

## Plastic Bottle Chandeliers: How to make your own light source

For Ages: 13+, grades: 8+

**Description:** In this experiment, students create a prototype solar light, to demonstrate a durable alternative to conventional electric light source. The project has been attributed as an open source project, the Liter of Light, innovated by Alfredo Moser of Brazil.



### Materials Needed

- Plastic Soda or Water Bottle
- Cardboard Sheet (9X10 inches)
- Cardboard Box
- Paper Glue
- Bleach
- Filtered Water
- Black Marker Pen
- Sand Paper
- Pliers (Long/short needle nose)
- Flash light or LED

### Background and Misconceptions

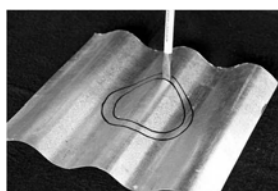
The working principle of a solar bottle is based mainly on two important properties exhibited by light, Total Internal Reflection and Refraction. Refraction can be described as light changing its path, as it travels from one medium to another, with differences in their refractive indices (r.i). Refraction happens in the case of our solar bottle as light travels through air, water, and back to air. Total Internal Reflection is a special case of refraction, when light travels from a denser medium to rarer medium, and is incident at an angle greater than the critical angle at the interface of the two media. Refraction helps guide solar light through the bottle into the room, causing the room to light up in a natural manner. Total Internal Reflection helps make the bottle shine brighter. (A similar thing happens with diamonds in which total internal reflection makes diamonds shine brighter.) Diffused Reflection, which occurs due to the irregular surface of the walls of a room, helps to illuminate the room by allowing diffused reflections of the light rays coming from the solar bottle. In this experiment we will use a cardboard box to portray how a room can be illuminated.

**Teacher Guided Questions to Inquiry** Use these questions to get the students started on their own inquiry.

1. **Why is bleach used in the experiment?** (To protect the water. Bleach helps the bottle to stay germ-free.)
2. **The experiment is based on what phenomenon?** (Refraction and Total Internal Reflection.)
3. **What are the applications for using the plastic bottles?** (Cheap and cost effective light source, alternative to electric light sources, and renewable energy, an environment friendly approach to light up the home.)
4. **What is the source used to light the bottles?** (Solar light. One can use torch light or LED lights for prototypes.)

### Guided Activity

1. Measure the width of your bottle about 1/3 from the top. Now, take your 9x10 inch sheet of cardboard and use this measurement to draw a circle in the center of your cardboard. Draw a second circle, outside of your first circle, 1 cm larger than the first circle. (In our experiment, the first circle is 6 cm in diameter, the second circle is 9 cm in diameter, which is 1 cm radial difference.)



2. The 1 cm radial difference between the circles is to make strips (teeth). Bend the teeth upwards. Draw periodic teeth or divisions in that 1 cm. Next, use pliers to cut small teeth, facing upwards.
3. Using sandpaper, scratch the upper third portion of the bottle where the cardboard will be placed. This is to allow the glue to stick and support the structure around the bottle.
4. Insert the bottle into the hole in the cardboard and slide it up to the upper third portion of the bottle. Apply glue on the strips (teeth) above and around below. Wait for it to dry. Make sure the strips are bent upwards and perpendicular to the cardboard.
5. Fill the bottle with filtered water + 10 mL (2 capfuls) of bleach. Screw the cap on the bottle and fill the gaps with glue.
6. Take your cardboard box and cut a hole in the top large enough so that 2/3 of the bottle stays below the top, and the rest fits tightly above so that it can be exposed to a light source. Cut a second peak-hole on the side so that you can see inside the box. Insert your bottle thru the top hole in your cardboard box. Now and place a light near the upper side of the plastic bottle. Look inside the box to see light scattered in the dark enclosed space.



## Guided Inquiry

1. You will see the bottle working as a light source as the accumulated sunlight enters the bottle. What mediums does the light traveling through to achieve refraction? (Light is traveling through air to water then back through air, directing light towards the bottom.)
2. When refracted light tries to refract again, it gets totally reflected back, producing a total internal reflection effect, making its journey to the end of the bottle. The refracted light bounces back and forth to produce as much light as a 40-60 watt incandescent bulb.  
When does internal reflection take place? (When the angle of incidence of the light ray is greater than the critical angle, then light is reflected back into the denser material.)

## Analysis Questions

1. How would you increase the light intensity of bottle? (Light intensity can be increased by using a more direct, alternate light source, such as a rechargeable battery + LED system.)
2. How would you make the solar light work at night? (By using a solar cell. Using a solar cell will store the energy input coming from the sun and will release it at a steady rate that can be used by an artificial source of light. Now it is really tough to install cells of such a huge size that can power an ordinary light bulb. Instead, we have to use LED lights which are brighter as well as consume less power. )

