Ages:
6-12 grade

Duration:
15 to 45 minutes

Materials:
- Wide masking tape or chalk
- One or more "stars" with a stand to hold them at eye-level
- Colored sheets of paper (any size) to make a pattern on the far wall
- Measuring tape

Modeling Parallax

Overview —

In this kinesthetic activity, students model the motion of the Earth around the Sun and observe the parallax motion of objects relative to a background. There is an option for older grade levels to measure the distance of the objects by measuring the angle with their hands and performing a trigonometric function.

Objective —

The students will:
- Model one method of determining the distance to nearby stars
- Determine that nearby objects have a greater parallax motion compared to more distant objects
- Measure the distance to an object through parallax

Before You Start: *The students should be very comfortable with the Earth's year-long orbit around the Sun.*

Preparation

Clear a 8 ft by 8ft area at one end of the classroom for the students to use. Use masking tape or chalk to make a very large circle on the floor.

Use a moveable stand to hold a paper star near the middle of the room.

Place a variety of different-colored sheets (colored paper, post-its, or construction paper) in a row at the far side of the room, at a height so that the star will appear in front of them as seen from the circle.

Activity —

Invite the students to suggest ways to measure the distances of stars. As different methods are suggested, invite the other students to describe the challenges of these measurements. Let the students know that they will be investigating one method of measuring stellar distances.

1. Describe parallax (the angle something appears to move, relative to more distant objects, caused by a change in observational position).

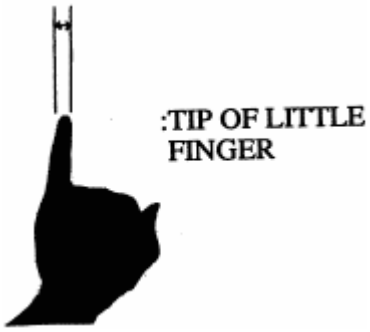
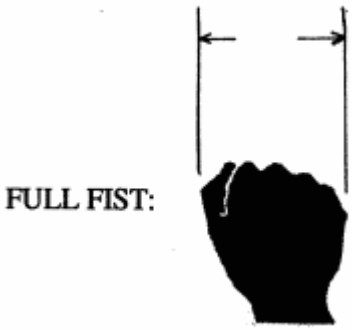
2. Invite the students to hold up a thumb, and see where it appears when one eye is closed, then notice where it appears when the other eye is closed. Invite them to partner with another student and describe their observations.

3. Show them the circle representing the Earth's orbit around the Sun. Invite a few students to slowly follow the path, watching how the "star" moves relative to the background papers. Ask those students to describe their observations to the class.

4. (Open option for older grades, familiar with trigonometry): Invite the students to determine how they could calculate the distance to that star, knowing only the size of the circle. Divide the students into groups to put together their proposals, then share the proposals. Allow the groups to make their own measurements and describe their findings.

ACTIVITY (CONTINUED)

5. (Guided option for older grades, slightly familiar with trigonometry): Ask the students to measure the distance to the star. They should begin by measuring the diameter of the circle, then identify the points in that orbit at which the star has "moved" the furthest. Using their hands, they can estimate the angle between the stars locations from these two points in the orbit. After they have that angle, they should solve the equation:
   radius of the orbit / tan(parallax angle) = distance
   - Notes on using hands to measure angles: Hold your arm at full length, close one eye and sight along the arm with the other eye. Then, based on how you hold your hand, you can measure different angles:

Hand Position	Nominal Angular Size
	1°
	10°
	20°

Background —

Measuring the distances to stars is kind of like a house of cards: we use one method to get nearby stars, use a new method for further away stars which depends on our first measurements of nearby stars, then yet another method at further distances, and so on.

The first method astronomers use to measure distances to stars is called parallax. Astronomers can measure parallax by measuring the position of a nearby star with respect to more distant stars behind it, then measuring that position again six months later when the Earth is on the opposite side of its orbit. The shift is tiny... less than an arcsecond even for the nearest star (an arcsecond is 1/60 of an arcminute, which is 1/60 of a degree). This was too small for astronomers to detect until 1838.

Parallaxes give us distances to stars up to less than two thousand light years. Beyond that, parallaxes are too small, so astronomers use some more indirect methods to measure more distant objects

Ties to Standards —

NSES Content Standards

Grades 5-8:

USE MATHEMATICS IN A LL ASPECTS OF SCIENTIFIC INQUIRY.
Mathematics is essential to asking and answering questions about the natural world. Mathematics can be used to ask questions; to gather, organize,, and present data; and to structure convincing explanations.

DESIGN AND CONDUCT A SCIENTIFIC INVESTIGATION. Students should develop general abilities, such as systematic observation… Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.