Educator Guide

Engineering Activity 2: Lighten Up! Investigating Light

Educator Preview

Activity Snapshot

Learners investigate how light travels and how mirrors can redirect light to gather data from a distance.

Timing | 45 minutes

Get Ready and Team Up	10 min.
Investigate Light	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5 min. each

Prep Snapshot*

Prep Time 30 min.

Set up sample obstacle course and Materials Table.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Habits of Mind

- Use systems thinking.
- Investigate properties and uses of materials.

Guiding Question

How can we redirect light to gather data from a distance?

Learners Will Do

Evaluate the properties of light and decide how to place mirrors to redirect its path.

Learners Will Know

Mirrors can change the direction of light.

Connecting Across Activities

Activity 1: Sharing Experiences	Activity 2: Investigating Light	Activity 3: Redirecting Light
Last time, learners shared experiences with, and stories about, technology.	**Today**, learners investigate how light travels and how mirrors can redirect light to gather data from a distance.	**Next time**, they will design portable light redirection systems. These systems are one technology they can use when designing their complete remote sensing technologies.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/955d7e8b

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF)
  Examples | Templates
  - index cards
  - markers
  - scissors
  - tape
- 1 box or other obstacle, 7" × 5" × 3" (approx. 18 cm × 13 cm × 8 cm) or larger
- 1 index card

For each group of four

- Redirecting Light Handout, pg. 36
- Set Up an Obstacle Course Handout, pg. 37
- Investigating Light Constraints and Criteria Handout, pg. 38
- 1 box, small, or other obstacle
- 1 fuzzy stick
- 1 index card
- 6 mirrors (distributed later)
- 6 binder clips, medium (distributed later)
- 1 pack of crayons or markers
- 1 pair of scissors
- 5–10 straws
- 1 protractor (for measuring angles, optional)
- 1 roll of tape, masking

For each learner

- Engineering Notebook (PDF)

Teaching Tip

Save straws for reuse in Engineering Activity 5.

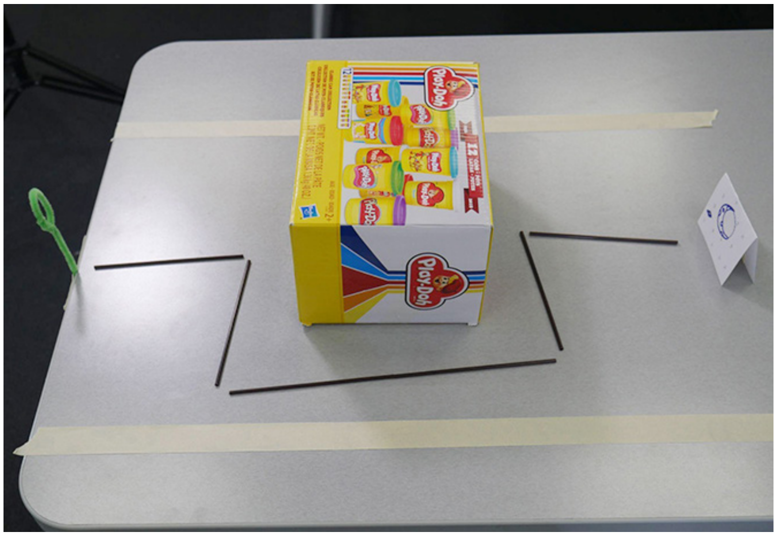
Activity 2 Materials Preparation (30 min.)

Ahead of Time

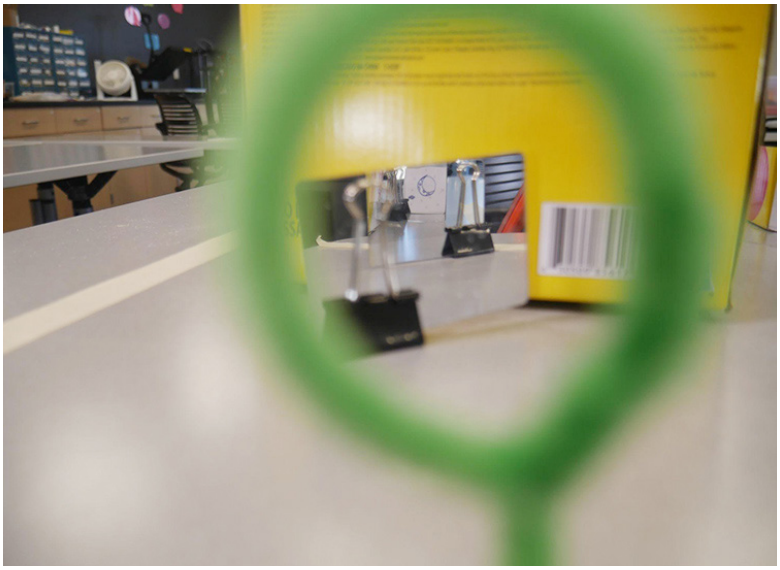
1. Print out one copy of Redirecting Light, pg. 36, and one copy of Investigating Light Constraints and Criteria, pg. 38, per group.
2. If you are using mirrors for the first time, remove plastic film from them.

In Your Space

3. If you did not do so before the Ready, S.E.T., Go activity, prepare to build on the *Our Ideas* poster by following the *Prep & Setup Guide*. Add the Guiding Question "How can we redirect light to gather data from a distance?" so learners can refer to it throughout the activity.
4. Set up a sample obstacle course according to Obstacle Course Setup, pg. 37. Ensure it will be in an area that all learners can access safely.



Obstacle Course



View through eyepiece of Obstacle Course

5. Create a Materials Table with the materials listed above as For each group of four. Do not include mirrors and binder clips. These will be distributed later.

Preparation for Engineering Activities 6–9 (60 min.)

The final design challenge for this unit requires the educator to prepare a multi-part model so learners can test their remote sensing devices. Read Activity 6 Materials Preparation, pg. 80 and decide whether to use the Space Screens with learners. **Then consider preparing the following models in parts or set aside at least an hour to assemble them in one session.**

- Model Landscapes for Site A (2 copies) and Site B (2 copies)
- Optional: Space Screens that prevent learners from looking at the model landscapes on the opposite side and represent the distance between the Earth and other planets

The complete instruction for building Site A and B, pgs. 85-87 and the Space Screens, pg. 88-89 are outlined in this guide, and a video that shows the process of how to build a model landscape is available. Since remote sensing engineers cannot see the surface of a planet up close, it is important that learners use only the remote sensing devices they create to gather information about each site and that they do not look at the models directly. Keep the model landscapes covered when not in use until groups complete their tests in Activity 9.

Activity Guide

Get Ready and Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** (*We told stories about why technology is important, which helped us understand why it's important to think carefully about designing technology.)* Draw learners' attention to their work on the *Our Ideas* poster about how technology makes a difference in their lives.
2. Say: **NASA wants to send a rover to Mars to see if liquid water was once there. If it was, Mars might have been able to support some form of life–in other words, it might have been habitable. As engineers, our ultimate goal is to help the scientists at NASA by answering the big question "How can we gather information about Mars from far away?"** Write the question in a prominent spot on the top of the *Our Ideas* poster.
3. Ask: **What smaller questions will we need to answer in order to answer this question?** Allow learners to think of questions in pairs, then share them with the whole group. Record their questions on the *Our Ideas* poster in related categories. Possible sets of questions include the following:
   - **Light:** How can we view the surface? How can we see Mars up close?
   - **Water:** Was there water on Mars? How can we tell if there was water on Mars? How can we learn about the surface?
   - **Land:** How can we figure out where to land a rover? What are the landforms on Mars? How can we learn about the physical properties of the surface?
4. Point out questions about light and say: **Today, we'll be investigating our questions about using technology to view Mars up close. Images or pictures need light.** Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **How can we redirect light to gather data from a distance?**
5. Organize learners into groups of four.

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. viii-xvi).

Teaching Tip

Each activity in this pathway has a suggested Guiding Question. As much as possible, replace these questions with similar ones from the list of questions learners have thought of. Using learners' questions will increase their engagement. There will likely be questions you do not answer in the pathway. When you can, mention these questions and have learners think about ways to answer them in the future.

Learners might ask questions about Mars and not the technologies they will design. That is okay. Each subsequent activity will answer questions related to each of the three categories above, but because they are engineers, they will focus on technologies needed to answer that question. For example, the first two activities answer questions related to viewing the surface of Mars. In order for scientists to answer the question "What does Mars look like?", engineers need to answer the question "How can we view Mars from a distance?"

Investigate Light (25 min.)

6. Have each group discuss: **What are technologies that redirect light and use it to gather data from a distance?** *(Mirrors, telescopes, cameras.)* Have learners record their ideas on the *Our Ideas* poster.

7. Distribute one copy of *Redirecting Light* to each group and the Engineering Notebook to each learner. Invite learners to refer to *Redirecting Light* to find out how technologies such as telescopes use mirrors to change the way light travels. Say: **Engineers often use technologies like the ones you talked about to gather data from a distance.**

8. Gather learners around the sample obstacle course you prepared (see *Obstacle Course Setup*). Say: **Instruments on spacecraft must fit in small spaces and work around things that might be in the way inside the spacecraft, called *obstacles*. You will use a model to practice working within spacecraft size limits and to understand how light is redirected to see around obstacles.**

9. Demonstrate as you say: **At your tables, each group will build a model like this one. The tape boundaries represent the size limits of the spacecraft. You will draw an image on a folded index card and place the card within the tape boundaries so it can be seen through the eyepiece. You will place a box between the eyepiece and the index card. It will block the view of the image from the eyepiece. It will be an obstacle. Straws represent the path of light. Because light has to reflect from an image and reach a person's eye for it to be seen, your goal is to create a path through the course with the fewest straws possible, beginning at the index card, going around the obstacle, and ending at the eyepiece.**

Support Learner Differences

Group learners with different abilities and strengths in a way they can all contribute. Check out the Intentional Grouping Strategies, pg. xxii.

As needed, allow learners to feel the obstacle course in order to become familiar with it. Also consider arranging your space to make room for accessibility devices. See our video on Supporting Learners with Diverse Physical Abilities.

Support Thinking

Demonstrate an obstacle by placing someone or something in a doorway and explaining that there is something in the way, or an **obstacle**, to getting into or out of the room. Ask learners if they can think of other examples of obstacles.

Level Up!

Tell learners that there are lots of different kinds of telescopes, such as the James Webb Space Telescope, which includes 18 six-sided mirrors that unfolded into a giant curved mirror after the telescope was launched into space. Cameras such as the Context Camera and High Resolution Imaging Experiment (HiRISE) onboard Mars Reconnaissance Orbiter use a complex system of mirrors to capture images in space. Explore more resources as an educator on our Quick Links and More Resources webpage, or have learners explore more on the Remote Sensing Learners website. (10 min.)

10. Distribute one copy of *Set Up an Obstacle Course, page 37* and one copy of *Investigating Light Constraints and Criteria*, pg. 38, to each group. Read through with learners and answer any questions. Have a volunteer from each group collect materials. Do not include mirrors and binder clips yet.

11. Give groups a few minutes to build their obstacle courses and begin to place the straws. Ask: **Can you create a path from the image to the eyepiece using straws? What do you notice about the path?** *(The path can't go in one straight line to get around the obstacle; it needs to turn a corner. The shortest path has the fewest turns. The path is made up of straight lines, not curves.)* **How did you decide where the path needed to change direction?** *(We reached a barrier. We recognized that we had gone far enough to be able to change direction and not touch the obstacle.)* Say: **Light travels in a straight line, just like the straws in the obstacle course.**

12. Grab a few mirrors. As needed, pass them around so learners can feel them. Say: **In a minute, you will get some mirrors like these.** Ask: **What happens when light hits a mirror?** *(It changes direction. It is reflected.)* **What is the source of light for these mirrors?** *(The Sun, lights in the room.)*

13. Demonstrate as you say: **Next, place mirrors to redirect the path of light so the drawing can be seen from the eyepiece, even though it is hidden behind the obstacle. Use the binder clips to hold up the mirrors. Keep the straws in place to guide you.** Pass out six mirrors and binder clips per group. Allow learners time to place the mirrors and try to see the drawing through the eyepiece.

14. As learners work, ask: **How are you using what you learned from the straws to place your mirrors?** *(We need to make light travel in a straight path. We are placing mirrors where the straws meet because that is where the light needs to change direction.)* **How is placing mirrors different from placing straws?** *(The angle of the straws didn't matter, but the angle of the mirrors does.)* **What advice would you give to other groups?** *(It helps to move the mirrors a little bit at a time. Make sure the mirrors are secure in their stands.)*

15. Invite learners to draw their solutions on Obstacle Course Diagram in their Engineering Notebooks. If there is time, allow groups to provide advice to each other.

Support Learner Differences

As needed, provide groups with a tub or other container to hold their materials.

Support Thinking

To access learners' prior knowledge, provide an image of a mirror at a corner in a hallway or show one in your own space. Ask learners why they think the mirror is there. Have them consider how this idea might help them place the mirrors in the obstacle course.

Level Up!

If learners finish quickly, challenge them to use fewer mirrors or to set the mirrors so that the image isn't reversed. (5 min.)

16. After groups finish, say: **You have made a technology that redirects light to gather data remotely. Ask: What parts did your technology have?** (Mirrors and an eyepiece.) Say: **Your technologies contain parts that work together. A term for a group of parts that work together is system. In what way is your technology a system?** (The mirrors and eyepiece work together to redirect light to a person.) **Remote sensing technologies are often systems with multiple parts. For example, a spacecraft on the Moon facing away from Earth can send signals to a satellite, which then sends the signals to Earth.** Write the word system on the *Our Ideas* poster. You can have learners add translations, drawings, or related images to the poster as well.

Reflect (10 min.)

17. Revisit the Guiding Question on the *Our Ideas* poster: **How can we redirect light to gather data from a distance?** *(We can redirect light using systems of angled mirrors.)* Remind learners of the terms *obstacle* and *system*.
18. Say: **Turn to a neighbor and discuss: What are places in your daily lives where people use mirrors to redirect light?** *(Examining people's mouths at the dentist, rearview mirrors in cars, etc.)* Have learners record their ideas on the *Our Ideas* poster. Consider returning to learners' ideas at the start of the next activity.
19. Say: **Good job working as engineers today! Next time, you'll use what you've learned to make a technology that both redirects light and is easily carried.**

Support Thinking

- Show the video [Using Light to See Around Obstacles] to help learners understand how systems of mirrors are used in technologies.
- When introducing questions that require learners to extend their thinking and formulate new ideas, invite them to share ideas with a partner or small group before sharing with the whole group.

Support Learner Differences

As needed, allow learners to choose other methods of sharing their ideas, such as audio recordings or Braille. Post index cards with filenames on them so the record can be referenced later.

Level Up!

- Refer to the [Engineering Design Process poster (PDF)]. Ask: **What phases of the *Engineering Design Process* did you use today?** (The Investigate phase. We investigated how light moves and gets reflected.)
- NASA uses special mirrors called retroreflectors to precisely locate places on the Moon. Read more about them: [How NASA Uses Simple Technology to Track Lunar Missions - NASA]. (5 min.)

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for Activity 3.
   - Save or throw away obstacle course materials. Save mirrors for Activity 3 and straws for Activity 5.
2. Plan ahead for Engineering Activity 3. See Activity 3 Materials Preparation on pg. 40.
3. Take time to reflect on the following educator prompt: How did you create connections between the straw part and the mirror part of this activity?

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9

Engineering Activity 2

Obstacle Course Setup

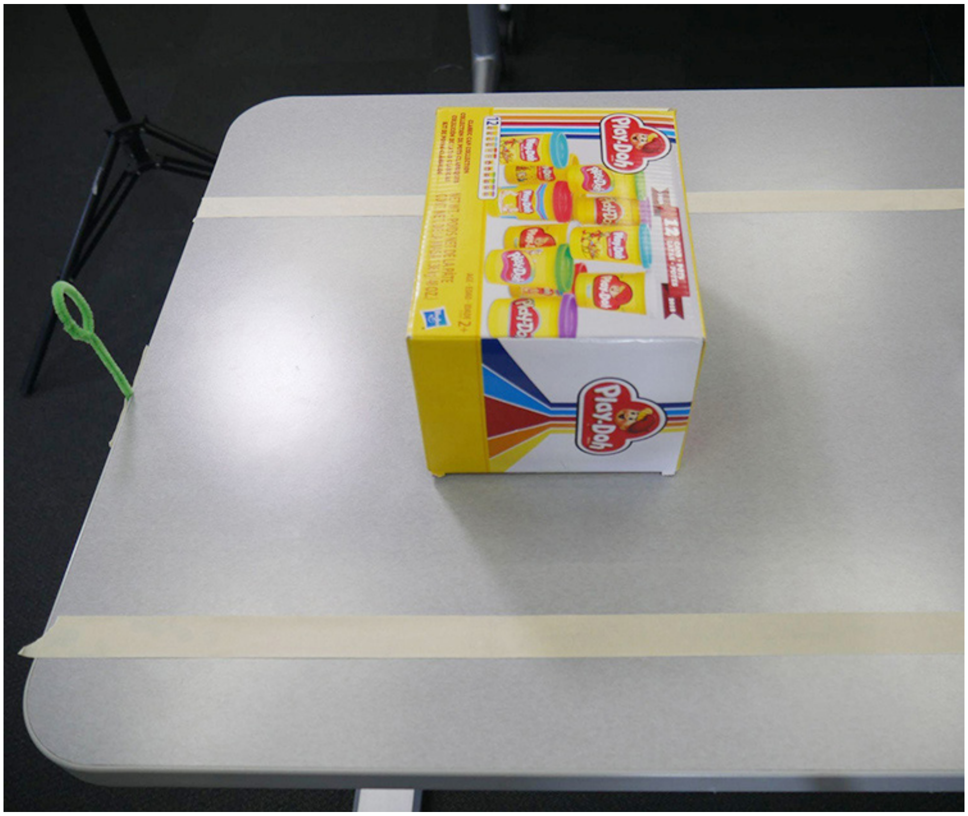
These instructions explain how to build a sample obstacle course for use in Step 3 of the "Investigate Light" section.

Materials for setup:

- index card
- obstacle
- fuzzy stick
- tape

Make an Eyepiece

1. Take a fuzzy stick and twist a loop about 1 inch in diameter, curling the fuzzy stick around itself to close the loop.
2. Bend the excess back.
3. Tape the eyepiece to the edge of a table.

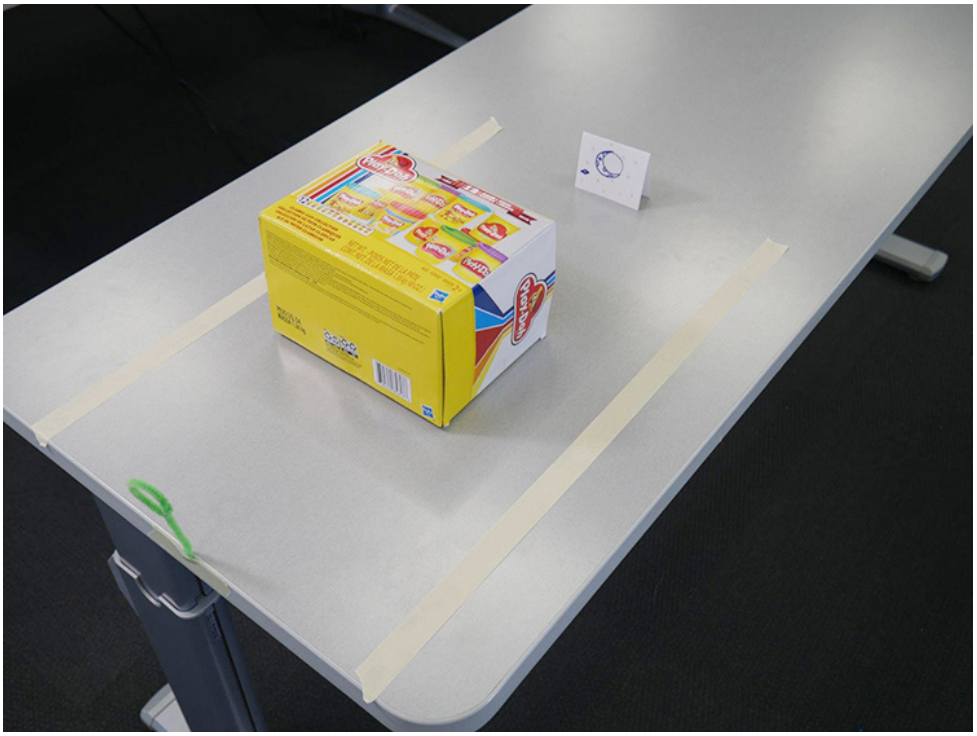


Obstacle Course Set Up

4. Fold an index card in half so it stands upright. Make a drawing learners will try to see using the mirrors. Make it asymmetrical so learners can tell if it is reversed.

5. Place an obstacle, such as a box or stacked books, between the eyepiece and drawing. The obstacle should be about 8" (21 cm) from the drawing and 8" (21 cm) from the eyepiece.

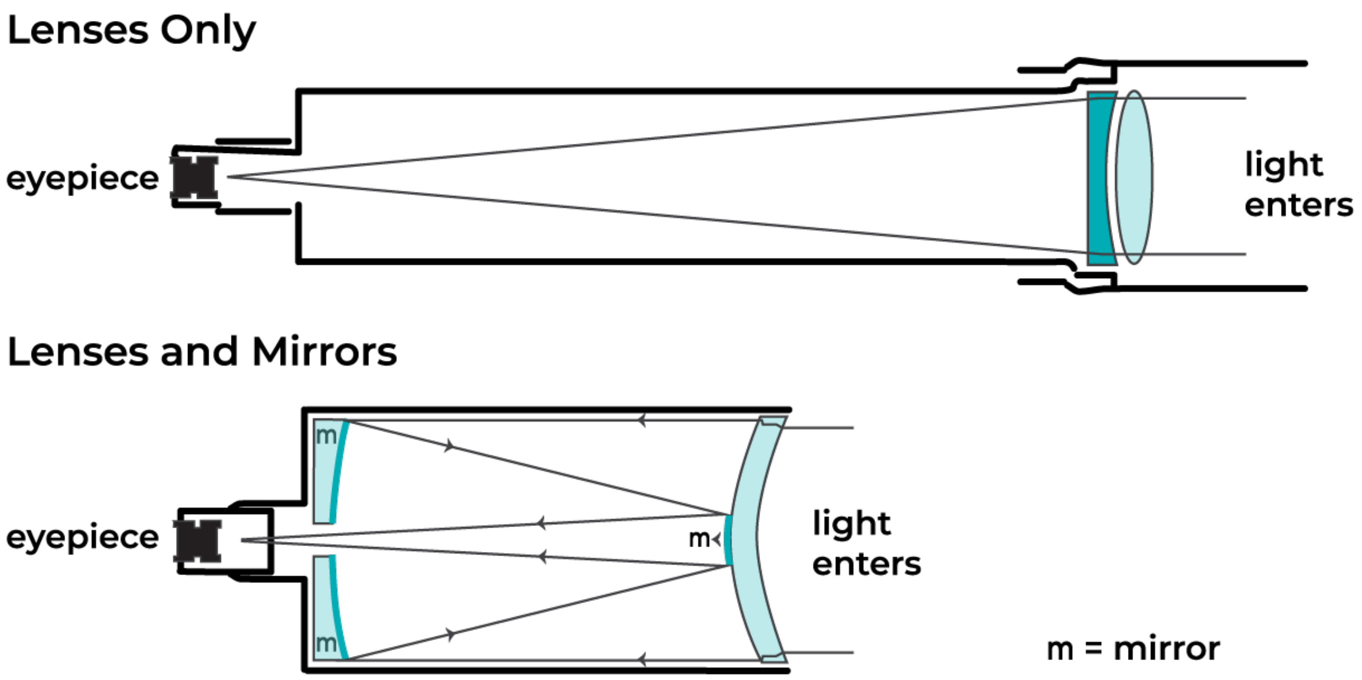
6. Use masking tape to make boundary lines around the obstacle course.



Obstacle Course Set Up - Alternate View

Redirecting Light

Lots of technologies use mirrors to change the way light travels from an object to your eye. See if you can trace the path of light in the technologies below!



Comparing Telescopes with and without Mirrors

A telescope is an example of a technology that collects and focuses light to capture information about faraway objects. Large telescopes often use mirrors to redirect light so that they don't have to be extremely long. The Hubble and James Webb Space Telescopes are reflecting telescopes used to study deep space. The HiRISE (High Resolution Imaging Science Experiment) telescope orbiting Mars is also a reflecting telescope. It can take detailed pictures of the planet's surface.

Set Up an Obstacle Course

1 Make eyepiece.


fuzzy stick


shape fuzzy stick to make eyepiece


tape to table edge

2


index card with drawing

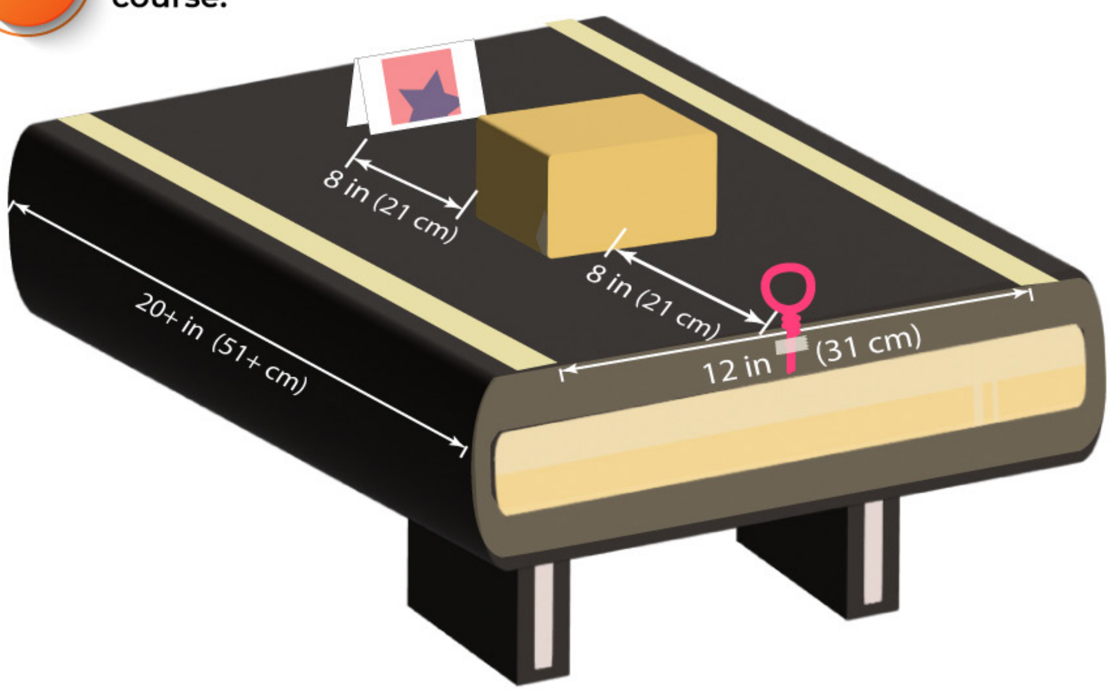
+


box to be the obstacle

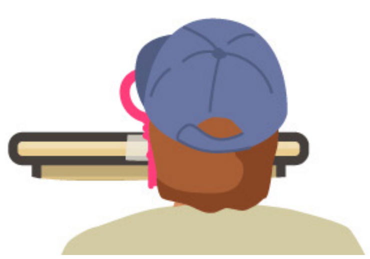
+


masking tape

3 Set up course.



4 Look through eyepiece.



Investigating Light Constraints and Criteria

Build your obstacle course.

- The course must be about 20 inches (51 cm) long.
- The tape must be 12 inches (31 cm) apart.
- Place an obstacle between the eyepiece and the drawing, about 8 inches (21 cm) away from the eyepiece.
- Place the index card drawing about 8 inches (21 cm) away from the obstacle.

Direct light through your obstacle course.

Create a path through your obstacle course with the fewest number of straws to model the path of light from the index card, around the obstacle, to the eyepiece. Every straw must always be in contact with other straws. If a straw is cut into pieces, each piece counts as a straw.

✗ Straws cannot touch the obstacle.

✓ Straws must lay flat on the table.

✓ Straws must stay within the tape boundaries.

✓ You may use more tape to keep straws in place on the table or to connect to each other.

Draw your solution to the obstacle course on the diagram in your Engineering Notebook (PDF), pg. 7.