PLANETS

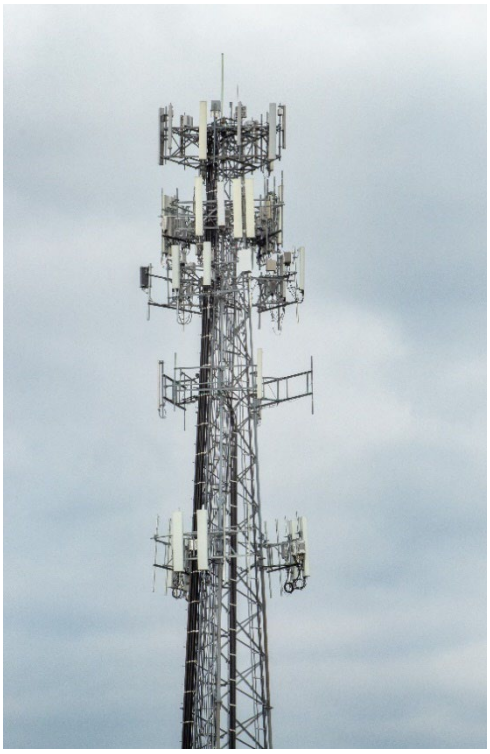
Engineering Notebook

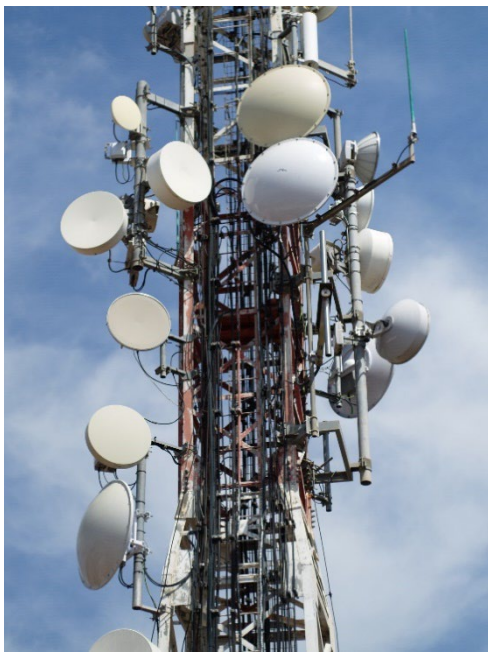
Worlds Apart: Engineering Remote Sensing Devices

Name: _____

Engineering Prep Activity

Cell Towers





Did You Know?

Spacecraft need **antennas** to communicate with rovers and landers on a planet's surface, and to send images and data back to Earth. Antennas on Earth communicate with spacecraft all over the solar system.

More to Explore

Find out more about communicating with spacecraft on the PLANETS website.

https://planets-stem.org/**betars-youth-resources-page/**

Engineering Prep Activity

Needs and Limits

What your design **needs** to do

- Your tower must be at least 1 foot (30 cm) tall, not including the antenna. (The higher a tower is, the larger an area it will serve.)
- Your tower must hold up the antenna for at least 10 seconds.

Ways in which your design is **limited**

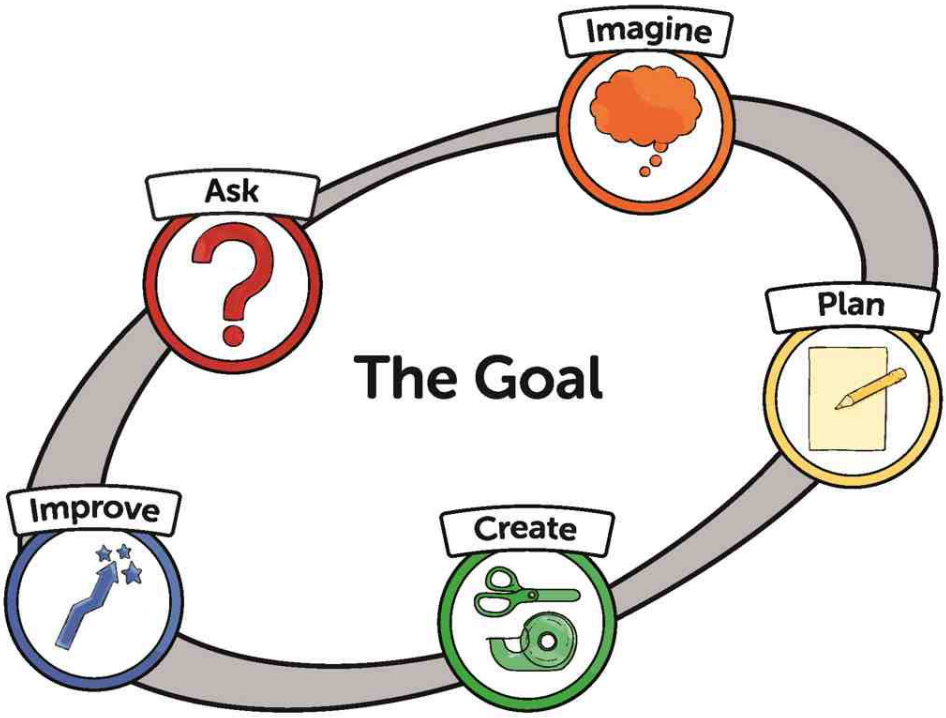
- Your group will have 100 index cards and masking tape as materials to build their tower.
- Your group will have a ruler and a pair of scissors to use as tools, but these tools cannot be part of the tower.
- You have 20 minutes to create your tower.

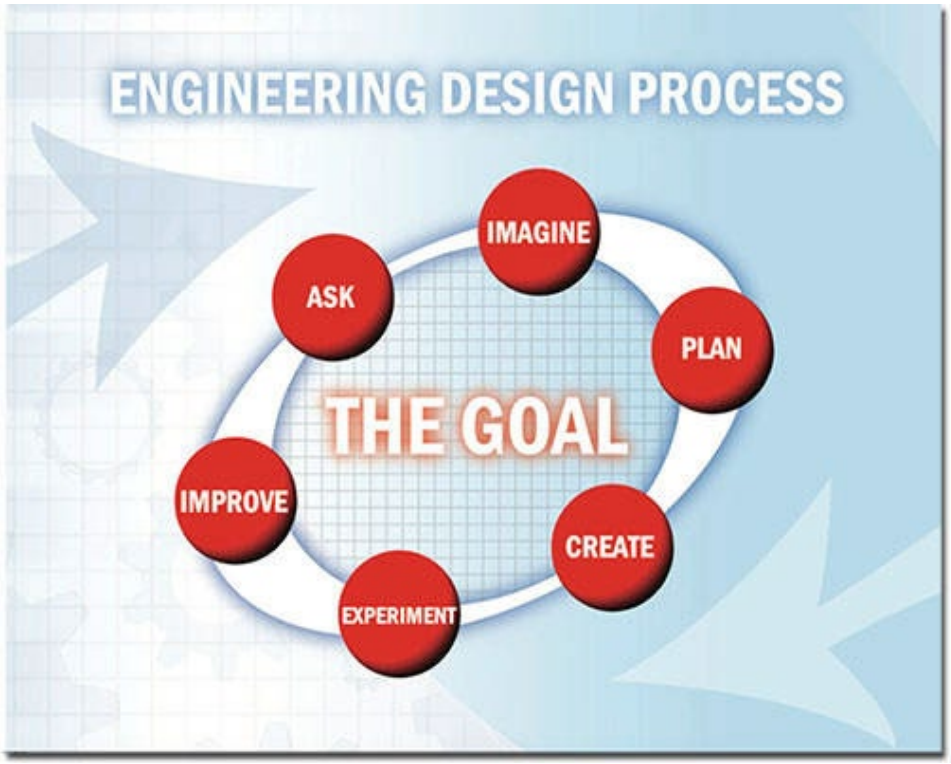
Did You Know?

Technology is any object, system, or process designed by people to solve a problem.

Engineering Prep Activity

Examples of Engineering Design Processes


Imagine
Ask
Plan
The Goal
Improve
Create


ENGINEERING DESIGN PROCESS
IMAGINE
ASK
PLAN
THE GOAL
IMPROVE
CREATE
EXPERIMENT

Engineering Prep Activity

My Engineering Profile

Record the skills that you have for solving problems. You can write, draw, or check off boxes below.

☐ **Communication**
- I give valuable feedback to others.
- I like sharing information.

☐ **Creativity**
- I imagine lots of ideas.
- I come up with new ways of doing things.

☐ **Critical Thinking**
- I solve problems.
- I make sense of complicated information.

☐ **Leadership**
- I help people work together.
- I make sure everyone gets to share their ideas.

☐ **Persistence**

- I learn from failure.
- I keep trying until I succeed.

☐ **Teamwork**

- I work well in teams.
- I like giving and receiving feedback on my work.

☐ **Technical Skills**

- I make things.
- I like working with different materials.

Record the skills you want to learn or develop for solving problems. You can write or draw below.

Engineering Context-Setting Activity

Remote Sensing Technologies

Match each remote sensing technology with what it does.

Remote Sensing Technology	**What the Technology Does**
x-ray or **CAT scan**	Makes images of the Mars surface and sends them to Earth
Automatic door	Makes a three-dimensional image of the Mars surface to make a map
HiRISE camera	Opens doors without you touching them
LiDAR	Looks inside your body without cutting you open

More to Explore

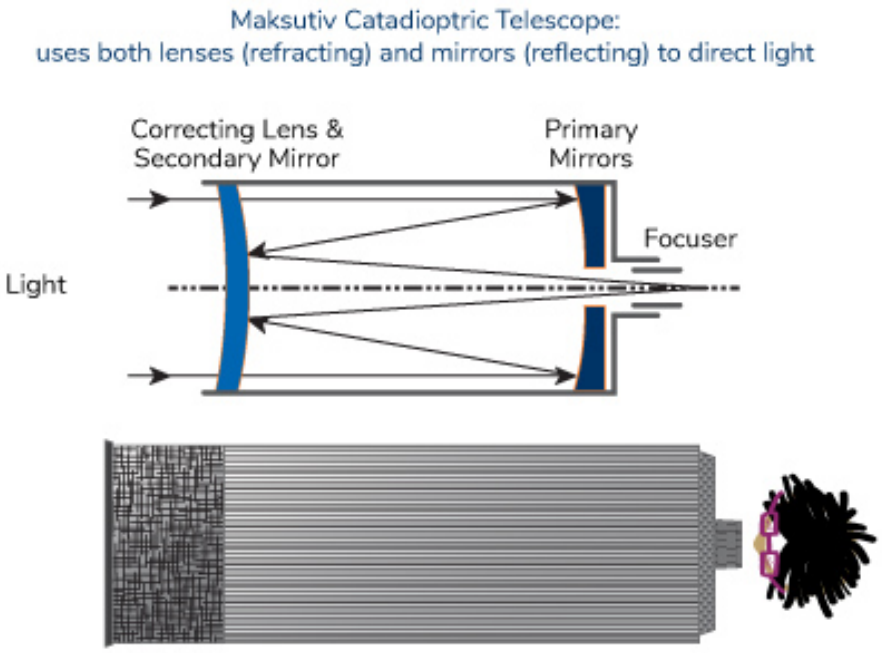
Find out more about Remote Sensing on the PLANETS website.

https://planets-stem.org/**betars-youth-resources-page/**

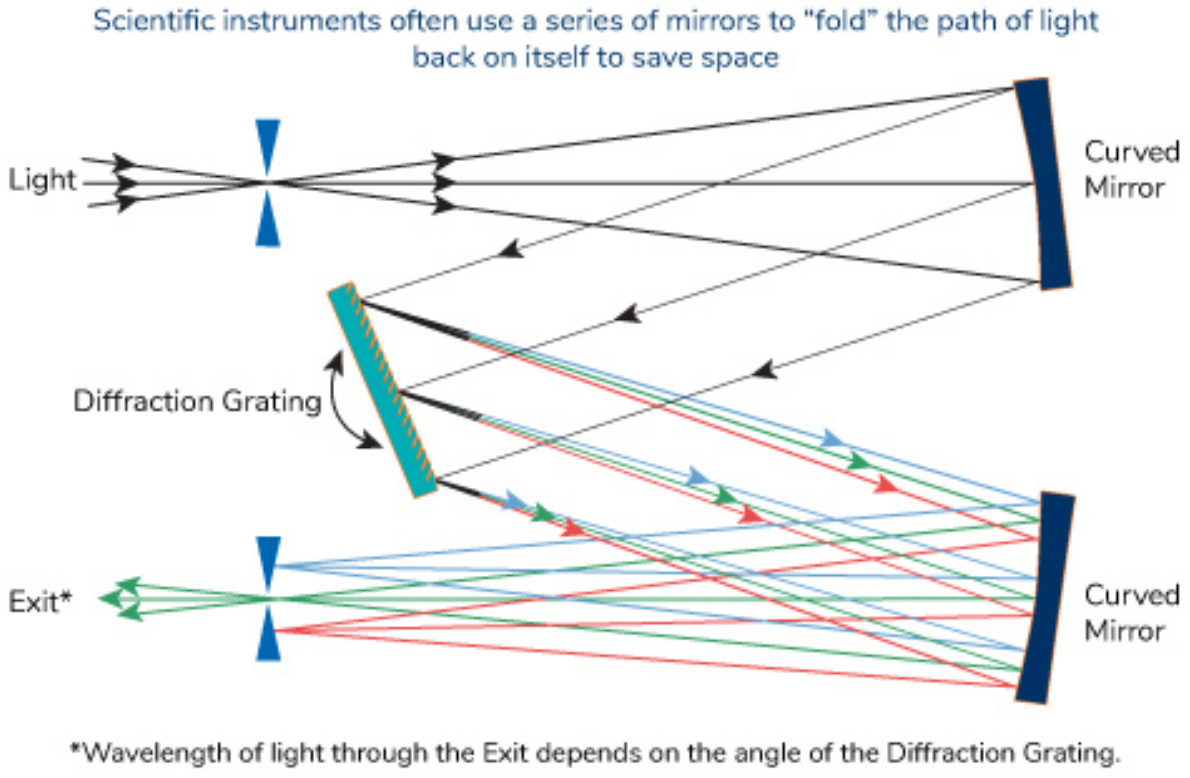
Engineering Activity 1

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!



1. 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 high-resolution pictures of the planet's surface.



2. Many **NASA** missions carry spectrometers, which split light into many different colors and measure how much light of each color there is. This diagram shows the type of spectrometer used in the ChemCam and SuperCam instruments on the Mars rovers Curiosity and Perseverance. Mirrors redirect the light back and forth inside the instrument, allowing it to be small enough to fit inside the rover. A special type of mirror called a “diffraction grating” reflects different colors of light at slightly different angles.

Did You Know?

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.

More to Explore

Find out more about the James Webb Telescope on the PLANETS website.

https://planets-stem.org/**betars-youth-resources-page/**

Engineering Activity 1

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.

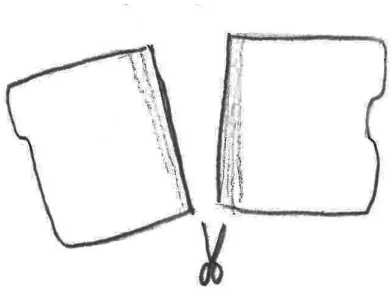
- Create a path through your obstacle course with the fewest number of straws to model the path of light from the index card, around the obstacle, to the eyepiece. Every straw must always be in contact with other straws.
- Straws cannot touch the obstacle.
- Straws must lay flat on the table.
- Straws must stay within the tape boundaries.
- The tape boundary can be used as a barrier.
- If a straw is cut into smaller pieces, each piece counts as another straw.
- 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 below.

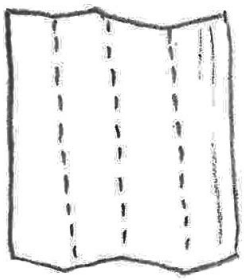
Engineering Activity 1

Getting Started with Light Redirection Systems

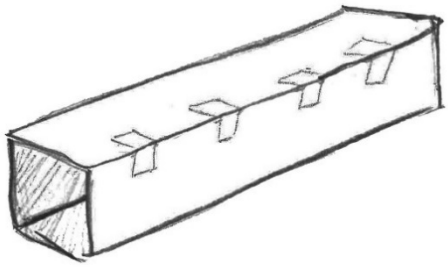
1. Cut the manila folder in half to get two sheets. Put one half aside.



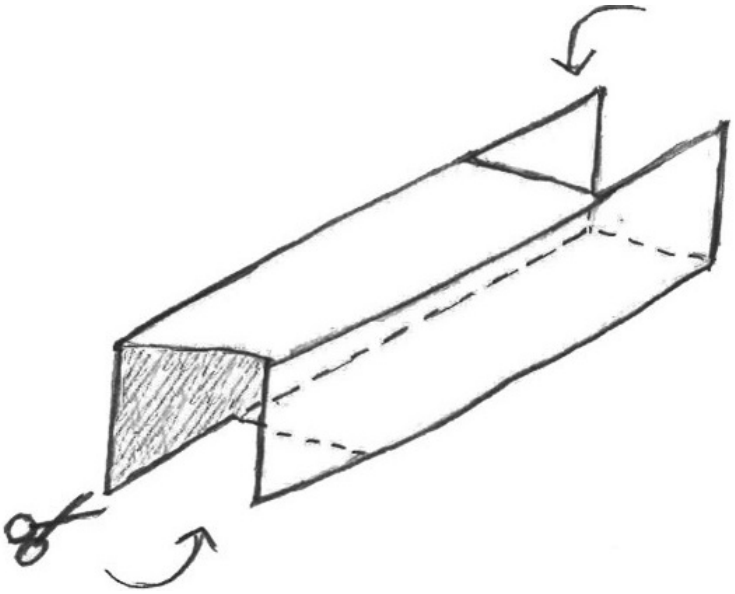
2. Fold one manila sheet in half longways, then fold it in half longways a second time. Unfold the manila sheet.



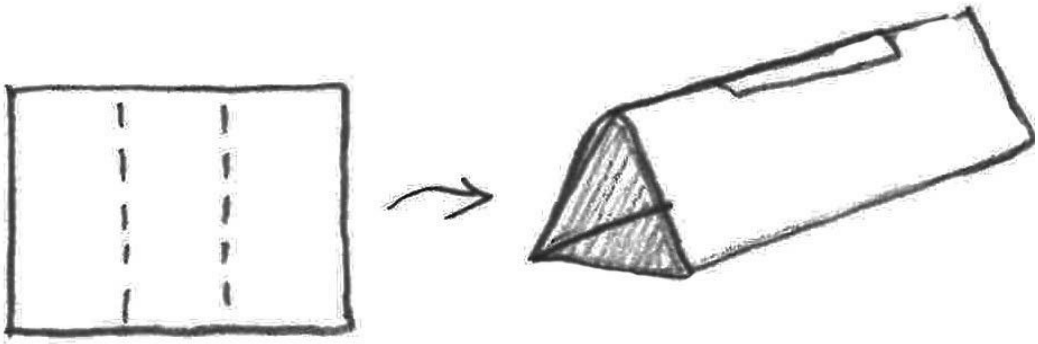
3. Fold the manila sheet into a box shape and tape it closed to make the light redirection system body.



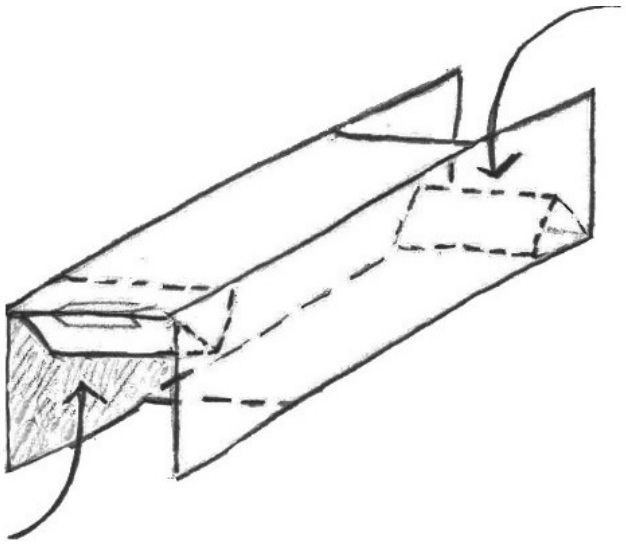
4. Cut two mirror-sized rectangles out of the box on opposite sides and opposite ends of the box. Save these rectangles for the next step.



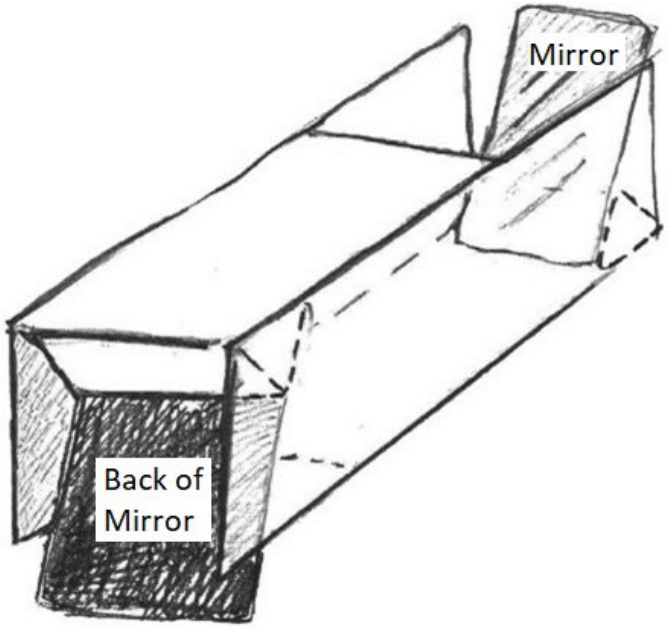
5. Fold and tape the rectangles into triangle shapes so they can be mirror stands.



6. Tape the triangles (mirror stands) inside the box at the long ends.



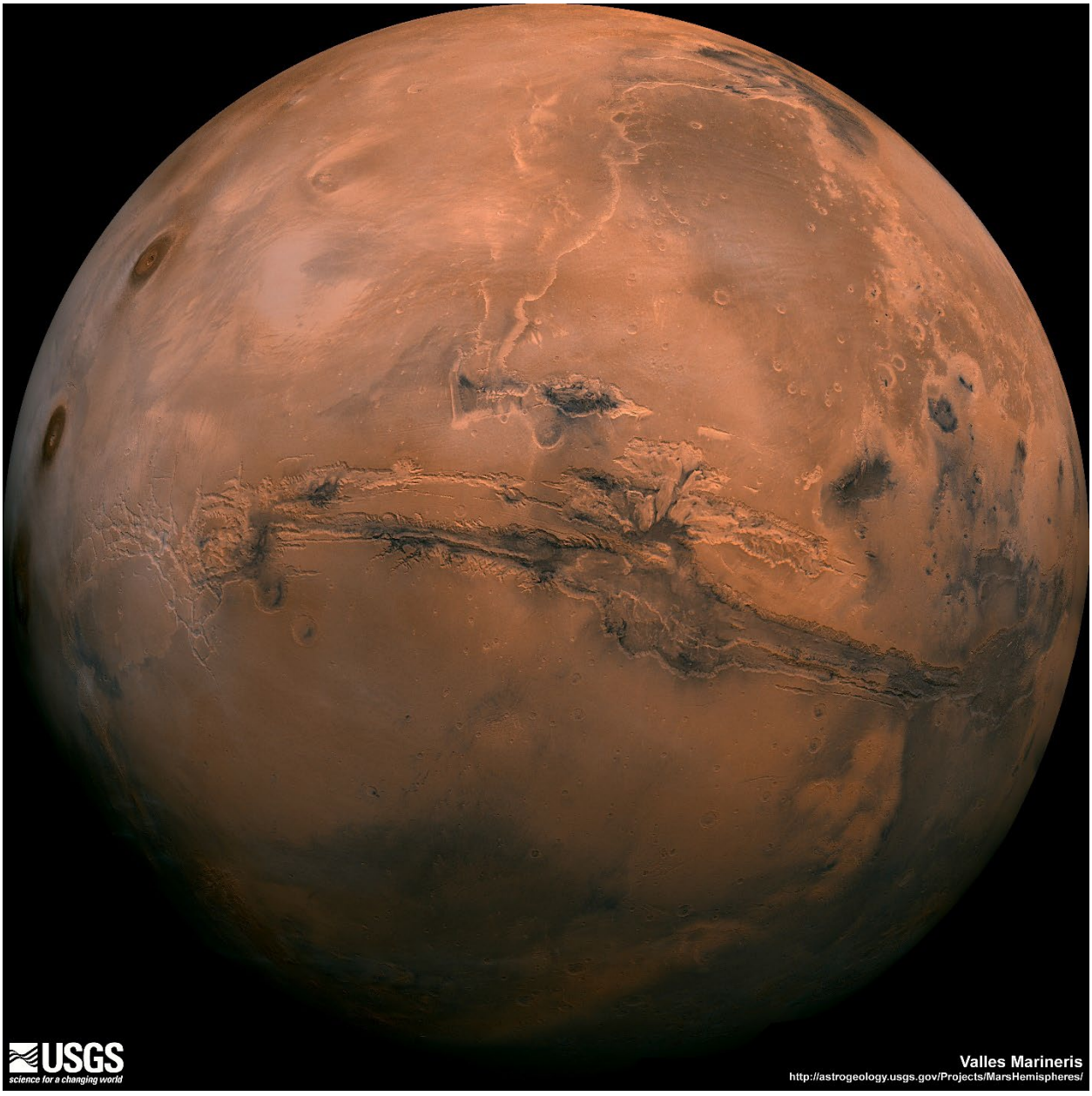
7. Position a mirror at each end of the box so it is resting against the triangle. Explore which angle is best for the mirrors before taping them down.



8. Test out your light redirection system!

Engineering Activity 2

Image of Mars



Engineering Activity 2

Data Detection Investigation—Sound

Use this space to record your observations. Which scrapers work best to help you identify the following materials, that stand for minerals?

Felt

Craft foam

Construction paper

Engineering Activity 2

Data Detection Investigation—Light

Use this space to record your observations. Which filters work best to help you identify the shapes that stand for minerals?

Different colored shapes on blue test sites

Different colored shapes on red test sites

Engineering Activity 2

Data Detection Investigation

Keep track of what you learned when combining technologies here.

More to Explore

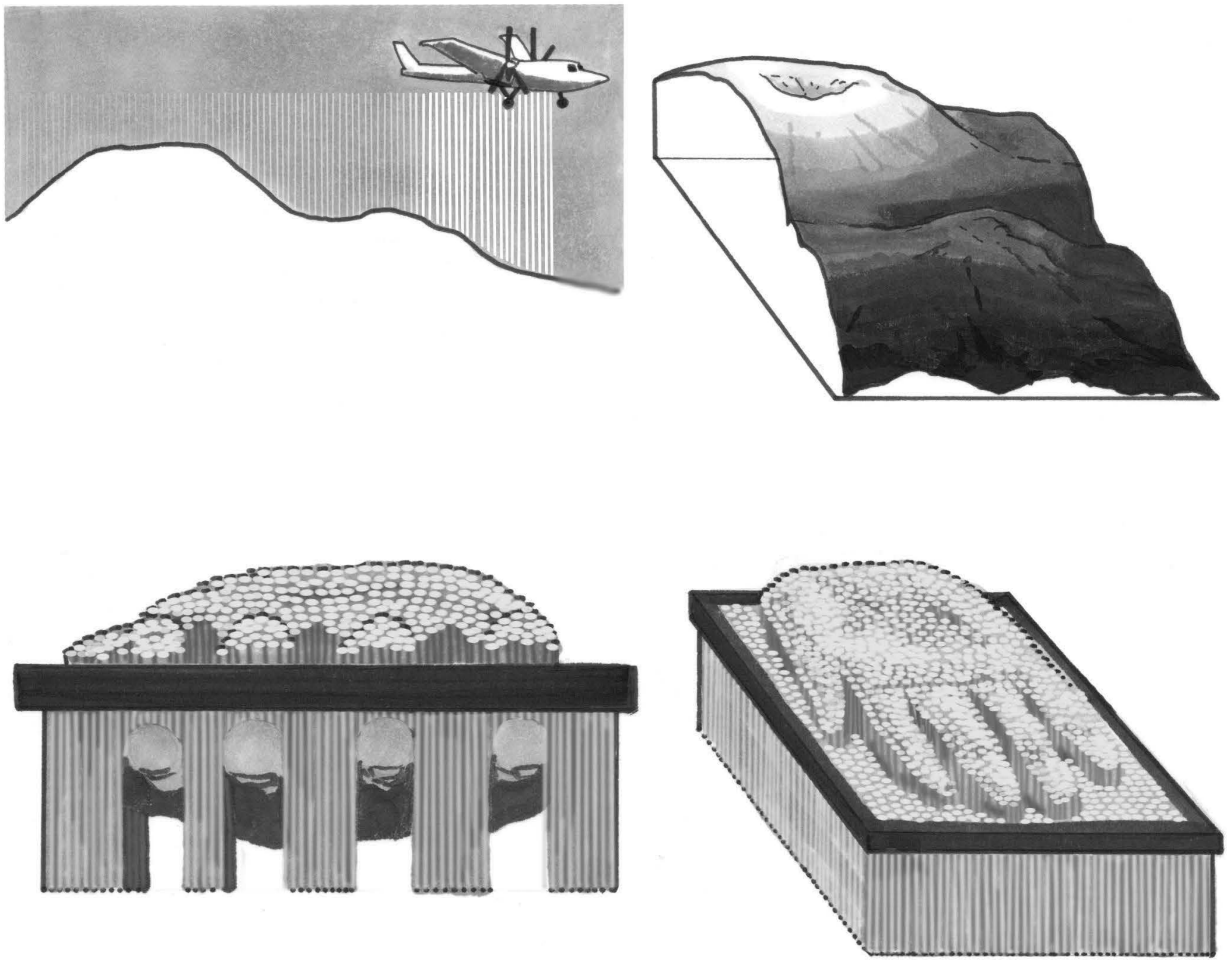
Find out more about NASA on the PLANETS website.

https://planets-stem.org/**betars-youth-resources-page/**

Engineering Activity 3

Pins and Pings

A LiDAR system measures **topography**, or the shape of land in an area, using a laser pulse. It records the time it takes for light to go to the ground and back and converts the time to distance.



Did You Know?

NASA uses lasers to collect many types of data. LiDAR can measure the height of landforms on planets, but the Curiosity and Perseverance rovers on Mars use lasers to vaporize tiny bits of rocks. The light from the resulting spark tells what the rocks are made of.

More to Explore

Find out more about the Mars Rover Missions on the PLANETS website.

https://planets-stem.org/**betars-youth-resources-page**/

Engineering Activity 3

Test Surface Elevations

Create a model LiDAR device that can detect the topography of a surface. Keep this page open so other groups can examine the data you collected.

Test 1

Examine the data you collected using your model LiDAR device and record the results. What shapes do you detect in the pattern of the straws?

Test 2

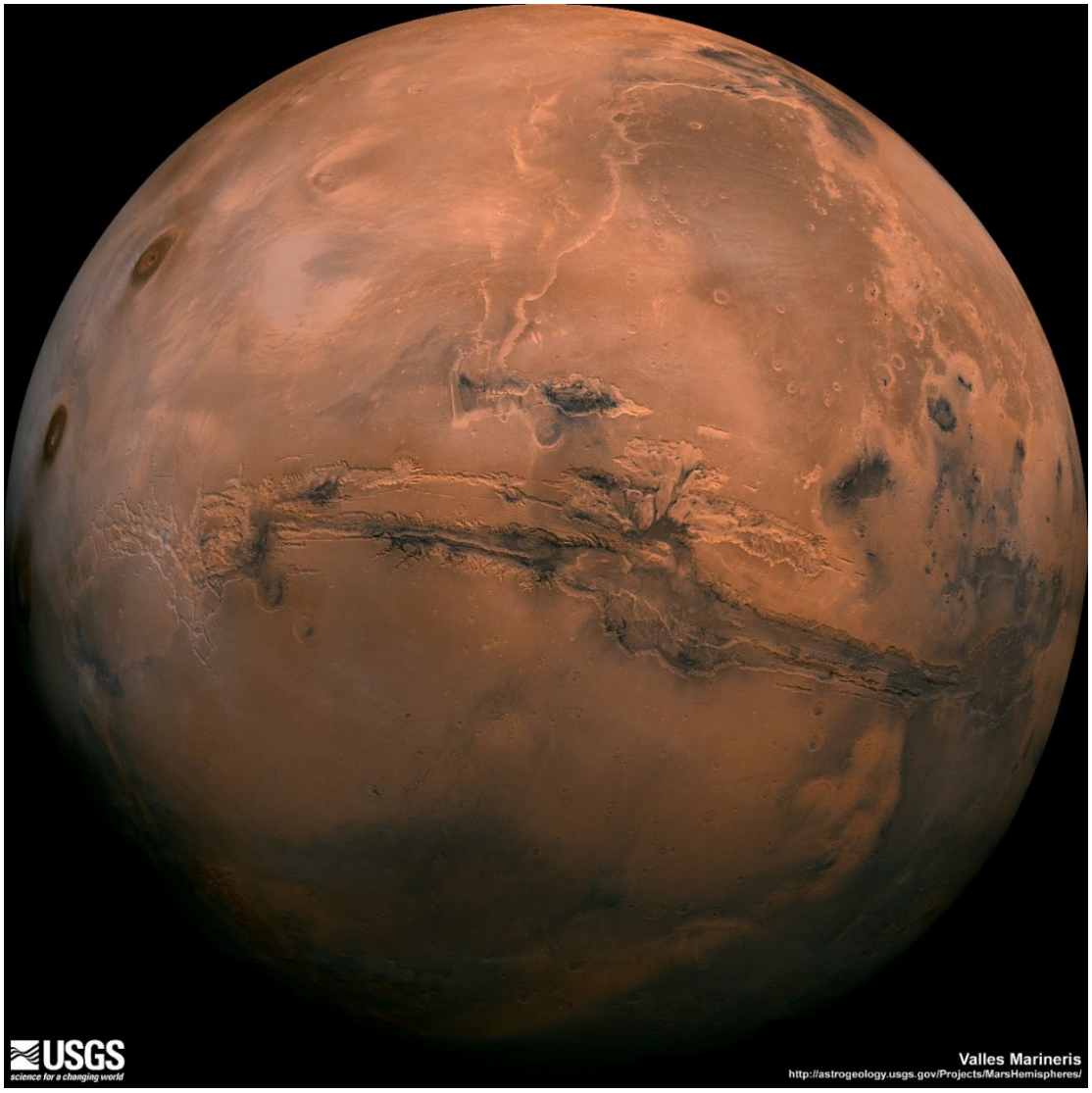
After you improve your device, record the new data you collected. What changed?

Did You Know?

Scientists like to have others check their work. It's called "peer review," and they use it to avoid making mistakes in their conclusions.

Engineering Activity 4

Remote Sensing Engineering Challenge



Your final design challenge is to engineer technologies that can collect information about the surface of Mars from a distance. You will work with one of three NASA scientists to determine what information is needed. You will test your technologies on multiple sites on Earth to make sure it works before launching to Mars.

Engineering Activity 4

NASA Scientist Cards

NASA Scientist: Jaime, planetary geologist

“I am interested in how Mars was formed. Minerals can tell me a lot about the planet’s history. What minerals are on the surface?”

Criteria

- The device must be able to identify the minerals that form in water like clays (triangle shape and felt) and sulfates (star shape and foam). It should also be able to identify volcanic minerals (circle shape and construction paper).
- The device must be able to fit through the opening in the Space Screen, which is 9″ × 20″ (23 cm × 50 cm), for testing.

Constraints

- You may only use the available materials to complete your design.
- You will have two sessions to engineer your remote sensing device(s).

NASA Scientist: Caris, planetary geologist

“I am interested in landing a rover on Mars. Sending a rover will allow us to collect samples and more closely examine what the planet is made of. Is there a flat, open space where the rover could land safely?”

Criteria

- Design a device to identify safe areas for the rover to land.
- The device must be able to determine the size of the area. To land safely, a rover needs an area of 3″ × 4″ (7.5 cm × 10 cm).
- The device must be able to fit through the opening in the Space Screen, which is 9″ × 20″ (23 cm × 50 cm), for testing.

Constraints

- You may only use the available materials to complete your design.
- You will have two sessions to engineer your remote sensing device(s).

NASA Scientist: Alex, astrobiologist

“I want to know if Mars can support life. One of the most important materials to support life is water. Are there any sites that show evidence of water?”

Criteria

- Design a device to identify places where water may have been present. Your device should identify landforms, like canyons, that may have been created by water. Your device should also identify minerals that form in water, like clays (triangle shape and felt) and sulfates (star shape and foam).
- The device must be able to fit through the opening in the Space Screen, which is 9″ × 20″ (23 cm × 50 cm), for testing.

Constraints

- You may only use the available materials to complete your design.
- You will have two sessions to engineer your remote sensing device(s).

Did You Know?

The Lunar Reconnaissance Orbiter is a spacecraft that launched in 2009 to investigate the surface of the Moon. It has six instruments onboard to investigate temperature and radiation. It also includes one “technology demonstration.” This is an instrument being tested to see if it works. Even NASA must do experiments before getting things right!

More to Explore

Find out more about the Lunar Reconnaissance Orbiter.

nasa.gov/mission_pages/LRO/spacecraft/index.html

Engineering Activity 4

Guidelines for Testing Devices

When collecting data with your remote sensing technology...

Do…

- Put your devices through the opening in the Space Screen.
- Reach through the opening in the Space Screen only when you need to push down on straws or scrape the surface.
- Move devices from left to right.
- Be careful when using the Space Screen so it does not fall over or break.

Do not…

- Peek around the sides or into the Space Screen opening.
- Put your face closer to the Space Screen than the edge of the table.
- Try to touch the inside of the model landscapes through the Space Screen with anything other than your devices.

Some of the NASA scientists are interested in the minerals on the surface of the planet. Use the key below to help decode your findings:

Felt triangles	Clay minerals
Construction paper circles	Volcanic minerals
Foam stars	Sulfate minerals

Did You Know?

About half of all Mars missions have failed. Even successful missions have had certain things that didn't work as well as desired. For example, the Curiosity Mars rover wheels get damaged by sharp rocks. Engineers learned from this problem and designed stronger wheels for the Perseverance Mars rover.

Engineering Activity 4

Remote Sensing Plan

Record a plan for your remote sensing device(s). After you test, choose areas of your design that you would like to improve.

Scientist:

Criteria:

What information is your scientist interested in?

What technologies will help you collect the data they need?

How will you improve?

You can use new materials, make your devices smaller, or improve in another way!

Engineering Activity 4

Data Collection

Record any data that you collect using your remote sensing device(s). Make sure that your device(s) can collect all of the data needed by the scientist you are working with. Be sure to visit Site A and Site B.

Site A

Record any data that you collect using your remote sensing device(s). Make sure that your device(s) can collect all of the data needed by the scientist you are working with.

Site B

Did You Know?

Some of NASA's first spacecraft sent their data to Earth so slowly that engineers could color in the image by hand, dot-by-dot.

More to Explore

Find out more about NASA's Mars Missions on the PLANETS website.

https://planets-stem.org/**betars-youth-resources-page/**

Engineering Activity 5

Data Collection: Improve

Record any data that you collect using your improved remote sensing device(s).

Site A

Record any data that you collect using your improved remote sensing device(s).

Site B

Engineering Activity 6

Communicate

You will share information about your design and the engineering challenge with others. What are some things you might want to communicate about engineering remote sensing devices?

Did You Know?

NASA's spacecraft and remote sensing devices record their own notes about the data they collect. This is called *telemetry*, and it helps scientists know all the details about how remote sensing data is collected.

More to Explore

Find out more about NASA's Missions and more on the PLANETS website.

https://planets-stem.org/**betars-youth-resources-page**/

Engineering Activity 6

My Engineering Profile 2

Think about how you have changed as an engineer and update your engineering profile.

☐ **Communication**

- I give valuable feedback to others.
- I like sharing information.

☐ **Creativity**

- I imagine lots of ideas.
- I come up with new ways of doing things.

☐ **Critical Thinking**

- I solve problems.
- I make sense of complicated information.

☐ **Leadership**

- I help people work together.
- I make sure everyone gets to share their ideas.

☐ **Persistence**

- I learn from failure.
- I keep trying until I succeed.

☐ **Teamwork**

- I work well in teams.
- I like giving and receiving feedback on my work.

☐ **Technical Skills**

- I make things.
- I like working with different materials.

Record the skills you want to use or learn for solving problems.

You can write or draw below.

Glossary

Antenna: a structure that helps send and receive signals

CAT (computed tomography) scan: an exam using x-rays to create images of the inside of a person's body

Engineering: the use of creativity and knowledge of math and science to design things that solve problems

Engineering design process: a set of steps that engineers use to design things to solve a problem

HiRISE: High Resolution Imaging Science Experiment, a camera on the Mars Reconnaissance Orbiter

LiDAR: Light detection and ranging, a technique using lasers to measure distance

NASA: the National Aeronautics and Space Administration

Technology: an object, system, or process designed by people to solve a problem

Topography: the shape of land in an area