Subject area: physical science

Activity title: Assembling a refracting telescope

Grade level: 6

Time required: 60 minutes

Keywords: telescope, lens, magnification, focal point, astronomy

Educational standards:
3.4.7B, C. Chapter 1, Section 2 of Holt Astronomy text

Concept/Vocabulary
Students will learn and understand concepts of light refraction, magnification and angles by constructing a simple refracting telescope. They will be exposed to the fundamental optical concepts that govern a telescope’s use, and the role of the telescope’s primary components. This activity is meant to complement to the Holt textbook section on telescopes. From the text, students should be familiar with the following terms:

- telescope
  - refracting
  - reflecting
  - radio
- focal point/plane
- electromagnetic spectrum
- Hubble Space Telescope
- Chandra X-Ray Observatory
- objective lens

Objectives
Students will…

- learn to identify the components of an refracting telescope, and will understand their function within the whole device
• learn about the concept of a focal point/plane and experiment by projecting an image of a sunlit window onto a wall
• observe how a single lens can be used as a simple magnifier
• construct a refracting telescope and use it to observe distant objects

Materials
This module activity is most easily accomplished using an educational telescope kit, such as the Project STAR Refracting Telescope Activity from Learning Technologies, Inc. (available from Anchor Optics Surplus, catalog no. B26057).

Included in the kit are:
• 43 mm diameter lens
• 17.5 mm diameter lens
• telescoping cardboard tubes
• assorted other small connecting hardware for assembly

This activity can be accomplished with any objective and magnifying lenses, with some means of adjusting and holding the distance between them.

Instructional Strategies
Group size: This activity can be performed in groups of 4-6 students.

Duration: It can be performed in one class period.

Students should first read Chapter 1, Section 2 of the Holt Astronomy text, to familiarize themselves with the vocabulary and basic functions of a variety of telescopes. This can be assigned ahead of time for homework. Students should take notes on the reading, and should be encouraged to draw sketches of the refracting and reflecting telescopes.

A short quiz is included in this module, and can be used to assess understanding of the concepts covered in the text. It may be beneficial for the students to take this as an “open-notebook” quiz, to encourage good note-taking skills. After the quiz has been administered and discussed, telescope kits can be distributed to each student group.

Experimental Procedure
• A diagrammatic illustration of the refracting telescope should first be drawn on the board, with the students’ assistance. Students should be able to identify the objective and magnifying lenses and the focal point. They should also be able to draw the path of light as it is funneled into and through the telescope’s two lenses.
• Student groups should be given a few moments to examine the contents of the telescope kit. Encourage them to consider the probable function of the main components (i.e. the tube and two lenses).
• This portion of the activity works best in a classroom with windows on only one side. Student groups should take the larger of the two lenses (the objective lens) and stand near the wall opposite the windows. Instruct them to hold the lens a few feet away from the wall
(with the flat end facing the wall). They should be able to see a projected image of the windows on the opposite side of the room.

- Students should adjust the distance between the lens and the wall until the projected image is in focus. At this point, the focal point is in the plane of the wall.

- If possible, try to project an image of more than one window at a time. Pull down the shade of one of the windows a little further than the shade of the other. Doing this will allow the students to see that the projected image is upside-down on the wall. A student can also stand in front of one of the windows. The projectionists should see if they can focus on the silhouette of their classmate.

- Now, the students should try using the smaller, magnifying or eyepiece lens, to project the same image on the wall. They should be able to identify that the larger lens has a longer focal length.

- While at their desks, students can try using each lens to magnify the text of a page. They should note which of the two lenses has a stronger magnification power. In their notebooks, they should sketch the two lenses, paying special attention to the amount of curvature each possesses.

- If the lenses have been taken from a telescope kit, students should follow their kit instructions to assemble simple refracting telescopes. They should practice focusing on objects, both near and far, by changing the distance between the two lenses (by “telescoping” the cardboard tubes). Students should be cautioned not to look at the sun. If the moon is visible in the daytime sky, they should examine it with their telescopes.

- Because of the simplicity of the kits, each student should be encouraged to disassemble and reassemble the telescope him/herself.

**Discussion**

At the conclusion of this activity, students should understand the fundamental operation of a simple refractive telescope. They have learned that the larger objective lens collects light and projects an upside-down image at the focal point. The smaller lens simply magnifies this image, to make it more visible to our eyes. The telescope tube allows us to control the distance between the two lenses. Students should be able to explain these concepts in their own words, as well as diagrammatically.
The concepts of a telescope can be put into context with examples of overhead slide projectors, computer projectors, and film projectors in cinemas.

**Assessment**
If a microscope has been examined previously, students should be called open to find similarities and differences between an optical microscope and a refracting telescope. Emphasis should be placed on correctly identifying the objective and eyepiece lenses in each instrument.

A short quiz on telescopes is attached.

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Telescopes Quiz

1. A device that collects light or other electromagnetic radiation and concentrates it for observation is called a ________________________________.

2. Two types of optical telescopes are called a _______________________________ telescope and a _____________________________ telescope. (hint: these are both “r” words). On the lines below, write both an advantage and a disadvantage of each of these two types of telescopes.

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___________________________________________________________________________

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3. A simple optical telescope contains

   a. an objective lens and a mirror.

   b. two objective lenses.

   c. an objective lens and a smaller lens in the eyepiece for magnification.

   d. a camera and eight mirrors.

4. Choose one of the following phrases and write a definition for it: electromagnetic spectrum; radio telescope; Hubble Space Telescope; Chandra X-Ray Observatory.

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