

# RAFT IDEAS

**Topics:** Light, Optics, Refraction, Astronomy

## Materials List

- ✓ Convex lens, 38mm (1½") diameter, 30 cm focal length
  - ✓ Concave lens with a shorter focal length
  - ✓ Tube, 4 cm (1½") diameter, 15 cm (6") long
  - ✓ Pipe insulation for 1 cm (½") pipe, or tube ~4 cm (1½"), 20 cm (8") long
  - ✓ Rubber band, #61, 5 cm x 6 mm (2 x ¼")
  - ✓ Paperclips, 3
  - ✓ Tape and/or labels
  - ✓ Portion cup and lid, ¾ oz. size
  - ✓ Hole cutting tool
- Optional
- ✓ Convex lens with a shorter focal length
  - ✓ Paper, 14 cm x 15+ cm (5½" x 6+")
  - ✓ Glue stick or glue

This activity can be used to teach:

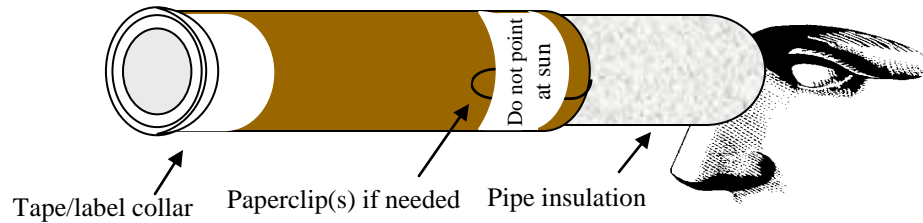
Next Generation Science Standards:

- Waves are reflected, absorbed, transmitted (Middle School, Physical Science 4-2)
- Science & Engineering Practices (Grades 7-12)



## (Tele) Scope it out!

Constructing a simple terrestrial (Galilean) telescope



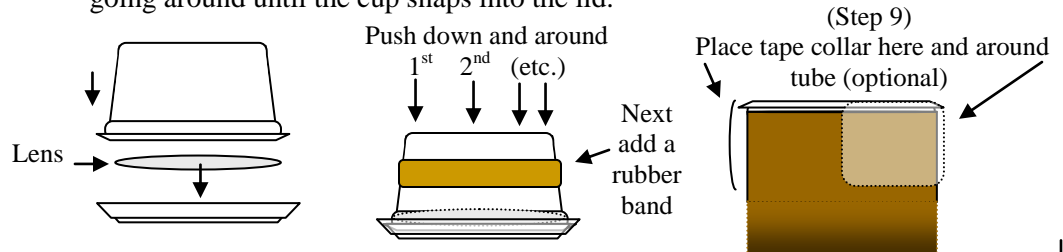
Explore (doubly) convex and concave lenses and build a low power telescope!

### Assembly (Caution! Glass lenses can break if dropped or mishandled!)

(Plano-convex or concave lenses with the same focal lengths can also be used)

Mounting the **convex glass lens**: (this lens is thicker in the middle than the edges)

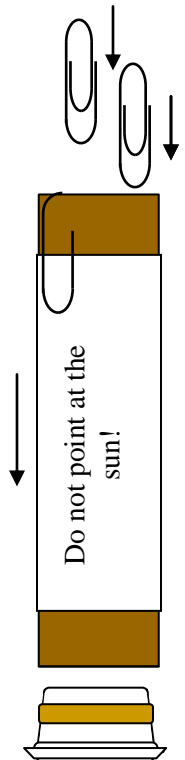
1. Cut a 22 mm (7/8") diameter hole in the center of a ¾ oz. portion cup and lid.
2. Place the lid, upside down, on a flat surface.
3. Unwrap the 38 mm convex glass lens and pick it up by holding onto the edges **only**. Clean the lens with a soft cloth or special lens cleaning paper, if needed.
4. Place the lens in the center of the upside down lid. Place the portion cup, regular opening downward, over the lens/lid. Gently push down on the cup bottom, going around until the cup snaps into the lid.



### Assembling the telescope:

(Teachers: Have students investigate the lenses and **then** do the following!)

5. **Optional:** Decorate a ½ sheet of paper with scientific and/or personal information, wrap it around the tube, and then secure with glue/tape.
6. Place the portion cup/lens on a flat surface with the lid downward.
7. Place the rubber band (#61) over the portion cup, as shown.
8. Place the tube over the portion cup and firmly push the tube down.
9. It may be necessary to reposition the rubber band and repeat step 8 to obtain a tight jam fit. A tape collar, as illustrated, could be added to ensure the portion cup stays attached to the tube.
10. Insert the pipe insulation into the tube. The fit must not be too loose. **If the fit is very tight then** use a twisting motion to insert the insulation. **If the fit is too loose then** insert 1 to 3 paperclips, as shown, evenly spaced around the tube, with the larger loops on the outside. If the fit is still too loose then reinsert the paperclips, or add more, but with the smaller loops on the outside of the tube.
11. Use tape or labels to cover and secure the paperclips, if any, to the tube. Print a warning "Do not point at the sun!" on the label or tube.
12. Secure a concave, or convex lens, to (or in) an end of the pipe insulation. The lens needs to be perpendicular to the tube's length. (Note: This lens is smaller in diameter than the objective lens.)
13. Insert the other end of the pipe insulation into the tube opening.

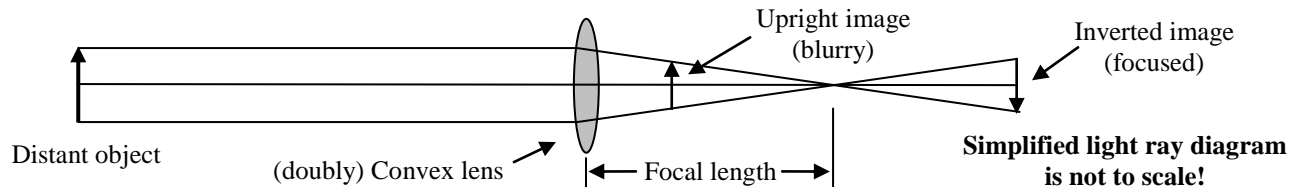


## To Do and Notice

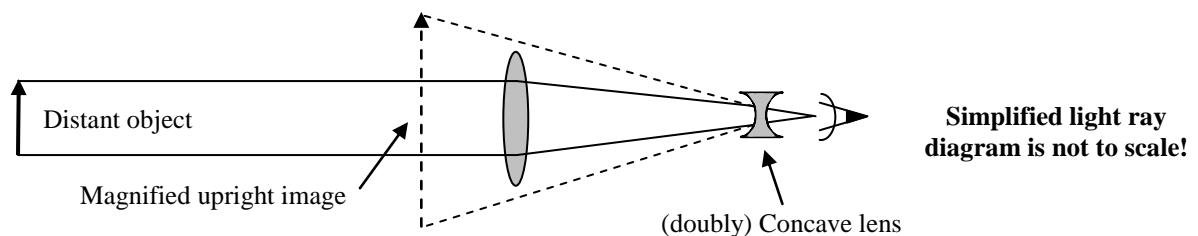
1. Have students investigate how the different lenses change near and far views, individually and in pairs.
2. Slide the pipe insulation in and out of the tube to focus on near and far views. If there is a very tight fit between the two tubes then use a twisting motion when pushing or pulling the pipe insulation in or out.

## The Science Behind the Activity

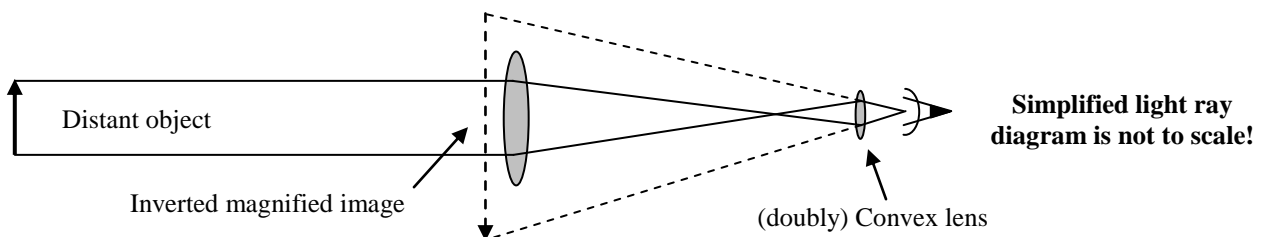
The convex lens, called the “**objective**,” is larger in diameter so as to collect more light from a distant object. The emanating or reflecting light rays are refracted (bent) and focused to form an image. This is similar to how a light ray is bent by a prism. The image formed is upright within a focal length of the lens and inverted at points farther away than a focal length. For a distant object the upright image is blurry and the inverted image is focused. For more details on lenses see the RAFT Idea Sheet *Lens Explorations*.



The smaller diameter lens, called the “**eyepiece**,” magnifies the image that was formed by the objective lens. The eyepiece lens should have a relatively short focal length as compared to the objective lens. A **concave** eyepiece lens is placed slightly inside the focal length of the objective lens, creating an upright magnified image. This combination of a convex and a concave lens creates a **Galilean or terrestrial telescope**.



A **convex** eyepiece lens is placed so that the distance between it and the objective is essentially equal to the sum of the focal lengths of both lenses. The inverted image formed by this **Keplerian or astronomical telescope** is not a problem since the concepts of up and down are not an issue for observations of objects in space.



The size of the human eye limits the useful diameter of the eyepiece lens. A larger diameter eyepiece lens would not increase the magnification of the object and could let in unwanted light.

Convex lenses converge and concentrate light rays. **Pointing a lens or telescope toward the sun could cause eye damage.** The sun’s rays could also be accidentally focused into a hot spot that could cause a fire.

## Taking it Further

How can the focal length of a lens be measured? How can the magnification of a telescope be calculated?

**Web Resources** (Visit [www.raft.net/raft-idea?isid=428](http://www.raft.net/raft-idea?isid=428) for more resources!)

- Lens and telescope basics - <http://www.lhup.edu/~dsimanek/scenario/lenses.htm>
- Ray Diagrams for Lenses <http://hyperphysics.phy-astr.gsu.edu/hbase/geopt/raydiag.html>
- Astronomical telescopes - <http://www.schoolsobservatory.org.uk/astro/tels/>