Curriculum topics:

- Light
- Optics
- Refraction
- Astronomy

Subjects:
Physical Science, Earth/Space Science

Grade range: 4 – 12

Who we are:

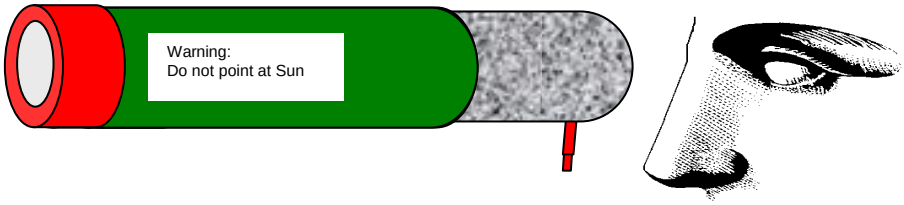
Resource Area for Teaching (RAFT) helps educators transform the learning experience through affordable "hands-on" activities that engage students and inspire the joy and discovery of learning.

For more ideas and to see RAFT Locations

www.raft.net/visit-raft-locations

SIMPLE TELESCOPE

Make a telescope like the one Galileo designed!



See how convex and concave lenses can be combined to magnify far-away objects.

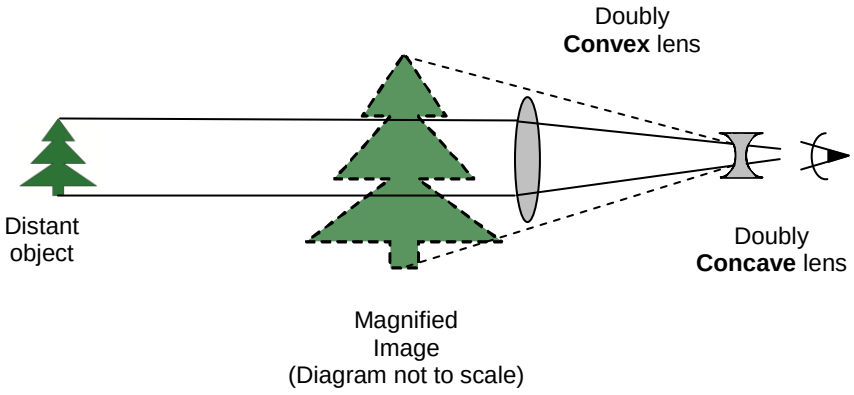


Figure 1: Simplified light ray diagram for Galilean (terrestrial) telescope

http://www.raft.net/raft-idea?isid=676

Materials required

Per telescope:

- Plastic pipe cap (open-ended thread protector for 1 ¼" nominal pipe). Note actual diameter is 1 ½" (38 mm)
- Convex lens, 38 mm (1½") diameter, 30 cm (~12") focal length
- Concave lens, 20 mm (¾") diameter, with shorter focal length than the convex lens (note: the kit uses a lens with a handle)
- Cardboard tube, 1½" (38 mm) diameter, 6" or 6½" long (15 cm or 16.5 cm) (include warning text shown on page 3)
- Insulating tube 1 ½" (38 mm) diameter, 8" (20 cm) long, or pipe insulation for ½" (13 mm) nominal pipe. Note actual diameter of hole in pipe insulation is 5/8" (16 mm).
- Optional: Lens cloth, non-woven

Note: Plano (one side flat) concave and convex lenses with same focal lengths can be used.

How to build it

Caution: Handle glass lenses carefully to avoid breakage. Do not drop lens

Mount the convex lens (a convex lens is thicker in the middle than at the edges)

1. Place plastic cap on a flat surface with the wide opening facing up.

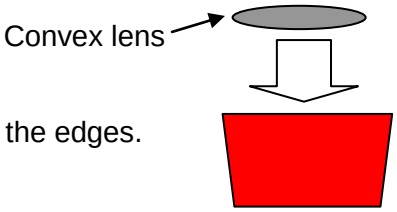


Figure 2

2. Remove convex lens from the envelope. Touch only at the edges. Optional: use lens cloth to wipe off fingerprints.
3. Place the lens in the cap. Make sure the lens is lying flat near the bottom of the cap. See figure 3.
4. Push the cardboard tube into the cap until it is firmly seated. The end of the tube should press on the lens. The lens should not rattle or move inside the cap.

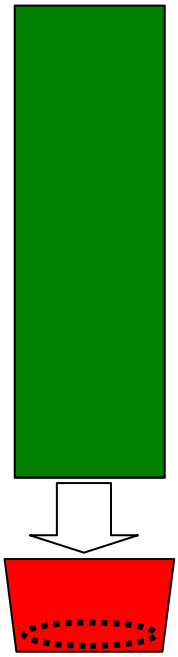


Figure 3

Optional: Stop and investigate the convex lens

- Look through one end of the tube at objects that are close and distant. Are the images larger or smaller than the actual objects?
- Turn the tube around and look through the other end – does the image change?
- Slowly move the tube away from the eye while looking at a distant object – can you see the image invert (flip) when the distance between the eye and the lens is greater than the focal length?

Optional: Stop and investigate the concave lens

- Look at objects through the concave lens. Are they reduced or enlarged? Are they inverted?

In the RAFT kit, to make the foam tube's lens slit easier to find there is a folded label or card section in the slit. Remove the inserted item and insert the concave lens, lens first, into the slit from the outside of the tube until the lens is centered in the tube opening. (See picture at www.raft.net/raft-idea?isid=676**)**

To ensure the concave lens (eyepiece lens) is parallel to the convex lens (the objective lens) the handle on the concave lens must be perpendicular (form a 90 degree, right angle, to the foam tube.

Complete the assembly

5 Insert the end of the foam tube farthest from the concave lens partway into the open end of the cardboard tube. Tip: Twisting the foam makes it easier to move it in or out of the cardboard tube.

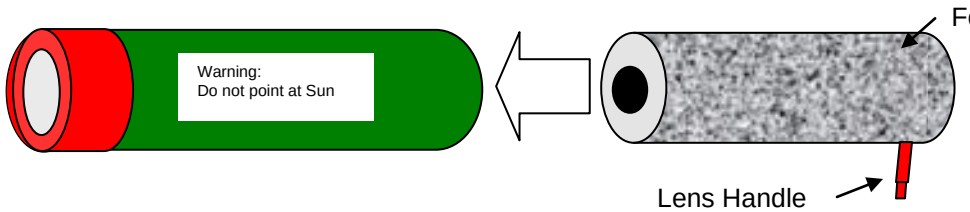


Figure 5

WARNING: Direct viewing of the sun can cause permanent eye damage. Do not attempt to look directly at the Sun with either this product or the naked eye.

To do and notice

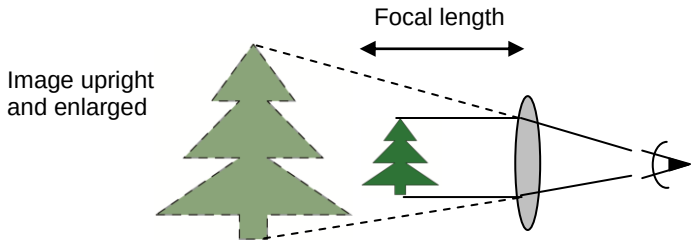
1 Look at a distant object. Slowly push or pull the foam tube in or out of the cardboard tube until the object is in focus. (Twist foam if needed.)

2 Look at a close object. Does the foam tube need to be pushed in or pulled out to bring the new object into focus?

CAUTION – Do not leave the telescope out in direct sunlight unattended. The sunlight passing through the lenses and/or reflecting off the lens will intensify which may cause a fire if the light is focused onto flammable material.

The science behind the activity

Lenses bend and focus light rays to form images. The **convex** lens, called the **objective**, is large in diameter, so it collects more light from distant objects. The image seen through a **convex** lens will appear upright and enlarged when the object being viewed is within the focal length of the lens.



(Diagram not to scale)

Curriculum Standards:

Light reflecting from objects and entering the eye allows objects to be seen
(Next Generation Science Standards: Grade 4, Physical Science 4-2)

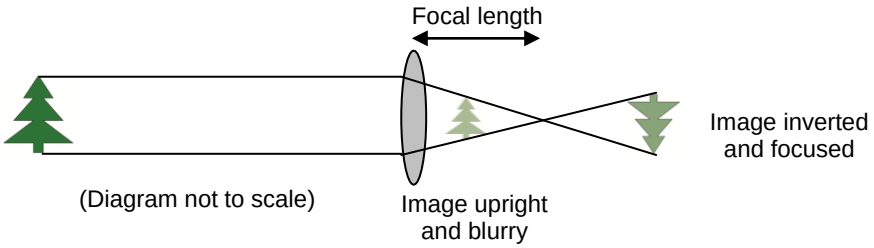
Waves are reflected, absorbed, or transmitted
(Next Generation Science Standards: Middle School, Physical Science 4-2)

Science & Engineering Practices
(Next Generation Science Standards: Grades 4 – 12)

Additional standards at: http://www.raft.net/raft-idea?isid=676

The science behind the activity (continued)

For a distant object, the upright image close the lens is blurry and the inverted image, beyond the focal length, is focused. See the RAFT Idea Sheet ***Lens Explorations*** for more details.



The smaller diameter lens, called the **eyepiece**, magnifies the image that was formed by the objective lens. The eyepiece lens should have a shorter focal length than the objective lens. A **concave** lens is placed slightly inside the focal length of the objective lens, creating an upright magnified image. This combination of convex and concave lenses creates a **Galilean** or **terrestrial** telescope. See light ray diagram on page 1.

Learn more

- How can the focal length of a lens be measured? Hint: use the lens to focus a distant light on a flat surface.
- How can the magnification of a telescope be calculated?
- Create a **Keplerian** or **astronomical** telescope. The image will be inverted, but that is no problem, since there is no "up" in outer space!

Related activities: See RAFT Idea Sheets:

Bubble Lenses -
http://www.raft.net/ideas/Bubble Lenses.pdf
Cylinder Liquid Lens -
http://www.raft.net/ideas/Cylinder Liquid Lens.pdf
Drop and Vial Lenses -
http://www.raft.net/ideas/Drop and Vial Lenses.pdf
Image Viewer -
http://www.raft.net/ideas/Image Viewer.pdf
Lens Explorations -
http://www.raft.net/ideas/Lens Explorations.pdf
Modeling Near and Farsightedness -
http://www.raft.net/ideas/Modeling Near and Farsightedness.pdf
Telescope it out! -
http://www.raft.net/ideas/Telescope it out!.pdf

Resources

Visit www.raft.net/raft-idea?isid=676 for "how-to" video demos & more ideas!

See these websites for more information on the following topics:

- **Lens and telescope basics** – http://www.lhup.edu/~dsimanek/scenario/lenses.htm
- **Image formation by lenses** – http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/imgfor.html
- **Astronomical telescopes** – http://www.schoolsobservatory.org.uk/astro/tels/