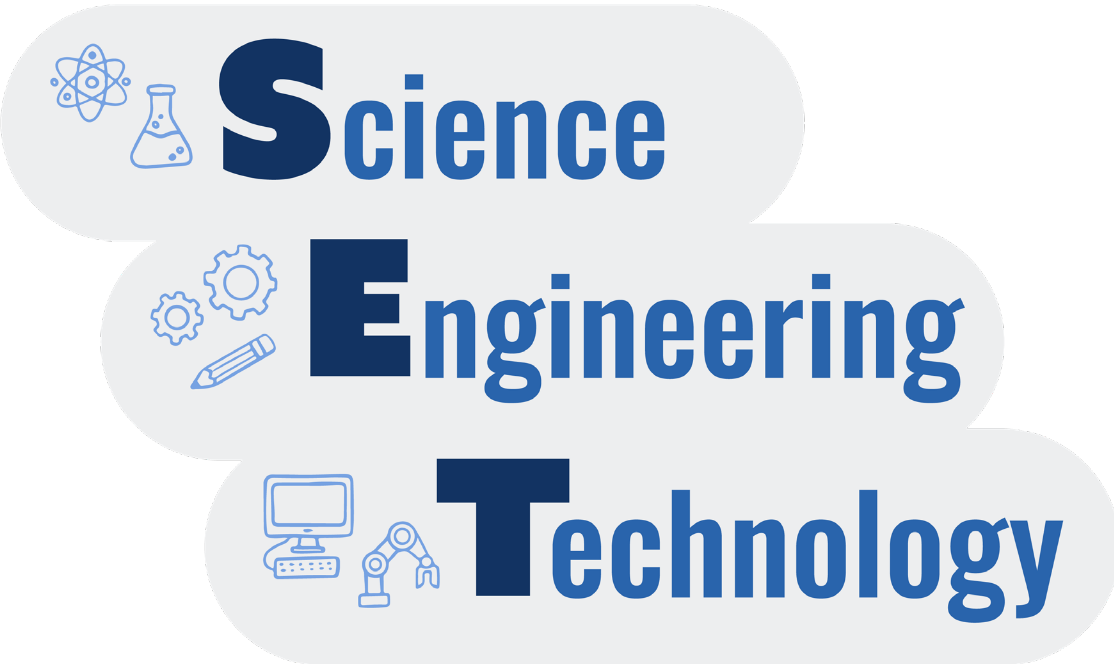
Ready, S.E.T. (Science, Engineering, Technology), *Go!*



Educator Preview

Activity Snapshot

Learners design spacecraft to gather data about Mars. As scientists, they choose a mission. As engineers, they figure out which instruments to send.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Plan & Create (S.E.T.)	25 min.
Reflect (Go!)	10 min.
Total	**45 min.**

Level Up Activities 5–30 min. each

Prep Snapshot*

Prep Time 60 min.

- Read unit.
- Print Notebooks.
- Cut out instruments.
- Make an *Our Ideas* poster.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Habits of Mind

- Use a structured problem-solving process.

Science Practices

- Planning and Conducting Investigations

Guiding Questions

Which survey mission should we send to Mars?

What instruments does a spacecraft need for it?

Learners Will Do

As scientists, choose a type of mission. As engineers, choose and arrange instruments for that mission.

Learners Will Know

Scientists and engineers can work together to solve problems.

Connecting Across Activities

Ready, S.E.T., Go!	Activity 1: Sharing Experiences
Today, learners design spacecraft to gather data about Mars. As scientists, they choose a mission. As engineers, they figure out which instruments to send on the mission.	**Next time**, learners share experiences with, and stories about, technology.

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/62c6fd93

Materials and Preparation

Materials

For the educator

- *Our Ideas* poster (on paper or a shared digital document). See Prep & Setup Guide (PDF) Examples | Templates
  - index cards
  - markers
  - scissors
  - tape

For each group of 4–6

- Cutouts from Fairing and Instruments Sheets, pgs. 14-17
- Engineering Ready, S.E.T., Go! Visual Instructions Handout, p.18

For each learner

- Engineering Notebook (PDF)

Ready, S.E.T., Go! Materials Preparation (60 min.)

Ahead of Time

1. Read through the entire PLANETS Engineering Pathway Educator Guide to learn more about the engineering content in this unit.
2. Read the Educator Background (weblink) for context about the science and engineering in the unit.
3. Print and staple one *Engineering Notebook* for each learner, in color if possible. As needed, prepare to share the Notebook digitally.
4. Print a copy of the Notebook for your own reference throughout the pathway.
5. Prepare an *Our Ideas* poster by following the online Prep & Setup Guide - Examples (PDF). Add the Guiding Question "Which survey mission should we send to Mars? What instruments does a spacecraft need for it?" so learners can refer to it throughout the activity.

Teaching Tip

This activity is the same in both the Science and Engineering Pathways. If you have already taught it in one pathway, you do not need to teach it again.

This activity can stand alone as a brief single-session program.

Support Learner Differences

- The *Engineering Notebook* can be printed in large font and you can share a digital version that will work with screen readers. The Notebook is written in English, but you can translate the instructions into other languages ; see translation guidance in our Translatable Glossary (DOCX).
- If you think learners will benefit from having more space in the Notebook, print one-sided or add sheets of blank paper as you make the Notebooks.

Teaching Tip

You can begin the *Our Ideas* poster with several standard 23" × 32" pieces of chart paper. If you fill them up before the end of the pathway, add more pieces. See the weblink for *Our Ideas* Examples in the Prep & Setup Guide (PDF).

The *Our Ideas* posters capture students' authentic language and ideas as they emerge in real-time discussions. The posters are not meant to simply display and front-load vocabulary. The posters develop over time as the educator listens for and adds the language that learners use in the moment, thus validating their ideas, providing feedback and supporting sensemaking and language development.

Support Learner Differences

Different learners have different needs. Choose from the following tips to best support your learners:

- View the Translanguaging Video to support learners who speak multiple languages.
- For those with low vision: add tactile elements, such as three-dimensional representations and Braille. Prepare a shared digital document all learners can access, ensuring that it supports text-to-speech for your learners.
- Add learner questions to the *Our Ideas* poster to foster an interest-led approach.

6. Cut out one set of instruments from the Fairing and Instruments Sheets, pgs. 14-16 for each group of 4–6 learners. Cut around the edges of the instruments themselves, not around the edge of the rectangles.

7. Print one Instruments Key, pg. 17 for each group of 4–6 learners.

8. Print one Engineering Ready, S.E.T., Go! Visual Instructions Handout, pg. 18, for each group of 4–6 learners.

In Your Space

9. Place the *Our Ideas* poster in a location all learners can access. Make a plan to store it between activities.

Support Learner Differences

If it will support your learners, consider making the following modifications to each instrument:

1. Punch out the white circle to indicate the top center.

2. Attach dots to indicate the relevant levels of communication, weight, and power: one dot if the feature does not appear, two dots if it is a low value (e.g., low power, low weight), and three dots if it is a high value (e.g., high power, heavy).

3. Attach a Braille sticker over the instrument number to indicate that number (e.g., "S4").

4. Print an extra Instruments Key, pg. 17, cut out the information for that item, and tape it to the back of that instrument.

Consider also placing all the instruments for each group in a tub or other container.

Activity Guide

Get Ready & Team Up (10 min.)

1. Organize learners into groups of 4–6.
2. Say: **NASA wants to learn about Mars; one way they do that is by sending spacecraft to orbit the planet. Today, you are going to choose a mission to learn about Mars and design a spacecraft for it.** Share the Guiding Question with learners aloud and in writing *(using multiple languages as needed)*: **Which survey mission should we send to Mars? What instruments does a spacecraft need for it?**

Plan & Create (S.E.T.) (25 min.)

Science: Choose a Mission

3. Ask: **What kinds of things do you think we should learn about Mars?** *(What it is made of, what mountains and other features it has, how big it is, where there is water, where a rover could land.)* Give groups five minutes to discuss and record their ideas on the *Our Ideas* poster. Say: **We will keep recording ideas on this poster.**
4. Say: **You've listed many possible things to study on Mars. It is not possible to study them all at once, so you will have to choose one mission to design for.**
5. Give each learner an Engineering Notebook. Say: **This Notebook is a place to record your observations and ideas.**

Support Learner Differences

- Check out the Intentional Grouping Strategies, pg. xxii.
- If learners are new to you or each other, have them share their names, name pronunciations, and other important parts of their identities. These introductions are important for all learners and can be especially relevant for Indigenous learners, multilingual learners, and learners with different physical abilities. You can also distribute index cards and have learners write anything they want you to know but do not want to share with the whole group, such as resources that will help them learn. If everyone knows each other's names, ask if anyone has a middle name or nickname you could learn to pronounce. Invite them to share about it.

For more strategies to engage learners, refer to Designing Instruction to Reach Diverse Learners, pg. xv.

Teaching Tip

Throughout this guide, information for you to say to students appears in **bold**. You can say the bold sentences exactly as they are written or paraphrase them.

Support Learner Differences

Recording learners' ideas using words, diagrams, and pictures on the *Our Ideas* poster or shared digital document throughout the activities allows them to refer to the poster to remember words and build on past ideas. You can refer to an "In-Use Example" in the online Prep & Setup Guide - Examples (PDF).

If you have learners who speak multiple languages, encourage them to share in their preferred languages.

6. Have learners turn to *Missions to Mars*, Engineering Notebook, pg. 2. Say: **NASA designs different missions for different purposes. This page describes two different kinds of missions to Mars. Decide as a group which one you want to complete.**
   - **A *global survey* is a long-term mission to explore and map a new planet or moon.**
   - **A *landing site* selection survey is a short-term mission to choose the best place to land a robot or human on the surface.**
7. Allow each group to discuss, choose one mission, and mark it on the Notebook page.
8. Say: **Now that you've chosen a mission, you need to figure out what the mission needs to succeed.**
9. Say: **Survey missions need to make images. Which mission do you think needs more detailed images? Which mission needs less detailed images?** *(A global survey needs less detail because it is observing the entire planet. A landing site selection survey needs more detail because it is observing specific smaller locations.)*
10. Say: **The amount of detail in an image is called its resolution. A global survey can have lower-resolution images; a landing site selection survey needs higher-resolution images.** Write the word *resolution* on the *Our Ideas* poster. You can have learners add translations, drawings, or related images to the poster as well. Have learners record the level of resolution their chosen mission needs in their Notebook.
11. Say: **Some missions need to know what the surface of a planet is made of, and some just need to know the planet's general shape and texture. Which do you think is needed for each mission?** *(A global survey needs to know about shape and texture, but not necessarily what the surface is made of, because nothing is landing on the surface. A landing site selection survey needs to know shape and texture as well as what the surface is made of, because that information is important when landing.)*
12. Say: **The shape and texture of a surface are called its *physical properties*. Knowing about these is required for all missions. What a surface is made of is called its *composition*. Knowing about this is required for a landing site selection survey and optional for a global survey.** Write the terms *physical properties* and *composition* on the *Our Ideas* poster. You can have learners add translations, drawings, or related images to the poster as well. Have learners record information their chosen mission needs in their Notebook.
13. Explain that things a successful design needs to do are its *criteria*. Learners have just listed criteria for each mission. Have learners write this word after its definition in the Notebook and add it to the *Our Ideas* poster.
14. Say: **Throughout history, people have figured out how to learn more about the world, from local plants and animals, to Earth, to other planets. Like these people, you have been using some of the same practices as scientists. Scientists do many other things that we did not have time to do today, such as analyzing data.** Write the word *scientist* on the *Our Ideas* poster. Have learners work together to come up with a description of scientists and record it on the poster. *(For example: Scientists often ask questions, test things out, make observations and measurements, and gather evidence to answer the questions.)* You can have learners add translations, drawings, or related images to the poster as well.

Engineering: Design a Spacecraft

15. Ask: **Now that you have chosen a mission and figured out its criteria, what do you think you should do next?** *(Figure out how to complete the mission, design a spacecraft to do it.)*

Support Thinking

To help learners understand what they will be doing during this activity, play the translatable video [Remote Sensing Instructional Read Aloud]().

16. Have learners discuss in their groups: **What kinds of things does a spacecraft need to work? What kinds of things does it need to study the surface of Mars?** *(A spacecraft needs a source of power and a way to communicate with Earth. It needs technologies like cameras and sensors to study the surface of Mars.)*
17. Hand out one set of *Fairing and Instruments Sheets* cutouts, one *Instruments Key*, and one *Engineering Ready, S.E.T., Go! Visual Instructions Handout*, to each group. Say: **You will design a spacecraft using these pieces of paper, which represent different instruments and parts of the spacecraft. This key explains what each instrument is.** Demonstrate how to use the key: for example, find the S1 instrument and look it up to determine it is the High Resolution Camera.
18. Ask: **What symbols are on these instruments? What do you think they mean?** *(The bars mean communication or signal. The weight means how much it weighs. The battery means power.)*
19. Have learners sort the instruments by how big they are. Ask: **What do you notice about the size of the instruments?** *(They are different sizes. Some are small, some are medium, and some are large.)* Say: **When NASA designs a spacecraft, they build it so it can fit on top of a rocket. The part that sits on top of the rocket and protects a spacecraft during launch is called the fairing. All the instruments need to fit inside the fairing and not overlap.** Have learners find the piece of paper that represents the fairing.
20. Have learners sort the instruments by how much power they need or how much power they give. Ask: **What is needed to power these instruments?** *(Different instruments need different amounts of power. Some power sources give more power than others.)* Say: **Your spacecraft must have as much power as whichever instrument needs the most power. For example, if you have an instrument that needs a full battery, you need a source that provides a full battery of power.**
21. Have learners sort the instruments by how much data volume they need or how much data volume they can communicate. Ask: **How much data volume do these instruments need to communicate?** *(Different instruments need to send different amounts of data. Some communications relays can send more data than others.)* Say: **Your spacecraft's communications relay must have a data signal that supports whichever instrument has the highest data signal needs. For example, if you have an instrument that needs more than two bars of signal, you need a relay that can transmit large data volumes.**
22. Explain that limits on a design are ***constraints***. Learners listed the constraints for their spacecraft. Have learners write this word after its definition in the Notebook and add it to the *Our Ideas* poster.
23. Say: **Now it is time to choose instruments for your spacecraft. You need to choose two types: instruments to help you learn about the planet for your mission (your criteria) and instruments to provide as much power and data volume as you need (your constraints).** Give groups 5 minutes to choose instruments.

Level Up!

Have learners sort the instruments by weight. Ask: **What do you notice about the weight of the instruments?** *(They have different weights. Some are light, some are moderate, and some are heavy.)* Set a limit for the maximum amount of weight on the spacecraft. (5 min.)

24. Say: **Now it is time to arrange the instruments inside your fairing. They must fit without overlapping and without going past the edge of the fairing.** Give groups 5 minutes to arrange the instruments.

Support Thinking

Help learners understand that this challenge does not have a single correct answer. Learners need to make trade-offs in what they include on their spacecraft.

25. Say: **Humans often need to learn about things that are far away. Throughout history, people have done this in many ways, from telescopes to spacecraft. Like these people, you have been using the practices of engineers.** Write the word *engineer* on the *Our Ideas* poster. Have learners come up with a description of engineers together and record it on the poster. *(For example: Engineers design things to solve problems.)* You can have learners add translations, drawings, or related images to the poster as well.
26. Say: **Scientists start with a question and work to answer it. Engineers start with a problem and work to solve it. The objects, systems, and processes engineers design to solve problems are *technology*; for example, the spacecraft you designed are technologies. Engineers often design technologies that help scientists answer their questions. They depend on each other.** Write the word *technology* on the *Our Ideas* poster. You can have learners add translations, drawings, or related images to the poster as well.

Reflect (Go!) (10 min.)

27. Have learners discuss the following questions in their small groups: **Where on Mars do you think it might be interesting to land your spacecraft? What would be useful to know about the place before it landed there?** Consider returning to learners' ideas at the start of the next activity.
28. Say: **You will be acting as engineers to help solve more problems in space. These problems will involve designing technologies to gather information from a distance. You will think about the phases you used to solve the problem of designing the spacecraft so you can use those phases again later with other problems.**

Level Up!

- Learners may believe that *technology* refers only to devices powered by electricity. Explain that anything designed by people to solve a problem is technology. Have learners identify non-electrical technologies around them. (10 min.)

  Have learners create portrayals–through drawing, acting, or some other method of their choice–of scientists and engineers working together to plan missions and design spacecraft. (30 min.)

- Instead of using the premade *Engineering Design Process*, you can have learners make their own. If you do so, skip Step 29 and refer to the Level Up! at the end of this section instead.

29. Have learners turn to Our *Engineering Design Process*, pg. 3 in their Notebooks. Say: **There are many different processes that engineers use to design things to solve problems. You will be using these seven phases as your *Engineering Design Process*: Frame, Investigate, Brainstorm, Plan, Create, Test, and Evaluate. Then you go through the cycle again, or Iterate, to improve your design.** Ask: **How did you use this *Engineering Design Process* when engineering a spacecraft?**

(We framed the problem of fitting instruments into the fairing, investigated the instruments' requirements, brainstormed ways they could fit, planned and created an arrangement, tested whether it would fit and evaluated the results, and iterated as necessary to find a better solution.)

30. Say: **Next time, we will think about what we already know about technology and why it is important.**

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for Activity 1.
   - Collect all paper cutouts. If possible, save them for reuse.
2. Have learners invite people from the community, including their families and friends to the Engineering Share-Out in Activity 9 (see pg. 103).
3. Plan ahead for Activity 1. See Activity 1 Preparation on pg. 20.
4. Take time to reflect on the following educator prompt. **How did you create connections between the science and engineering portions of the activity?**

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

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

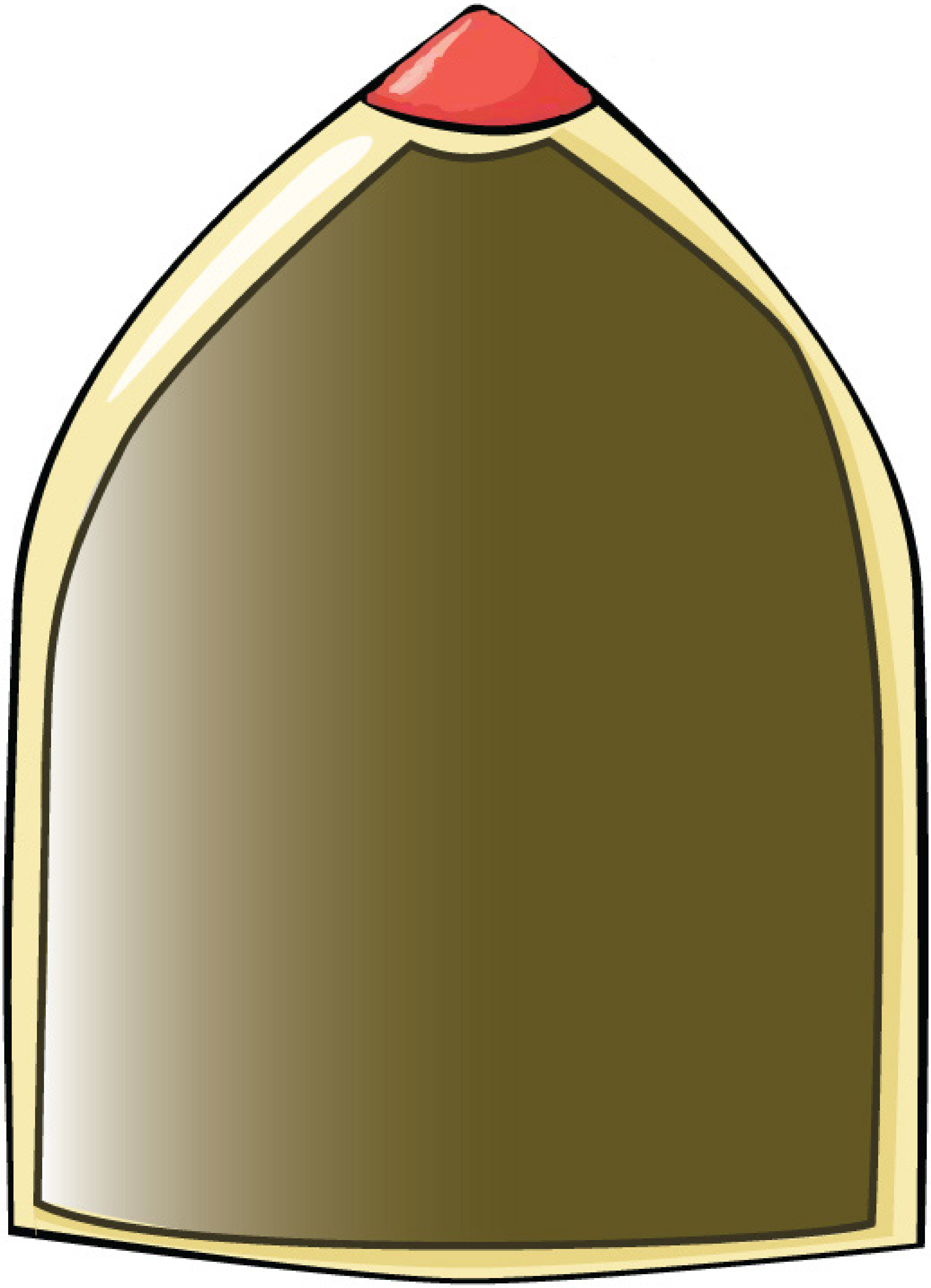
Level Up!

If time permits, have learners create their own engineering design processes:

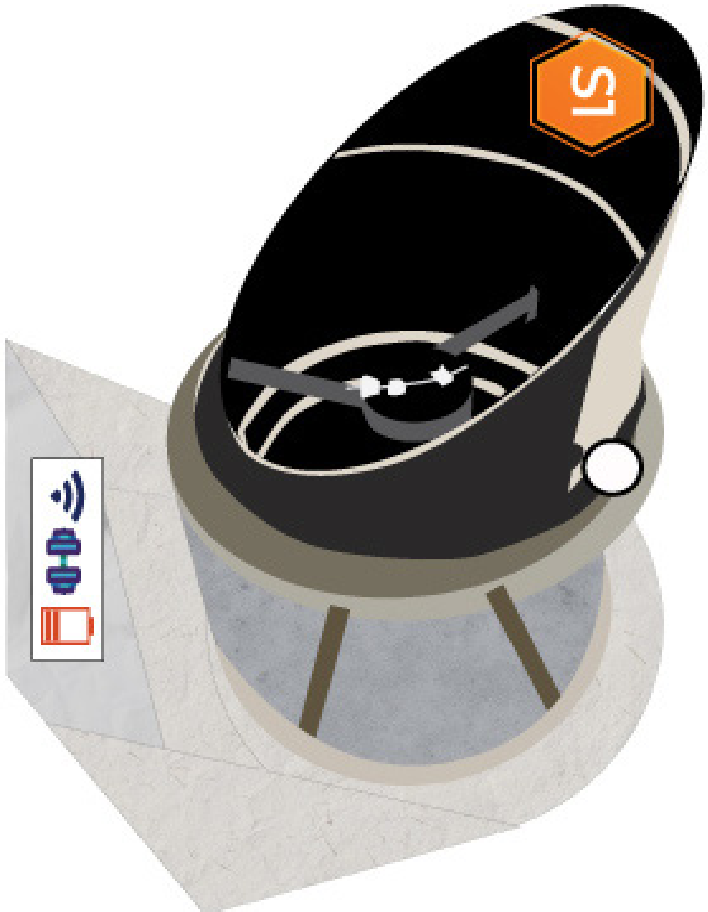
- Give each group index cards, markers, and one set of Phase Cards (PDF). Explain that they should choose the phases they used to design a spacecraft. They can choose some or all of the Phase Cards, and they can write or draw their own cards (one phase per card). They should put the phases in the order they used them. (Note that the options shown on the phase cards are intentionally different from the phases of the EDP in the Engineering Notebook, tto avoid implying that the EDP in the Notebook is the "correct" answer.)
- When writing their own phases, learners may describe specific actions, such as "We folded the index cards." Through discussion, encourage learners to come up with terms to describe each phase of the process more generally, such as "We talked about it" and "We tested the materials." If learners speak multiple languages, encourage them to discuss in their preferred languages.
- Give groups copies of the *Engineering Design Process Example* for inspiration.
- Gather the group and compare processes. Organize all the cards in groups on a poster to create a whole-group engineering design process of between three and ten phases. *(For example: ask, imagine, plan, create, test, improve.)* Save this *Engineering Design Process* poster for use in future adventures.
- Say: **You have just designed a set of phases like the ones engineers use to solve problems: an engineering design process.**

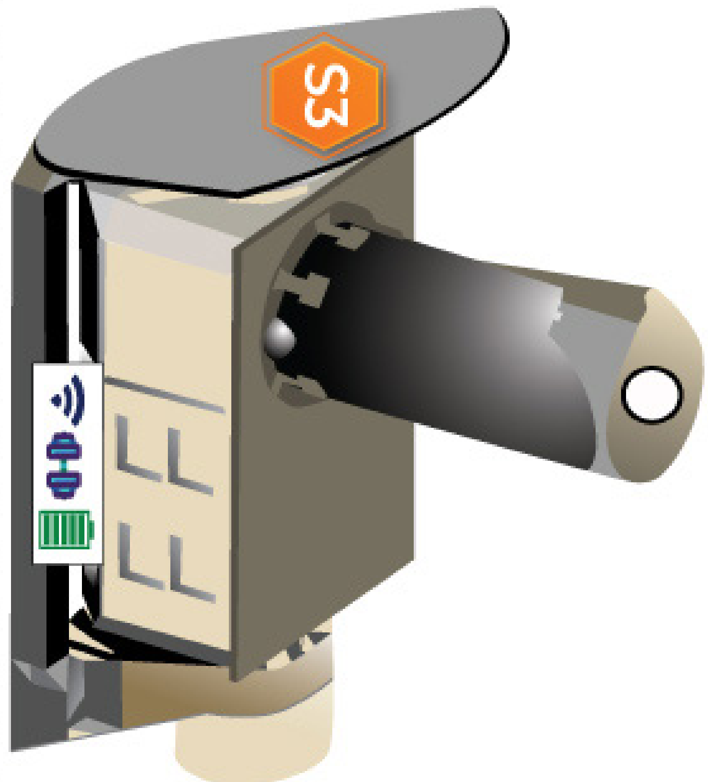
Watch this video about plans for sending humans to the Moon during the Artemis missions. How We Are Going to the Moon - 4K. Discuss how spacecraft must be designed differently if they are carrying robots versus if they are carrying humans. (15 min.)

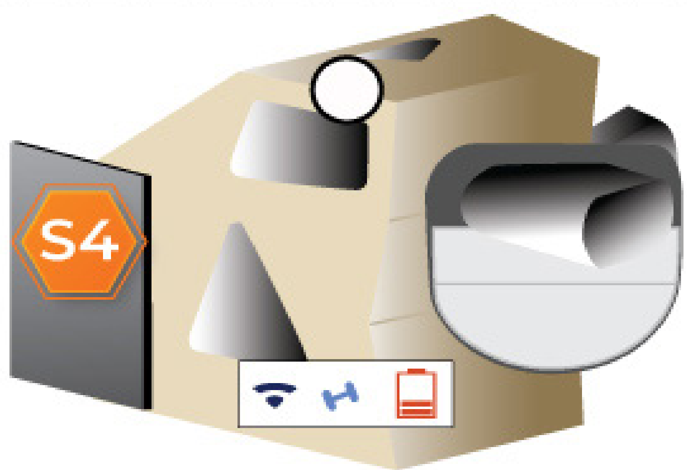
Fairing Handout



Instruments Sheet Handout – 1







Instruments Sheet Handout – 1

Instruments Key Handout

S1

Science Instrument 1:
High Resolution Camera
Can take 3D images of the surface and can take scientific measurements, which makes it great for making different kinds of maps.
high signal, heavy weight, low energy

S2

Science Instrument 2:
Low Resolution Camera
Can take good images of the surface, but has more limited scientific measurements.
low signal, light weight, low energy

S3

Science Instrument 3:
High Resolution Spectral Imager
Can take images of the surface and can take high resolution scientific measurements.
high signal, heavy weight, high energy

S4

Science Instrument 4:
Medium Resolution Spectral Imager
Takes good scientific measurements, but with reduced detail.
low signal, light weight, low energy

S5

Science Instrument 5:
Magnetometer
Measures the magnetic field of the planetary body.
low signal, light weight, low energy

S6

Science Instrument 6:
Thermal
Measures the temperatures of the surface, which can be used to figure out the grain size and where rocks are.
low signal, light weight, high energy

S7

Science Instrument 7:
Radar Instrument
Detects below the surface, showing us buried rocks, ice, and caverns.
low signal, light weight, high energy

C1

Comms Instrument 1:
High-Volume Communications Relay
Can transmit large data volumes.
light weight

C2

Comms Instrument 2:
Low-Volume Communications Relay
Can transmit small data volumes.
light weight

PS1

Power Source 1:
High Power Source
Can last for a long-duration mission.
heavy weight

PS2

Power Source 2:
Low Power Source
Can last for a short mission.
light weight

S8

Science Instrument 8:
Gamma Ray Spectrometer
Detects gamma rays on the surface, showing where different elements may be located.
low signal, light weight, low energy

S9

Science Instrument 9: LiDAR
"Light Detection and Ranging" instruments can measure distances using light, which helps to understand the shape of the surface.
low signal, light weight, high energy

Last Updated
033125 tmsr

Engineering Ready, S.E.T., Go! Visual Instructions Handout

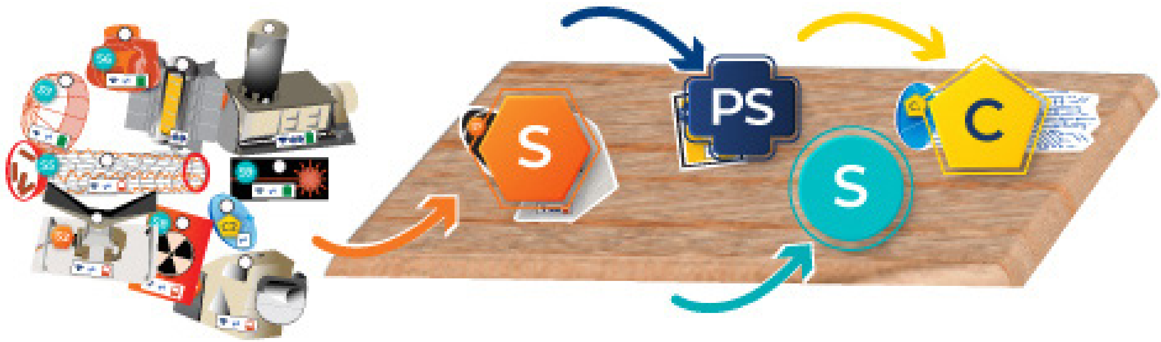
Prep for your Mission to Mars

1

Cut out all pieces

2

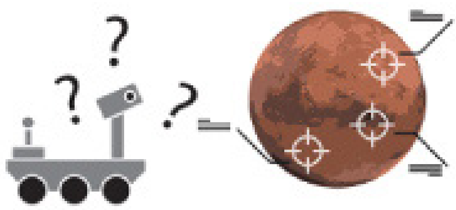
Sort the instruments



3

Choose your mission!

The Landing Site Mission –or– The Global Mission



Once you decide, you are on your way!

4

Guidelines