More Than Meets The Eye
Telescopes

Introduction:

Telescopes are tools that allow us to explore the sky in exquisite detail. They do this by collecting a large amount of light and focusing this light into our eyes (or a camera). Because stars are very far away, a lot of light must be collected so we can see them clearly. Telescopes are sometimes called "light buckets;" like a bucket collects water, a telescope collects light. The more light that is collected, the fainter and farther the telescope will be able to "see."

In this series of experiments, students will explore reflection and refraction using mirrors and lenses to discover how telescopes work.

Engage:

1. Ask students the following questions:
   - How do telescopes work?
   - Why do we use telescopes and why are telescopes important?
   - What are telescopes made of?
   - How do mirrors work? Research the materials used to make mirrors.
   - Research how magnifying lenses work.

2. Have students view one or more of the videos on the James Webb Telescope and the types of mirrors used to focus light from distant objects in the universe.

   The Webb Telescope's Optics (3:55) youtube.com/watch?v=LwkeoA-0SFA

   Social Media Short: James Webb Space Telescope Laser-Focused Sight (1:12) youtube.com/watch?v=_2zQiWeXTg4

   Looking into the Past with Telescopes (5:21) youtube.com/watch?v=c0q1p4toRa8

3. Have students define the key vocabulary words:
   Reflection – when light bounces back or "reflects" off a surface
   Refraction – when light bends as it passes at an angle through a material, like glass or plastic.

4. Tell students they will complete several experiments to determine how light interacts with mirrors and lenses, which are important components of telescopes.

Safety first:

Explain to students - NEVER use mirrors or lenses to shine light from any source into their eyes or the eyes of another person.

Materials:

- Magnifying glasses (one per student or student group; use various types if available – lens size, thickness, material (glass, plastic))
- Small mirrors (one per student)
- Rulers (one per student group)
- Index cards or small piece of cardstock (one per student group)
- Pencils (one per student)

Activity 1 | **Exploring Reflection**

1. Place students in pairs or small groups. Give each group one mirror and one index card.
2. Tell the students they must use the mirror and light in the room (not sunlight!) to create a spot on the index card. How bright can they make the spot? The index card must remain on the table; however, they can place the mirror at different angles and positions.
3. After a few minutes, and after each student has had an opportunity to experiment with the mirror and light, review their results. Could they create a spot on their index card? Can they think of a way to make the spot brighter? Refer to the video on the James Webb Telescope. The telescope is made of many hexagonal mirrors placed together to make a larger mirror (the largest mirror ever launched into space!). Each mirror is positioned to focus light into one area.
4. Distribute additional mirrors to students. Have them attempt the challenge again using 2, 3, then 4 mirrors. How many mirrors created the brightest spot? How were they able to create the spot using the mirrors (can they explain how the light was reflected)? Was the number of light sources in the room the same/did the light sources change?
5. Did the mirror reflect or refract the light?

Activity 2 | **Exploring Refraction**

Safety first:
Explain to students - NEVER use sunlight as the source of light with magnifying glasses, as it may cause a fire. If sunlight is shining into the room, close the shades in the classroom.

1. Place students in pairs or small groups. Give each group one magnifying glass and one index card.
2. Tell the students they must use the magnifying glass and light in the room (not sunlight!) to create a spot on the index card. How bright can they make the spot? The index card must remain on the table; however, they can place the magnifying glass at different angles and positions.
3. Review student results.
4. At what distance was the magnifying glass from the index card that produced the sharpest spot of light? Have the students measure this distance using a ruler and compare results. Explain focal length, which is the distance from the magnifying lens to the focal point, which is the point at which all the light passing through the lens meets at one spot.
5. Did the magnifying glass reflect or refract the light? What is the difference between reflection and refraction?

Discuss:

How are mirrors, lenses, and light used in telescopes? Because stars are so far away, telescopes use mirrors and/or lenses to gather and focus as much light as possible. There are many different types of telescopes, such as reflecting, refracting, combination, and compound telescopes. The James Webb Telescope is a type of reflecting telescope.

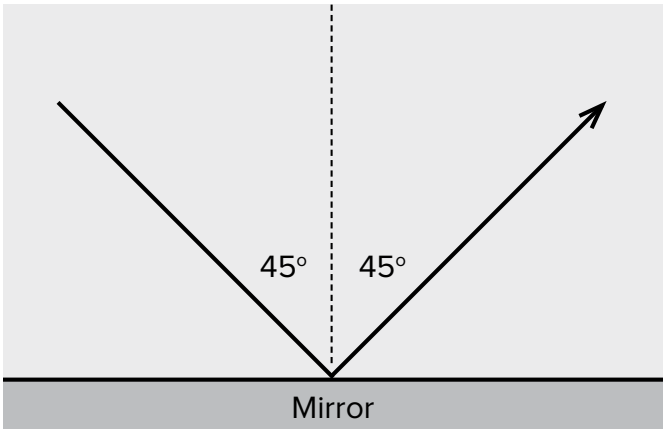
In Activity 1, students reflected light onto a specific point using a mirror. The James Webb Telescope uses many mirrors to gather light and focuses that light into a smaller area, which magnifies the image.

In Activity 2, students refracted (bent) light onto a specific point using a magnifying glass. Refracting telescopes bend light inward towards a point.

Extension Activities:

Activity 3 | Exploring Reflection and Refraction

The law of reflection states that that angle at which a beam of light hits a flat mirror (angle of incidence) and the angle at which the light bounces off the mirror (angle of reflection) will be the same. For example, if the angle of incidence is 45°, the angle of reflection will also be 45°.



Materials:

- Flat mirror (silver-backed mirror)
- Protractor
- Laser pointer or laser level
- Pencil
- Paper

Safety first

Never point a laser beam into your eyes or another person's eyes. Have students draw the following image on a piece of paper, using the protractor to measure the angles. Have them line up the mirror with the mirror line on the paper. Direct them to point the laser along the line of incidence (towards the mirror). Observe the line of reflection of the laser beam. Draw the line of the reflected laser beam. Is the angle of reflection as expected? Explain.

Explanation:

As the laser light travels from the air to the glass or plastic of the mirror, the light refracts or bends, reflects off the shiny metal backing or coating of the mirror, then changes direction as it passes out of the glass. The reflected light may not line up with the expected line of reflection.

Activity 4 | **Exploring Magnifying Lenses and Refraction**

Explore how magnifying lenses refract light.

Safety first

Do not concentrate sunlight onto paper, as this may cause a fire. Experiment under adult supervision.

Materials:

- A room with a window
- White paper
- Magnifying glass

1. Stand with your back to the window, with the lights turned off in the room.
2. Hold the paper in one hand and the magnifying glass in the other hand.
3. Carefully move the magnifying glass back and forth until you see an image on the paper. Look at the paper, NOT the magnifying glass.
4. What do you see on the paper? How does the image look?
5. Is the image right side up or upside down? Explain. Is this reflection or refraction?

See the video below for a demonstration:

Reverse Image Magnifying Glass Experiment youtube.com/watch?v=7D2QYJBzrh4

Further Exploration

1. Students can research different types of telescopes and how each telescope works. Is one telescope better suited for looking at deep space objects than others?
2. Students can experiment with prisms and light. What happens when the light passes through the prism? Is this reflection or refraction?
3. What other scientific tools use mirrors and/or lenses to magnify?

Activities adapted from sciencefriday.com/educational-resources/fun-with-optics/ and Mirror, mirror - Teacher Guide, The University of Texas at Austin, McDonald Observatory