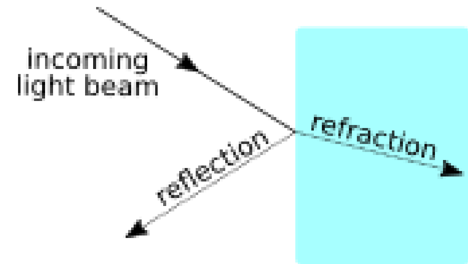
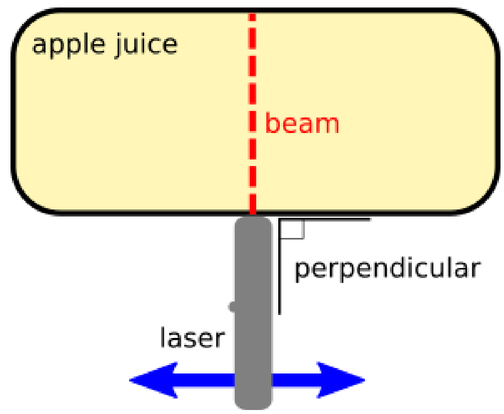
Light Beams: Reflection and Refraction



- 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.

Part 1: Reflection

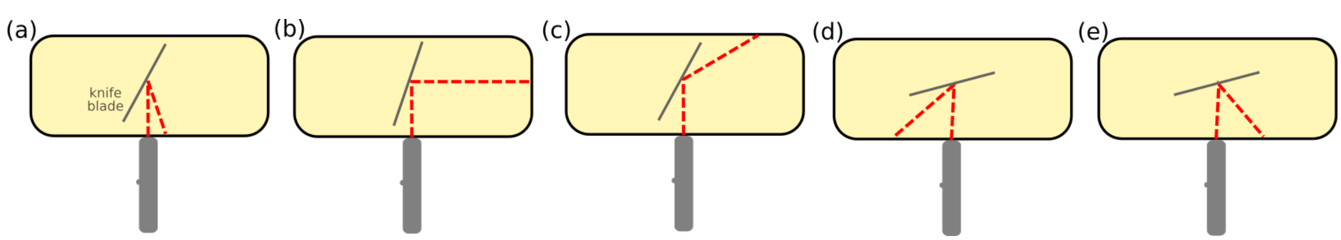


1. Pour apple juice in a flat-sided container at least 1" deep.
2. Place the laser perpendicular to the flat side so that the beam goes into the juice. Slide the laser back and forth along the flat side and watch the beam move.

2. Dip a mirror vertically into the juice, in the path of the laser beam.

Discuss: what happens to the beam when it hits the mirror?

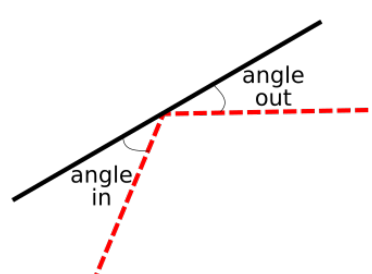
Try tilting the mirror so that the beam hits it at different angles.



Which of the pictures above can you reproduce? Which ones are impossible?

In your notebook: sketch a diagram of one beam path that you made.

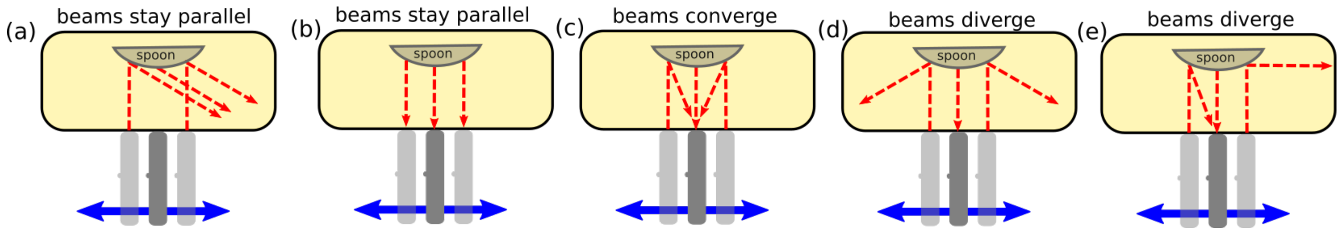
Based on your observations fill in the **Law of Reflection:**



When a light beam hits a surface, it **reflects** so that:
angle coming in is ______________ angle going out.
(greater than? less than? equal to?)

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 forth and look at the reflected beams that bounce off the spoon.

Sketch the beams you see in your notebook.
Does it look like one of the ones below?

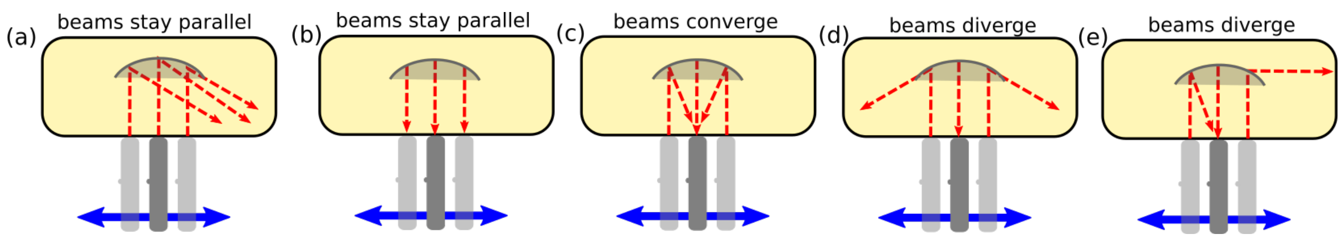


4. What do you think will happen if you reflect the laser off the inner surface of the spoon? Write down your hypothesis.

Hypothesis: the surface curving inward will make the beams ________________

stay parallel? converge ? (come together) Diverge? (split apart)

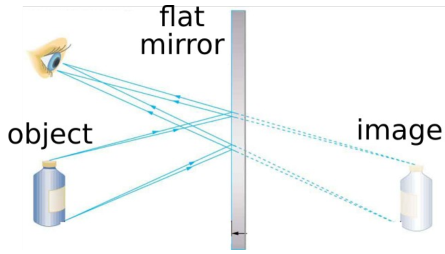
Try the experiment and sketch the pattern you see.
Which of the ones below looks most like what you see?



Observation: the surface curving inward made the beams ________________________

stay parallel? Converge? Diverge?

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 off 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 convex mirror (back of spoon) and look at its reflection.

Fill in your observations:
A convex mirror makes a _________________ (right-side-up / upside down) reflection that is __________________ (bigger / smaller) than the object.

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

Fill in your observations:
An object far from a concave mirror makes a _________________ (right-side-up / upside down) reflection that is __________________ (bigger / smaller) than the object.

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

An object very close to a concave mirror makes a _____________ (right-side-up / upside down) reflection that is ________________ (bigger / smaller) than the object.

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!

Part 2: Refraction

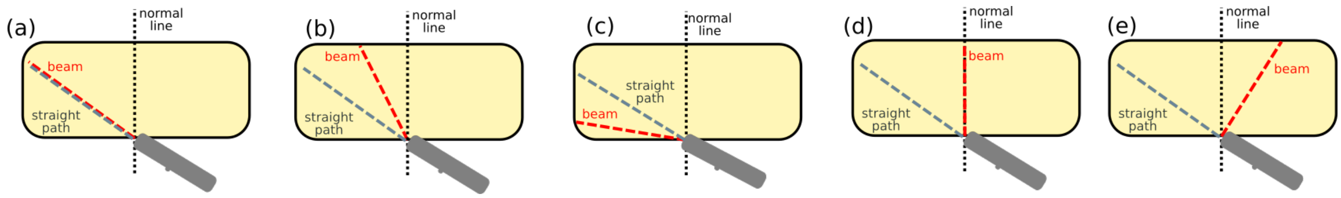
Refraction is the bending of a light beam when it goes from one material into another.

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.

Draw a sketch of what you see. Fill in below.

When going from air into juice, the light beam ______________________

(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



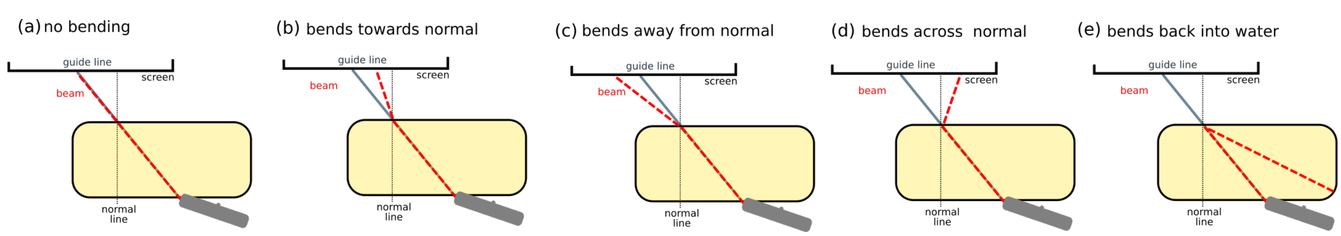
2. Use the template to place your container of juice and a vertical cardstock screen, as shown below. There will be a diagonal guide line going from the container to the screen.

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?

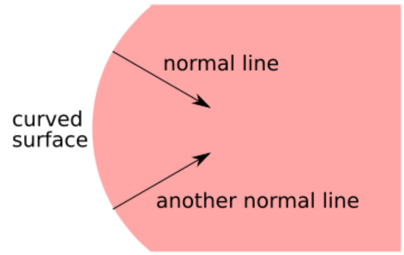
When going from juice into air, the light beam ______________________

(a) Keeps 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

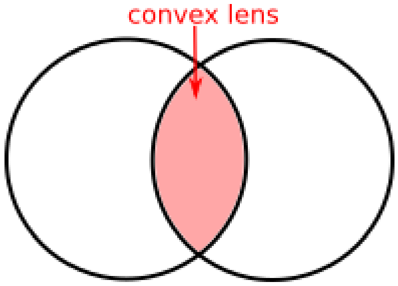


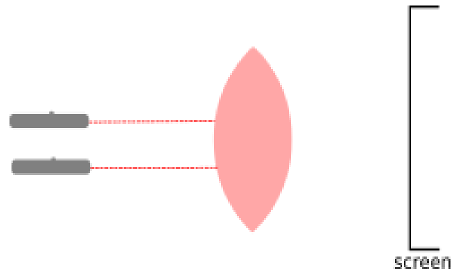
Jello Lenses

A curved surface has normal lines that point in different directions. Just like a curved mirror, refraction at curved surfaces can make light rays converge or diverge.
A **lens** has curved surfaces that bend light by refraction.



1. Make a **convex lens** from jello, by cutting two intersecting circles.





2. Working together with another pair, place 2 laser pointers next to each other and shine them both at the lens. Set up a vertical screen behind the lens. Try lifting the lens out of the way and putting it back again, to compare what it does to the ligh beams.

A convex lens makes light rays ________________________.

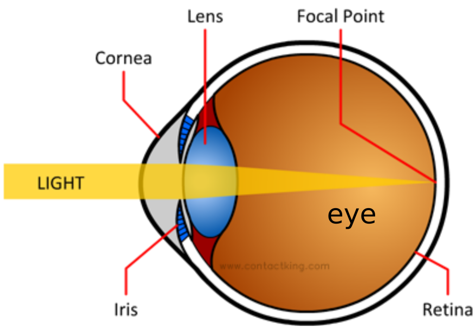
converge? diverge? stay parallel?

3. If you move the vertical screen very close, you will see 2 laser spots. If you move it far, you will again see 2 laser spots. Can you find where the two laser beams hit together and there is only one spot on the screen? This is called the **focus** of the lens.

Measure the distance from the center of the lens to the focus point, This is called the **focal length** of the lens.

The focal length of your jello lens is _______________________ cm.

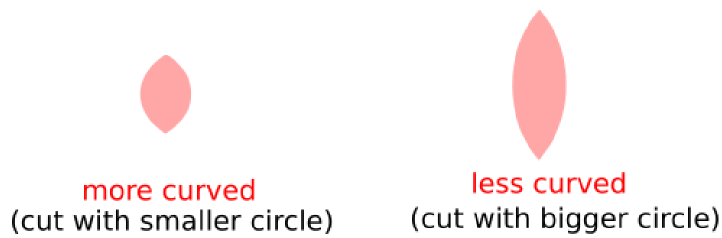
Your eye has a lens with a focal length that's exactly as long as your eyeball, to focus light rays on the retina (screen) at the back. The retina senses the light and sends signals to your brain, allowing you to see!



4. Now borrow a cookie cutter of a <u>different size</u> from another group. Try to find one much bigger or much smaller than your first one. Measure the focal length again.

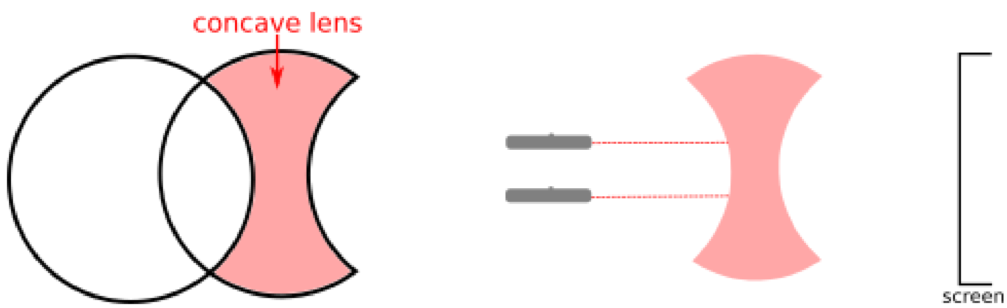
Sketch the two lenses in your notebook, and write down the focal length of each.

Which lens has a longer focal length? (circle one)



Your eyeballs change their curvature to adjust the focal length when you look at objects nearby or far away.

5. Cut out a **concave lens** by using the crescent-shaped jello that remained from your intersecting (cup-cut) circles.



6. Again, shine 2 parallel laser beams at it. Look at where the rays land on the screen behind the lens. Try lifting the lens out of the way and putting it back again to compare.

A concave lens makes light rays ________________________.

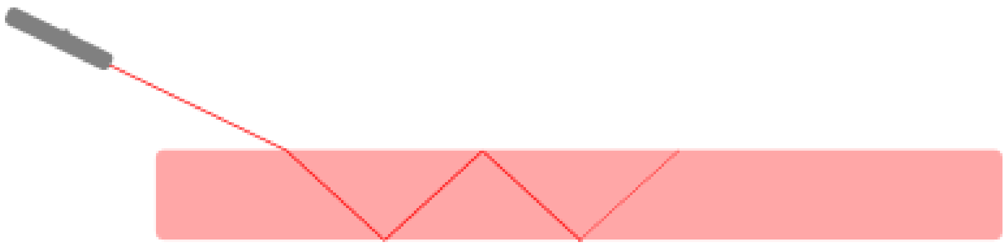
converge? diverge? stay parallel?

Near-sighted people have eyes that bend light beams too much (the focal length is too short). **Glasses** with concave lenses help compensate by spreading the light beams apart.

Jello "Fiberoptics"

(just for fun if you have time)

1. Cut a long thin slice of jello with smooth sides.



2. Try shining the laser beam into the sides of this slice, at an angle. Can you make the beam bounce?

How many bounces could you manage?

3. By bending the jello slice, can you get the laser beam to turn around a corner?

This bouncing of the beam inside a fiber is called total internal reflection. It is the principle behind fiberoptics. Fiberoptic cables are used to transmit telephone and TV signals, so provide light during surgery, and for many other applications.