The Hubble Space Telescope

STARFINDER
PROGRAM 0

Instructional Objectives

After viewing the program and participating in the follow-up activities, the student will be able to:

1. explain the advantage the Hubble Space Telescope represents over earth-based telescopes,
2. describe the general role of the chief engineer in a large space project,
3. explain the role of the concave primary mirror, and
4. diagram the path of light in a Cassegrain reflector telescope.

Synopsis

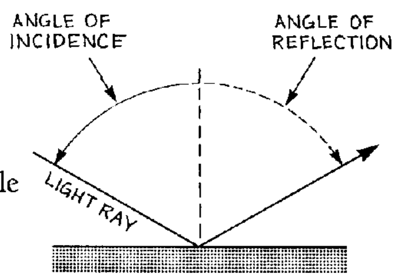
The program outlines the central purpose and significance of the Hubble Space Telescope (HST). It describes how the HST is designed to orbit above the earth's atmosphere, collecting data and transmitting them to earth. The anticipated differences between images from earth-based telescopes and the HST are animated for the students.

The Cassegrain reflector telescope is introduced as the telescope model from which the HST was derived. The path of light in the telescope, the role of the concave primary and convex secondary mirrors, as well as other inner workings of the telescope, are demonstrated. Video footage of the HST before deployment is used to give students an understanding of the total size of the telescope. Actual deployment of the HST will also be shown.

The role of the head of the operations division of the Space Telescope Science Institute is highlighted in the Science Career Profile section. The students are shown the complexity, responsibility, and excitement of this position. The operations division leader speaks about his interests as a youth and how he got involved with science, engineering, and astronomy.

Vocabulary

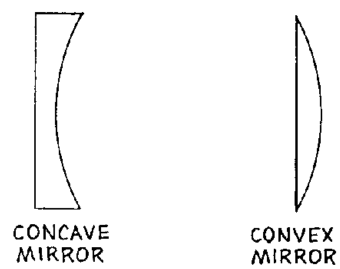
Angle of Incidence—The angle formed by a ray of light striking a reflecting surface, such as a mirror, and the line perpendicular to the surface at the point where light strikes the surface (see diagram). The angle of incidence is always equal to the angle of reflection.



Angle of Reflection—The angle that a light ray reflecting from a surface makes with a line perpendicular to the reflecting surface (see diagram).

Animation Sequence—Motion video made from a series of computer graphic images that simulate specific objects or processes.

Concave—Hollow and curved like the inside half of a hollow ball; the appearance of the inner edge of a circle (see diagram).



Convex—Curving outward like the surface of a sphere or ball (see diagram).

Deployment of the Hubble Space Telescope—Placement of the HST into orbit around the earth by the space shuttle crew.

Focal Point—Point where rays of light reflecting from a curved surface converge.

Transmit—Send out by electromagnetic waves.

Previewing

Discuss the function of the telescope.

Ask the students to name different types of telescopes and describe how they are different and alike.

If available, have samples of telescopes for students to look through and handle.

Introduce the Hubble Space Telescope and why it is different and exciting. Ask if anyone saw the launch or has heard of the Hubble Space Telescope.

Postviewing

Ask students what difference the Hubble Space Telescope will make in astronomy.

Ask students what makes the Hubble Space Telescope unique.

Have the students draw a diagram of the Cassegrain reflector and describe the path of light.

Ask students what they felt was the most interesting aspect of the head of operations job.

Ask students to predict what the Hubble Space Telescope might show us that would be of interest to them.

Active Involvement

In *Teaching K-8* (February, 1990, "Eye in the Sky," pages 58–59), John W. Cowens and his class build a one-seventh scale model of the Hubble Space Telescope for under $20.00. Perhaps your class would be interested in building a model. Mr. Cowens obtained information about the telescope from NASA and the Space Telescope Science Institute, 3700 San Martin Dr., Baltimore, MD 21218.

Plan to take your class to a planetarium either at a local community college, university, or science center (or urge older students to go on their own).

Hang a map of the sky in your classroom. Map the focus of the HST as it changes throughout the year. Record the discoveries and dates on a chart as they are reported in the programs or in the news media.

Encourage the students to bring in articles on the Hubble Space Telescope and have students form a bulletin board from their clippings. Using information from the clippings and the video, have students write an article on the Hubble Space Telescope for the school newspaper.

Bibliography

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For middle school readers:

Branley, Franklin M. *Space Telescope.* New York: Thomas Y. Crowell, 1985.

Lampton, Christopher. *The Space Telescope.* New York: Franklin Watts, 1987.

Vogt, Gregory. *The Space Shuttle.* New York: Franklin Watts, 1983.

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See for Yourself: Experiments/Projects

STARFINDER
PROGRAM 0

The Behavior of Mirrors

▶ MATERIALS:
- clock (wrist watch or alarm clock is fine)
- 2 small rectangular mirrors
- tape
- protractor
- small flash light or pen light

▶ DIRECTIONS:

Look at your wrist watch or an alarm clock; the numbers are said to run in clockwise direction. Place a mirror directly in front of your clock face. In the mirror's reflection, in what direction do the numerals appear to be running? Sketch the path of light from the object to the mirror to your eye. Does this explain the reflection you see? Remember, light traveling in the same substance travels in straight lines.

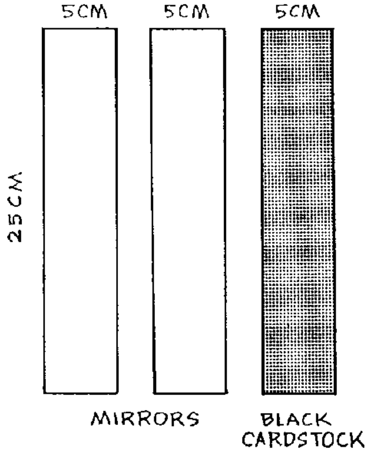
Tape two mirrors together at right angles (90 degrees) to each other, placing the tape on the metallic sides. Flash the pen light (or cover most of the light from a larger flashlight) onto one of the mirrors at a 90 degree angle from its surface. Diagram the path of light. Try the same thing with the other mirror. What is the path of light? Flash the light directly in front of the surface of the two joined mirrors (avoiding the line down the middle formed from the two mirrors). Sketch the path of light.

Place the clock face back in front of the mirror so that the line segment where the mirrors join runs up and down the middle of the clock's reflection when you view the clock face in the mirror from directly in front. Are the numerals on the clock's face running in the same direction or the opposite direction of the actual clock? When you look back at the clock, the numeral three is on the left side of the clock. Where is it in the reflected image? Sketch the path of light from several specific points on both sides of the clock to the mirrors and back to your eye. Describe the paths of light.

Building a Kaleidoscope

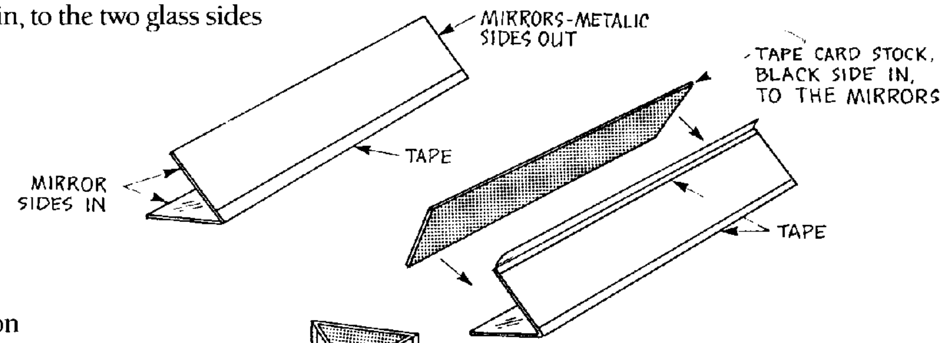
Most kaleidoscopes are closed tubes with a small hole at one end to look through and a translucent material to let light shine through at the other end. Pieces of colored glass are placed between layers of glass at one end. Mirrors and the path that light takes when striking a reflecting surface do the rest of the work.

▶ MATERIALS:
- 2 mirrors of equal length roughly 5 cm x 25 cm
- cardstock of same size as mirror
- insulating or bandage tape
- clear (cellophane or scotch) tape
- white paper 6 cm x 6 cm
- clear cellophane or thin somewhat stiff plastic
- colored bits of paper or sequins
- scissors

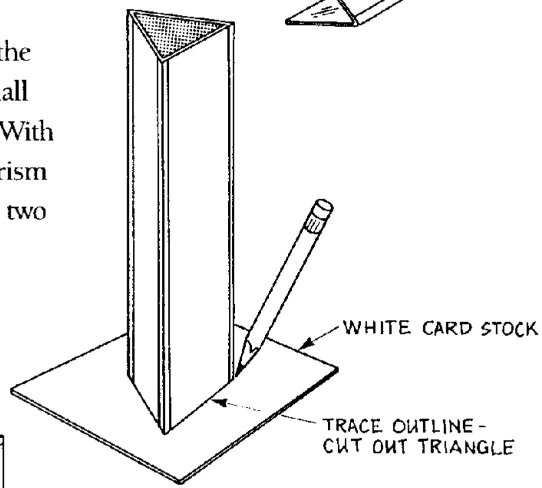


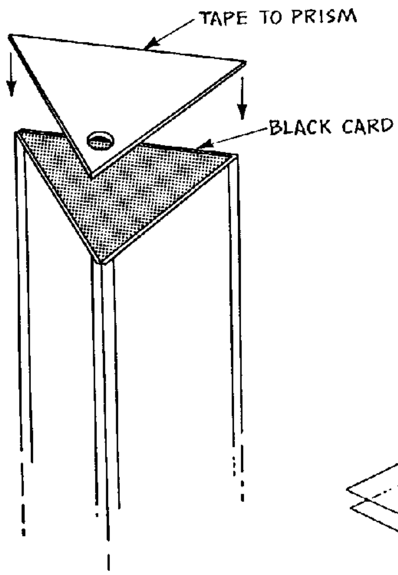
1 Paint the cardstock flat black (or use black cardstock).

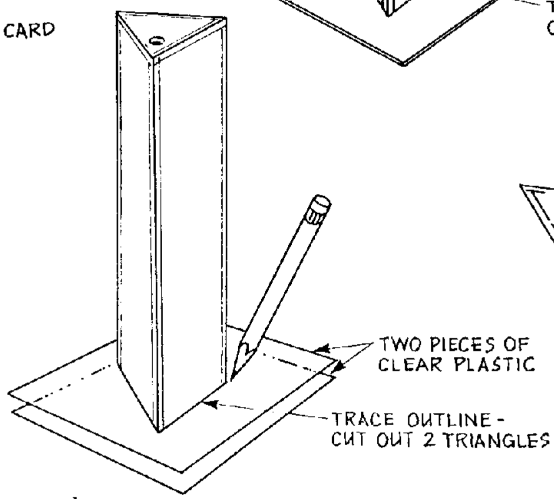
2 Tape the mirrors together along one of the 25 cm sides by placing glass sides together and adhering the tape to the metallic sides. Using the cardstock, form a triangle with the mirrors. Attach the cardstock, black side in, to the two glass sides of the mirror.

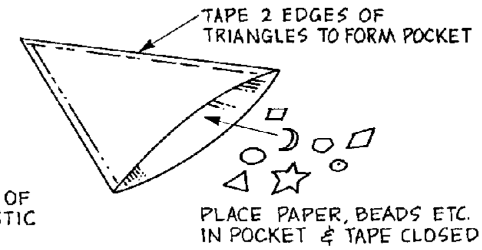


3 Stand the prism you just made on top of the white paper. Trace around the edge of the triangular base and cut the shape out. Make a small (1 cm) hole in the paper near one of the corners. With clear tape, attach the paper over one end of the prism with the hole between the two mirrors. Now trace two triangles of clear plastic and cut them out.

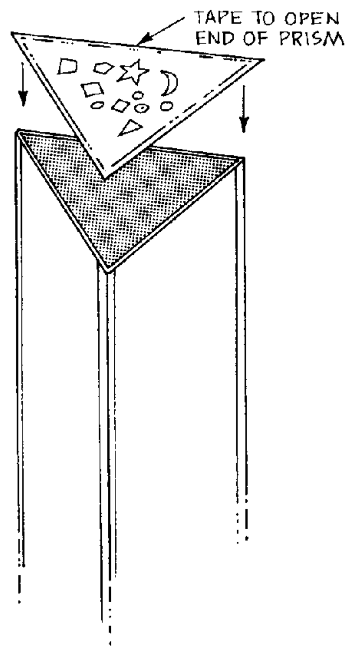








4 Place one triangle over the other and tape two of the three sides together using the clear tape. Place bits of paper, sequins or beads into the pocket. Don't overfill the pocket—leave room for the objects to move. Close the third side with tape. Attach the triangular envelope over the open end of the tube with clear tape.



5 Look through the kaleidoscope. Gently shake the tube and look through it again.

How are the different images you see being formed? Write down your answer.

Science Career Profile

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JIM CROCKER
Head of Operations Division
Hubble Space Telescope Science Institute
Education: B.S. Electrical Engineering, M.S. Electrical Engineering, M.S. Management of Technical Organizations

Chief Responsibilities

As head of the operations division, Jim Crocker is responsible for carrying out the day-to-day operations of the Hubble Space Telescope Observatory. This includes:

– Planning and scheduling – Real time observation support – Post observation data processing

The planning and scheduling activities involve putting together the detailed, second-by-second operating instructions for the observatory. To formulate these instructions, the planning staff must consider not only the location of the target and type of observation required, but numerous other constraints like sun and moon position, communication satellite position, target motion, and location of guide stars. The Science Operation Ground System (SOGS) computers assist the operators in this task.

Once data have been collected, the Post Observations Data Processing System (PODPS) in operations is utilized to calibrate the data, correcting it for errors caused by imperfections in the instruments and telescope, and converting instrument units to physical units. In addition, the operations division is responsible for the large cluster of main frame computers which carry out the planning, real time support, and data processing.

The operations division consists of approximately 70 astronomers, engineers, and technicians who work as a team to provide coverage 24 hours a day 7 days a week to carry out the extensive scientific research program of the Hubble Space Telescope.

A Typical Day

An important part of Jim's job is information gathering. One way this is accomplished is through staff meetings, typically starting at 8:30 a.m. with a status meeting. This allows him to deal with quick breaking problems, as well as keep track of all the different elements of the program.

In the afternoon, he reads documents and keeps up with his electronic mail on his computer. This mail comes from sources within the building, around the country, and around the world. In the evening, Jim reads and tries to understand the technical implications of the day's problems. Why does a problem exist? What is the fundamental problem? During the day, they have probably put a temporary solution in place. Now he must see the whole problem. Have they put the right people on the problem? Does anybody else need to be informed? What are the technical implications?

In order to keep up with the ever changing technology, Jim puts in eight to ten hours a week above and beyond his regular duties to work with scientists to develop science instruments. He feels this keeps him closer to his "art" of being an engineer.

Career Viewpoint

Jim's job allows him to see the big picture. This is exciting for an engineer who has dealt with details most of his career. He also likes to be able to work and interact with people. Many engineers deal primarily with things.

Jim believes that the best management tools, people skills and problem solving skills, are not taught in schools. Experience can be the best teacher in these areas. When a particular venture does not turn out as well as expected, Jim calls this type of learning "failing forward." In other words, it is okay to fail provided you use the experience to learn and move forward in your skills and knowledge.

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If you are interested in more information about STARFINDER and how to purchase it, contact Kate Harrison, Maryland Instructional Technology, at (301) 581-4207.