National Aeronautics and Space Administration

INSPIRE - ENGAGE - EDUCATE - EMPLOY

The Next Generation of Explorers

# Why Pressure Suits

# Introductory Video

View the video at http://y4y.ed.gov/stemchallenge/nasa

# The Engineering Design Process

# NASA Engineering Design Challenge

## Why Pressure Suits: The Challenge

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.

*A NASA pressure suit currently being used by astronauts on the International Space Station.*

# NASA Engineering Design Challenge

## Supporting Science Investigations

- Support student learning of background information
- Explore primary concepts used during the challenge

NASA Glenn Research Center's Plum Brook Station in Sandusky, Ohio, houses the world's largest vacuum chamber. It measures 100 feet in diameter and is a towering 122 feet tall. (NASA)

# NASA Engineering Design Challenge

## Supporting Science Investigation 1: Balloons in Space

- A vacuum is a lack of atmosphere.
- Objects within a vacuum behave differently than they would in Earth's atmosphere.
- The greater the vacuum, the more it affects an object.
- Even an object that contains very little air will expand when placed in a vacuum.

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

# NASA Engineering Design Challenge

## Supporting Science Investigation 1: Balloons in Space

### Discussion

1. How did the vacuum affect the objects?
2. How is this different than in Earth's atmosphere?
3. How do you think the water-filled balloon would react if the glass broke and the pressure equalized immediately?
4. How will you apply what you learned in this investigation to your design?

# NASA Engineering Design Challenge

## Supporting Science Investigation 2: Hands-On Vacuum

- A vacuum is a lack of atmosphere.
- Objects within a vacuum behave differently than they would in Earth's atmosphere.
- The greater the vacuum, the more it affects an object.

*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)*

# NASA Engineering Design Challenge

## Supporting Science Investigation 2: Hands-on Vacuum

### Discussion

1. How did the vacuum affect the objects?
2. How is this different than in Earth's atmosphere?
3. Imagine the syringe was three times larger. Would it create three times the change in pressure?
4. If this investigation used a small rock inside the syringe instead of a marshmallow, what do you think would happen to the rock? Why?
5. How will you apply what you learned in this investigation to your design?

# NASA Engineering Design Challenge

## Teamwork

Develop a team name, mission patch, and vision statement. Then, work together as a team to complete the challenge.

## Jobs

**Design engineer** – Sketches, outlines, patterns, or plans  the ideas the team generates

**Technical engineer** – Assembles, maintains, repairs, and modifies the structural components of the design

**Operations engineer** – Sets up and operates the model to complete testing

**Technical writer/videographer** – Records and organizes data and prepares documentation via text, pictures, and/or video to be reported and published

*This Apollo 11 patch depicts an eagle landing on the Moon with a view of the Earth in the background. (NASA)*

# NASA Engineering Design Challenge

## Why Pressure Suits: The Challenge

### 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.

*A NASA pressure suit currently being used by astronauts on the International Space Station. (NASA)*

# NASA Engineering Design Challenge

## Materials Needed

The following is a suggested list of materials needed to complete the challenge.

- General building supplies
- Digital scale or balance
- Measuring tape that includes metric units
- Rulers that include metric units
- Grid paper
- Balloons
- Vacuum pumps
- Marshmallows

# NASA Engineering Design Challenge

## Identify a Need or Problem

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

- State the problem in your own words. Example: "How can I design a _____ that will _____?"
- What needs to be solved or improved?
- What are we trying to accomplish?
- What general scientific concepts need to be considered before beginning to solve this problem?

*Astronauts Stan Love and Stephen Bowen wear spacesuits to practice tasks in the Neutral Buoyancy Laboratory at Johnson Space Center. Photo Credit: Bill Brassard (NASA)*

# NASA Engineering Design Challenge

## Research

Conduct research and record what you learn about the challenge.

Use these questions as a guide when researching your questions:

- Who is currently working on this problem or similar problems? What solutions have they created? What solutions are they working on?
- What questions would you ask a NASA scientist or engineer who is currently trying to solve problems like this one?
- Who in our society will benefit from this problem being solved?
- What have you learned from the Supporting Science Investigations that you can apply to this challenge?

Capture an image for the team's presentation product

# NASA Engineering Design Challenge

## Research With a NASA Scientist or Engineer

### Connecting With NASA

- First, watch this video in which Commander Sunita Williams gives a tour of the International Space Station to find out about space travel and living in space.
- Second, connect with a NASA scientist or engineer to learn more!

### Potential Questions

- What does the NASA person we are connecting with do at NASA?
- Why are engineers trying to solve the problem in the challenge we are working on?
- Why is this an important problem to solve?

# NASA Engineering Design Challenge

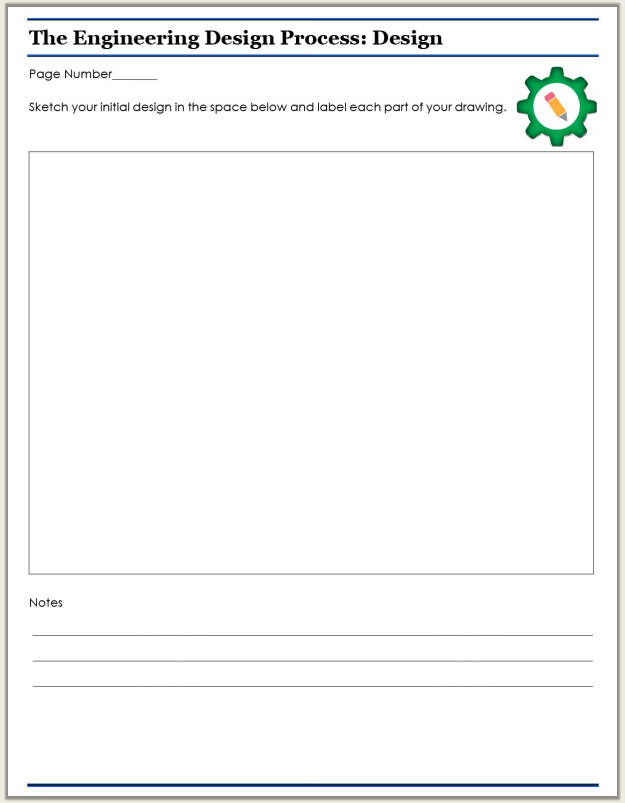
## Design

How can I solve the problem?

Use your research and scientific knowledge to brainstorm all the possible ways you can think of to design a solution. Now, sketch your idea for a solution in your Student Journal.

Use these questions as a guide when brainstorming your ideas:

- What are all the different ways I can imagine to solve this?
- What do I need to add to the design?
- Are all the criteria and constraints addressed?


The Engineering Design Process: Design

Page Number_____

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

Notes

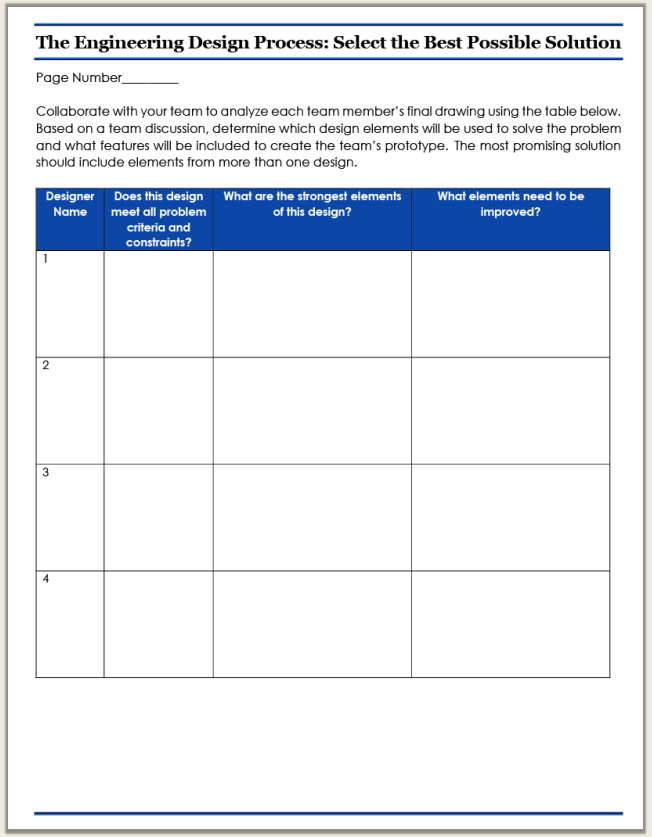
# NASA Engineering Design Challenge

## Select the Best Possible Solution

Work with your team to share ideas and answer each other's questions. Then, create a design to solve the problem that has elements from more than one team member's final drawing and meets the criteria and constraints.

Use these questions to guide team collaboration:

- What is one strength of each student's individual design?
- How can that be incorporated into a group design?
- Are the strengths in each design related to the criteria and constraints of the challenge?
- Are elements from each team member's design represented in the final design?



**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 | | | |

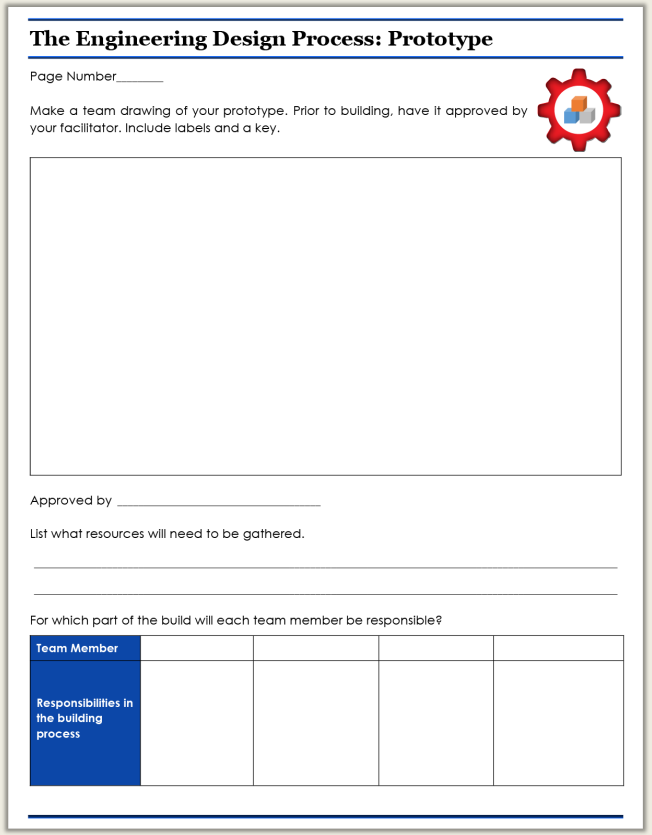
# NASA Engineering Design Challenge

## Prototype

Choose ideas from each team member. Create a team design of the model your team will be testing. Be sure to label all parts and make a key.

Use these questions to guide your construction plan:

- What resources does your team need to gather?
- What is the plan?
- Who is doing what?



**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 | | | | |

# NASA Engineering Design Challenge

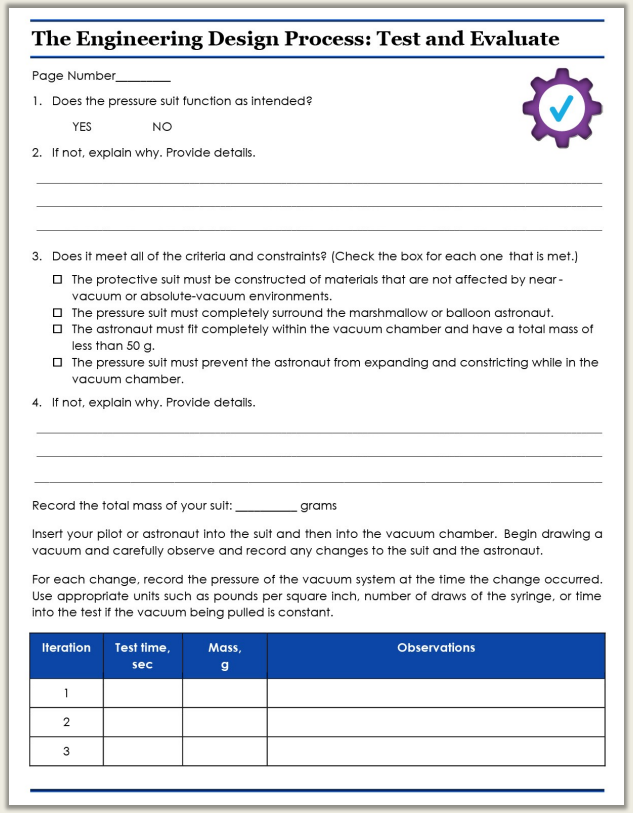
## Test and Evaluate

It is not enough to just collect data during testing. Scientists and engineers need to interpret the data so that they can convince others that their results are meaningful.

Test the model three times for each iteration. Make observations and record the data. Document how the prototype reacts to the testing.

Use the following guiding questions as discussion prompts to focus student understanding.

- Did the team collect enough data to analyze the design?
- How did the prototype perform when tested?
- Did the design meet or exceed the criteria and constraints?



**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 | | | |

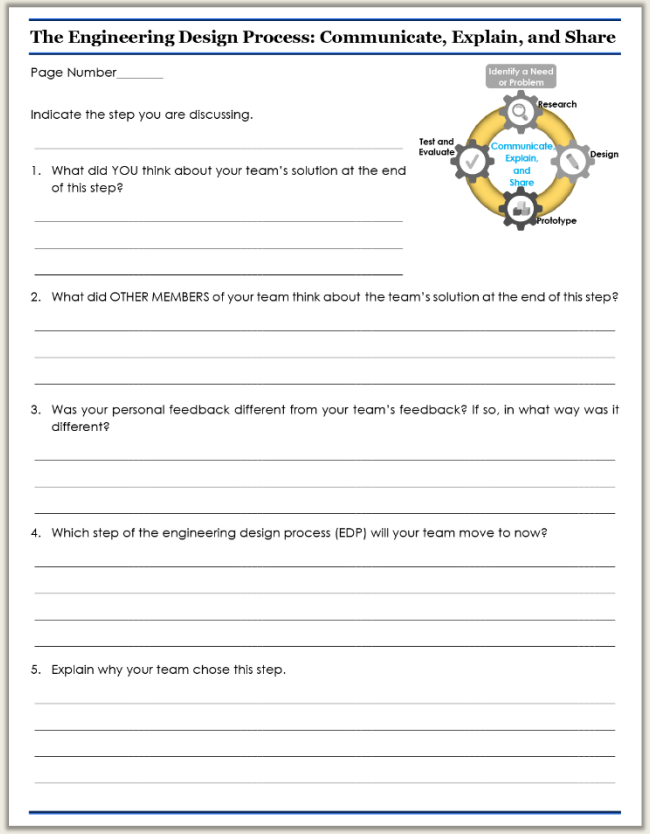
# NASA Engineering Design Challenge

## Communicate, Explain, and Share

Scientists often reflect on ongoing experiments in order to move forward with more and better information. Take time to reflect on your progress.

Use the following guiding questions as discussion prompts to focus student understanding.

- What did or did not work in the latest iteration of the design? Why or why not?
- What are the pros and cons of this solution?
- Did each team show that they used all of the processes of the EDP?



**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?

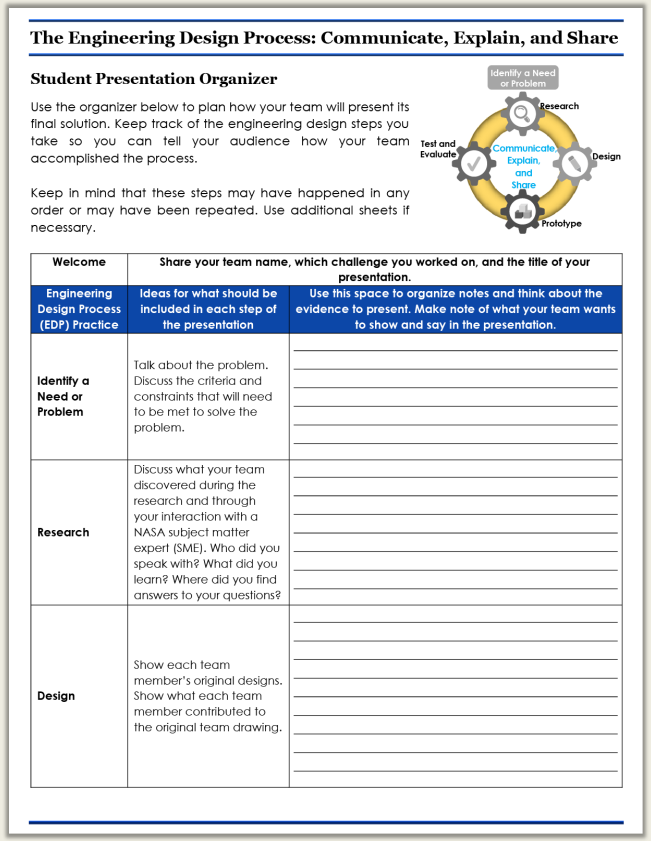
5. Explain why your team chose this step.

# NASA Engineering Design Challenge

## Communicate, Explain, and Share

Documenting the solution and design is essential to conveying how it works, how it solves the identified need or problem, and how it meets the criteria and constraints.

Use the Student Presentation Organizer to help create the presentation that will be submitted when the challenge has been completed.



**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.



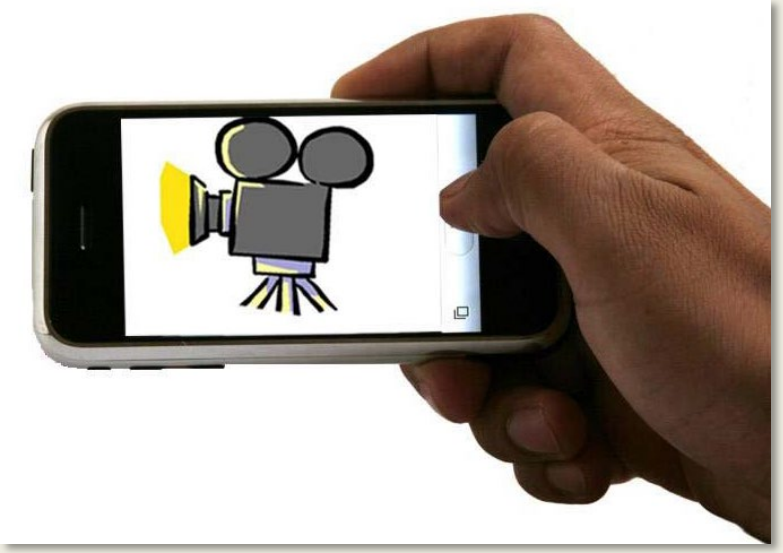
| Welcome | Share your team name, which challenge you worked on, and the title of your presentation. | |
|---|---|---|
| **Engineering Design Process (EDP) Practice** | **Ideas for what should be included in each step of the presentation** | **Use this space to organize notes and think about the evidence 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. | |

# NASA Engineering Design Challenge

## Conclusion

Students teams, have you

- Created a video or slide presentation documenting what the team has done during the engineering design process and challenge?
- Used the Student Presentation Organizer and Team Progress Chart to help with communication?
- Determined that the presentation meets the criteria for submission?
- Submitted a video product for review?



# NASA Engineering Design Challenge

## Submitting Your Presentation

To submit your final video or slide presentation, follow the instructions on the Y4Y (You for Youth) website: https://y4y.ed.gov/stemchallenge/nasa