National Aeronautics and
Space Administration

INSPIRE - ENGAGE - EDUCATE - EMPLOY

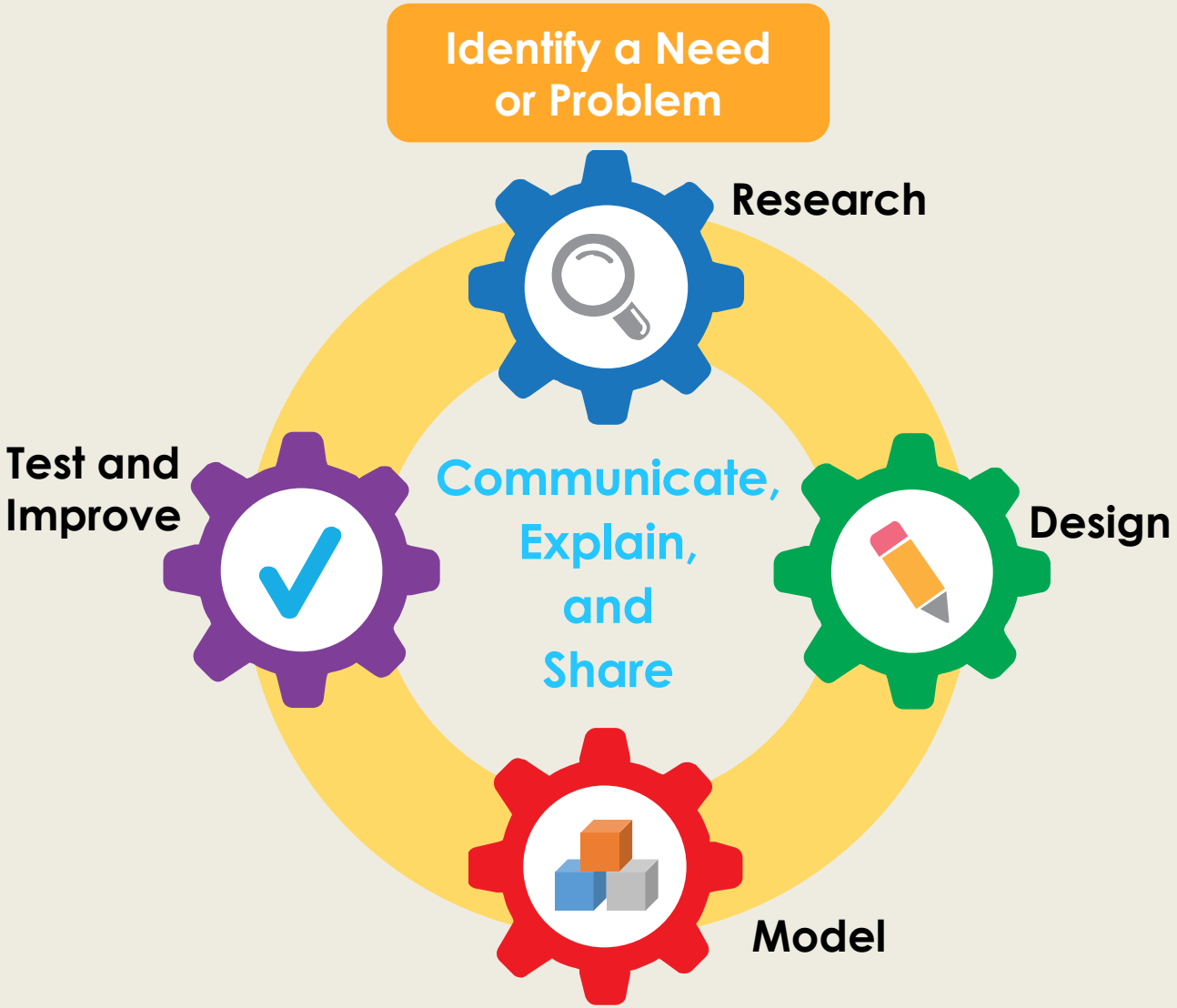
The Next Generation of Explorers

M2M: Mission to Mars

Introductory Video

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

The Engineering Design Process



NASA Engineering Design Challenge

M2M: Mission to Mars: The Challenge

Because spacecraft that land on the surface of Mars travel at extremely high speeds, they need some sort of drag device to slow them down to prevent them from crashing into the planet and becoming damaged.

As missions increase in complexity, landers and rovers become heavier and require even more effective drag devices.

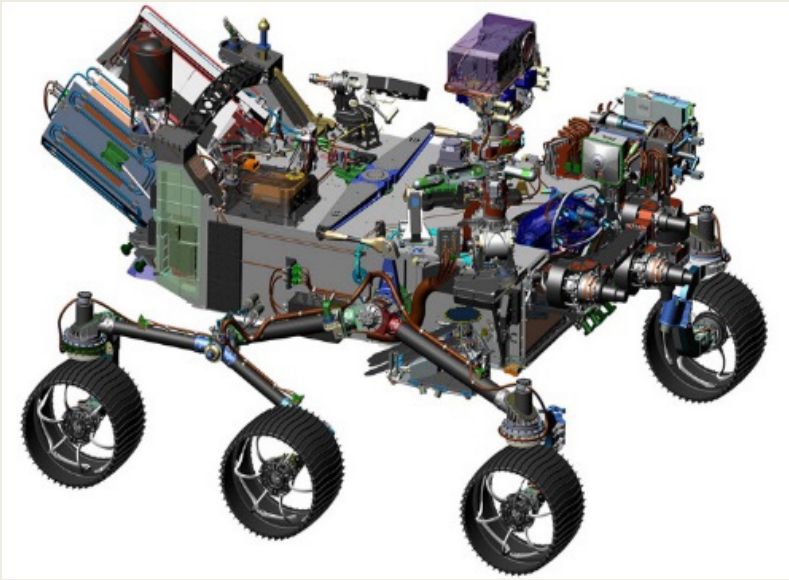
Illustration of NASA's InSight lander descending toward the surface of Mars with its parachute. The lander arrived on Mars in November 2018. (NASA/JPL-Caltech)

NASA Engineering Design Challenge

STEM Investigations

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

A drag chute helped slow down Space Shuttle Endeavour when it landed at Edwards Air Force Base in 2002. (NASA)



Computer-assisted design of NASA's 2020 Mars rover. (NASA/JPL-Caltech)

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STEM Investigation 1: It's a Drag

- You will investigate drag as a force that is created as an object interacts with air.
- You will investigate the amount of drag created by paper of various sizes.
- You will identify the difference between balanced and unbalanced forces.

Hint: Drag is a force made by an object moving through air. People often call this air resistance. Have you ever put your hand out of a car window while the car was moving and felt your hand being pushed back and forth? If so, you have felt the force that is called drag.

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STEM Investigation 1: It's a Drag

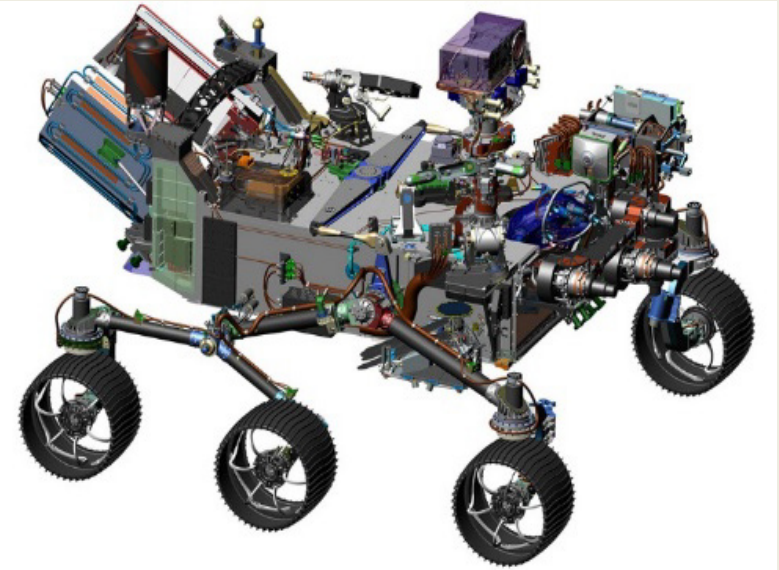
Discussion

- Which of the various sizes of folded paper do you think will create more drag and fall to the ground more slowly?
- How will you apply what you learned in this investigation to your design?

NASA Engineering Design Challenge

STEM Investigation 2: Touchdown

- You will investigate the energy of a falling object and what happens to that energy when it hits the ground.
- You will investigate ways to create a shock-absorbing system for a landing device.
- You will identify the difference between balanced and unbalanced forces.



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STEM Investigation 2: Touchdown

Discussion

1. What kinds of systems could be used to absorb the shock of an object falling to the ground?
2. 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

M2M: Mission to Mars: The Challenge

Criteria and Constraints

- Each team **must** design and make a drag device to connect to the cargo bay. The device **must** make the cargo bay slow down when it is tested, or dropped.
- The entire device **must** be deployed from 2 meters and **must** remain intact throughout the drop.
- The cargo bay **must** hold 10 grams of cargo secured inside.
- The overall mass **must not** exceed 50 grams.

Illustration of NASA's InSight lander descending toward the surface of Mars with its parachute. The lander arrived on Mars in November 2018. (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
- Hole reinforces or stickers with holes
- Pennies or washers as weights
- Cargo bay template

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Identify a Need or Problem

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

- What is the problem you and your team will be working on in this challenge?
- What are the things our solution **must** do?
- What are the things our solution **must not** do?

Orion uncrewed test December 5, 2014. (NASA)

NASA Engineering Design Challenge

Research

Conduct research and record what you know, what you wonder, and what you learn about the challenge.

Use these questions as a guide when researching your questions:

- Where can you find more information about the topic?
- What questions would you ask a NASA scientist or engineer who is currently trying to solve problems like this one?
- Why are we trying to solve this problem?
- What objects in this room have been made or developed by a scientist?

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 do NASA scientists and engineers design that may affect our daily lives?
- What kinds of jobs are found at NASA?
- Is working in a team important at NASA?

NASA Engineering Design Challenge

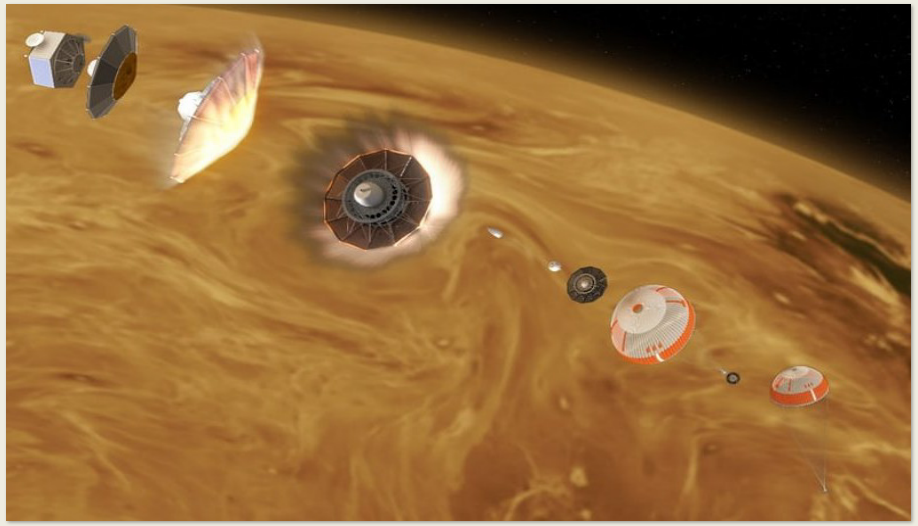
Design

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?
- Does my drawing address all the criteria and constraints?



Artistic rendering of an entry, descent, and landing system concept designed to safely deploy scientific payloads or enable long-term human exploration to other planets. (NASA)

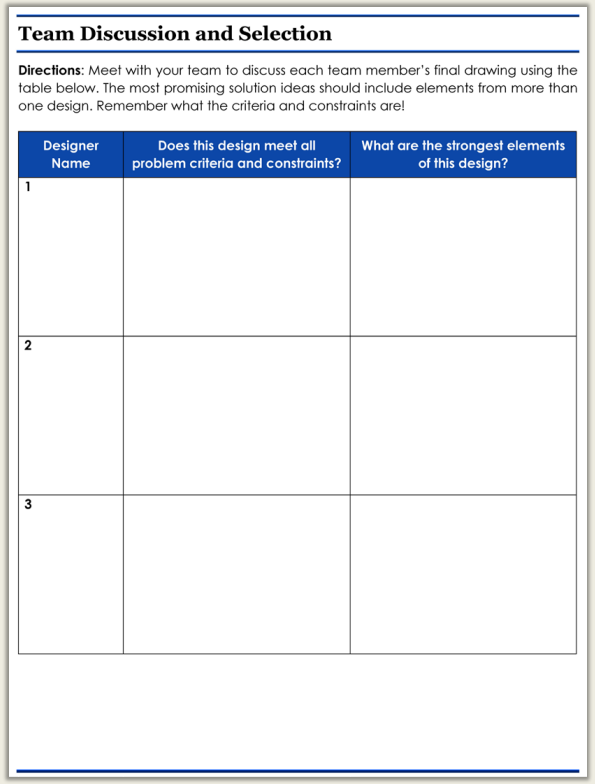
NASA Engineering Design Challenge

Team Discussion and Selection

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?



Team Discussion and Selection

Directions: Meet with your team to discuss each team member's final drawing using the table below. The most promising solution ideas should include elements from more than one design. Remember what the criteria and constraints are!

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

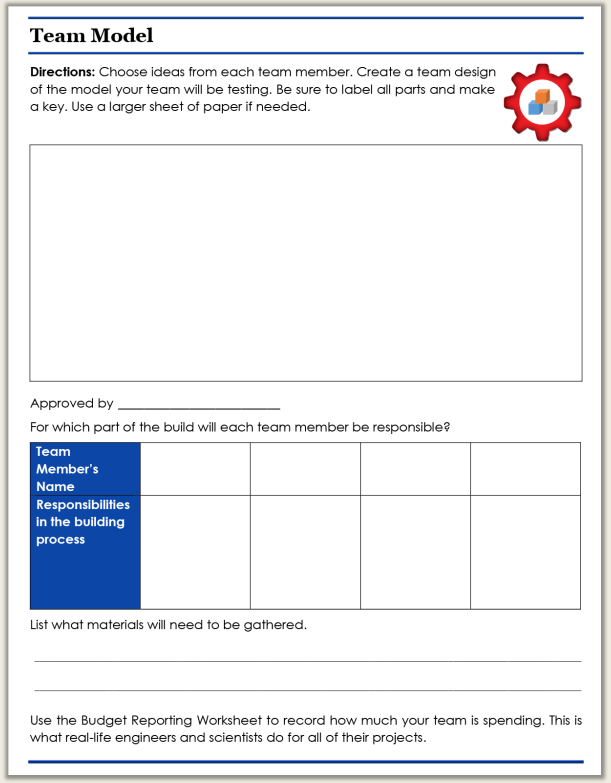
NASA Engineering Design Challenge

Model

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:

- How can our team create a model representing the team's design from available and provided building materials?
- How can our team create a budget sheet that will record and calculate the material cost of the team's model within an established budget?
- How can our team Communicate, Explain, and Share the reasons for the team's decisions, research, and improvements?



Team Model

Directions: 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 a larger sheet of paper if needed.

Approved by _____

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

Team Member's Name				
Responsibilities in the building process				

List what materials will need to be gathered.

Use the Budget Reporting Worksheet to record how much your team is spending. This is what real-life engineers and scientists do for all of their projects.

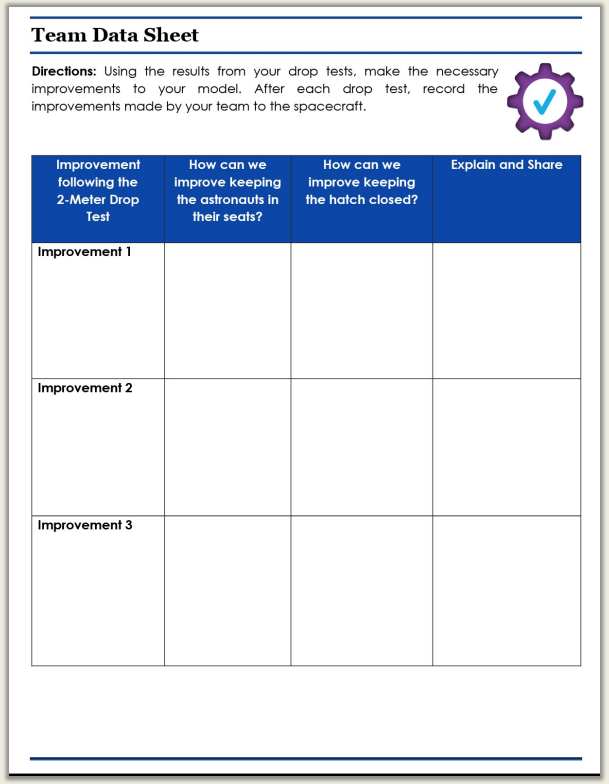
NASA Engineering Design Challenge

Test and Improve

Conducting tests of the team model and then recording the results are what engineers do when trying to solve a problem. During each of the drop tests, observe how your team model met the criteria and constraints of the challenge.

Use these questions to guide you in this step:

- How can our team conduct tests that represent the criteria and constraints of the challenge?
- How will our team identify areas for model improvements based on test data?



Team Data Sheet

Directions: Using the results from your drop tests, make the necessary improvements to your model. After each drop test, record the improvements made by your team to the spacecraft.

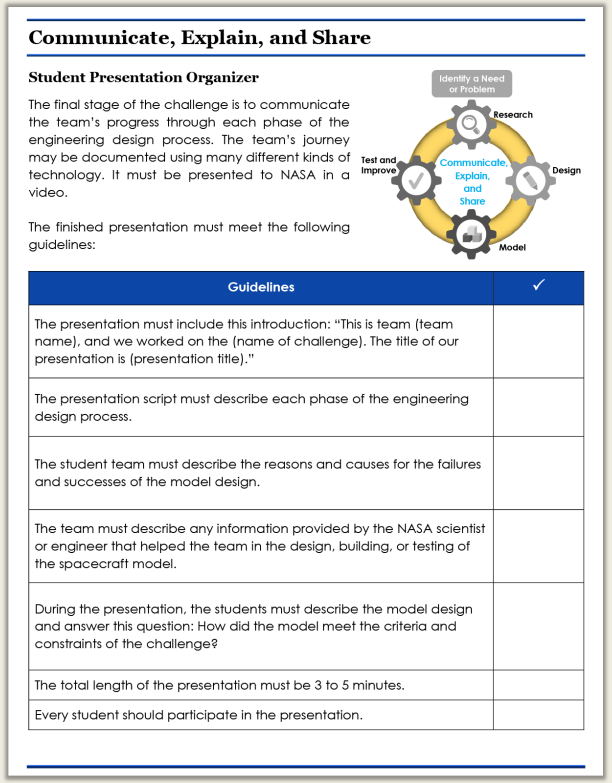
Improvement following the 2-Meter Drop Test	How can we improve keeping the astronauts in their seats?	How can we improve keeping the hatch closed?	Explain and Share
Improvement 1			
Improvement 2			
Improvement 3			

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.

- How can our team Communicate, Explain, and Share the reasons for the team's decisions, research, and improvements?
- How can the team use technology to represent and describe our solution to the challenge?



Communicate, Explain, and Share

Student Presentation Organizer

The final stage of the challenge is to communicate the team's progress through each phase of the engineering design process. The team's journey may be documented using many different kinds of technology. It must be presented to NASA in a video.

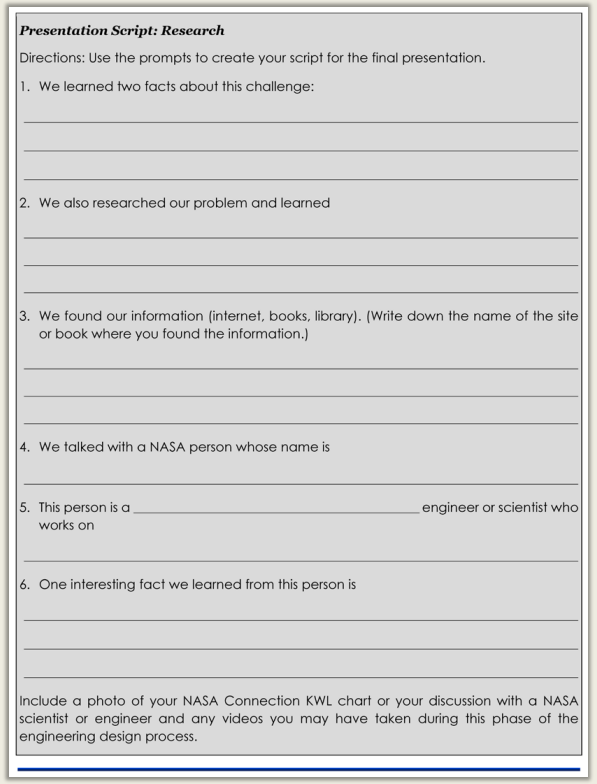
The finished presentation must meet the following guidelines:

Guidelines	✓
The presentation must include this introduction: "This is team (team name), and we worked on the (name of challenge). The title of our presentation is (presentation title)."	
The presentation script must describe each phase of the engineering design process.	
The student team must describe the reasons and causes for the failures and successes of the model design.	
The team must describe any information provided by the NASA scientist or engineer that helped the team in the design, building, or testing of the spacecraft model.	
During the presentation, the students must describe the model design and answer this question: How did the model meet the criteria and constraints of the challenge?	
The total length of the presentation must be 3 to 5 minutes.	
Every student should participate in the presentation.	

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 Presentation Script sections to help create your team's presentation that will be submitted when the challenge has been completed.



Presentation Script: Research

Directions: Use the prompts to create your script for the final presentation.

1. We learned two facts about this challenge:

_____

_____

_____

2. We also researched our problem and learned

_____

_____

_____

3. We found our information (internet, books, library). (Write down the name of the site or book where you found the information.)

_____

_____

_____

4. We talked with a NASA person whose name is

_____

5. This person is a _____ engineer or scientist who works on

_____

6. One interesting fact we learned from this person is

_____

_____

_____

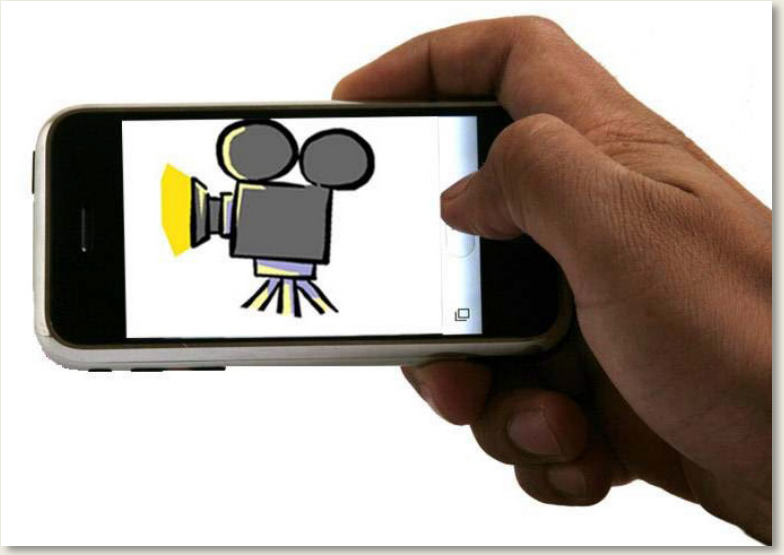
Include a photo of your NASA Connection KWL chart or your discussion with a NASA scientist or engineer and any videos you may have taken during this phase of the engineering design process.

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 presentation scripts 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