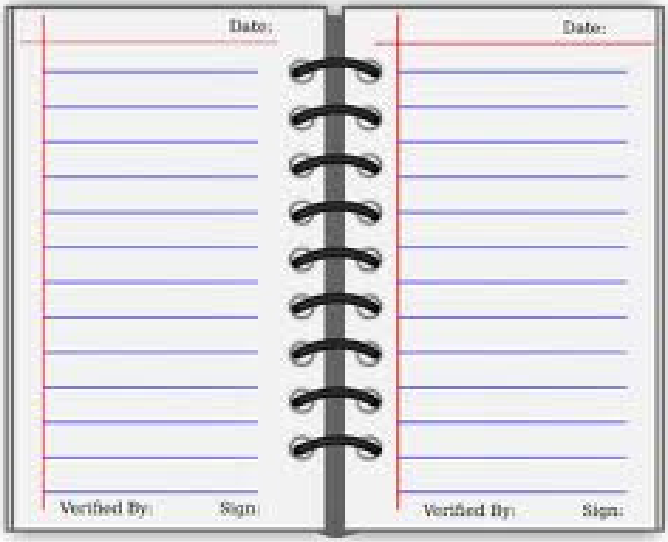
Student Team Challenge Journal



Supporting Science Investigation 1: Balloons in Space

Concept

Balloons will expand in a vacuum environment. Your skin and your lungs, which are somewhat similar to a balloon, can expand and stretch, but only to a certain point. Placing a small balloon inside a vacuum chamber will show you what would happen to your lungs if you were in a vacuum environment such as space.

Figure 18. Spacesuit training in a vacuum chamber at Johnson Space Center. (NASA)

Materials

For each group of 3 students:

- Vacuum pump and bell jar
- 2 small balloons (1 transparent)
- Water (optional)
- Tape measure
- Permanent marker

Procedure

1. Using the permanent marker, put a line around the largest part of the balloon before it is inflated. This will help you measure the circumference after it is inflated.
2. Inflate a small balloon. Do not overinflate the balloon. Measure the circumference of the balloon prior to testing and record your findings on your Data Collection Sheet.
3. Place the balloon inside the bell jar. It will expand to many times its normal size, so leave plenty of room for expansion in the jar.
4. Turn on the vacuum pump and observe what is happening to the balloon in the vacuum. Record your observations and answer the questions on your Data Collection Sheet. Measure and record the circumference of the balloon after you have tested it.
5. Optional: Place a small transparent balloon filled with water in the chamber and turn on the vacuum pump. Record your observations and answer the questions on your Data Collection Sheet.

Data Collection Sheet

1. Make a drawing of the inflated balloon prior to placing it in the vacuum jar. Use the tape measure to find the exact circumference of the inflated balloon. Record the measurement on the drawing.

2. Draw and describe what happened to the balloon while it was in the vacuum jar. Measure the circumference of the balloon after testing and record below.

3. Why do you think this happened?

_____

_____

_____

4. If you performed the optional water-filled balloon experiment, describe the difference in how the balloon reacted to the vacuum. Why do you think this happened?

_____

_____

_____

Discussion Questions

The Balloons in Space investigation uses a vacuum pump to demonstrate how a water-filled balloon reacts when subjected to the vacuum of space.

1. How do you think the water-filled balloon would react if the glass broke and the pressure equalized immediately?

_____

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_____

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2. How will you apply what you learned in this investigation to your design?

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Supporting Science Investigation 2: Hands-On Vacuum

Concept

In this activity, you and your team will take small marshmallows and place them in a large plastic syringe. You will create a miniature pressure chamber that will allow you to change the amount of pressure acting on your marshmallows. Your team will make observations about the effects of varying amounts of air pressure on the marshmallows.

Figure 19. The Altitude/Environmental/Space Testing facilities at Johnson Space Center provide vacuum, thermal, and thermal-vacuum chamber test operations for both manned and unmanned test environments. (NASA)

Materials

For each group of 2 students:

- Large plastic syringes with caps, pieces of clay, or electrical tape to plug the ends of the syringes
- Small marshmallows

Procedure

To avoid injury, always use the syringe cap, a piece of clay, or electrical tape to cover the syringe tip opening. Do not use your finger as a cap.

1. Place a small marshmallow inside your syringe.
2. Put the plunger back into the syringe, making sure the rubber piece is about halfway down the syringe.
3. Once the plunger is in place, put the cap, the piece of clay, or electrical tape on the tip of the syringe.
4. Pull back on the plunger, creating a lower-pressure environment. Use your Data Collection Sheet to record what happens to the marshmallow.
5. Push the plunger in as far as you can to create a higher-pressure environment. Record on your Data Collection Sheet what happens to the marshmallow.
6. In teams, experiment with the marshmallow. Use your Data Collection Sheet to record the effects of changes in air pressure inside the syringe

Data Collection Sheet

1. What is happening to the pressure as you pull back on the plunger? Explain this in a complete sentence and draw a picture.

_____

_____

2. What happened to the marshmallow when a vacuum was applied? Explain this in a complete sentence and draw a picture.

_____

_____

3. What is happening to the pressure as you push forward on the plunger? Explain this in a complete sentence and draw a picture.

_____

_____

4. What happened to the marshmallow when pressure was applied? Explain this in a complete sentence and draw a picture.

_____

_____

Discussion Questions

The Hands-On Vacuum activity uses a syringe to create a vacuum and a high-pressure environment.

1. Imagine the syringe was three times larger. Do you think it would create three times the change in pressure?

_____

_____

_____

_____

_____

2. Think about the characteristics of a rock as compared to the marshmallow. If we used a small rock inside the syringe instead of a marshmallow, what do you think would happen to the rock? Why?

_____

_____

_____

_____

_____

3. How will you apply what you learned in this investigation to your design?

_____

_____

_____

_____

_____

The Engineering Design Process

The engineering design process (EDP) consists of a series of steps, each designed to help you develop a solution to a problem. Start with "Identify a Need or Problem" and use the EDP diagram shown here to help solve this challenge.

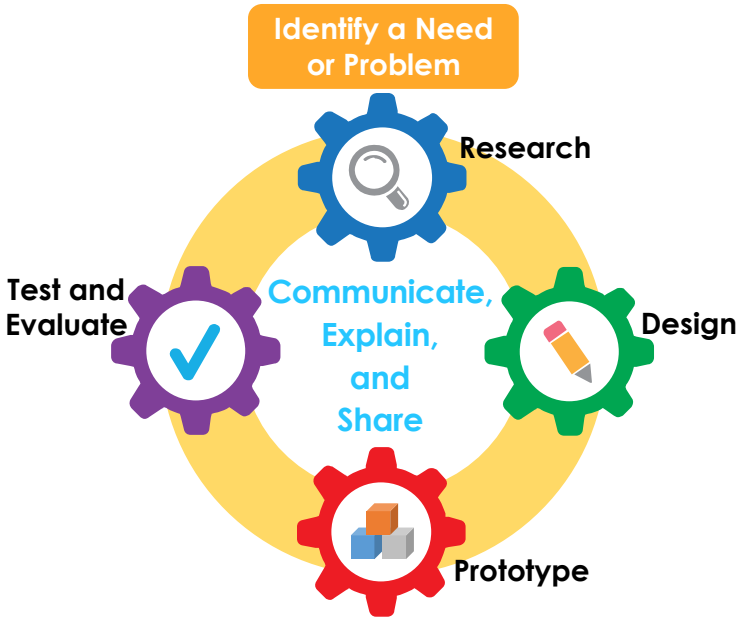


Figure 20. Engineering design process model. Model and accompanying text adapted from 2016 Massachusetts Science and Technology/Engineering Curriculum Framework, Massachusetts Department of Elementary and Secondary Education, http://www.doe.mass.edu/frameworks/scitech/2016-04.pdf.

Identify a Need or Problem. Identify a need or problem to be solved, improved, or fixed. Identify the criteria and constraints that will need to be met to solve the problem.

Research. Use resources from the internet, the library, or discussions with NASA scientists and engineers to learn more about the need or problem and possible solutions. Investigate how this problem is currently being solved or what efforts scientists and engineers are making to find a solution.

Design. Use all information gathered to create the design(s). Design includes modeling possible solutions, refining models, and choosing the model(s) that best meets the original need or problem.

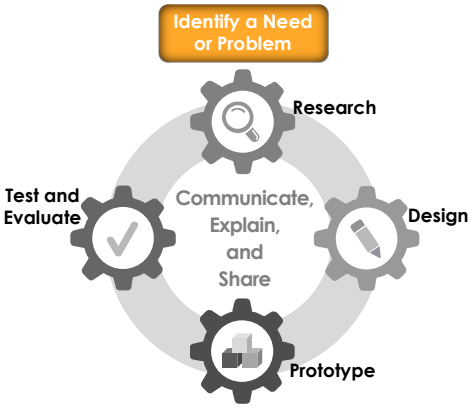
Prototype. Construct a prototype, or physical model, based on the design model(s). Prototypes are used to test proposed solutions.

Test and Evaluate. Test prototype to determine how effectively it solves the need or problem. Collect data to use as evidence of success or need for improvement. Redesign and refine prototypes to continue looking for possible solutions.

Communicate, Explain, and Share. Communicating, explaining, and sharing the solution and design is essential to tell others how it works, how it solves (or does not solve) the identified need or problem, and how it meets (or fails to meet) the criteria and constraints. Determining how to communicate and act on constructive criticism is critical.

The Engineering Design Process: Identify a Need or Problem

NASA works tirelessly to ensure the safety of its pilots and astronauts. As research continues, the pressure suits that provide many layers of protection against the harsh environments of the upper atmosphere and space also improve. Pressure suits are necessary for space exploration. Because pilots and astronauts must complete their work in a near-vacuum or absolute-vacuum environment, the protective suits must exert pressure on the body to simulate Earth's environment to keep the pilots and astronauts safe at all times.



The Challenge

Your team will design and build a pressure suit that will protect pilots and astronauts from the dangers of low-pressure environments. All materials used for the spacesuit must be tested in a vacuum to make sure they are safe in low-pressure environments. Your team can use a marshmallow or a balloon to represent the pilot or astronaut.

Figure 21. A current NASA pressure suit. (NASA)

Criteria and Constraints

1. The protective suit must be constructed of materials that are not affected by near-vacuum or absolute-vacuum environments.
2. The pressure suit must completely surround the marshmallow or balloon astronaut.
3. The astronaut must fit completely within the vacuum chamber and have a total mass of less than 50 g.
4. The pressure suit must prevent the astronaut from expanding and constricting while in the vacuum chamber.

Based on this information and the challenge's introductory video, answer the following questions.

1. Using your own words, restate the problem in this form: "How can I design a _____ that will _____?" Be sure to include all expected criteria and constraints.

_____

_____

2. What general scientific concepts do you and your team need to consider before you begin solving this need or problem?

_____

_____

_____

The Engineering Design Process: Research

Page Number_____

Conduct research to answer the following questions related to the challenge. Cite where you found your information on the lines labeled "Source(s)."

1. Who is currently working on this problem (or a similar problem)? What solutions have they created? What solutions are they currently working on?

_____

_____

_____

Source(s): _____

2. What questions would you ask an expert who is currently trying to solve problems like this one?

_____

_____

_____

3. Who in our society will benefit from this problem being solved? How could this relate to everyday use?

_____

_____

_____

Source(s): _____

4. What have you learned from the Supporting Science Investigations that you can apply to this challenge?

_____

_____

_____

The Engineering Design Process: Design

Page Number_____

Sketch your initial design in the space below and label each part of your drawing.

Notes

_____

_____

_____

_____

The Engineering Design Process: Select the Best Possible Solution

Page Number_____

Collaborate with your team to analyze each team member's final drawing using the table below. Based on a team discussion, determine which design elements will be used to solve the problem and what features will be included to create the team's prototype. The most promising solution should include elements from more than one design.

Designer Name	Does this design meet all problem criteria and constraints?	What are the strongest elements of this design?	What elements need to be improved?
1			
2			
3			
4			

The Engineering Design Process: Prototype

Page Number_____

Make a team drawing of your prototype. Prior to building, have it approved by your facilitator. Include labels and a key.

Approved by _____

List what resources will need to be gathered.

_____

_____

For which part of the build will each team member be responsible?

Team Member				
Responsibilities in the building process				

The Engineering Design Process: Test and Evaluate

Page Number_____

1. Does the pressure suit function as intended?

   YES NO

2. If not, explain why. Provide details.

_____

_____

_____

3. Does it meet all of the criteria and constraints? (Check the box for each one that is met.)

   - ☐ The protective suit must be constructed of materials that are not affected by near-vacuum or absolute-vacuum environments.
   - ☐ The pressure suit must completely surround the marshmallow or balloon astronaut.
   - ☐ The astronaut must fit completely within the vacuum chamber and have a total mass of less than 50 g.
   - ☐ The pressure suit must prevent the astronaut from expanding and constricting while in the vacuum chamber.

4. If not, explain why. Provide details.

_____

_____

_____

Record the total mass of your suit: _____ grams

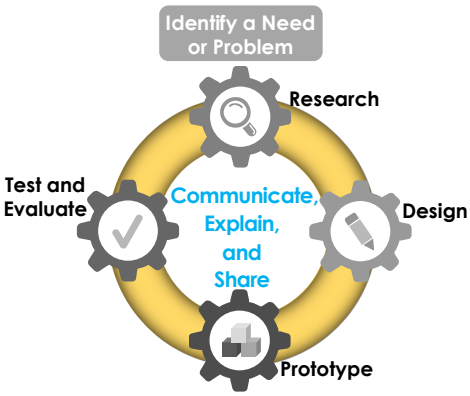
Insert your pilot or astronaut into the suit and then into the vacuum chamber. Begin drawing a vacuum and carefully observe and record any changes to the suit and the astronaut.

For each change, record the pressure of the vacuum system at the time the change occurred. Use appropriate units such as pounds per square inch, number of draws of the syringe, or time into the test if the vacuum being pulled is constant.

Iteration	Test time, sec	Mass, g	Observations
1			
2			
3			

The Engineering Design Process: Communicate, Explain, and Share

Page Number_____



Indicate the step you are discussing.

_____

1. What did YOU think about your team's solution at the end of this step?

_____

_____

_____

2. What did OTHER MEMBERS of your team think about the team's solution at the end of this step?

_____

_____

_____

3. Was your personal feedback different from your team's feedback? If so, in what way was it different?

_____

_____

_____

4. Which step of the engineering design process (EDP) will your team move to now?

_____

_____

_____

_____

5. Explain why your team chose this step.

_____

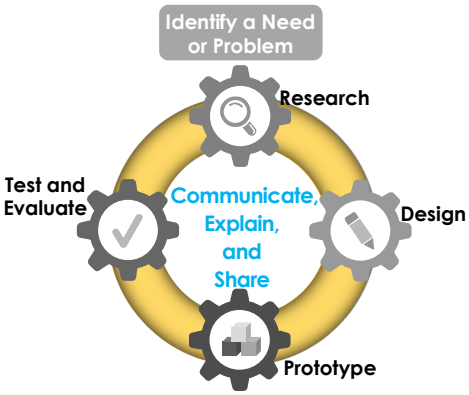
_____

_____

_____

The Engineering Design Process: Communicate, Explain, and Share

Student Presentation Organizer



Use the organizer below to plan how your team will present its final solution. Keep track of the engineering design steps you take so you can tell your audience how your team accomplished the process.

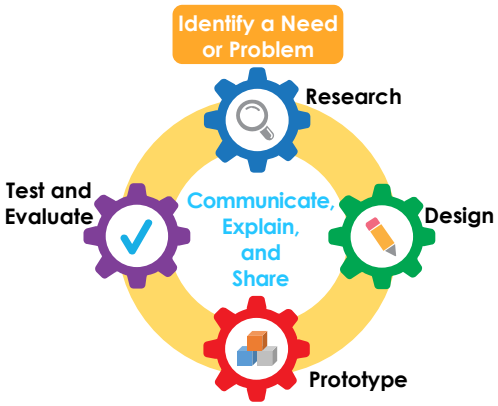
Keep in mind that these steps may have happened in any order or may have been repeated. Use additional sheets if necessary.

Welcome	Share your team name, which challenge you worked on, and the title of your presentation.	
Engineering Design Process (EDP) Practice	**Ideas for what should be included in each step of the presentation**	**Use this space to organize notes and think about the evidence to present. Make note of what your team wants to show and say in the presentation.**
Identify a Need or Problem	Talk about the problem. Discuss the criteria and constraints that will need to be met to solve the problem.	
Research	Discuss what your team discovered during the research and through your interaction with a NASA subject matter expert (SME). Who did you speak with? What did you learn? Where did you find answers to your questions?	
Design	Show each team member's original designs. Show what each team member contributed to the original team drawing.	

Prototype	Show materials used and how you put the prototype together.	
Test and Evaluate	Talk about how your team tested the design and discuss the results. Using the data, discuss the strengths and weaknesses of your team prototype.	
Communicate, Explain, and Share	Talk about your data. Was your team able to solve the problem or not? What improvements did your team make to reach your final solution? Discuss any further action your team would take to improve this solution. Describe how your team members communicated with each other to improve the solution. Also describe how you discussed options with people outside your group.	

Engineering Design Process Team Progress Chart

Use the table below to keep track of which practices your team did, and in what order. This table, along with your Student Presentation Organizer, will help you in summarizing your team's entire process from beginning to end.



Practice Order	Which engineering practice did your team do?	Notes on what your team did or learned during this practice
1	**Identify a Need or Problem**	
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

Solution Presentation

The final stage of the challenge is to document your progress for sharing with other groups who have completed this engineering design challenge. Your journey may be documented using video or slide presentations.

The finished presentation must meet the following guidelines:

- The introduction must say this: "This is team (team name), and we worked on the (name of challenge). The title of our presentation is (presentation title)."

  Do not identify by name any student, teacher, school, group, city, or region in your presentation. Submissions that do not follow these directions will be disqualified.

- The presentation must document every step you took to complete the challenge, including the Supporting Science Investigations. Use every page of your Student Team Challenge Journal to help complete this presentation.
- Identify any information provided by NASA subject matter experts (SMEs) that helped you in your design or testing.
- Explain which characteristics of the design provided the most reliable results and why.
- The total length of the presentation should be 3 to 5 minutes.

Student Presentation Rubric

This rubric will be used to assess your final presentation. Use it as a checklist to make sure you have included something from every category. Try to achieve as many 3's as you can!

Engineering Design Process	Exemplary = 3	Proficient = 2	Novice = 1	Not Included = 0
We can **identify** the challenge and the criteria.	Challenge was restated and all criteria and constraints were described.	Challenge was restated with only the challenge criteria.	Only the challenge story was stated.	Team did not include a description of the challenge or the criteria.
We can discuss the results of our **research**, the Supporting Science Investigations, and connections with a NASA scientist or engineer.	Three or more facts relating to the challenge were discussed.	Two facts relating to the challenge were discussed.	One fact relating to the challenge was discussed.	No facts relating to the challenge were discussed.
Each of our team members sketched an original **design** that demonstrated the challenge criteria and constraints.	All criteria and constraints were represented (sketches and photos) in each team member's design.	Two criteria were represented (sketches and photos) in each team member's design.	One criterion was represented (sketches and photos) in each team member's design.	No criteria were represented.
Our final team **design** represented elements from each team member's original design.	Team design included the best from each member's design to represent the challenge and the criteria.	Team design included ideas from two team members' designs to represent the challenge and the criteria.	Team design included ideas from one team member's design to represent the challenge and the criteria.	Team was not able to provide a design to represent the challenge and the criteria.
Our team constructed a **prototype** to represent the challenge criteria and constraints.	A prototype was completed that met all of the challenge criteria and constraints.	A prototype was completed that met only two of the challenge criteria and constraints.	A prototype was completed that met only one of the challenge criteria and constraints.	A prototype was completed that did not meet the challenge criteria or constraints.
Our team collected and recorded data to **test and evaluate** our model's solutions.	Data were collected by testing to represent all of the criteria and constraints.	Data were collected by testing to represent only two criteria.	Data were collected by testing to represent only one criterion.	No data were collected and/or no testing was completed.
Our team made **design** improvements after testing the prototype.	All improvements to the prototype were described.	Two improvements to the prototype were described.	One improvement to the prototype was described.	No improvements to the prototype were described.
Our team was able to **communicate and explain** our design and how we solved the challenge.	Difficult issues were explained and their solutions described.	Difficult issues were explained with no solutions offered.	Discussion of difficult issues was unclear and no solutions were presented.	No discussion of difficult issues was included.
Our team was able to **share** our work through the **presentation process**.	All the presentation requirements and procedures were met.	Three or more of the presentation requirements and procedures were met.	One or two of the presentation requirements and procedures were met.	The presentation requirements and procedures were not met.