Engineering Activity 5: Taking Shape: Finding the Shape of the Land

Educator Preview

Activity Snapshot

Learners engineer a model of a LiDAR technology to capture the shape and height of a landscape (topography).

Timing | 45 minutes

Get Ready and Team Up	10 min.
Using LiDAR	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–15 min. each

Prep Snapshot*

Prep Time 30 min.

Set up a Materials Table.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Collaboration
- Creativity

Habits of Mind

- Construct models and simulations.
- Investigate properties and uses of materials.

Guiding Question

How can we learn about the shape of the surface of Mars?

Learners Will Do

Use a straw model to gather information about the shape of a surface.

Learners Will Know

Engineers often use models to represent the technologies or materials they are investigating and test their technologies in model conditions.

Connecting Across Activities

Activity 4: Finding Minerals	Activity 5: Taking Shape	Activity 6: Creating a Remote Sensing Device
Last time, learners explored the use of filters and scrapers to gather data about minerals. These tools are a second technology they can use when designing their complete remote sensing technologies.	**Today,** they design straw model LiDAR systems to gather data on topography. These systems are a third technology they can use when designing their complete remote sensing technologies.	**Next time,** they will combine tools and systems from previous Activities and use their engineering design process to design and test remote sensing devices.

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/851cbb1e

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document). See Prep & Setup Guide (PDF)
  Examples | Templates
- towel or similar fabric object
- 1 set of 100 pattern blocks (optional)
- pin screens (optional)

For each learner

- Engineering Notebook (PDF)

For the Materials Table

- coffee stirrers
- rubber bands
- felt
- foam, craft

For each group of four

- Pins and Pings, pg. 76-77
- 2 folders, manila
- 1 ruler
- 1 pair of scissors
- 200 straws, regular size
- 1 sheet of foam, craft
- 1 rubber band
- 1 roll of tape, masking
- 4 cups, paper, 3 oz. (approx. 90 mL)
- 4+ Data Collection Grids, pgs. 62-63

Activity 5 Materials Preparation (30 min.)

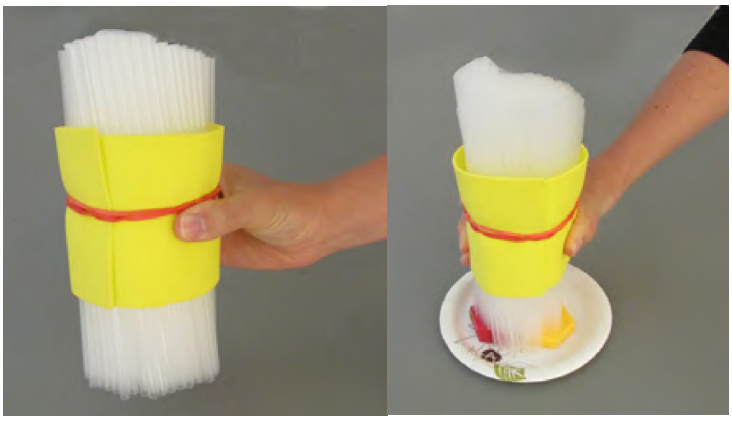
Ahead of Time

1. Review the "In-Use Example" in the Prep & Setup Guide - Examples (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. Print one copy of Pins and Pings, pg. 76-77, per group.

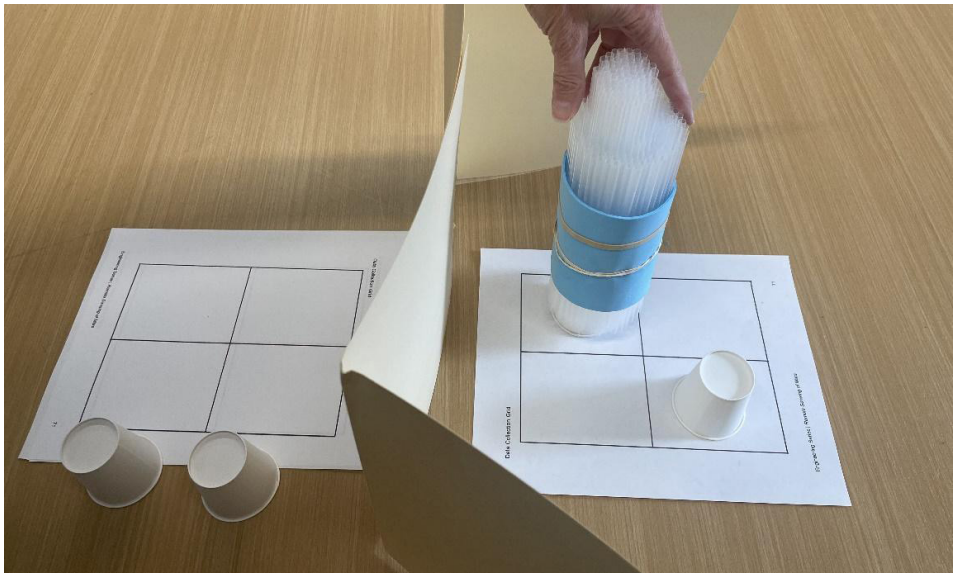
Teaching Tip

Put the materials for each group in a bag so learners can collect them quickly.

3. Print out 4–5 *Data Collection Grids* per group.
4. Bundle a handful of straws together using a rubber band and craft foam to demonstrate one way learners can keep the straws packed together in their model LiDAR device.



Model LiDAR Device



LiDAR test setup with cups

In Your Space

5. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.
6. Arrange all materials on the Materials Table.

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 on 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 instructions for building Site A and B, pgs. 85-87 and the Space Screens, pgs. 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 used scrapers and filters to gather information about minerals to answer questions about what Mars is made of.)* Indicate the scraper and filter charts on the *Our Ideas* poster.

2. Ask: **What is the problem we are trying to solve?** *(We are trying to figure out how we can gather information about Mars from far away.)*

3. Draw learners' attention to the questions on the *Our Ideas* poster about physical properties of the surface, such as height and landforms. Say: **Today, you will think about how to measure the shape of a planet's surface. It will be useful for scientists to know about the shape of the surface, so they know if it will be possible to land a rover.** Share the Guiding Question with learners: **How can we learn about the shape of the surface of Mars?**

4. Organize learners into groups of four.

Using LiDAR (25 min.)

Investigating Test Surfaces (10 min.)

5. Place the towel on the floor of the room and bunch it up so it has a variety of bumps and flat areas. Say: **Imagine this towel is a landscape. How would you describe the parts of the landscape?** *(Hills, mountains, valleys, plains, mesas.)* Allow learners to discuss in their groups.

   If needed, allow learners to feel the towel.

6. Say: **The shape of land in an area is called that area's *topography*. You will be investigating the topography of Mars.** Write the word *topography* on the *Our Ideas* poster.

7. Show the videos Using Light to Measure Distance (LiDAR Theory) and Using Light to Map Surfaces (LiDAR Uses).

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).

Support Thinking

- If time permits, go outside and travel with learners across areas of varying height and slope. Ask: **What do you notice about the shape and height of the land as we travel?** *(It is going up or down; it is steep, not steep, or flat; it is difficult or easy to travel on; there are a lot of buildings around; it is a valley or hill.)*

- To support learner understanding of the word *topography*, tell learners that it comes from the roots *topo*, meaning "place," and *graph*, meaning "to write or draw." Have learners think of other words they know that come from similar roots, such as *utopia* (a good or nonexistent place), *dystopia* (a bad place), *graph* (a drawing of data), *graphite* (a soft mineral that leaves a gray streak, used to make pencil "lead"), and *bolígrafo* (Spanish for *pen*).

8. Give each group one copy of Pins and Pings, pgs. 76-77. Say: **Scientists use a technology called Light Detection and Ranging, or LiDAR, to learn about topography from a distance. LiDAR is a tool that sends out laser pulses of light from a device to a landscape. It then measures how long those pulses take to return. This timing helps determine the height of the surface. Data from LiDAR can be used to make a representation of the shape of land in an area, which is called a *topographic map*.** Write these words on the *Our Ideas* poster.

9. Say: **Look at the images on Pins and Pings. Will someone volunteer to read the information about LiDAR and pin screens?** After it is read, say: **Turn to a neighbor to discuss: How are the pin screen and LiDAR similar?** *(They both measure topography and create a three-dimensional image.)* **How are they different?** *(LiDAR collects data from a distance by using a laser pulse that moves across an area and measures how long those pulses take to return. The pins in a pin screen are all the same length and need to touch an object to measure its topography.)* Invite sharing.

Level Up!

In the PLANETS Worlds Apart Science Pathway, learners build three-dimensional topographic models and turn them into two-dimensional topographic maps. After they have a better understanding, they interpret topographic maps of Mars to choose the best landing site for a rover.

To support understanding of LiDAR and other science topics, see the resources on the Quick Links and More Resources webpage (weblink).

10. Say: **Engineers use models to represent technologies when the real things are too big, expensive, or dangerous. Because LiDAR is expensive and difficult to build, you will create a model of it.** Demonstrate as you say: **You will use a bundle of straws as a model for the laser used in LiDAR. One way to make a model LiDAR is to collect the straws in a bundle, wrap a piece of foam around the middle, and wrap a rubber band around the foam to hold the bundle in place.**

11. Demonstrate how the straws react by pressing one end of the bundle onto a small, flat object, such as a roll of masking tape, to reveal its shape. (See photographs of this procedure on pg. 69.) Say: **The straws will touch a surface and show the topography underneath, similar to the pin screen.** As needed, pass the demonstration bundle of straws around so learners can feel it.

12. Say: **Your team will assemble a LiDAR model and make sure it works by pressing it on some items on your table. Then you will play a game in your groups. If you were here last time, the game will be familiar.**

13. Demonstrate the set up as you explain (a video demonstration is also available): One pair will be the Hiders and set up two manila folders to hide a *Data Collection Grid*. They will put two cups on the grid in secret. The other pair will be the Detectors. They must use a model LiDAR to figure out which boxes–A, B, C, or D–the cups are in. The Detectors will record what they find by placing the cups in the matching boxes on their own *Data Collection Grid*. Then, they will remove the barrier and check if they were correct. The pairs will switch roles and play again. As needed, give learners time to feel the setup.

Mapping a Test Surface (15 min.)

14. Send one member of each group to retrieve two boxes of 100 straws, a piece of craft foam, a rubber band, two manila folders, a ruler, and four *Data Collection Grids*. Say: **When you have your materials, you may create your test surfaces, test your devices and evaluate the quality of the topographic data your devices collect.**

15. Circulate as groups are testing. Ask: **What happens when the straws hit an object?** *(Straws move up where they hit something. All the straws together show the object's shape.)* **How can you tell when the straws hit a flat area?** *(The straws are all the same height.)*

16. After you are sure learners have gotten the hang of the game, get the group's attention. Say: **The LiDAR devices you engineer must produce information about topography that scientists will use to understand the landscape of Mars. The places NASA is interested in have a more complicated topography than the simple one you just modeled. How can you record and represent where the landscape features are and how high the surface is, so someone else can understand?** *(We could represent how the landscape appears from the side and from above. We could create a 3D image like the one on* Pins and Pings *or a topographic map.)*

17. Say: **As engineers, we don't need to focus on creating a detailed topographic map. Our focus is designing a technology that captures the best information about where landscape features are located and how high they are. As you test, notice the raised shape in the straws, use a ruler to measure differences in height, and draw what the shape looks like from the side in *Side View* on *Test Surface Heights*, page 12 in your Engineering Notebooks. We also need to represent where the landscape features are in relation to the other features. A perspective from above is sometimes called a *bird's-eye view* because it is how a bird would see a landscape while flying over it. Draw what the landscape looks like from above in *Bird's Eye View (page 13).* Add labels as needed.** Add the term *birds'-eye view* to the *Our Ideas* poster.

18. As groups are testing, ask: **What data are you able to collect with your model LiDAR device?** *(The general shape and height of objects on the test surface.)* **How might this data be useful to scientists?** *(Scientists can use it to determine if there are any flat surfaces to land a spacecraft on a planet.)*

Teaching Tips

Learners may need to use tools to make the manila folder barrier slightly shorter or they may need to reach around the barrier.

If you have enough materials, have learners work in pairs.

Support Learner Differences

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

Consider assigning learners to collaborative groups or to roles that value their abilities for this part of the activity. See the Intentional Grouping Strategies, pg. xxii.

Support Thinking

Direct learners to the side view image on *Pins and Pings*. Have them shine a light on the side of the LiDAR devices and view the shadows that are created. This process will help them see the differences in height and draw a side view of the landscape.

Reflect (10 min.)

19. Invite groups to share what they have learned. Ask: **What worked well? What didn't work so well? What was the best way to record what you learned?** Encourage learners to share their designs and drawings.

20. Revisit the Guiding Question on the *Our Ideas* poster: **How can we learn about the shape of the surface of Mars?** *(LiDAR shines a laser on the surface of a planet and measures how long it takes the laser to bounce back. This time lets us calculate how far away the surface is. By using many laser bounces, we can gather information about the topography.)* Remind learners of the terms *topography*, *topographic map*, and *LiDAR*.

21. Ask: **When might someone need to know about topography in everyday life?** *(Finding a place to play soccer or camp, using depth finders for fishing, etc.)* Have learners record their ideas on the *Our Ideas* poster. Consider returning to learners' ideas at the start of the next activity.

22. Point to the *Our Ideas* poster and ask. **What questions do you still/now have?** Record any new ideas.

23. Say: **Good job working as engineers today! Next time, you will use what you learned to design and test remote sensing devices to gather information from a distance so you can recommend the designs that gather the best information.**

Teaching Tip

Let learners know that peeking might help them with this challenge, but it won't help them when they are trying to determine the topography of the surface of a planet!

Level Up!

- After learners have tested their devices and recorded the information once, encourage them to use materials (such as stacks of pattern blocks taped together) to make the test surfaces more complex and challenging. They can also make improvements to their LiDAR models using materials from the table. For example, they can use smaller straws to increase the resolution or improve the model to keep the straws from falling out. (15 min.)

  The PLANETS Worlds Apart Science Pathway goes into more depth about how to interpret topographic maps.

- Refer to the Engineering Design Process poster (PDF). Ask: **What phases of the Engineering Design Process did you use today?** *(We investigated how LiDAR systems work.)*

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for use in Activity 6.
   - Store learners' technologies and collect testing setups and unused materials for use in Activity 6.
2. Plan ahead for Engineering Activity 6. See Activity 6 Materials Preparation on pg. 80.
3. Take time to reflect on the following educator prompts: **How did you help learners understand the ways in which the straw model is similar to and different from real LiDAR? How did you support learners in acquiring difficult vocabulary?**

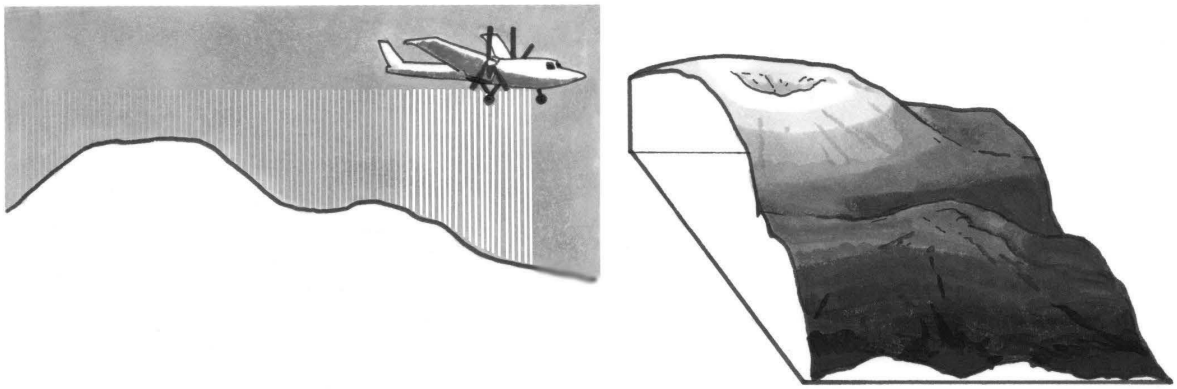
Remote Sensing Additional Resources

QR code leads to resources available for this unit.

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

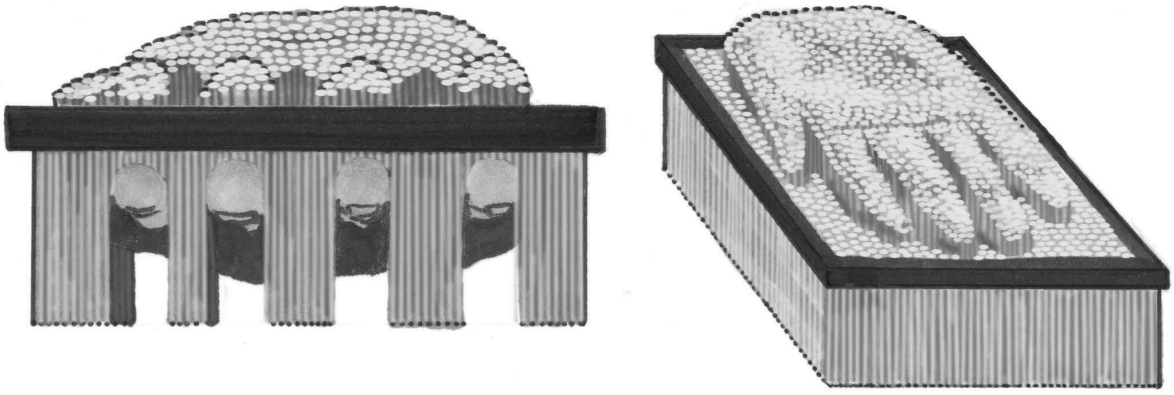
Pins and Pings

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



Side View *Bird's Eye View*

Illustration of an airplane with LiDAR measuring topography and the three-dimensional model it creates after multiple scans.



Side View *Bird's Eye View*

Illustration of a hand pushing up pins on a pin screen and the three-dimensional model of the hand a pin screen creates.

More to Explore

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

weblink: https://planets-stem.org/remote-sensing/rs-learners/