection

1. Pour apple juice in a flat-sided container at least 1" deep.
2. Place the laser perpendicular to the flat side so that the beam goes into the juice. Slide the laser back and forth along the flat side and watch the beam move.

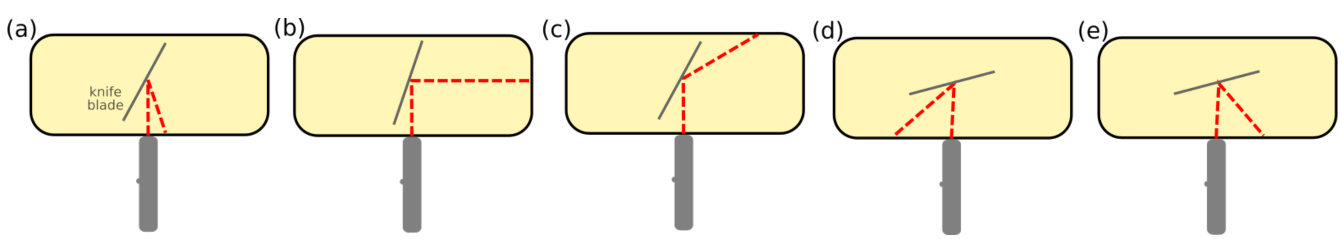


If the laser points perpendicular to the flat side, does the beam always go perpendicularly or does it bend?

2. Dip a knife blade into the juice, in the path of the laser beam.

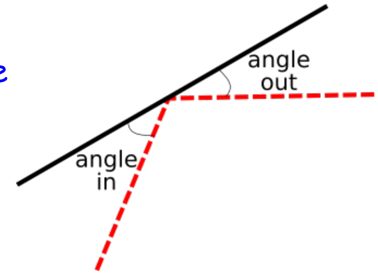
What happens to the beam when it hits the knife?

Try tilting the knife so that the beam hits it at different angles.



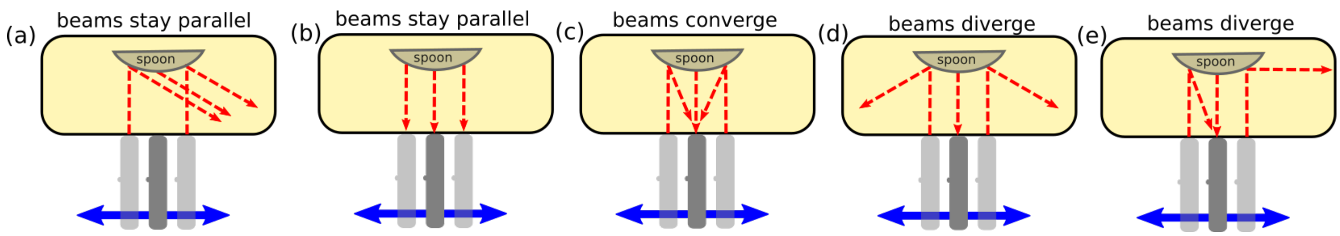
Which of these shows the path of the beam when it hits the knife at an angle? Circle all the pictures that you can successfully reproduce.

Law of Reflection: When a light beam hits a surface, it **reflects** (bounces back), so that the angle at which it came in is exactly the same as the angle at which it leaves.



3. Place a spoon in the apple juice, so that its back surface is facing the laser beam. The surface should curve away from the beam. Keeping the laser perpendicular to the container side, slide it back and force and look at the reflected beams that bounce off the spoon.

Which pattern of beams do you see?

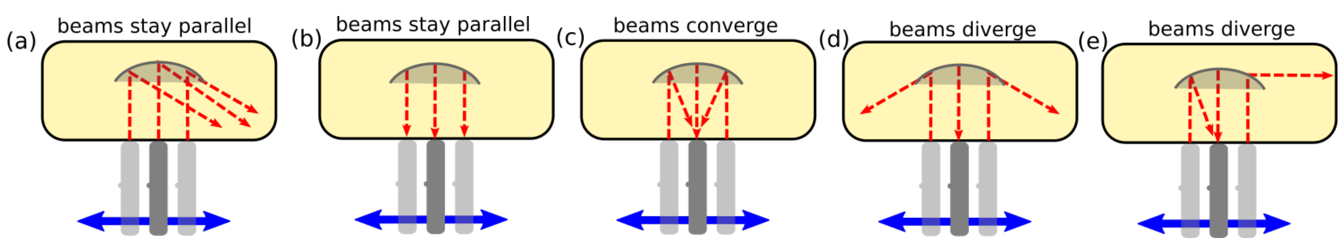


Does the curved back of the spoon keep the beams parallel, **converge** them (bring them together) or **diverge** them (spread them apart)?

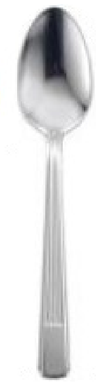
4. Predict what will happen if you reflect the laser off the inner surface of the spoon (curving towards the beams). What will the inner face of the spoon due to the beams?

Keep them parallel converge them diverge them

Try the experiment using the inner surface of the spoon. What happens to the beams?



Curved mirrors change the path of incoming light beams. A **convex** mirror (curving outward) diverges the beams and a **concave** mirror (curving inward) converges the beams. When an object is reflected in the mirror, each point in the object sends of many light beams. By changing where these beams go, the mirror makes an “image” of the object --- the reflection that we see.



5. Hold a Lego minifigure next to the back of the spoon and look at its reflection.

Is the reflection: right-side-up or upside-down
bigger than minifigure or smaller than minifigure

6. Hold the minifigure a few inches from the inner surface of the spoon and look at the reflection.

Is the reflection: right-side-up or upside-down
bigger than the minifigure or smaller than the minifigure

7. Now bring the minifigure very close to (touching) the inner surface of the spoon.

Is the reflection: right-side-up or upside-down
bigger than the minifigure or smaller than the minifigure

You can also try using your face as the object. Bring the inner surface of the spoon right up next to your eye to see a magnified reflection of your own eye!

What do you think would happen if the spoon was much more flat?

More distorted reflection Less distorted reflection

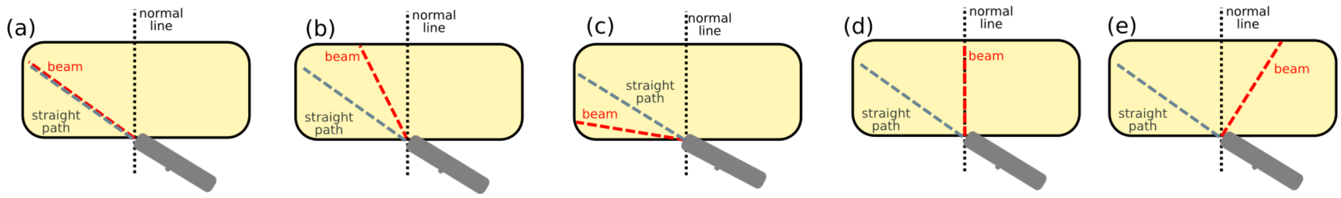
Eye doctors use this trick to measure the curvature of your eyeball when prescribing glasses. They place an object near the eyeball and measure how big the reflection looks.

Part 2: Refraction

1. A **normal line** is a line that is perpendicular to the surface. When you direct the laser into the juice container along the normal line, the beam keeps going in a straight line. Now try directing the laser at an angle to the normal line, as shown below.

What does the beam do?

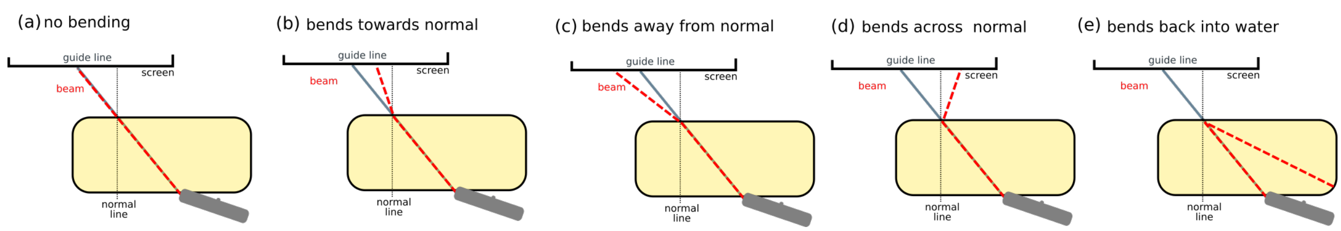
(a) Keep going straight
(b) Bends towards the normal line
(c) Bends away from the normal line
(d) Bends onto the normal line
(e) Bends across the normal line



2. Use a ruler to draw a long line on a piece of paper. Place your container on top of it, so the line goes diagonally underneath the juice. Fold the sides of a piece of white paper to make a vertical screen. Place the screen behind the container of juice, so that the straight guide line hits the screen.

Now adjust your laser so that the beam inside the juice is directly along the guide line.

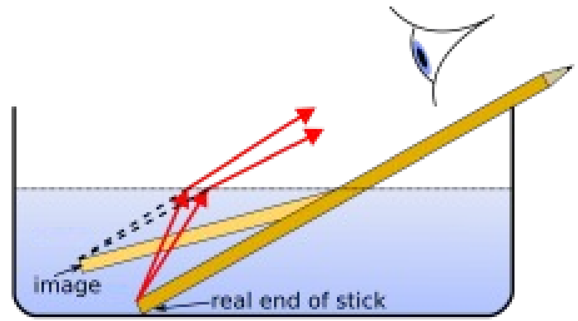
Where does the laser beam hit your screen? Did the beam bend away from the normal or towards the normal when leaving the juice?



Refraction is the bending of a light beam when it goes from one material into another. When passing from air to water, the beam bends towards the normal line. When passing from water to air, it bends away from the normal line.

Just like reflection, refraction distorts the paths of light beams and makes an image appear some place other than the actual object.

3. You can see an image formed by refraction for yourself. Place a stick at an angle into your container of apple juice. Look at the underwater part of the stick from above at an angle, as shown.



What do you see?

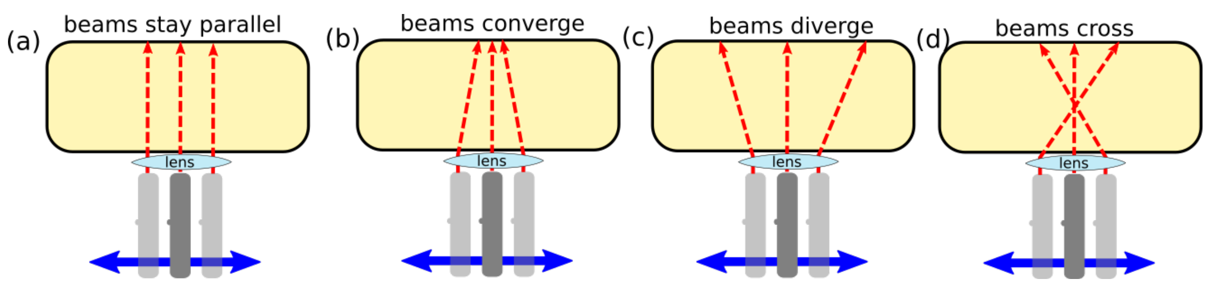
Try placing the stick vertically directly in front of you and look at it through the side of the container. Does it look broken?

If you move the vertical stick to your left, where does the underwater part seem to be compared to the part of the stick you see in air?

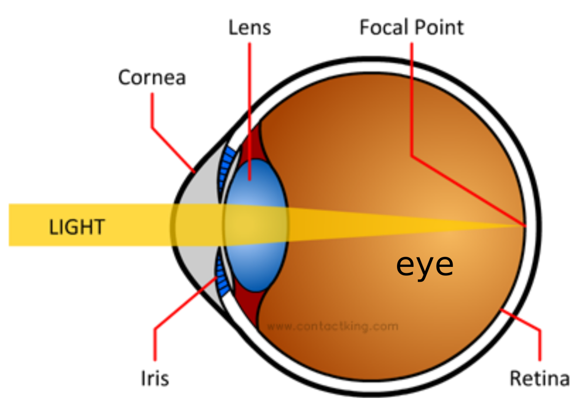
To the right   to the left   directly underneath

4. Place a magnifying glass between your laser and the container of juice. Move the laser side-to-side, keeping it perpendicular to the side of the box.

What does the magnifying glass do to the laser beams? Do they converge, diverge, or stay parallel?



The magnifying glass is a **converging lens** that bends light beams closer to each other. Your eye also has a converging lens, that takes the many light beams emitted by an object and converges them all onto a very small point at the back of your eye (the **retina**) where your brain can perceive the light. This enables you to see a clear image.



5. Try placing a paper screen on the far side of the juice container. Move the laser side to side again, sending many light beams through the magnifying glass.

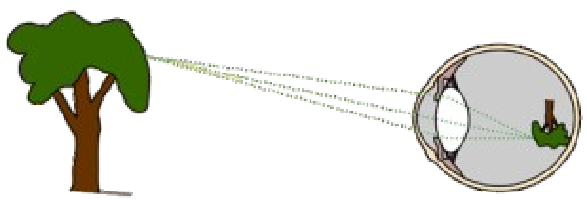
How far back should you put the screen so that while the laser pointer moves, the dot of light on the screen stays nearly in the same place?

This distance is called the **focal length** of a lens. Your eye has a focal length that is exactly the distance from the front of the eye to the retina.

6. Hold the magnifying glass at arm's length away from you and look at a far-away object.

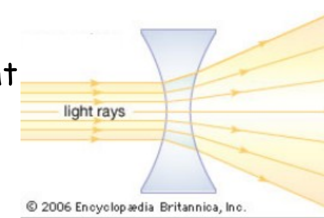
How does it look? Smaller / larger? Right side up / Upside down?

The image formed on the back of your eye is also upside down! Your brain is used to mentally flipping the image upright for you.

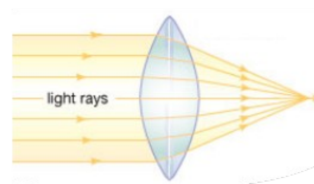


7. Some people's eyes do not have the right focal length, so that light beams from an object do not all come together to one point on the retina. People with this problem need corrective lenses (glasses or contacts) to see clearly.

- **Near-sighted** people have trouble seeing objects far away. They are prescribed **diverging lenses** (ones that bend apart incoming light beams).
- **Far-sighted** people have trouble seeing objects close up. They are prescribed **converging** lenses (ones that bend light beams closer together).



diverging lens for near-sightedness



converging lens for far-sightedness

If you have a pair of glasses handy, try placing them in front of your laser instead of the magnifying glass. Slide the laser back and forth as before and see whether the beams are converging or diverging.

Can you determine if the glasses came from a near-sighted or far-sighted individual?

Ask the owner of the glasses to find out if you were right!