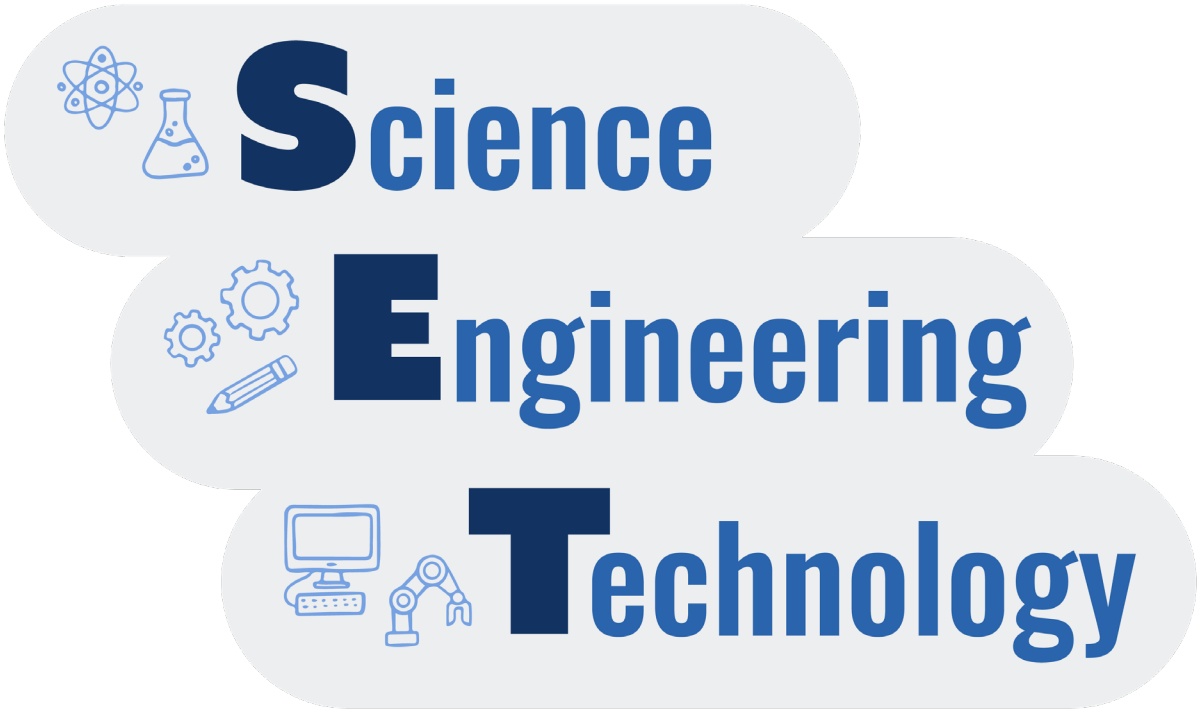
Ready, S.E.T. (Science, Engineering, Technology), Go!



Educator Preview

Adventure Snapshot

Learners scientifically investigate the energy from space trash impacts, and they engineer a device to protect against those impacts.

Timing | 60 minutes

Get Ready & Team Up	5 min.
Plan & Create (S.E.T.)	50 min.
Reflect (Go!)	5 min.
Total	**60 min.**

Level Up Activities 5–30 min. each

Prep Snapshot*

Prep Time 70 min.

- Read unit.
- Print Notebooks.
- Prepare materials.
- Make an poster.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Habits of Mind

- Use a structured problem-solving process.

Science Practices

- Constructing Explanations

Guiding Question

How does space trash damage spacecraft and can we design ways to protect against it?

Learners Will Do

As scientists, measure the energy of space trash as it impacts spacecraft. As engineers, design technology to protect against space trash impacts.

Learners Will Know

Scientists and engineers work together to solve problems.

Connecting Across Adventures

Ready, S.E.T., Go!	Adventure 1: Sharing Experiences
Today, learners explore space trash. As scientists, they measure the energy of space trash impacts. As engineers, they design ways to protect against those impacts.	**Next time**, learners share experiences with and stories about making hazards safer.

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/.

weblink: https://hov.to/07c21986

Materials and Preparation

Materials

For the whole group

- blank poster or sheet of chart paper
- *Our Ideas* poster (on paper or a shared digital document) Examples | Templates
  - index cards
  - markers
  - scissors
  - tape

For each learner

- Engineering Notebook (PDF)

For each group of 4

- Engineering Ready, S.E.T., Go! Visual Instructions Handout, p. 19
- salt or rice, 1/8 tsp per trial
- 1 piece of aluminum foil, 6" × 6"
- 1 aluminum tray, 12" × 10" × 2.5"
- 1 piece of cheesecloth, 6" × 6"
- 1 piece of craft foam, 4.25" × 5.5"
- 1 piece of felt, 4.25" × 5.5"
- 1 pack of index cards (about 100 cards)
- 1 piece of masking tape, at least 12"
- 2 rulers
- 4 washers
- 1 piece of dark-colored paper (optional)

Ready, S.E.T., Go! Materials Preparation (70 min.)

Ahead of Time

1. Read through the PLANETS Engineering Pathway Educator Guide Introduction (pgs. iii–xxvi) to learn more about the engineering content in this unit.
2. Print and staple one Engineering Notebook for each learner, in color if possible. As needed, prepare to share the Notebook digitally.

Teaching Tip

- This adventure is the same in both the Science and Engineering Pathways. If you have already taught it in one pathway, you do not need to fully teach it again. The only exception is the introduction of an Engineering Design Process and a fun Level Up tip at the end. See the reflect section of pg. 16 to determine if you would like to add this option for your learners to benefit the remainder of the pathway.
- This adventure can stand alone as a brief single-session program.

3. Print a copy of the Notebook for your own reference throughout the pathway.
4. Prepare an *Our Ideas* poster by following the online Prep & Setup Guide (PDF). Add the Guiding Question "How does space trash damage spacecraft and can we design ways to protect against it?" so learners can refer to it throughout the adventure.
5. For each group, cut a 6" × 6" piece of aluminum foil, a 6" × 6" piece of cheesecloth, a 4.25" × 5.5" piece of craft foam, and a 4.25" × 5.5" piece of felt. All sizes are approximate.
6. Print one Engineering Ready, S.E.T., Go! Visual Instructions Handout, p. 19 for each group of 4 learners.

In Your Space

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

Teaching Tip

You can begin the *Our Ideas* poster with several standard 23" × 32" pieces of chart paper. You may fill them up before the end of the pathway, in which case you can add additional pieces as needed. See the weblink for an Our Ideas poster example (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:

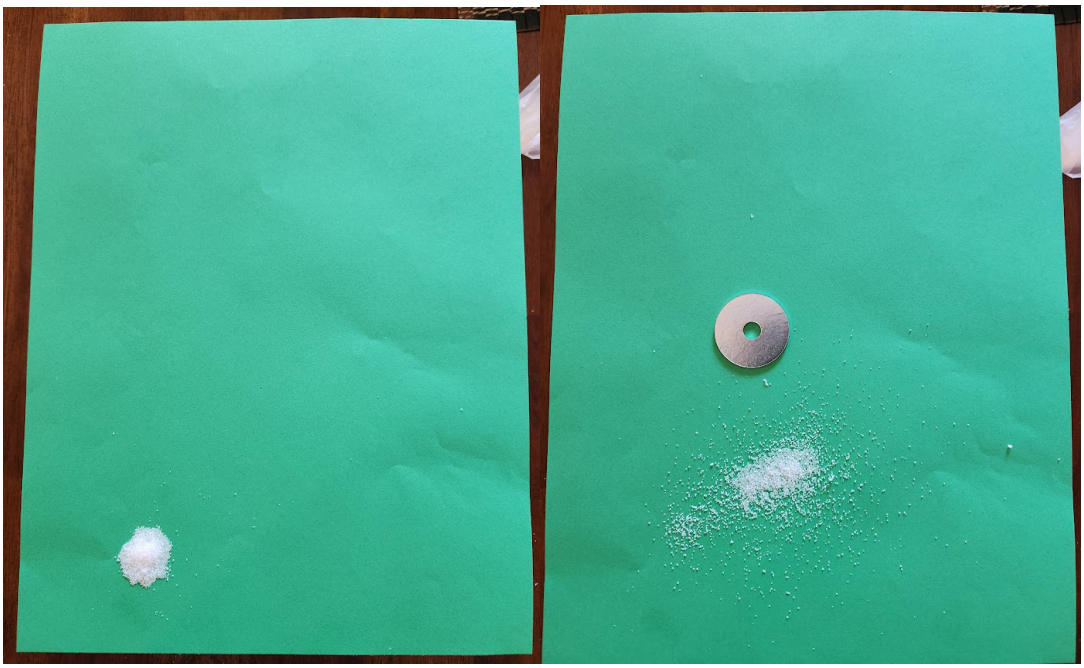
- View the Translanguaging Video to support learners who speak multiple languages.
- For those with low vision: add tactile elements, such as three-dimensional representations and Braille. Prepare a shared digital document all learners can access, ensuring that it supports text-to-speech for your learners.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

Teaching Tip

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.

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).



Learners follow the directions on Investigate It!, pg. 7 in their Engineering Notebooks to measure the amount of damage to their "spacecraft" based on how much salt is disturbed. Then, they attempt to reduce the damage using the materials provided.

Adventure Guide

Get Ready & Team Up (5 min.)

1. Give each learner an Engineering Notebook. Say: **This Notebook is a place to record your observations and ideas.**
2. Have learners read the *Ready, S.E.T., Go! Comic*, pgs. 2-6 in their Notebooks, to set the context for the adventure. Say: **Today you are going to investigate and solve the problem of space trash**. Share the Guiding Question with learners aloud and in writing (using multiple languages as needed): **How does space trash damage spacecraft and can we design ways to protect against it?**

Plan & Create (S.E.T.) (50 min.)

3. Ask: **What kinds of trash might be in space?** *(Pieces of old rockets and satellites.)* **Why could space trash be a problem for people?** *(Space trash can hit astronauts and hurt them.)*

Support Learner Differences

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. x.

You can project a digital version of the comic or share it so learners using text-to-speech technology can access the comics.

- iOS or macOS users should enable text-to-speech or voice-over.
- Windows users should use JAWS or NVDA at NV Access.

Be sure to read carefully and leave a visual shortcut to exit the program, or have your learner restore settings when they are done.

Have learners talk about places in outer space they know about and if any of those places are important to them. *(Possible responses include planets, moons, comets, and the Sun. Learners may have seen particular objects with family or community members, or they may know stories about those objects.)* If you have learners who speak multiple languages, encourage them to share in their preferred languages.

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.

4. Say: **Even if space trash is tiny, it can cause a lot of damage to spacecraft because it is traveling so fast. Today, we're going to investigate what happens when space trash hits a spacecraft.**
5. Organize learners into groups of 4. Give a copy of Engineering Ready, S.E.T., Go! Visual Instructions Handout, p. 19, to each group.
6. Give each group materials: an aluminum tray, four washers, a piece of tape, and two rulers. Say: **The washers represent a piece of space trash, and the aluminum tray represents the outside of the spacecraft. You will drop the washers onto the upside-down tray, making changes and observing what happens each time.**

Level Up!

- If you can, show the video clip NASA has big 'guns' to study micrometeorite & space debris impacts - See test fires (2:33–2:53). Preview audio before playing; it compares the speed of the test trash to the speed of a gun. (5 min.)
- Introduce this activity with a children's book about trash like Team Trash by Kate Wheeler and Trent Huntington (weblink), or one that is relevant to your community to get your learners invested in the character's problem. (30 min.)

Support Learner Differences

As needed, provide groups with a tub or other container to hold their materials. Give learners time to examine the materials before beginning the tests.

Check out the Intentional Grouping Strategies, pg. xxii.

7. Have learners turn to *Investigate It!*, pg. 7 in their Notebooks. Say: **You will be testing two kinds of changes.**
   a. **You will drop one, two, three, or four washers to represent space trash of different sizes. When you are dropping more than one washer, you will tape them together. It is important that you only *drop* the washers and do not throw them, in order to keep the test results consistent and avoid damaging the tray.**
   b. **You will drop the washers from one or two feet above the tray to represent space trash traveling at different speeds. You will measure how much the energy of the space trash damaged the spacecraft. You can measure this damage in three ways:**
      - **A louder sound means more damage.**
      - **More vibrations in the tray mean more damage.**
      - **A small pile of salt or rice will be on the edge of the tray. More movement of the salt or rice means more damage.**

Support Thinking

Play the translatable video Space Hazards Instructional Read Aloud, which describes the testing procedure.

8. Have groups discuss and record their predictions about damage in the "prediction" columns on the top part of *Investigate It!* in the Engineering Notebook, pg. 7.

9. When groups have made their predictions, put 1/8 tsp of salt or rice on the edge of each group's tray. Have learners begin testing. Have them record the results in the "actual" columns on the top part of *Investigate It!* in the Engineering Notebook, pg. 7.

10. When groups are finished testing, revisit the first part of the Guiding Question: **How does space trash damage spacecraft?** *(When space trash hits a spacecraft, its energy can break the spacecraft. We can observe this energy when the tray moves, vibrates, and makes noise.)* Ask: **What patterns do you notice about space trash damaging the spacecraft?** (*Space trash that is larger or moving faster does more damage.*) Give groups five minutes to discuss and record their ideas on the *Our Ideas* poster. Say: **We will keep recording ideas on this poster.**

Support Learner Differences

Covering the tray with a piece of dark-colored paper makes the salt or rice easier to see and has a minimal effect on sound and vibration. Vibrations can be felt by lightly touching the side of the pan during testing.

If necessary, increase the drop height so it is easier to time the fall.

Level Up!

If you have decibel meters or a decibel meter smartphone app available, learners can use them to measure the loudness of each impact. They can graph the results to observe how the loudness changes as other things change. (10 min.)

Have groups time how long it takes the washers to fall two feet, then calculate the average fall speed by dividing two feet by the amount of time. (Note that the average fall speed is not the same as the speed on impact, because the washers get faster as they fall.) (10 min.)

Support Learner Differences

Recording learners' ideas using words, diagrams, and pictures on the *Our Ideas* poster or shared digital document throughout the adventures 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 Prep & Setup Guide (PDF).

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

As needed, allow learners to choose other methods of sharing their ideas, such as audio recordings. Have them write the filename of each record on an index card and put the index cards on the *Our Ideas* poster. They will serve as placeholders. When necessary, you can ask, "Who has the idea named X?" and have the learner in question share the record.

11. Say: **You have been acting as scientists. Scientists often ask questions and gather evidence to answer the questions. Besides space trash, what other things do you know about that scientists study?** *(Responses will vary. Possible responses include living things, the Earth, and what objects are made of.)* Write the word *scientist* on the *Our Ideas* poster. Have learners come up with a description of scientists together and record it on the poster. (For example: Scientists 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.

12. Say: **Now that you have identified a problem, you will design something to solve the problem of protecting spacecraft when they are hit by space trash. You need to design a shield to absorb as much energy as possible when space trash hits it. You can use a variety of flat materials: cheesecloth, felt, foam, foil, and an index card. You will compare the damage done to the tray without any material with the damage done to the tray that is protected by each material.** Give each group one piece of each material.

13. Have groups discuss how well they think each material will absorb the energy of the space trash. Have them record their predictions about damage in the first column on the bottom part of *Investigate It!* in the Engineering Notebook, pg. 7.

14. When groups have made their predictions, have them test the shielding materials one at a time (dropping four washers from two feet each time). Have them record the results in the second column on the bottom part of *Investigate It!* in the Engineering Notebook, pg. 7.

15. Ask: **Which materials absorbed the most energy? Why do you think so?** *(The foam and felt absorbed a lot of energy because the space trash was quiet when it hit them and didn't make a lot of vibrations that were felt or transferred to the salt or rice.)*

16. Explain that learners can now combine these materials to make the most effective shield. Have groups begin and work for about 15 minutes.

17. Revisit the second part of the Guiding Question: **How can we design ways to protect against space trash?** *(Responses will vary. Possible responses include we can stack layers of materials, and we can fold materials like index cards to make them more absorbent. When these materials absorb energy from the space trash, the spacecraft is protected.)*

Level Up!

- Tell learners that when washers are dropped from 2 feet, they are moving at 11.2 feet per second when they hit the tray. Actual space trash can move at up to 18,000 miles per hour. Have them figure out how much faster the actual space trash is moving than the washers. (10 min.)
- For an additional challenge, have groups construct a shield using only 10 index cards, 12 inches of tape, and no other materials. (10 min.)
- Introduce the terms ***criteria*** (requirements for evaluating a design), ***constraints*** (limitations on a design), and ***tradeoff*** (a compromise engineers make to balance competing design requirements). Have learners consider how each term applies to the shields they are engineering. (10 min.)

18. Say: **You have been acting as engineers. Engineers design things to solve problems.** 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.

19. Say: **Your designs to protect against space trash are *technologies.* Technology is anything designed by people to solve problems. Scientists often ask questions, and engineers help them by designing technologies to answer those 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.

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. (5 min.)

Have learners explore actual shielding for NASA spacecraft in the video How Can We Protect Our Astronauts in Space? (1:31 min.)

Reflect (Go!) (5 min.)

20. Say: **You will be acting as engineers to help solve more problems in space. These problems will involve learning about and protecting against other *hazards*, or dangers.**

21. Say: **Space trash is one kind of hazard. What other hazards can you think of?** *(Accept all responses.)*

22. Say: **You will be acting as engineers to help solve more problems in space. These problems will involve protecting against other *hazards*, or dangers. You will think about the phases you used to solve the problem of space trash so you can use those phases again later with other hazards.**

Level Up!

Instead of using the premade *Engineering Design Process*, you can have learners make their own.

1. Give each group index cards, markers, and one set of cards cut from Engineering Ready, S.E.T., Go! Phase Cards Handout, (PDF). Explain that they should choose the phases they used to solve the trash problem. 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 *Engineering Design Process* (EDP) in the *Engineering Notebook*, to avoid implying that the EDP in the Notebook is the "correct" answer.)

2. 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.

3. Give groups copies of the Engineering Ready, S.E.T., Go! Engineering Design Process Example Handout, (PDF) for inspiration.

4. 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 (PDF) for use in future adventures.

5. Say: **You have just designed a set of phases like the ones engineers use to solve problems: an engineering design process**. Ask: **How can you use your engineering design process to solve the problem of trash or litter here or in your neighborhood?** (*We can use our process to make tools for picking up the trash.)*

Note: If you've used this Level Up, skip step #23 that follows.

23. Have learners turn to *Our Engineering Design Process,* pg. 8, in their Notebooks. Say: **There are many different processes that engineers use to design things to solve problems. You will be using these five phases as your Engineering Design Process: Ask, Imagine, Plan, Create, and Test, with an Improve cycle.** Ask: **How did you use this Engineering Design Process when engineering protection against space trash?** *(We asked what materials we had, imagined possible designs, planned and created one design, and tested it. If necessary, we improved our design to absorb more energy.)*

24. Say: **Next time, we will think about what we already know about protecting against other types of dangers.**

After the Adventure

1. Clean up:
   - Keep the *Our Ideas* poster for Adventure 1.
   - Throw away the salt, rice, and any materials that are too damaged to reuse. Check to ensure the foil trays have not developed holes.
   - Collect the washers and other shielding materials.
2. Have learners invite people from the community, including their families and friends, to the Engineering Share-Out in Adventure 9.
3. Plan ahead for Adventure 1. See Adventure 1 Preparation on pg. 22.
4. Take time to reflect on the following educator prompt. **How did you create connections between the science and engineering portions of the adventure?**

Space Hazards Additional Resources

Resources include All Downloads, All Videos, Family Connections, and more.

weblink: https://hov.to/940428f7

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

Part 1

1

Gather materials

salt and colored paper

+

ruler

+

various sizes of metal washers

+

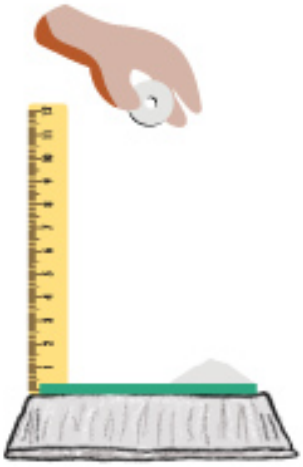
foil tray

2

Impact testing

tray with paper then salt in the corner

How to test:



3

Record your results

On the *Investigate It!* page:

1. Write your predictions.

2. Test.

3. Record what happened.

Part 2

4

??? What other materials can you use?

Reset

1. Clean up the salt.
2. Put all materials back where they belong.