Hands-On Learning! Protective Engineering

This activity has **two** parts! There is a hands-on part and a brains-on part!

Part 1: The Power of Pressure

Space is a vacuum. Humans can't survive in a vacuum, because it will break apart our cells and organs. NASA engineered a solution to this issue by designing spacesuits that could handle the different levels of **pressure** in space. In this short activity, you will explore how powerful pressure can be.

What will you need?	
• 1 potato	• A few plastic straws

What will you do?

1. Try to poke a hole all the way through the potato using only one plastic straw. Do this without bending or breaking the straw. Simple! Right…?

- Hold the potato by its sides when you poke it, so your hand is safe!

When you poke the straw through the potato, the straw should not have any bends or breaks. It should be able to stand up straight in the potato.

2. Observe: What happened? Why do you think that happened?

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3. If your first strategies did not work, try to poke a straw through the potato while covering the other end of the straw with your thumb. Seal the hole!

   - This will increase the pressure inside the straw when you poke it through. So, the straw will be stronger, and it will not break.

4. Observe: What happened the second time? ______________________________

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5. Think about what happened with your straw and potato. How could the same ideas about pressure apply to astronauts going into space?

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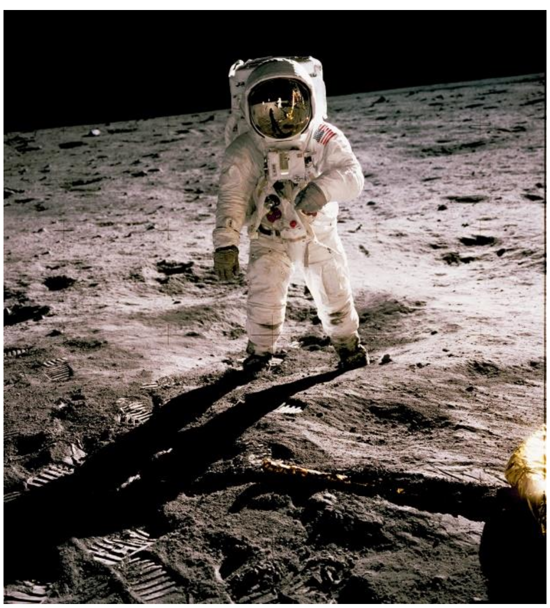

Pressure in space is different than it is on Earth. This picture shows astronaut Buzz Aldrin standing on the Moon during the Apollo 11 mission. (Read more about Apollo 11 in Chapter 13!) NASA prepared Buzz Aldrin to stay safe in the pressure of outer space.

Part 2: Your Engineering Adventure

Astronaut suits protect humans from many different challenges in space, like the vacuum of space and dangerous rays of energy from the Sun. Over the next several chapters, you will **engineer** a spacesuit that keeps the wearer at a comfortable temperature. To be successful, you need to consider the challenges of maintaining a temperature. Engineers call this step "**Defining the problem**." Answer these questions to start defining the problem and begin your engineering adventure!

These first questions help you consider your real experiences with this challenge:

1. What temperatures make you feel comfortable? (include units!)

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2. What clothes help you maintain a good temperature when it's cold?

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3. What clothes help you maintain a good temperature when it's warm?

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Now, use those ideas to **define the** problem of this challenge:

4. What are challenges for an astronaut trying to maintain a good temperature?

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5. What are some materials that would be useful for creating an astronaut's suit?

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6. What are some challenges for building an astronaut's suit?

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Hands-On Activity! Possible Solutions

After defining the problem, engineers imagine possible solutions. One tool they use for this is called "**Analysis of Alternatives**." The big idea is to brainstorm **4** very different possible solutions, called alternatives. Then, they create 3-5 criteria to judge the solutions. Criteria are like categories on a grading rubric that show what will make a very good idea. Different criteria will suggest different solutions are better. Think carefully about the criteria you want to use for a good solution. Finally, engineers like you grade each idea using the criteria they came up with. You will be doing this today!

First, brainstorm **four** possible spacesuits you could build to keep an astronaut at a good temperature while in space. (But, since you are not sending an actual astronaut to space, your suit should protect something smaller: either candy, or ice cubes!) Describe what they will look like and what materials you will use.

Alternative #1:	**Alternative #2:**
Alternative #3:	**Alternative #4:**

Second, brainstorm 3-5 criteria that you could use to evaluate your spacesuit:

Look back at your criteria. Choose the best 3 that you want to use. Consider what is the most important to you as you get ready to grade your alternatives.

Then, decide how many points each criterion is worth. Make the most important criterion worth the most points. If two criteria are equally important, make them worth the same number of points.

<u>Criteria #1:</u> Worth ___________ points
<u>Criteria #2:</u> Worth ___________ points
<u>Criteria #3:</u> Worth ___________ points

Finally, compare your alternatives! On the next page, write your criteria in the left column and describe your four alternatives in the second row. Then, evaluate each alternative. Write a few phrases to describe how you came up with the point grades for each criterion. Then, total the points to get a winner!

Analysis of Spacesuit Alternatives

	Alternative #1	Alternative #2	Alternative #3	Alternative #4
Description:				
Criteria 1:	Points earned: __ of ___	Points earned: __ of ___	Points earned: __ of ___	Points earned: __ of ___
Criteria 2:	Points earned: __ of ___	Points earned: __ of ___	Points earned: __ of ___	Points earned: __ of ___
Criteria 3:	Points earned: __ of ___	Points earned: __ of ___	Points earned: __ of ___	Points earned: __ of ___
Total Points				

Hands-On Activity! Build a Prototype

Engineers test ideas, see what works, then make better versions. Failure is part of the process—in fact, we often learn more from failures than successes! You just read about this with the 17 Apollo missions. Before testing, engineers build prototypes. A **prototype** is an initial version of the solution. It's like a first draft in writing. We know it can be improved, but it's a great starting point.

As a reminder of the challenge, your prototype should protect ice cubes or hard candy (like a mint or lollipop). The spacesuit you build can still be in the shape of a human if you want, just use many ice cubes or candies to make a human-like shape. Make sure your spacesuit has a way for people to get in and out, too! You should be able to take out any candy or ice after you finish today.

When you build your prototype, be sure to look at the alternative designs you brainstormed. It's okay if your design does not exactly match what you build today, but try to use the ideas you already analyzed.

Create your best prototype using your materials. Diagram your prototype here.

In the next activity, you will test the prototype. The diagram above is the first part of the prototype test. It shows what we are going to attempt to use to solve the problem. Then, you will see how it works!

Hands-On Activity! Testing Your Prototype

Engineers do lots of tests. These are different from tests you take in school! They are like experiments to see whether their designs are working and how to make them better. To test your spacesuit from the last activity, we are going to put it in a warm environment to see how it works protecting your "astronaut."

First, place your "astronaut" ice cubes or candy inside your spacesuit.

These pictures show how to test, not how to design. Your design will protect an "astronaut" better than this simple foil example!

Make sure you can get your ice or candy "astronaut" into the space suit quickly! You don't want it to start melting before you start the test.

Then, put your prototype under a simple heat source, like a lightbulb or sunlight.

During the test, be sure you can see into your prototype a little bit. This way you can check on your "astronaut" to see if they are melting and make observations.

Every 10 minutes, check back on your prototype. In between your observations, read the following page about the spacesuit prototyping process that NASA used to figure out how to keep astronauts safe in space. After 40 minutes (or when your astronaut is melted), reflect on your test below:

1. How fast did your astronaut melt? ______________________________

2. How much of your astronaut melted? ______________________________

3. What did you notice while observing your test?

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4. What worked well about your prototype?

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5. What could be improved to make your prototype better?

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Today's activity and reading show that it's critical to test your designs and make sure they are effective when used. All those tests on Earth made sure astronauts were safe when they took the first real spacewalks in their suits.

Spacesuit Prototyping Process

NASA first needed to make spacesuits for the Mercury missions. The problem was clear: they had to keep astronauts safe. A lot about space was unknown, but we understood the lack of oxygen, dangerous temperatures, and the vacuum of space. Employees at NASA researched what U.S. Navy pilots wore to fly high in the 1940s. This research helped them create designs that looked like these suits. They provided oxygen and were tight to keep the oxygen in the suit. These suits were specially designed for the Mercury missions.

The Mercury missions went to space but did not involve spacewalks. NASA spacesuit designers knew the astronauts would be inside the spacecraft at all times. They designed the suit to be connected to the spaceship. The powerful systems of the spaceship provided the oxygen, heat, and communications that the astronauts needed. Over time, NASA got better and better at designing smaller and smaller machines. They used these ideas and new technology to improve the spacesuit designs.

More recently, NASA scientists made the parts of spacesuits smaller. These developments mean that astronauts can carry around their own oxygen, heat, and communications. The spacesuit technology keeps astronauts safe whether or not they are inside the spacecraft. Astronauts can walk in space! The designs continue to improve, and each improvement lets astronauts accomplish more in space.

In the future, NASA is building new suits to allow astronauts to spend time on the Moon's South Pole. These suits will be in space for longer periods of time, and they will be subject to even more dangers. In addition, designers want to provide more freedom of movement to the astronauts so they can move more easily. These designs build off of previous learnings and involve some new ideas. For example, designers are trying new ways to store and recycle oxygen. Even though we have been in space since the 1950s we continue to learn new things!

1. How has NASA improved their spacesuits over time?

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Hands-On Activity! Improve Your Design

What can you do to make your astronaut suit better? Use your thinking from the Analysis of Alternatives chart in Chapter 12 and the results of your prototype test in Chapter 14. Keep what worked—and maybe even use more of it! If anything was unsuccessful, try to think of a new solution to that part of the challenge. No spacesuit is perfect. Find ways to improve your first design so these astronauts can survive an overnight test!

In the space below, draw and label your improved design. Describe any part of the design you are changing from your last prototype.

Hands-On Activity! Overnight Test

You've already tested your prototype once, but now it's time to test your improved version! This time, it will be a little more challenging. Your "astronaut" could still be made of ice cubes or candy, but they will have to survive all night long! You will still set up your astronaut under a light, but this time you will leave them there for at least 8 hours. For an extra challenge, make your astronaut out of an extra melty candy, like chocolate. Since you will not be observing your test every 10 minutes this time, take a picture before and after your test to help compare what happened.

After your test is complete, answer these questions to reflect on your test:

1. What changes did you observe in your suit and astronaut after the test?

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2. What was different from the first test of your initial prototype?

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3. What worked well about your prototype in this test?

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4. What do you think could be improved to make your prototype better?

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Hands-On Activity! Chapter 17: Improve Your Design Again!

It is time to improve your prototypes again! This time, you will make your **final design**. Use everything you have learned in the last two tests to decide what changes you will make to your spacesuit. When we check in again in Chapter 18, your astronaut will go through one final test to complete the challenge.

In the space below, draw and label your final, improved design. Describe any part of the design you are changing from your last prototype.

Hands-On Activity! Final Testing Challenge

Engineers, you have worked so hard to finalize your design over the last 7 activities! Now, we will complete one last test to see how well your spacesuit keeps an "astronaut" at safe temperatures. To make it even more exciting, this test is a competition! You can submit your design and testing data at this link to compete with other engineers: https://myedme.com/login/spacesuit/

For this test, we will use ice cube astronauts and measure specific data to see how successful your suit is. You will need to weigh the ice astronaut before and after the test to see exactly how much they melted while under a light source for 8 full hours. Use the space below to record your data and observations.

Ice Weight Before Test	**Ice Weight After Test**	**Percentage of Weight Lost Through Melting**

What other observations do you notice about your design after the test?

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Congratulations! You have almost completed the entire engineering process. Next time, you will finish the final step by communicating your results to other engineers. But, you can always keep improving and testing your design if you are curious to see what will happen!

Hands-On Activity! Engineers Write

There is one last step in the engineering process: **communicate**. After designing, building, testing, and improving a solution, engineers share what they learned. Now, it's your turn! Describe your prototyping journey and explain the benefits of your final design.

This **outline** will help you organize your thoughts before writing.

I. Explain the challenge and first prototype.

a. "design a suit to maintain good temperatures"

b. First, I/We decided the main criteria for this challenge were:

i. ____

ii. ____

iii. ____

c. I/We analyzed four designs

i. ____

ii. ____

iii. ____

iv. ____

d. We decided that the first prototype would:

i. Describe shape: ___________________________________

ii. Describe material: _________________________________

iii. (Note: You will draw the prototype and create a caption)

e. This solution addresses the challenge because _____________

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II. Explain testing and prototype improvements

a. In the first test

i. I/We liked ______________________________

ii. I/We wanted to improve ______________________

b. The second prototype had these changes:

i. ______________________________

ii. ______________________________

c. Our second prototype test showed ________________

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III. Final design

a. Describe key components of the final design

i. ______________________________

ii. ______________________________

b. Describe the results of the final test

i. ______________________________

ii. ______________________________

c. If I/we were going to improve this design further, I/we would

____

d. This shows that NASA spacesuits would ______________

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Great work! On the next page, use the ideas from this outline to write a complete draft of your reflection.

Prototype 1 caption:

Prototype 2 caption:

Final Design caption: