National Aeronautics and
Space Administration

INSPIRE - ENGAGE - EDUCATE - EMPLOY
The Next Generation of Explorers

Packing Up for the Moon

Introductory Video

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

The Engineering Design Process

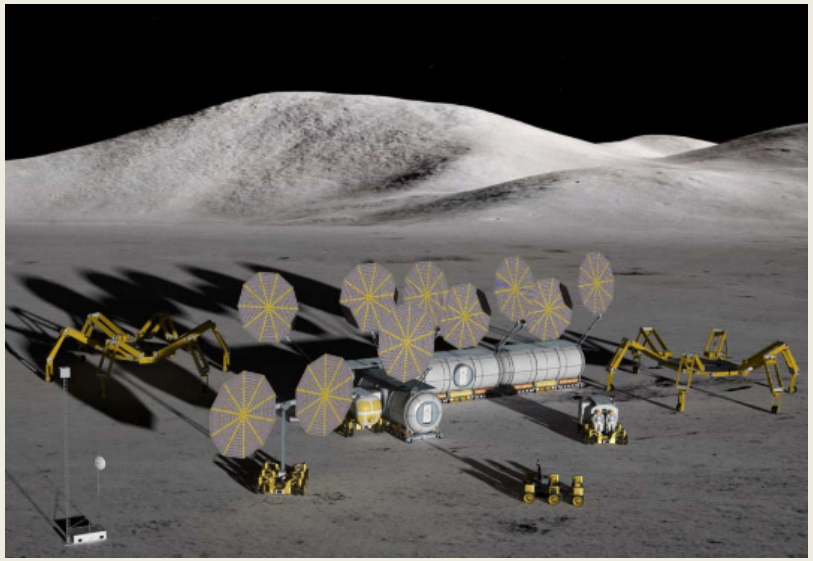
NASA Engineering Design Challenge

Packing Up for the Moon: The Challenge

Future astronaut crews on long-duration missions will need to learn how to grow safe, edible, and nutritious plants while living and working in space, on the Moon, and on other planets.

All the essential supplies and materials needed to survive on the Moon will be stowed on a rocket, shipped to the Moon, and deployed on the surface.

There is a limited amount of space available on the rocket for the large amount of lunar cargo needed.



Artist's conception of a potential lunar outpost. (NASA)

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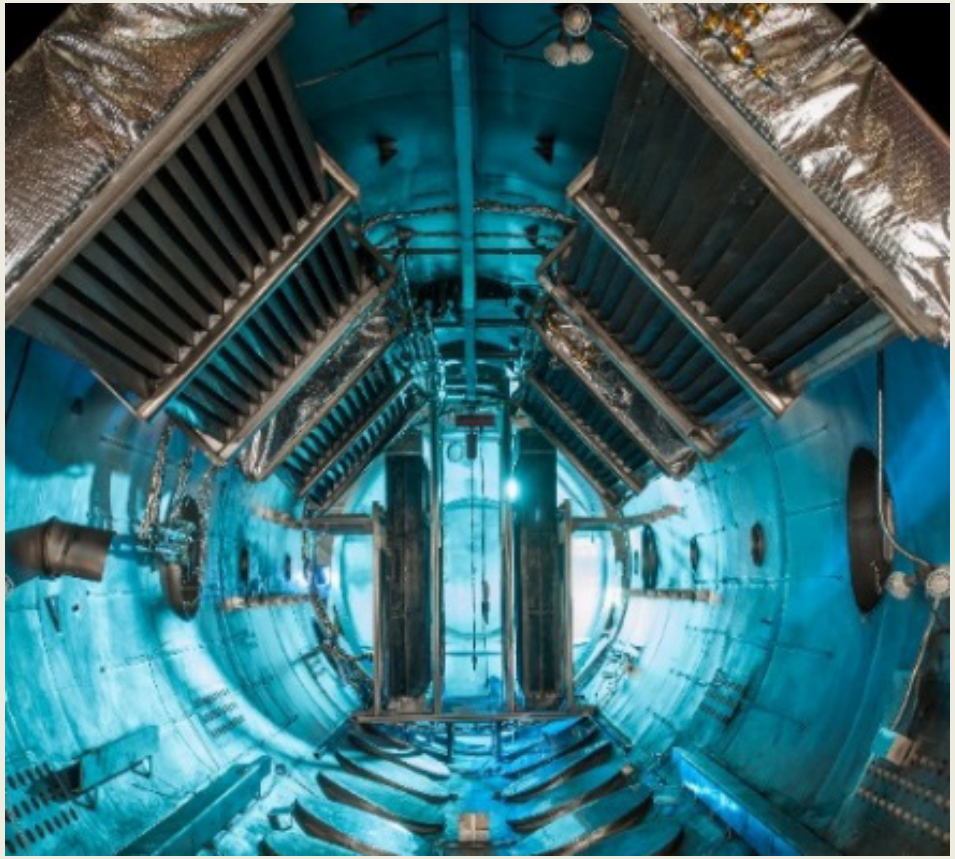
Supporting Science Investigations

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



Vacuum Chamber 5 (VF–5) at NASA's Glenn Research Center provides an environment that simulates space-like conditions. VF–5 has been used to test electric propulsion systems and power systems for in situ resource utilization.

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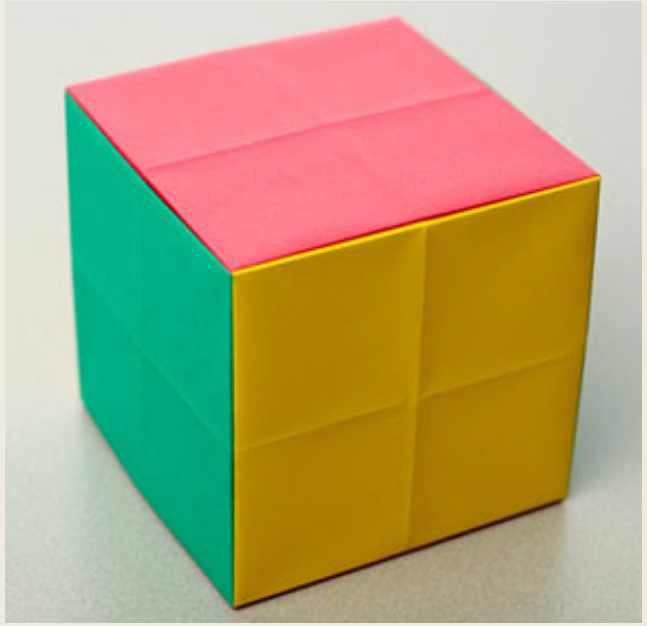
Supporting Science Investigation 1: Jackson Cubes

- Thin materials can be folded to create large-volume spaces.
- Folded objects can be expanded, contracted, and resized easily.
- Large objects can be made from smaller, pre-made units.



Students will create a sturdy cube by folding squares of paper.

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Supporting Science Investigation 1: Jackson Cubes

Discussion

The Jackson Cubes activity showed us that it is possible to make objects with a large volume using materials that by themselves contain very little volume.

1. Imagine you had to construct a large building using this method. How practical would it be? Are buildings built this way today?
2. Now, imagine you had to construct a building on Mars using this method. Would it have to be built differently?
3. How will you apply what you learned in this investigation to your design?

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Supporting Science Investigation 2: Stability

- The shape of a material can affect the strength of a system in which it is used.
- The properties of a material may be modified.
- There are multiple ways to modify a material.

Inside the Kennedy Space Center's Space Station Processing Facility, the International Space Station's P3/P4 integrated truss segment is lowered into the cargo hold for transport and installation in the orbiter Atlantis. (NASA/Troy Cryder)

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Supporting Science Investigation 2: Stability

Discussion

The Stability activity demonstrated how a material can be modified into different shapes to enhance its stability when used as part of a design system. The stability of each section of a system can affect the strength of the whole system, helping it withstand weight and maintain its structure.

1. Can you think of any other materials that have multiple properties?
2. How could a material with multiple properties be used by astronauts in space?
3. How will you apply what you learned in this investigation to your design?

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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)

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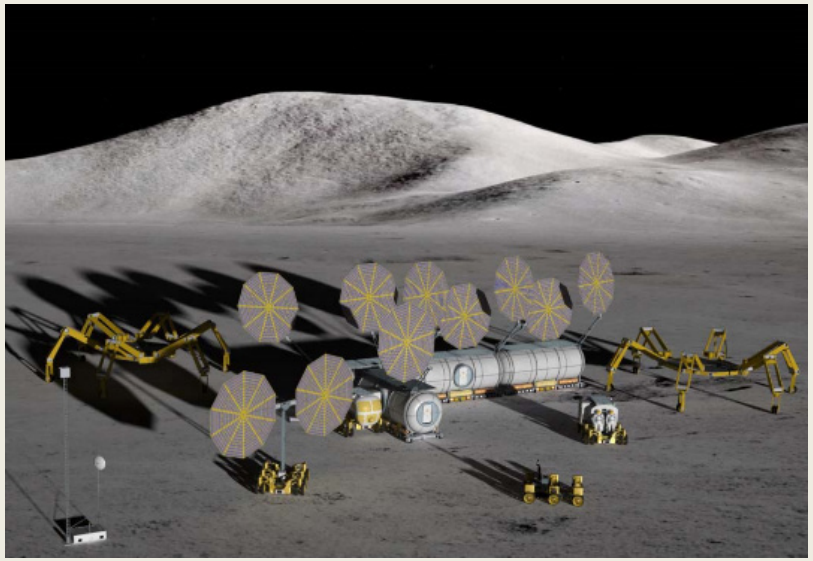
Packing Up for the Moon: The Challenge

Criteria and Constraints

1. On the rocket, the plant growth chamber model must not exceed a mass of 50 g and a stowed volume of 1,000 cm^3.
2. The deployed plant growth chamber can be any shape; however, the volume cannot exceed 1,000,000 cm^3.
3. The deployed plant growth chamber may or may not be connected to the lunar habitat, but it must provide a way for astronauts to have access to the chamber.
4. The model plant growth chamber must use a system of expansion from its stowed shipment package on the rocket to its final deployed structure on the Moon.



Artist's conception of a potential lunar outpost. (NASA)

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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

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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?

Orion uncrewed test December 5, 2014. (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

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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?

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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?

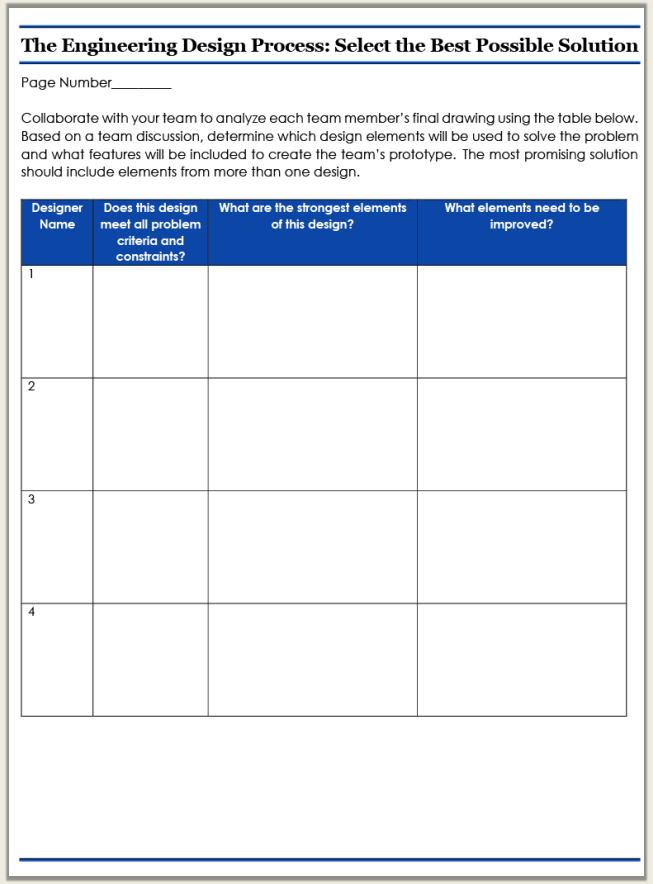
NASA Engineering Design Challenge

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			

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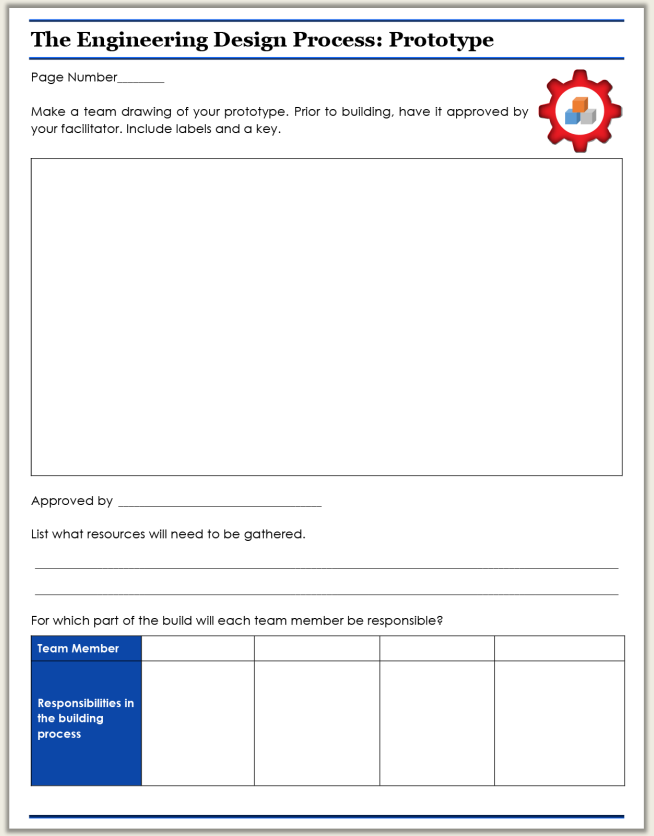
Prototype

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

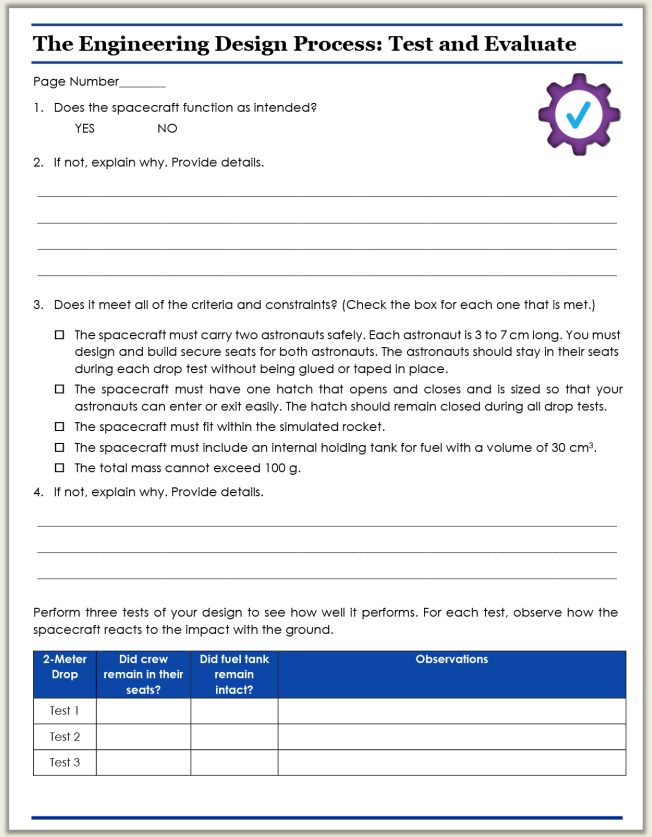
Test and Evaluate

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 spacecraft 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 spacecraft must carry two astronauts safely. Each astronaut is 3 to 7 cm long. You must design and build secure seats for both astronauts. The astronauts should stay in their seats during each drop test without being glued or taped in place.
   - ☐ The spacecraft must have one hatch that opens and closes and is sized so that your astronauts can enter or exit easily. The hatch should remain closed during all drop tests.
   - ☐ The spacecraft must fit within the simulated rocket.
   - ☐ The spacecraft must include an internal holding tank for fuel with a volume of 30 cm^3.
   - ☐ The total mass cannot exceed 100 g.
4. If not, explain why. Provide details.

Perform three tests of your design to see how well it performs. For each test, observe how the spacecraft reacts to the impact with the ground.

2-Meter Drop	Did crew remain in their seats?	Did fuel tank remain intact?	Observations
Test 1			
Test 2			
Test 3			

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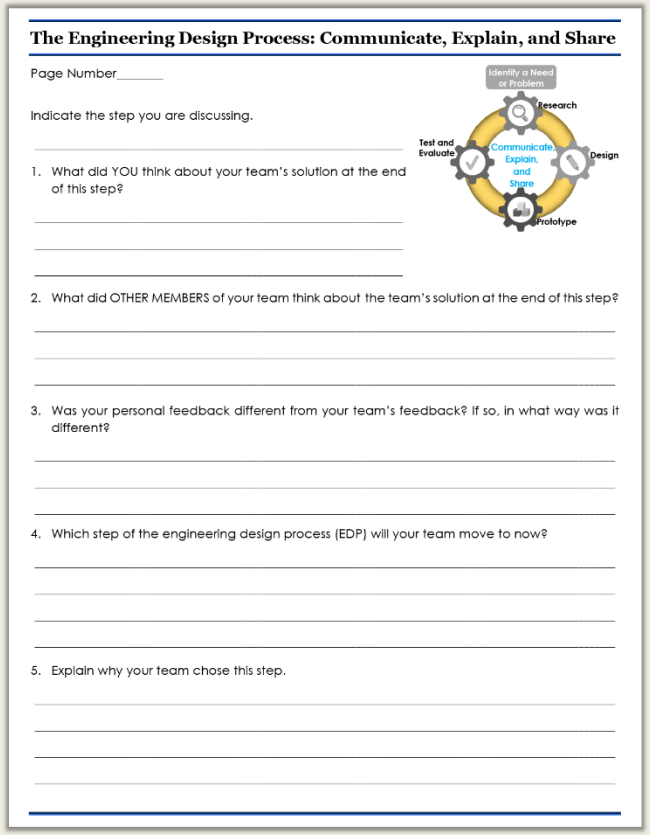
Communicate, Explain, and Share

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?

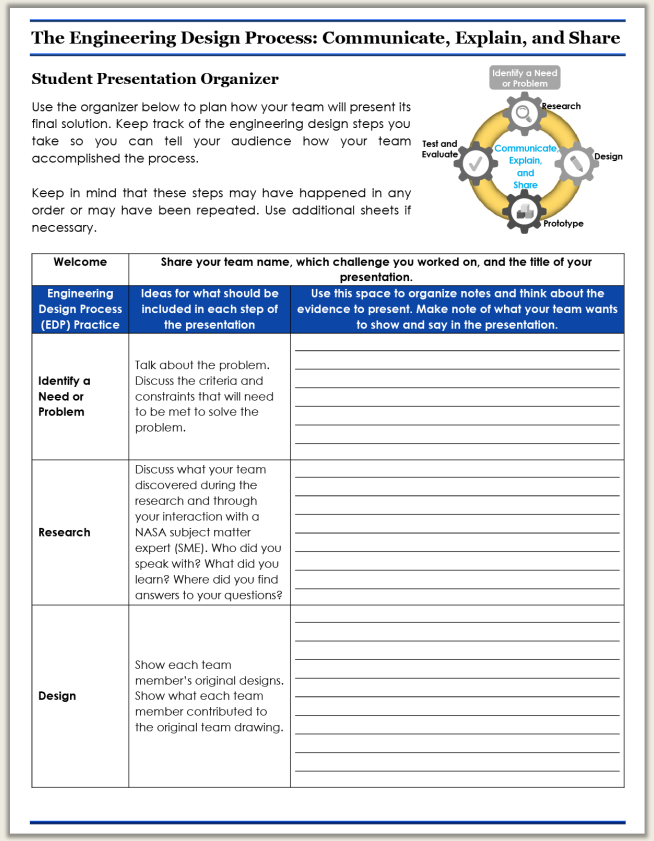
5. Explain why your team chose this step.

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.

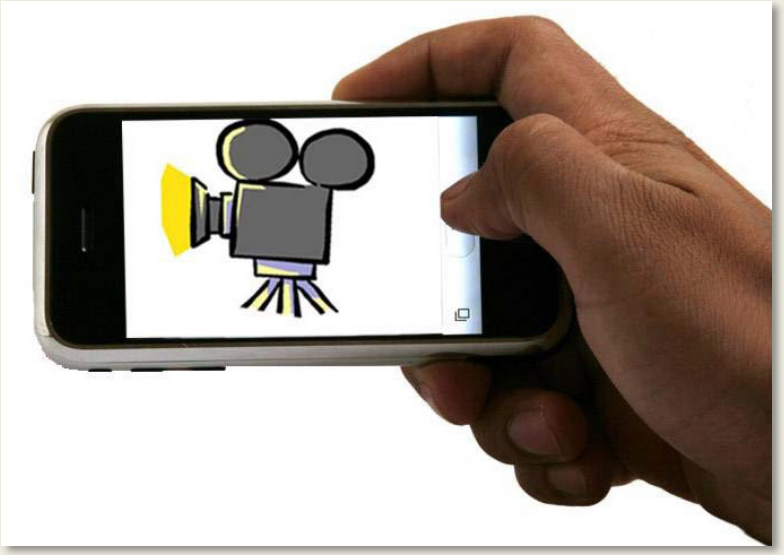
Welcome	Share your team name, which challenge you worked on, and the title of your presentation.	
Engineering Design Process (EDP) Practice	**Ideas for what should be included in each step of the presentation**	**Use this space to organize notes and think about the evidence to present. Make note of what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



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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