Tracking Objects in Orbit

Pages 1-3 Tracking Objects in Orbit with Capt Adrian Castillo

Watch the Video Here

Materials Required for This Lesson/Activity	
Quantity	**Description**
Per group of 4	2 converging lenses
Per group of 4	a 5x6 piece of white cardboard
Per group of 4	one sheet of vellum paper (cut to the size of the flashlight cap) with a geometrical shape on it (can be made with black permanent marker)
Per group of 4	one meter stick
Per group of 4	12-inch ruler
Per group of 4	flashlight
1 roll	tape
Per student	calculator

Tracking Objects in Orbit with Captain Adrian Castillo

Grade/ Grade Band 6-8	**Topic:** Earth's Place in the Universe	

Brief Lesson Description: U.S. Air Force Captain Adrian Castillo works in the field of adaptive optics. He spends his days working to make sure we can clearly see the objects in space for space domain awareness. In this lesson, students will explore lenses and their role in creating a sharper image.

Performance Expectation(s):
MS-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system.

Specific Learning Outcomes:
Students will experiment with a converging lens that has a focal point that can be easily measured.

Narrative / Background Information

Prior Student Knowledge:
Students should be able to distinguish between a convex and a concave lens.

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. ● Analyze and interpret data to determine similarities and differences in findings. (MS-ESS1-3)	**Ess1.B: Earth and the Solar System** ● The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-3)	**Scale, Proportion, and Quantity** ● Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-3) **Interdependence of Science, Engineering, and Technology** ● Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. (MS-ESS1-3)

Possible Preconceptions/Misconceptions: A common misconception is light travels in a straight line.

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Students begin the lesson by watching the video: Tracking Objects in Orbit with Capt. Castillo. While watching the video, students will take notes. Then in small groups, each team will create a list of questions (3-5) for the other groups to answer. The goal is to ensure students engage with the content in the video. The class will come together and discuss Capt. Castillo's advice and answer each other's questions.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:
Have students hold their pen/pencil out in front of themselves vertically with the writing end pointed down to the floor. Then ask them to close their left eye and notice the position of the pen/pencil (it should have shifted slightly to the right). Next, ask them to open their left eye and close their right eye (now the pen/pencil should shift slightly to the left). Ask students to move the pen/pencil various distances toward their face and repeat opening and closing one eye at a time and record their observations.

This phenomenon is known as **parallax**. Parallax is the observed displacement of an object caused by a change in the observer's point of view. Now let students know that in astronomy, it is an invaluable tool for calculating distances of faraway stars.

Students then discuss how they believe parallax is used to measure the distance of stars. They are making hypotheses.

EXPLAIN: Concepts Explained and Vocabulary Defined:
Explain that visual parallax is the apparent shift in the position of an object when viewed from different angles. Tell students another example of the parallax effect can be seen in games like Super Mario Bro., when the main character moves on the screen, the background moves at a different speed, creating an illusion of depth and dimension. Another example is when you are riding in a car and the trees closest to you appear to zoom by while homes, mountains, and trees in the distance don't appear to be moving as fast. Let's take a look at this video clip and see if you can relate.

Next, explain that Capt. Castillo works with adaptive optics. Define adaptive optics as a technique used to correct distortions in the images produced by telescopes due to atmospheric turbulence. It's used to improve the clarity and resolution of images of objects in space. Share images from NOIRLab, TMT International Observatory, or Sky & Telescope

While lenses cannot improve resolution, they can be used to focus light.

When light from a source that is an infinite distance away passes through a converging lens, the light will come to a focus at the focal point of the lens. Since it is inconvenient to get infinite distances in the classroom, the following lens equation is used to compute the focal length of a lens:

$$\frac{1}{f} = \frac{1}{D_o} + \frac{1}{D_i}$$

The measured distance of the object, D_o, from the lens, and the measured distance of the image, D_i, is used to compute the focal length, f, of a converging lens.

Vocabulary:
Parallax- the observed displacement of an object caused by a change in the observer's point of view
Parallax Angle- the angle between the Earth at one time of year, and the Earth six months later
Adaptive Optics- a technique used to correct distortions in the images produced by telescopes due to atmospheric turbulence.
Focal Length- the distance from the lens to the focused object

ELABORATE: Applications and Extensions:
Prior to starting the elaboration section of this lesson, you will need to gather the following materials (per group):

- 2 converging lenses
- white cardboard (5x6)
- one sheet of vellum paper (cut to the size of the flashlight cap) with a geometrical shape on it (can be made with black permanent marker)
- one-meter stick
- 12-inch ruler
- flashlight
- tape
- calculator

Instructions:

1. Begin this experiment exploring with the lenses. Hold each lens above a surface such as your hand or textbook. Adjust the lens until the surface is in focus and you can clearly see the object. At this point, you are using the lens as a magnifier. Details of the object should be sharp.
2. Use the ruler to measure the distance from the edge of the lens to the image you have in focus. This distance will be D_1.
3. To calculate an estimated magnification power, divide 10 by the distance at which you measured the object in focus, (D_1).
4. Experiment using various objects and the two lenses. Noting if there is a difference in the distance and/or the magnification.
5. Place the meterstick on the floor, at the zero-end of the meterstick place the white cardboard. Next tape the vellum paper on the flashlight and turn it on, testing if it is working and if the image of the object can be seen. Now at the other end of the meterstick place the flashlight and turn it on such that it is shining onto the cardboard.
6. Hold each lens, one at a time, between the light source and the cardboard. Move the lens along the meterstick until the image is in sharp focus on the cardboard.
7. Measure the distance from the object to the lens D_o and the distance from the cardboard (screen) to the lens D_i. Record measurements in your notebook and repeat using the second lens and then using both lenses at the same time.
8. Calculate the focal length: $\frac{1}{f} = \frac{1}{D_o} + \frac{1}{D_i}$

Answer the following questions in your notebook:

1. How does the focused image compare with the object?
2. If you found two clear images, what was different about them? Why do you think there were two images?

3. How is this activity different from the parallax activity?
4. How do you think this activity is similar to the work Capt. Castillo does?

EVALUATE:

Formative Monitoring (Questioning / Discussion): students are making hypotheses and measurements

Summative Assessment (Quiz / Project / Report): Calculations for magnification and focal length and the answers to the questions.

Elaborate Further / Reflect: Enrichment: Students make their own telescopes.
Materials: two cardboard tubes (paper towel), 2 convex lenses, masking tape
Step 1: Cut one cardboard tube lengthwise (this will be the inner tube).
Step 2: Insert your cut tube into the second cardboard tube.
Step 3: Use the masking tape to secure one of the convex lenses to the outer edge of the inner tube, such that the curve is facing inside the tube.
Step 4: Secure the second convex lens to the outer edge of the second cardboard tube with the curve of the lens pointing out from the tube.
Step 5: Now use your DIY telescope to view objects in the distance. But never use the telescope to look at the sun!

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency: Self-Management
A key component of self-management is the ability to identify and use stress management strategies. Capt. Castillo shares how he uses hobbies to maintain a work-life balance and develop his sense of resilience when working on something challenging. In this activity, students will develop strategies for reducing their stress levels.
Begin this activity with a 1 minute dance party. Select a song that really makes your students want to move. Have them stand away from their desks and chairs. Then inform them they must keep moving for the duration of the song, once the song ends the must stop moving. After playing the music for 1 minute, have students return to their seats and ask students how they feel, do they feel relaxed, and how they would define stress. **Stress is the feeling of being overwhelmed or unable to cope with mental or emotional pressures which could cause physical, emotional, or psychological strain.**
Lead a discussion about what is causing students to stress. Write the items students identify as stressors on the board and try to categorize them: family, school, peers, self-esteem, etc. (Be mindful of who is speaking and who is not speaking and watch the reactions and acknowledge everyone's feelings).
Ask students to complete the Teenage Stress Quiz (on laptops or phones). After 5 mins, lead a discussion about coping with stress the students encounter and the strategies for managing the stress they can incorporate into their daily routines.

INTERDISCIPLINARY CONNECTIONS/IDEAS

6.RP.A.1 - Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS1-3)
7.RP.A.2 - Recognize and represent proportional relationships between quantities. (MS-ESS1-3)
MP.2 - Reason abstractly and quantitatively. (MS-ESS1-3)

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Lesson Created by Stacy Douglas
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