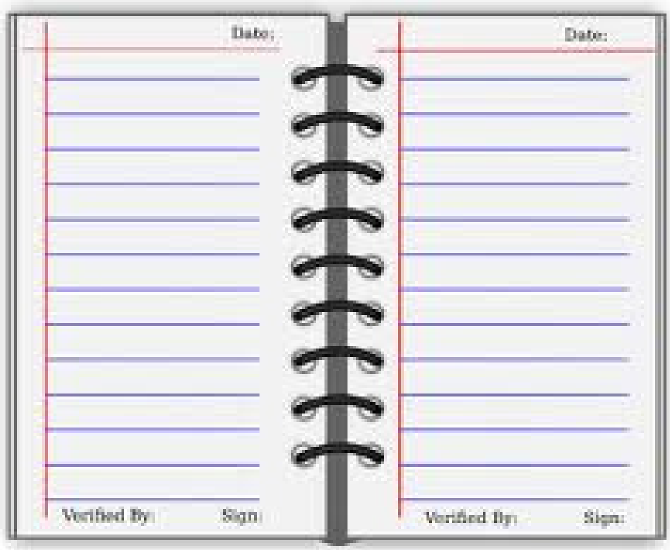
Student Journal



NASA Mission Background

What is NASA?

NASA is short for a much longer name: The National Aeronautics and Space Administration. NASA is many different people and places. Everyone at NASA has the same vision: *To discover and expand knowledge for the benefit of humanity.*

For more than 50 years, the people of NASA have worked to change the history of the human race. From walking on the Moon to sending spacecraft to the Sun and every planet in the solar system, we continue to be curious and work together as a team to reach our goals.


Figure 14. Raja Chari is a member of NASA's 2017 Astronaut Candidate Class.

What is NASA's Orion spacecraft?

NASA is building a new spacecraft called Orion. It will take humans to the Moon, Mars, and beyond. Orion will carry astronauts into space, provide for the crew during space travel, and return the astronauts safely to Earth from deep space. Orion will be launched on NASA's new Space Launch System (SLS). This rocket is more powerful than any rocket ever built.


Figure 15. Artist's rendering of the Space Launch System with the Orion spacecraft. (NASA)

How is Orion's hatch designed?

The hatch, or spacecraft door, is located on the side of the capsule so that astronauts can enter and exit. Orion will be both a transport vehicle and a home vehicle for the crew. NASA engineers designed a hatch that can be locked and sealed securely to protect the astronauts during the journey.


Figure 16. NASA astronaut Stan Love exits from Orion's side hatch during a test of the capsule at sea. (NASA)


Figure 17. How is Orion's hatch similar to a car door? (Photo courtesy of Christopher Ziemnowicz.)

How do astronauts stay in their seats?

Seats are one of the most important parts of a spacecraft. Astronauts must be safe in their seats during the launch and the landing. When spacecraft are designed, the location of the seats helps engineers design all the other parts in the crew cabin, like windows, controls, and forms of entry and exit.

Spacecraft use harness systems that connect to the seats in several places. Orion has been tested with four- and five-point harnesses to keep astronauts safe in their seats. Cars come with two-point harnesses (a single belt across the lap) and three-point harnesses (a lap belt and another belt connected over one shoulder).

Interesting fact: Each astronaut has a seat made just for them!

Figure 18. NASA Astronaut Ellen Ochoa buckles into a collapsible seat in preparation for traveling in Earth orbit. (NASA)

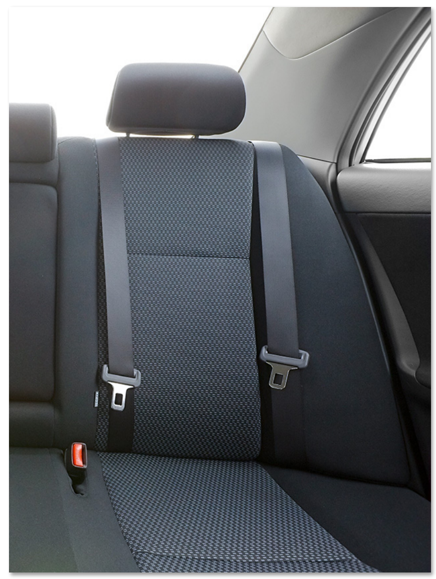


Figure 19. Pictured above is a pair of shoulder belts, which are one way passengers stay safe when traveling in cars.

STEM Investigation 1: Egg Drop

Mission

You and your partner will create a package to hold and successfully land a raw egg, unbroken, from a fall to the ground.

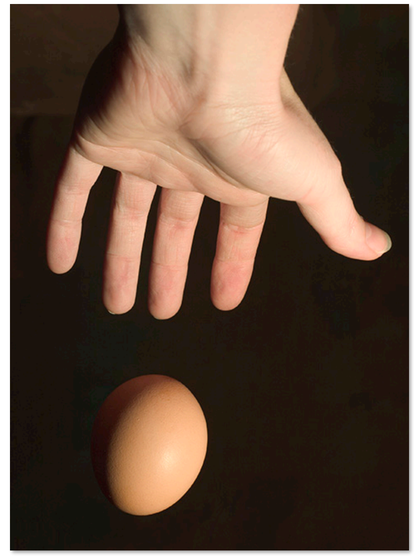


Figure 20. How can you protect your egg from breaking when it is dropped?

Materials

- 1 egg, uncooked
- Small zip-top plastic bag
- Packing material
- Masking tape
- Meter stick or yardstick
- Stopwatch

Procedure

1. Brainstorm with your team ways you can protect the egg from breaking when it is dropped.
2. Draw a model of your container and the materials you will use.
3. Select one type of packing material for your model.
4. Put the egg into a zip-top bag and seal the bag, removing as much air as possible.
5. Wrap the egg to protect it during its fall.
6. Hold the meter stick upright and drop the egg from 30 centimeters.
7. Record on the Data Collection Sheet the result and observations.
8. If the egg breaks, as a team think of other materials you can use to keep the egg from breaking.
9. Repeat steps 1 to 7 with a new material.
10. If the egg does not break, test your model from 40 centimeters and record the data. Increase the height by 10 centimeters until the egg breaks. Record all data.
11. Answer the questions on the Data Collection Sheet.

Data Collection Sheet

Directions: Use your data to decide what materials worked best during your tests and what materials did not.

1. What materials did your team use for the first model?

____

2. Did the egg break? **Yes** **No**
3. If yes, what new materials is your team thinking of using for the next trial?

____

____

4. Did the egg break on your next trial? **Yes** **No**
5. At what height did the egg break? What materials were you using at the time?

____

____

6. If your team used new material, how did you change your design to better protect the egg?

____

____

7. What did you learn in this investigation that you and your team can think about for the engineering design challenge?

____

____

Drop Height	Did the egg break?	Materials Used	Observations
30 centimeters (cm)			
40 cm			
50 cm			
60 cm			
70 cm			
80 cm			

STEM Investigation 2: Wall Smashers

Mission

You and your partner will investigate how to use friction to slow down a ball in a tube. Your goal is to have the ball roll down the ramp and slow to a complete stop just as it touches the wall.

Figure 21. How can you slow down a moving object using materials that create friction?

Materials

- Ball, 5 centimeters wide
- Toy bricks, building blocks, logs, or other interconnecting blocks to create a wall
- Stopwatch
- Mailing tube section, 55 centimeters long and 8 centimeters wide
- Friction material
- Stack of books 5 centimeters high
- Straws, small pom-poms, string, or yarn
- Scissors
- Masking tape
- Meter stick

Procedure

1. Place one end of the tube on the stack of books to make a ramp. Use tape to hold the tube in place.
2. Measure 55 centimeters from the lower end of the tube and use a piece of tape to mark the measurement.
3. At that mark, build a wall.
4. One person should time the ball traveling to the wall, and the other person should release the ball at the top of the ramp.
5. Place the ball at the top of the ramp and roll it down the tube.
6. Record the time on the Data Collection Sheet.
7. Use different materials to create friction to slow down the ball. Materials can be placed inside the tube and between the end of the tube and the wall.
8. Record each different material and the time the ball took to travel down the ramp on your Data Collection Sheet.

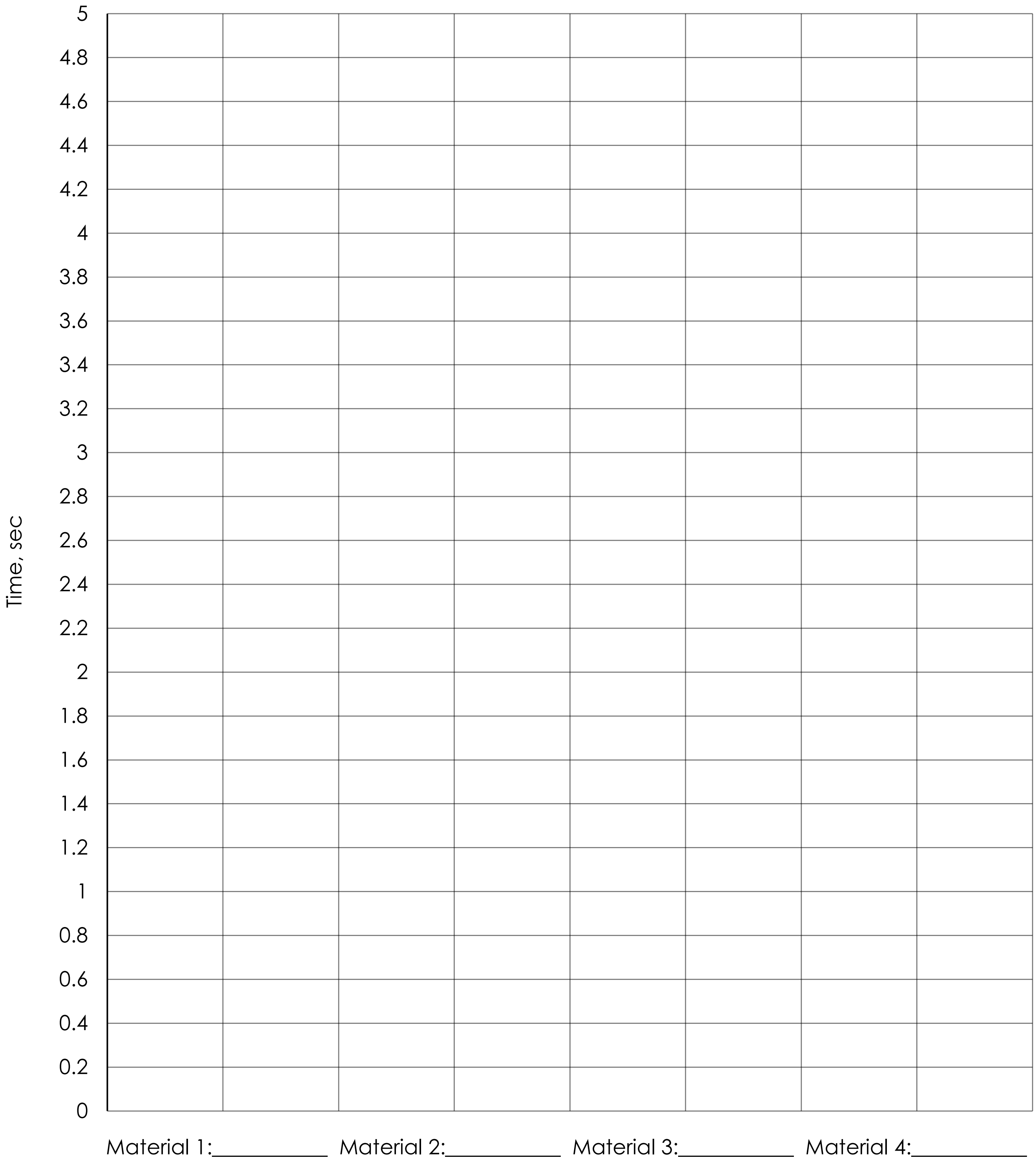
9. Continue trying to slow the ball to a stop just as it touches the wall.
10. Use the data from your Data Collection Sheet to create a bar graph of the results.
11. Complete the remaining questions on the Data Collection Sheet.

Data Collection Sheet

Directions: You are a scientist trying to slow down a speeding object. Use the data you collect to decide what materials worked the best during your tests and what materials did not work well.

Attempt Number	Time	Friction Material Used and Observations
1		
2		
3		

Create a bar graph that shows the material used and reflects the time the ball traveled down the ramp.



1. What type of friction materials did you use?

____

____

2. How do you think the materials changed the speed of the ball? Use your data to answer this question.

____

____

3. When did you see balanced and unbalanced forces at work on the ball?

____

____

4. Why was it important to find just the right mix of friction materials to slow down the ball?

____

____

5. Were you surprised by any of the outcomes for the different materials?

____

____

6. What did you learn in this investigation that you and your team can think about for the engineering design challenge?

____

____

Student Team Building

Directions: Work together to decide on a team name, design a mission patch, and create a group motto.

Figure 22. This Apollo 11 patch depicts an eagle landing on the Moon with a view of the Earth in the background. (NASA)

Team Name

Team Patch

NASA's vision statement: To discover and expand knowledge for the benefit of humanity.

Team Motto

Engineering Design Process

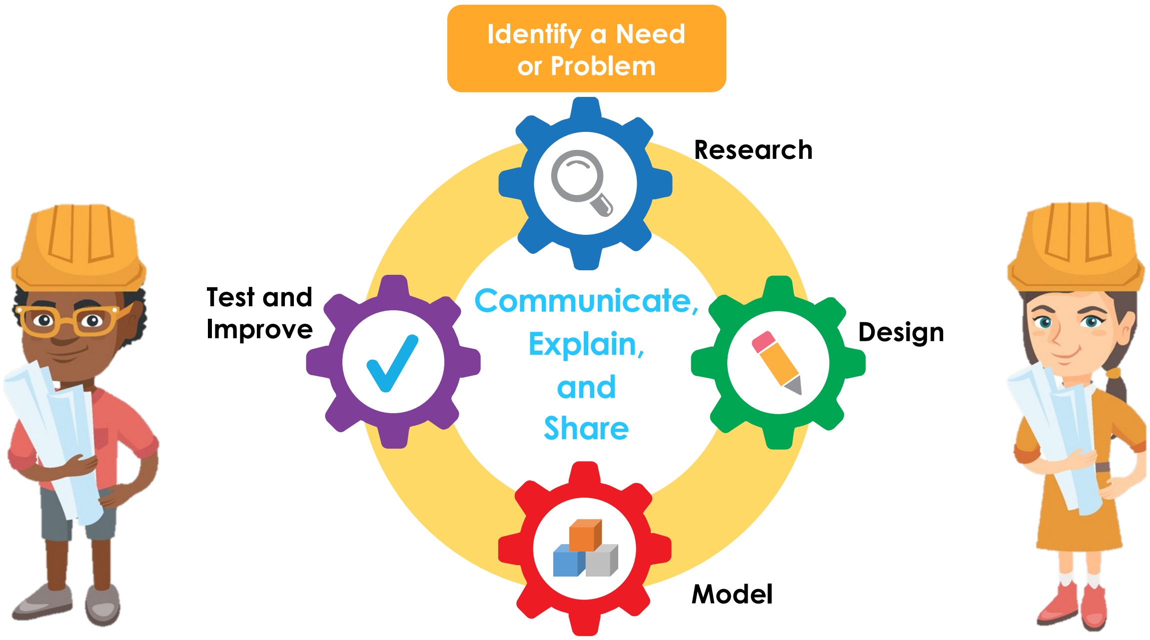


Figure 23. Engineering design process model. Model and accompanying text adapted from the 2016 Massachusetts Science and Technology/Engineering Curriculum Framework, Massachusetts Department of Elementary and Secondary Education, http://www.doe.mass.edu/frameworks/scitech/2016-04.pdf.

Identify a Need or Problem. This phase is designed to ask this question: How can we design a model that will meet the criteria and constraints of the challenge?

Research. During the research phase, students will find the answers to their questions by exploring the internet, visiting a library, or interviewing a NASA scientist or engineer.

Design. In the design phase, each student will draw a model that could solve the challenge. Teams will combine the drawings and design a team model drawing that meets the criteria and constraints.

Model. In the model phase, the team will use their drawing to build their model.

Test and Improve. The model will be tested. Teams will gather and evaluate data to improve the design.

Communicate, Explain, and Share. During each phase, the team will record and share progress. Teams should discuss the design solutions and present ideas to others, describing the engineering design process.

Engineering Design Process

Directions: Use the diagram of the engineering design process to answer the questions.

Questions

1. What is the first phase of the engineering design process?

____

____

____

2. What do you think is the second phase of the engineering design process? Why?

____

____

____

3. What is the phase of the engineering design process when your team observes whether your possible solution works or not? Is it okay to have your model fail?

____

____

____

4. When using the engineering design process, can you repeat phases? Why?

____

____

____

Presentation Script

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

Talk about two things you learned about the engineering design process.

____

____

____

____

Is there a phase of the engineering design process that you have used before?

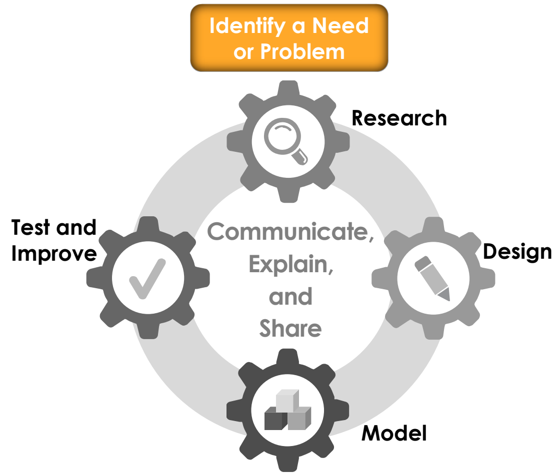
____

____

____

____

What Is the Need or Problem?



The Challenge

You and your team will design and build a model of a spacecraft that can safely carry two astronauts on a mission in space. You will test your model to see if your design protects the astronauts during landing. For the test, your model will be dropped from a height of 2 meters. The hatch must stay closed. The astronauts must stay securely in their seats during the test.

Criteria (MUST) and Constraints (MUST NOT)

1. **Astronaut Seats**
   - ❑ The spacecraft model **must** be designed with seats for two astronaut figures.
   - ❑ The astronauts **must** stay in their seats during the drop test without being glued or taped in place.
2. **Hatch**
   - ❑ The spacecraft **must** have one hatch that opens and closes for the astronauts to safely enter or exit.
   - ❑ The hatch **must** stay closed during the drop test.
3. **Spacecraft Size**
   - ❑ The model spacecraft **must** fit within the container your teacher gives you.
   - ❑ The total mass of the model spacecraft **must not** be more than 100 grams.

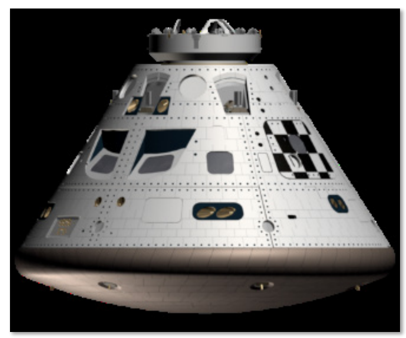


Figure 24. Illustration of the Orion command module. (NASA)

What is the problem you and your team will be working on in this challenge?

____

____

____

Our design MUST ____

Our design MUST NOT ____

Presentation Script

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

Write an introduction to your video that describes your team and the challenge. Start with the following sentence:

"This is team (team name) and we worked on the (name of challenge). The title of our presentation is (title)."

____

____

____

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____

____

Research

Directions: You will conduct research and record what you already **know**, what you **wonder**, and what you **learn** (KWL). After reading the challenge and watching the Introductory Video, work with your team on this KWL chart.

KWL Chart

What do I know?	What do I wonder?	What have I learned?

Research With a NASA Scientist or Engineer

Directions: Use this before, during, and after your connection with a NASA scientist or engineer.

NASA Connection KWL Chart

What do I know?	What do I wonder?	What have I learned?

NASA Scientist and Engineer Connection Notes

1. Who are we speaking to?

2. What kind of scientist or engineer is the person we are speaking to?

3. How long has this person worked at NASA?

4. Why are engineers trying to solve the problem or need presented in this challenge?

5. Why do you think this is an important problem to solve?

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.

Design Your Idea

Individual Design: How can I solve the problem?

Sketch your initial design and label each part of your drawing.

Notes (list what materials you may use, how big the model will be, how it will be constructed, etc.):

Approved by: ___________________

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		

Stop and Check

Directions: Review the engineering design process by answering the following questions. If you answered "No" to any of the questions, go back and review the material.

Questions	Response (circle one)	
Did we determine what needed to be solved or resolved?	**Yes**	**No**
Did we research how to solve the problem?	**Yes**	**No**
Did we ask a NASA scientist or engineer our questions?	**Yes**	**No**
Did we design a solution that met all the criteria and constraints?	**Yes**	**No**
Have we included ideas from all team members' drawings in our team design?	**Yes**	**No**
Do we have a team drawing?	**Yes**	**No**

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.

Budget Reporting Worksheet

Real-World Connections

Directions: As a team, complete the cost sheet below. Be sure to include all materials needed, unit cost, and quantity (how many) needed to complete your design. At the end, add up the total cost of your solution.

Line Item Number	Material	Unit Cost	Quantity	Item Total
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
			Total Cost:	

Model Data Sheet

1. Does the model meet all of the criteria and constraints?

   Yes **No**

2. Does the spacecraft stay together when tested?

   Yes **No**

3. If not, explain what happened.

____

____

Construction Checklist

Astronauts are secure in their seats No glue or tape is used	Hatch opens and closes Astronauts fit through the hatch	Spacecraft fits into the container from the teacher	Mass of spacecraft is not more than 100 grams
Yes **No**	**Yes** **No**	**Yes** **No**	**Yes** **No**

Presentation Script

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

These are two ways the team worked together to build our model:

1.____

____

____

2.____

____

____

This is how we included all of the data in our presentation:

____

____

____

____

____

____

____

Test Data Sheet

Directions: Test the model 3 times to see how well it performs. For each test, observe how the spacecraft reacts to the impact with the ground. Record your observations here.

2-Meter Drop Test	Did the astronauts remain in their seats?	Did the hatch remain closed?	Observations
Test 1			
Test 2			
Test 3			

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			

Stop and Check

Directions: Review the engineering design process by answering the following questions. If you answered "No" to any of the questions, go back and review the material.

Questions	Response (circle one)	
Did we create a plan to solve the engineering design challenge?	**Yes**	**No**
Did we decide a role for everyone in our group?	**Yes**	**No**
Did the design meet all the criteria and constraints?	**Yes**	**No**
Was the model tested 3 times?	**Yes**	**No**
Did we describe what did or did not work in our design?	**Yes**	**No**
Did we describe how the design could be improved?	**Yes**	**No**
Did we provide feedback to our team members and document the discussion?	**Yes**	**No**
Did we use all the phases of the engineering design process in the engineering design challenge?	**Yes**	**No**

Communicate, Explain, and Share

Presentation Script

Use this page to share details about your data and your final model.

The data we collected during the engineering design process (EDP) support the challenge. Here are the data that show how we met ALL the criteria (include photos or use video to communicate this phase of the EDP):

____

____

____

____

____

Does the final design solve the challenge?

Yes **No**

What were the strengths of the team model(s)? What were the concerns?

____

____

____

Describe the improvements the team made to the model.

____

____

What two suggestions does your team have for future engineers who would like to solve this challenge?

1. ____

____

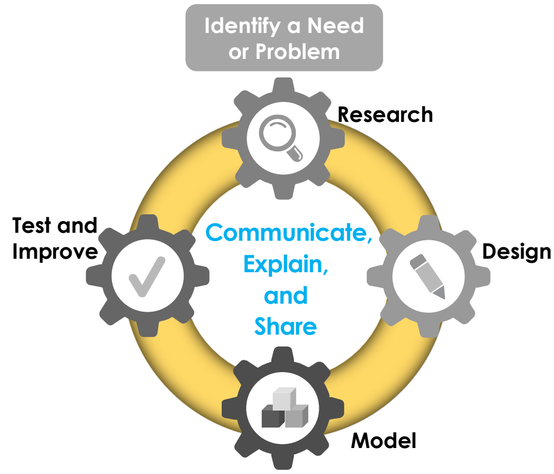
2. ____

____

____

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.	

Rubric

Use this rubric as a checklist to make sure you have included all phases of the engineering design process in your team presentation.

Engineering Design Process	Excellent	Needs Improvement	Not Included
We can **identify** the challenge and the criteria.	We described the challenge and ALL the criteria and constraints.	We only described some of the challenge, criteria, or constraints.	We included less than half of the information required.
We can discuss the results of our **research**, the STEM Investigations, and connections with a NASA scientist or engineer.	We showed that we were great researchers by including three or more facts we learned.	We only discussed one or two facts that we learned.	We forgot to include our facts.
Our final team **design** represented elements from each team member's original design.	Our final design included the best ideas from EACH of our team members' designs.	We included ideas from some of our team members' designs, but not all.	We only included ideas from one team member.
Our team constructed a **model** to represent the challenge criteria and constraints.	Our model was built according to ALL of the challenge's criteria and constraints.	Our model met one or two of the challenge's criteria and constraints.	Our model did not meet the challenge's criteria or constraints.
Our team collected and recorded data to **test** and **improve** our model's solutions.	We collected data on ALL of the criteria and constraints and recorded our observations.	We collected data on one or two of the criteria or constraints and recorded most of our observations.	Our data collection and records were incomplete.
Our team was able to **explain** and **share** our design and talk about our improvements.	We discussed how we worked together to explain AND solve difficult issues.	We tried to explain how to solve our difficult issues but were not clear about doing so.	We did not discuss any difficult issues we had in the engineering design challenge.
Our team followed the presentation process to **communicate** our team design.	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.