



# BEST

BEGINNING  
ENGINEERING,  
SCIENCE,  
AND TECHNOLOGY

**An Educator's Guide to the Engineering Design Process  
Grades K-2**

## PREFACE

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The NASA BEST Activities Guide has been developed by a team from the NASA Goddard Space Flight Center's Office of Education in support of the NASA's Exploration Systems Mission Directorate (ESMD). ESMD develops capabilities and supporting research and technology that will make human and robotic exploration possible. It also makes sure that our astronaut explorers are safe, healthy, and can perform their work during long-duration space exploration. ESMD does this by developing robotic precursor missions, human transportation elements, and life-support systems. Ultimately, this Directorate of NASA serves as a stepping stone for the future exploration of Mars and other destinations.

The NASA BEST Activities Guides were designed to teach students the **Engineering Design Process**. This project created three guides to accommodate three grade groups: K-2, 3-5 and 6-8. All follow the same set of activities and teach students about humans' endeavor to return to the Moon. Specifically, how we investigate the Moon remotely (Part 1), the modes of transportation to and on the Moon (Part 2), and humans living and working on the Moon (Part 3).

The Engineering Design Process is a series of steps that engineers use to guide them through the process of solving problems. Engineers must ask a question, imagine a solution, plan a design, create that model, experiment and test that model, then take time to improve the original – all steps that are crucial to mission success at NASA. What makes this guide different from others is: (1) there are no specific instructions or a “recipe” for building the items; and (2) there are no given drawings. The emphasis is for students to understand that engineers must “imagine and plan” before they begin to build and experiment. To successfully complete the NASA BEST Activities, students must **draw their ideas first** before constructing.

Many of the activities have been adapted from others, and then aligning them with the theme of efforts to return to the Moon and to focus on the Engineering Design Process. Each activity features objectives, a list of materials, educator information, procedures, and student worksheets. When appropriate, the guide provides images, charts, and graphics for the activities. All activities are intended for **students to work in teams**. It is recommended that each team consist of 3 or 4 students. The activities can be used as in-school curriculum or after-school clubs; as a set or individually. This guide of activities was also designed to keep material costs to a reasonable limit, using materials often already found in the classroom or from home. Furthermore, all activities correlate to national science, mathematics, technology, and engineering standard(s). A list of national standards is included at the end of this guide.

We appreciate your interest in this product and remember, *let the students have fun!*

- Susan Hoban, Project Manager

# ACKNOWLEDGEMENTS

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# MATERIALS

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*Below is a suggested list of materials needed to complete all activities in this guide for a group of 24-32 students (~8 teams). However, for your convenience, a NASA BEST Kit is available for purchase from Science Kit/Boreal Laboratories (<http://www.sciencekit.com/NASABEST/>), which supports ~30 students.*

## STANDARD MEASURING TOOLS

Digital scale (1)  
Graduated cylinder (1)  
Meter sticks (1 per team)  
Measuring tape (1)  
Rulers (1 per team)  
Stopwatches (1 per team)  
Thermometers (2 per team)

## BUILDING SUPPLIES

aluminum foil	index cards
balloons, assorted	mailing tube, 4" diameter / oatmeal canister
bamboo skewers	mini foil pie plates (1 per team)
binder clips, assorted	modeling clay
blindfolds (1 per team)	paper bags
bubble wrap	paper clips, assorted
buttons, assorted (~10 per team)	pipe cleaners
cardboard	plastic cups
card stock	plastic eggs (1 per team)
cardboard boxes (1 per team)	plastic wrap
c-clamps (at least two)	popsicle sticks and tongue depressors
cheesecloth	rubber bands, assorted
clothespins (with springs)	staplers and staples
cloth swatch, i.e. quilting square	stirrer sticks
coffee filters	straws
colored pencils	string
cotton balls	tape: masking, electrical, transparent and duct tapes
crayons (for K-2 module)	toy pinwheel
empty paper towel tubes (1 per team)	wheels: i.e. model car wheels (plastic or wood), empty thread spools, rotelle pasta (4 per team)
empty toilet paper tubes (2 per team)	
fishing line, ~20lb. test, 5 m	
glow sticks (for K-2 module)	
gluesticks	





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# ENGINEERING DESIGN PROCESS



# BUILD A SATELLITE TO ORBIT THE MOON

## OBJECTIVE

To demonstrate an understanding of Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

The challenge is to build a satellite that falls within certain size and weight constraints. This satellite will be designed to orbit the Moon. It will have to carry some combination of cameras, gravity probes, and heat sensors to look at or probe the Moon's surface.

## PROCESS SKILLS

Measuring, calculating, designing, evaluating

## MATERIALS

General building supplies

Bag of buttons of a variety of sizes

## STUDENT WORKSHEETS

Imagine and Plan (2 pages)



## MOTIVATE

- Spend a few minutes asking students if they know what engineers do.
- Display the *Engineering Design Process* diagram and discuss:
  - **Ask** a question first.
  - **Imagine** a possible solution.
  - **Plan out** a design and draw your ideas.
  - **Create** and construct a working model.
  - **Experiment** and test that model.
  - **Improve** and try to revise that model.

## SET THE STAGE: ASK, IMAGINE, PLAN

- Share the *Design Challenge* orally with the students (see next page).
- Have students brainstorm ideas and then create a drawing of their satellite (Imagine and Plan worksheet).

## CREATE AND EXPERIMENT

- Distribute materials for students to build their satellites based on their designs and specifications.
- The Experiment phase will occur during the next activity, *Launch Your Satellite*.

## IMPROVE

- If there is time, have students inspect their satellite and rework their design if needed.

## CHALLENGE CLOSURE

- Ask all groups to come back to their seats to have a discussion about today's activity:
  - Name two things you learned about what engineers do through building your satellite today.
  - What was the hardest thing for your team to complete while building your satellite?
  - How did your team solve this problem?

## PREVIEWING NEXT SESSION

Ask teams to bring back their satellite model for use at the next session. You may want to store them in the classroom or have one of the facilitators be responsible for their safe return next session.

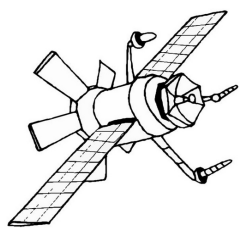
### NASA's Lunar Exploration Missions

NASA's lunar exploration missions will collect scientific data to help scientists and engineers better understand the Moon's features and environment. These missions will ultimately help NASA determine the best locations for future human exploration and lunar bases.

The information gathered by lunar exploration missions will add to information collected during earlier missions. Some of these missions gathered data that caused scientists to have more questions — questions they hope to solve with new instruments. For example: scientists and engineers need to know if there is any ice on the Moon. Humans need lots of water to live, and it is way too heavy to carry with us up to the Moon! One lunar exploration mission will carry instruments (sometimes called “detectors” or “sensors”) to look for ice (water in solid form). Additionally, NASA needs to make exact maps of the Moon's surface so that a safe landing site may be chosen. And, for safety, we need to make careful measurements of the radiation falling on the lunar surface.

The different instruments are designed, tested, and assembled by different teams of engineers and scientists. The separate teams must work together to make sure that the instruments are the right weight, fit correctly, and make proper measurements. Working together is an important skill for students to practice.

Overall, the weight (strictly speaking, the mass) of anything we want to send into space is the most challenging problem for the engineers. The more an object weighs, the more energy it takes to launch it.



**The Challenge:** *Your mission is to build a model of a lunar exploration satellite with the general building supplies available. Use different shape/sizes of buttons to represent the various instruments. The challenge is to use a combination of instruments that cannot go above four (4) solar cells to power your satellite.*

## IMAGINE AND PLAN

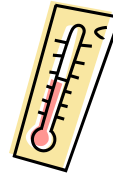
The objective of this activity is to design your own satellite. These are the instruments you may choose to put on your satellite:




**Camera**  
(takes pictures)



**Gravity Probe**  
(measures gravity)



**Heat Sensor**  
(measures temperature)

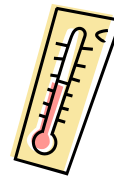
Each of these instruments requires a certain number of solar cells to operate on your satellite. A solar cell  is a battery that collects energy from the sun to power the instruments.



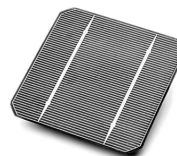
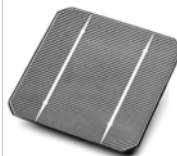
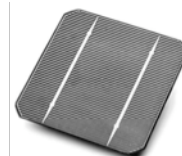
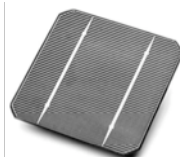
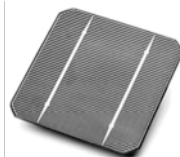
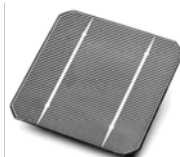
**needs**



**needs**



**needs**



## IMAGINE AND PLAN (continued)

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Using the diagram on the previous page, if you were to build a satellite with one (1) camera and one (1) heat sensor, how many solar cells would you need?

Complete the number sentence below:

$$\begin{array}{ccccc} \underline{\hspace{2cm}} & + & \underline{\hspace{2cm}} & = & \underline{\hspace{2cm}} \\ \text{(camera)} & & \text{(heat sensor)} & & \text{(total solar cells)} \end{array}$$

Now draw your own satellite. Include the correct number of solar cells it will need. Make sure to label your instruments.



# LAUNCH YOUR SATELLITE

## OBJECTIVE

To demonstrate an understanding of Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

The team challenge is to launch the satellite that was built in the last activity by using a balloon rocket. The goal is to get the satellite to travel as far as possible.

## PROCESS SKILLS

Observing, communicating, measuring, collecting data, inferring, predicting, making models.

## MATERIALS

Satellite model from last week's activity

General building supplies

Binder clips or clothes pins

Balloons (several per group)

5-meter fishing line set-up strung between two tables

## STUDENT WORKSHEETS

Imagine and Plan

Experiment and Record

## PRE-ACTIVITY SET-UP



The fishing line apparatus should be at least 5 meters in length. Clamp or tie one end at table or chair height and stretch the line across the space to another table/chair at the same level.

Holding the free end of the line taut for each trial enables easy restringing of the successive balloon rockets. The line must be very taut for best results. Shoot the rockets toward the tied end. Two fishing line set-ups should be sufficient for most clubs. *Note: If the opening in the balloons tends to stick, try putting a little hand lotion inside the opening.*

## MOTIVATE

- Ask the groups to retrieve their satellite that was created during the last session.
- Show the video of a recent rocket launch titled, "Liftoff...To the Moon!"

<http://lunar.gsfc.nasa.gov/launch.html>

## SET THE STAGE: ASK, IMAGINE, PLAN

- Ask the students, *How can we best launch our satellite to go to the Moon?* We need it to go far to get into orbit around the Moon. The objective is to *design* a balloon rocket that will take their satellite as far as possible on the fishing line.
- Demonstrate how a balloon rocket works by sending a balloon connected to a straw up the fishing line. Do not model how best to attach the satellite or how best to power the rocket, other than releasing the air by using your fingers.
- Ask students to imagine a solution for a balloon rocket design and then draw their ideas.

## CREATE

- Challenge the teams to build their rockets based on their plans and remind them to keep within specifications. They will also need to attach their satellites from the previous session.

## EXPERIMENT

- Send each team to their assigned launch sites to test their rockets, filling in the data table as they conduct each trial launch.

## IMPROVE

- After their first trials, allow teams to make adjustments to their rockets.
- Teams re-launch satellites and record launch distance.
- Teams should then discuss how far their rocket traveled and which combination of variables gave the best results.

## CHALLENGE CLOSURE

- Engage the students in the following questions:
  - Which straw length did you choose and why did you choose it?*
  - What was the hardest part of the activity today?*
  - If you had more time, what other rocket element would you change (ex: balloon shape or size)?*

## PREVIEWING NEXT SESSION

Ask teams to think about how humans navigate robotic rovers on a distant planet or moon. How are they programmed? How do the rovers receive messages from a team on Earth?

## IMAGINE AND PLAN

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Last session, you designed and built your NASA satellite to go to the Moon. This session, you will **plan** and **create** a balloon rocket, and attach your satellite to the balloon. You will then launch your satellite using the balloon rocket.

Sketch your balloon rocket design that includes the satellite design:

## EXPERIMENT AND RECORD



Your challenge is to launch your balloon rocket the farthest distance! Build your rocket with ONE balloon attached to a piece of drinking straw. You will control the length of the drinking straw. Test three different lengths of straw.

**BALLOON ROCKET DATA TABLE 1**

	Trial 1	Trial 2	Trial 3
Straw Length	Short _____ cm	Medium _____ cm	Long _____ cm
Distance traveled (cm)			

Now that you have experimented with three different lengths of straw, build your final rocket – the one you expect to go the farthest.

**BALLOON ROCKET DATA TABLE 2**

Rocket Elements	New Trial after re-design
Balloon length (cm)	
Straw Length (cm)	
Distance traveled (cm)	

# PREPARE FOR A MISSION

## OBJECTIVE

Students will demonstrate an understanding of the Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

Teams will execute a mini-simulation of a robotic mission. The ultimate goal is to get the human-robot from one end of the course to the other, and the robot should pick something up, i.e. "lunar rock", at the end of the course.

## PROCESS SKILLS

Mapping, communication, measuring, graphing, logical thinking

## MATERIALS

Rulers and meter sticks  
Colored pencils or crayons  
Blindfolds  
"Lunar sample"

## STUDENT WORKSHEETS

Imagine and Plan (2 pages)  
Create  
Experiment and Record

## PRE ACTIVITY SET-UP

Set up a small obstacle course with a few chairs, waste paper baskets, and/or a table as designed on the Student Imagine and Plan Worksheet.

*Please note:* This activity may require two 60-90 minute sessions to complete.

(insert pic of students in activity here)

## MOTIVATE

- Explain to the students that many of NASA's missions are conducted by robots. While some robots can make decisions based on data received from sensors, humans must program the robots - we tell robots what to do and how to execute their missions.

## SET THE STAGE: ASK, IMAGINE, PLAN

- Share the *Design Challenge* with the students.
- First, have students draw their chosen course on the map. Students must include at least one right turn and one left turn.
- Let students practice commands to use with their robot. These commands are simple words, plus a number for steps taken.

## CREATE

- Programming – Students will define the robot's route through the lunar landing site and count the number of steps needed for each command. They will then create a command sequence to use for their robot that matches the route they have planned on their maps.

## EXPERIMENT

- Student teams now must navigate the lunar landing site, using the command sequence each team designed. Have students cut out the commands into strips of paper and designate two students per team deliver each command. Designate another team member to run a stopwatch. Position the robots at the start and have the teams sitting or standing aside from the obstacle course. The students designated to deliver commands are to deliver one command at a time – one student walks to the robot, delivers one command, then returns to the team. Robot performs the command. The next student then walks to the robot and delivers the command, returns, etc. Have each team record how much time it takes to successfully complete the experiment when the robot picks up the "lunar ice".

## CHALLENGE CLOSURE

- Engage students in the following questions:
  - Did each team pick the same route or were there several routes to get to the lunar ice?*
  - Which route worked the best?*

## PREVIEWING NEXT SESSION

Ask teams to think about how a spacecraft might land on the Moon safely. Ask them to think about why it does not make sense to use a parachute on the Moon because there is no air on the Moon to fill up the parachute.

### The Discovery Mission



Every NASA mission has several parts leading to its success. When leading a remote mission on another planet or moon, NASA scientists and engineers must plan every step of the mission carefully. When using robots or rovers, each mission team calibrates and programs these machines to accomplish the mission objective, such as to travel to certain locations on that planet or moon. In

addition, NASA must use radio signals to send their commands. So a mission on a distant planet could take minutes to hours to days to communicate to that robot.

**The Challenge:** Your team has been chosen to operate a robotic Discovery Mission on the surface of the Moon. You will be given a specific starting location, and your robot must move through a lunar landscape to the location of the “lunar ice” without bumping into any “lunar boulders” or other obstacles. To successfully complete the Discovery Mission, your robot must pick up a piece of “lunar ice.”

Before your robot begins to move on the lunar surface, you will have to complete the following activities:

1. **Designate your robot** - One student in each team must volunteer to be the robot. The robot will be the person who actually walks through the course, following the instructions of her/his team. The team should give their robot a name.
2. **Map the robot's route** – Using the map in your worksheets, mark out a route for the robot.
3. **Learn to communicate with your robot** – Each team must develop commands for your robot. You will practice these commands until you and the robot are comfortable with them. These will be the commands that you will give the robot to travel through the path you have drawn on the map.
4. **Program the robot** – you will use the commands that you practiced to tell the robot how to navigate the path you have drawn on the map.

Your mission will be complete when your robot picks up a piece of “lunar ice.”

## IMAGINE AND PLAN

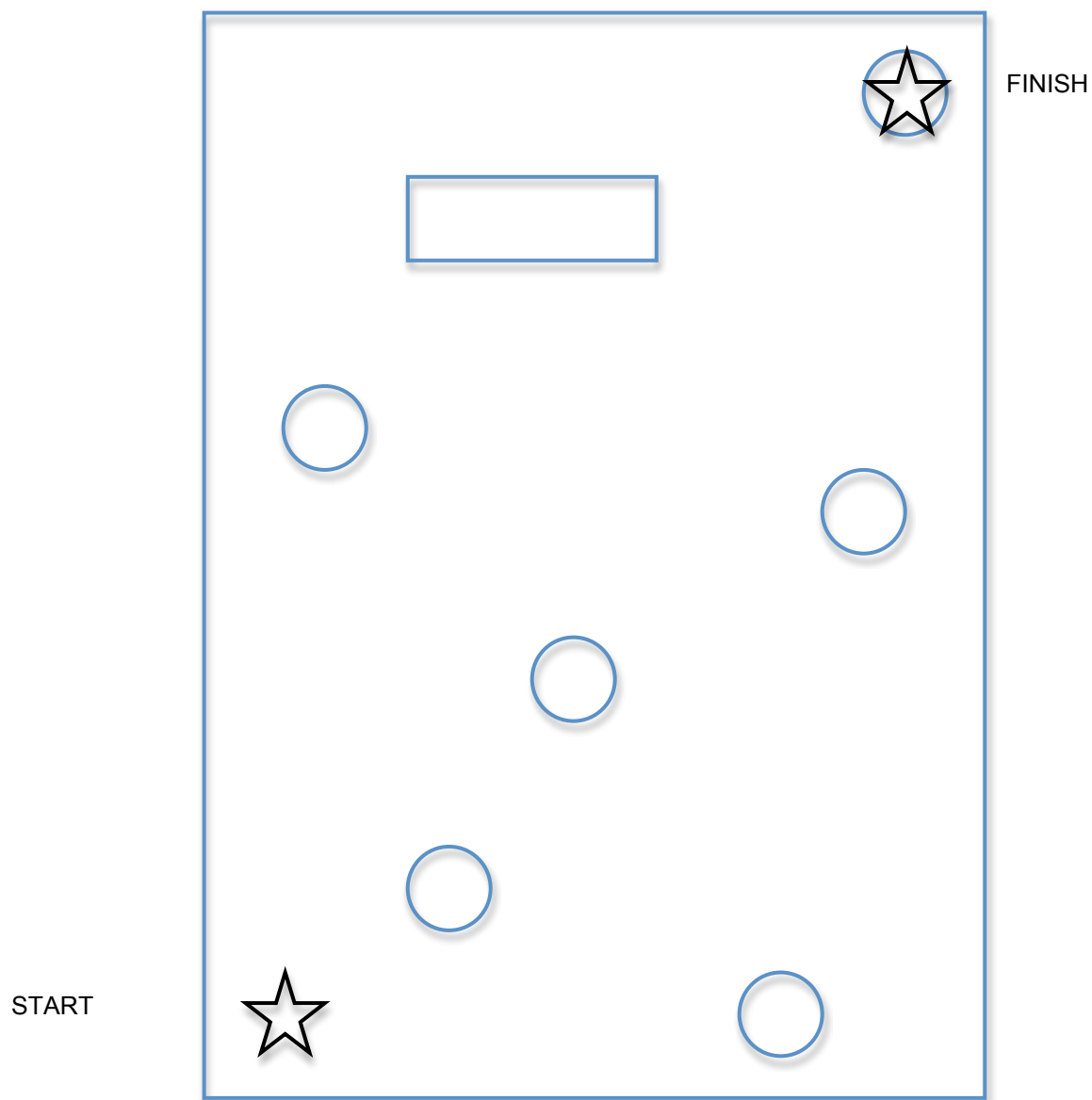
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### STEP 1 – Designate your robot.

One person from your team must volunteer to be the robot.

### STEP 2 – Mapping

Below is a map for the Discovery Mission. Using a pencil, draw small arrows on your map, create a route your robot will take to get to the landing site. You must include at least one right turn and one left turn.



## IMAGINE AND PLAN (continued)



### STEP 3 – Communicate with your robot

When you program a robot, you must use simple words and be specific in your directions. If you want your robot to go forward, how many steps should the robot go?

Practice the words below with your robot and see if your robot follows the commands correctly.

Sample Command for Robot	Action by robot
MOVE FORWARD TWO STEPS	Walk forward two steps.
MOVE BACKWARD ONE STEP	Walk backward step.
TURN RIGHT	Turn to the right
TURN LEFT	Turn to the left
PICK UP LUNAR ICE	Pick up the lunar ice sample

Were any of these commands difficult for your robot to execute? If so, which ones?

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Suggest a better command to use with your robot.

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### STEP 4 – Program your robot

Review the map with the route your team has created for your robot. Now your team needs to create commands for your robot to match your route. Write down one command that matches each arrow on your map.

#### Command Sequence

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.



## EXPERIMENT AND RECORD

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### Execute the Discovery Mission!

It is time to let your Robot explore the Moon! You planned your route and practiced your commands, now let's complete the mission. Take the complete command sequence your team designed and cut each command out of the page as separate pieces of paper. Designate two team members to deliver the commands to the Robot and divide those sheets of paper amongst them. Another team member must use a stopwatch to time how long it takes for the Robot to reach the Lunar ice sample. Record each team's time in the table below to compare how long the mission took for each team!

**Discovery Mission Data Table**

Team Name	Time (seconds)
1.	
2.	
3.	
4.	
5.	

# DESIGN A LUNAR ROVER

## OBJECTIVE

To demonstrate an understanding of Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

The teams' challenge is to design and build a model of a Lunar Rover that will carry equipment and people on the surface of the Moon. It must be able to roll down a ramp. Later, they will design and build a landing pod for this rover and simulate a lunar landing. The goal is that the rover survives the landing so that it can roll down a ramp.

## PROCESS SKILLS

Measuring, calculating, designing, evaluating

## MATERIALS

General building supplies and tools

small plastic people (2 per rover)

plastic eggs

pennies to represent cargo weight

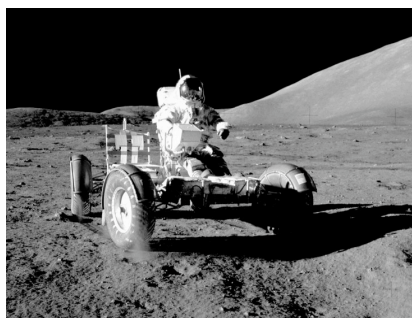
"wheels" (spools, model wheels, etc)

Something to use as a ramp (a flat surface that would enable the rover to roll for 25 cm or more)

## STUDENT WORKSHEETS

Imagine and Plan

Experiment and Record



## MOTIVATE

- Show the video about the Apollo 15 Lunar Rover on the Moon:  
[starchild.gsfc.nasa.gov/Videos/StarChild/space/rover2.avi](http://starchild.gsfc.nasa.gov/Videos/StarChild/space/rover2.avi)
- Ask students to pay attention to the comments made about the difficulties in driving in the lunar soil.

## SET THE STAGE: ASK, IMAGINE, PLAN

- Share the *Design Challenge* with the students.
- Remind students to imagine a solution and draw their ideas first.

## CREATE

- Challenge the teams to build their Lunar Rovers based on their designs. Remind them to keep within specifications.
- While each group is working, the teacher should create a ramp in which all groups will use to roll their rovers and record observations.

## EXPERIMENT

- Students will let their rover roll down the ramp and record their observations.
- Students will test how much cargo weight their rovers can support by adding pennies to the plastic egg. Each penny represents 1 gram of cargo weight.

## IMPROVE

- Students should *improve* their Lunar Rovers models based on results of the *experiment* phase.

## CHALLENGE CLOSURE

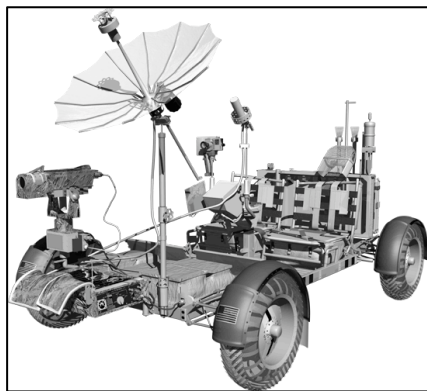
The Summary of this activity will come at the very end (two sessions from now), after the simulated lunar landing.

## PREVIEWING NEXT SESSION

Ask teams to bring back their Lunar Rover model for use in next session's challenge. You may want to store them in the classroom or have the facilitator be responsible for their safe return next week.

Ask teams to think about potential landing pods during the next session. Tell students they will be building the landing pod out of the materials that have been available to them. The pod will be dropped from as high as possible (out a second story window, off a tall ladder, or the top of a staircase).

### Let's Go For A Ride!



During the first set of activities, we have spent some time thinking about how to get to the Moon. Now we need to think about landing on the Moon, and what we are going to do once we get there. Astronauts will need a mode of transportation to get around to investigate different areas of the Moon. During the Apollo missions, astronauts drove a Lunar Rover several kilometers away from their spacecraft. Today you get to be the engineers designing a new Lunar Rover that can perform functions the

Apollo Lunar Rover could not. Thus, your challenge is to build a model of a Lunar Rover that will eventually carry *people and cargo* on the Moon.

**The Challenge:** To design and build a Lunar Rover with the following constraints:

1. *It needs to carry one plastic egg snugly. The egg may NOT be taped or glued into place. The egg will represent the materials carried in and around the Moon.*
2. *It needs to carry cargo weight (the pennies) inside the plastic egg. Groups should test how much cargo weight they can carry in the egg and record this observation (1 penny = 1 gram of cargo weight).*
3. *It must have room for two plastic people. The people do not land with the rover. They will get in the rover on the Moon and drive it around.*
4. *It must roll down a ramp unassisted for 25 cm or more.*
5. *It must survive the “landing.” This means it should be able to roll down the ramp after the landing, and the plastic egg should not have popped open.*

## IMAGINE AND PLAN

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What parts do you need to make your rover roll?

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What will hold the egg in place?

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Draw your Lunar Rover:



## EXPERIMENT AND RECORD

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Test your rover on the ramp. Measure the distance it travels down the ramp. Measure the amount of weight it carries. (1 penny = 1 gram of cargo weight.) Record your data in the table for Trial 1.

**Lunar Rover Data Table**

	<b>Trial 1</b>	<b>Trial 2</b>
Number of Pennies Carried:		
Gram(s) of Cargo Weight Carried:		
Distance travelled down ramp:		

Did your design work well? If not, redesign your rover and try a different amount of weight, then experiment again. Record your data in the table for Trial 2.

List any changes you made to your Rover here:

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# DESIGN A LANDING POD

## OBJECTIVE

To demonstrate an understanding of Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

The team challenge is to design and build a Landing Pod for the model Lunar Rover that was built in the previous session.

## PROCESS SKILLS

Measuring, calculating, designing, evaluating.

## MATERIALS

General building supplies and tools

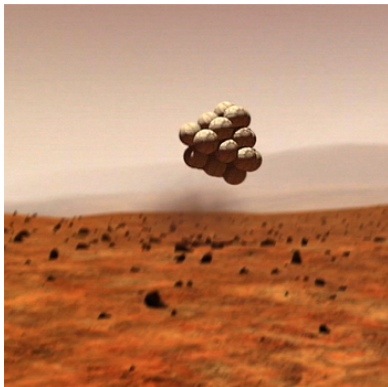
Bubble wrap

Balloons

## STUDENT WORKSHEETS

Imagine and Plan

Experiment and Record



## MOTIVATE

- Show the video titled "Six Minutes of Terror."  
[marsrovers.nasa.gov/gallery/video/challenges.html](https://marsrovers.nasa.gov/gallery/video/challenges.html)
- Ask students to pay attention to the ways NASA slowed the rovers down as they entered the atmosphere. Notice how some techniques will or will not work on the Moon. Explain that with no atmosphere on the Moon, a parachute will not work!

## SET THE STAGE: ASK, IMAGINE, PLAN

- Share the *Design Challenge* with the students.
- Remind students to imagine a solution and draw their ideas.

## CREATE

- Challenge the teams to build their Landing Pod based on their designs. Remind them to keep within specifications.
- Members should also be sure that the egg inside the rover is empty and is not carrying remaining cargo from the previous lesson.

## EXPERIMENT

- The students should test to make sure that the rover, carrying the empty plastic egg, fits inside the Landing Pod. They should also be sure that they are able to open the Landing Pod after it comes to rest. Each group will complete two trial drops and within this phase they will have the opportunity to make one improvement to their Landing Pod before experimenting with a second trial drop.

## CHALLENGE CLOSURE

Engage the students in the following questions:

- What is the hardest part of this activity and how did your team overcome the challenge?
- Do you need to improve your design again? How will it change?

## PREVIEWING NEXT SESSION

Ask teams to bring back their Lunar Rover model and the Landing Pod for use in the next session's challenge. You may want to store them in the classroom or have one of the facilitators be responsible for their safe return next week.

Remind the teams that their Landing Pods, loaded with their Lunar Rovers, will be "landing" from a long drop. Decide whether to drop each Lander from a second story window, ladder, etc, then let the students know the height from which the models will be dropped.

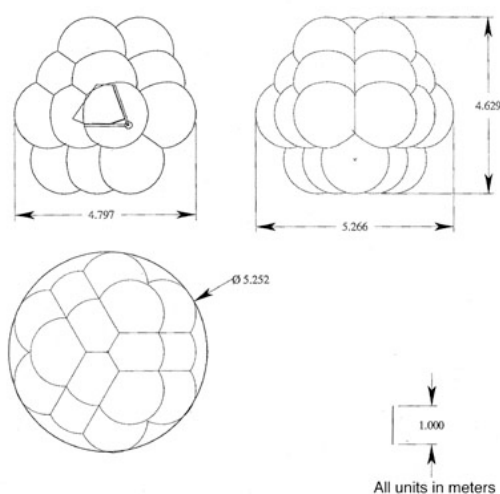
## DESIGN CHALLENGE

### Fragile Cargo! Handle with Care!

Now that we have designed our Lunar Rover that will carry our astronauts on the lunar surface, we need to think about safely delivering the Lunar Rover to the Moon's surface. When NASA sent its two robotic rovers, **Spirit** and **Opportunity**, to Mars, they landed on Mars in a very interesting fashion: they fell out of the Martian sky and bounced on the surface until they came to a stop! How did they do that? They were inside a landing pod made of...AIR BAGS! Wasn't that a clever idea? Now it's your turn. Your challenge is to build a Landing Pod so that your Lunar Rover will land safely on the surface of the Moon. Once the landing is complete, you will open the Landing Pod and roll your Lunar Rover down a ramp.

**The Challenge:** Design and build a *Landing Pod* that meets the following constraints:

1. *It must safely deliver your Lunar Rover to the surface from a height given by the teacher.*
2. *It must land RIGHT-SIDE up. The rover must be able to roll out, so it must land in the correct orientation.*
3. *It must be reusable. The pod must be able to open so students can retrieve their Lunar Rover, and then use the Landing Pod again.*



The "landing" is simulated by the facilitator. Suggestions: toss it safely out of a second story window, or toss it across the classroom. Just be sure the students know ahead of time what to expect.

## IMAGINE AND PLAN

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From what height will you drop your rover for testing? \_\_\_\_\_ meters

Draw pictures of some of the materials you could use to protect the rover *inside* the Landing Pod.

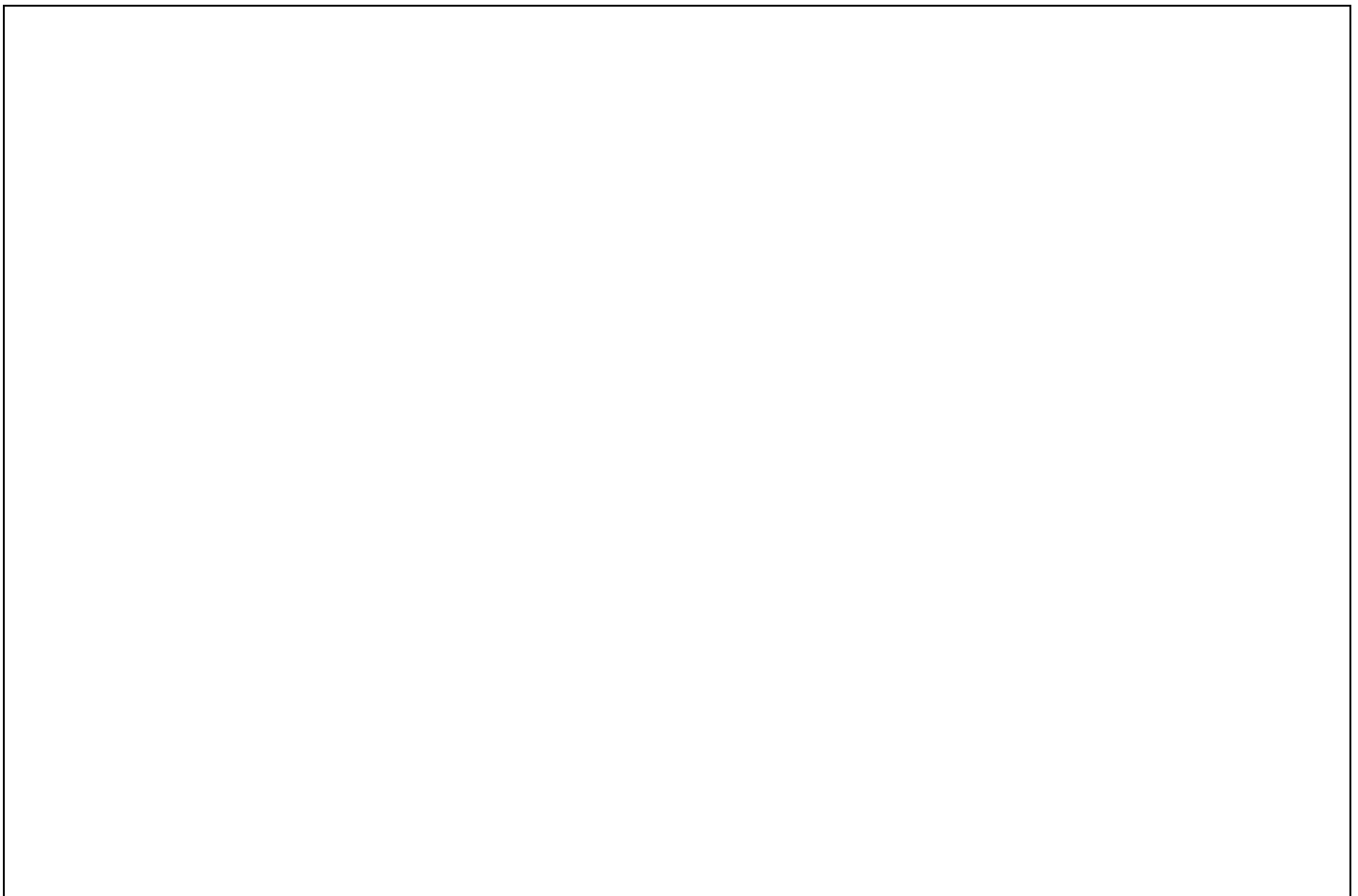
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How will you make sure the Landing Pod lands right-side up?

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Draw a picture of the side of your Landing Pod that also shows the “door” or “hatch”:





## EXPERIMENT AND RECORD

Make two test drops with your Landing Pod, but use a height that is less than the final drop height given by your teacher. Record what happens to your Landing Pod and the Lander inside.

**Landing Pod Data Table**

<b>Trial</b>	<b>Drop Height (m)</b>	<b>Observations</b>
1		
2		

What changes did your team make to your Landing Pod to improve its landing?

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# LANDING THE ROVER

## OBJECTIVE

Students will demonstrate an understanding of the testing phase of the Engineering Design Process by testing their landing pod designs.

## CHALLENGE

The Landing Pod, with the Lunar Rover inside, is to land and deliver the payload safely when dropped from a significant height.

## PROCESS SKILLS

Predicting, observing, measuring, evaluating.

## MATERIALS

General building supplies and tools

## WORKSHEETS

Experiment and Record



## MOTIVATE

- Show the video titled, “Seven Minutes of Terror” and ask students to explain why this type of landing would not work for the Moon.

<http://anon.nasa-global.edgesuite.net/qt.nasa-global/ccvideos/jpl/phx20080327-480cc.mov>

- Inform the students how high the Landing Pods will be dropped and then show them this height for a visual connection.

## SET THE STAGE, ASK, IMAGINE, PLAN

- Host a discussion amongst all the students about their design process. Ask the students to compare their experiences with other group experiences. Also have the share their designs and discuss similarities and differences. Ask students what would they do to the designs if there were no rules or constraints?

## EXPERIMENT

- Gather the teams together – everyone should observe all of the landing events.
- One at a time, drop the Landing Pods.
- Open each Landing Pod after it comes to rest. Place ramp up against the Landing Pod and let the Lunar Rover roll out. (It might require a little push.)
- The students should measure the distance the rover rolls and check to see if the egg stayed closed.

## IMPROVE

After all of the Landing Pods have “landed,” engage the students in a discussion guided by the following questions:

- *What do you worry most about when your Landing Pod hits the surface?*
- *What is similar about all the designs built? What is different?*

## CHALLENGE CLOSURE

Ask the students to listen as you read the following:

- *Think about any observations you made during the experiment to land the Lunar Rover. Now think about any changes that you could make to your Lunar Rover and Landing Pod to improve them for future uses. Sketch or draw a picture on a separate piece of paper to show any changes you would make to the Lunar Rover and Landing Pod.*

## PREVIEWING NEXT SESSION

America will send the next generation of explorers to the Moon and onward to Mars and other destinations in the solar system aboard a new crew exploration vehicle. The next session will have teams design and build a *Crew Exploration Vehicle* (CEV) that will carry two cm-sized passengers safely and will fit within a certain size limitation.

## EXPERIMENT AND RECORD



**Landing Pod Data Table**

Drop Height (m)	Number of Pieces of Bubble Wrap Used	Distance Rolled (cm)

### ***Post Landing Questions***

Did your Landing Pod remain closed during impact?      **Y**      **N**

Did the egg remain closed during impact?      **Y**      **N**

Did your rover roll down the ramp?      **Y**      **N**

How far did it roll?      \_\_\_\_\_ cm

Draw a picture showing your Lunar Rover and Landing Pod after the drop.  
Include any damage that may have occurred.

A large, empty rectangular box with a black border, intended for a student to draw a picture of their Lunar Rover and Landing Pod after the drop, including any damage that may have occurred.

# DESIGN A CREW EXPLORATION VEHICLE

## OBJECTIVE

To demonstrate an understanding of the Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

The teams' challenge is to design and build a Crew Exploration Vehicle (CEV) that will carry two cm-sized passengers safely and will fit within a certain volume (size limitation). The CEV will be launched in the next session.

## PROCESS SKILLS

Measuring, calculating, designing, evaluating.

## MATERIALS

General building supplies and tools  
2 small plastic people per team

## STUDENT WORKSHEETS

Imagine and Plan

Experiment and Record

## MOTIVATE

- Show the NASA BEST video titled "Repeatability":  
<http://svs.gsfc.nasa.gov/goto?10515>
- Ask the students why it is important to test their own designs.

## SET THE STAGE, ASK, IMAGINE, PLAN

- Share the *Design Challenge* with the students.
- Remind students to *imagine* and *plan* before building. Ask them to list the challenges they face in meeting the design constraints. Why should they not tape or glue the people in place?

## CREATE

- Challenge the teams to build their CEVs based on their designs and to keep within specifications.

## EXPERIMENT

- Each team should conduct three drop tests from about 1 meter. The students can simply hold the CEV model over their heads and drop it. They should record their results after each test, and note what changes they plan to make as a result of the drop test.

## IMPROVE

- After each drop test, the students should *improve* the CEV models based on the results of the experiment.

## CHALLENGE CLOSURE

- Ask the students, *What was the greatest challenge for your team today?*

## PREVIEWING NEXT SESSION

Ask teams to bring back their CEV model for use in next session's challenge. You may want to store them in the classroom or have one of the facilitators be responsible for their safe return next week.

Ask teams to think about potential launch mechanisms during the next week. Tell them they will be building a launcher out of the standard materials that have been available to them, including large rubber bands.



## DESIGN CHALLENGE

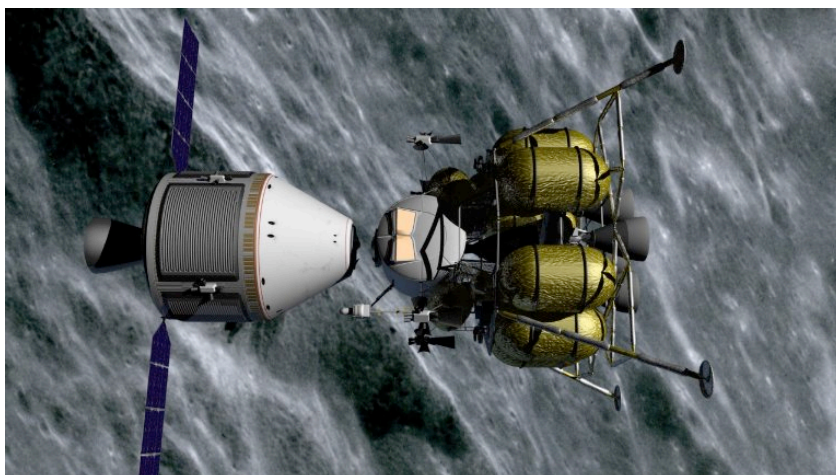
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### Taking humans back to the Moon...40 years later!

NASA needs a vehicle to take people to the Moon. The Space Shuttle cannot do that, because it was never designed to leave the Earth's orbit. NASA scientists and engineers are working on a space vehicle that can take astronauts to the Moon, Mars, and beyond. This spacecraft is called the Crew Exploration Vehicle (CEV). The CEV is a vehicle to transport human crews beyond low-Earth orbit and back again. The CEV must be designed to serve multiple functions and operate in a variety of environments.

The Challenge: To design and build a *Crew Exploration Vehicle* that meets the following constraints:

1. *Safely carry two little plastic people. You must design and build a secure seat for these people, without gluing or taping them in place. The people should stay in their seats during a Drop Test from over your head.*
2. *Create a hatch that can open and close on your vehicle.*
3. *Fit within a 4" diameter mailing tube (or the size constraints as indicated).*



## IMAGINE AND PLAN

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Draw a picture of the top of your Crew Exploration Vehicle (CEV):

Draw a picture of the inside of your CEV to show where the people sit:

### YOUR CEV'S CHARACTERISTICS

Vehicle components	Use	Measurement or Calculation
Little plastic people	Crew	How many?
CEV	Carries crew to Moon	Does it fit the size restrictions?
Hatch	Allows entry and exit	How many people wide?  How many people high?

## EXPERIMENT AND RECORD

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Drop your CEV from over your head. Answer the questions in the table.

**Drop Test Data Table**

<b>Trial Number</b>	<b>Results</b>
<b>1</b>	Did the people stay in their seats? Did the door fly open?
<b>2</b>	Did the people stay in their seats Did the door fly open?
<b>3</b>	Did the people stay in their seats? Did the door fly open?

Suggest some ways you could improve the design of your CEV:

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# LAUNCH YOUR CEV

## OBJECTIVE

To demonstrate an understanding of the Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

The challenge is to design and build a Reusable Launcher for the Crew Exploration Vehicle (CEV) that they built last week. The CEV should travel 3 meters when launched. The Reusable Launcher should produce repeatable results.

## PROCESS SKILLS

Measuring, calculating, designing, evaluating.

## MATERIALS

General building supplies and tools  
C-clamps and lots of rubber bands  
Model CEV that was built last week

## STUDENT WORKSHEETS

Imagine and Plan  
Experiment and Record

## MOTIVATE

- Show the first two minutes of the video titled “Constellation: Flight Tests”. (if time permits, show all)  
[www.nasa.gov/mission\\_pages/constellation/multimedia/index.html](http://www.nasa.gov/mission_pages/constellation/multimedia/index.html)
- Ask the students what was the most important lesson learned from those images? (test, test and test again!)

## SET THE STAGE, ASK, IMAGINE, PLAN

- Share the *Design Challenge* with the students.
- Emphasize to teams that the objective is to build a launcher that gives repeatable results. It is more important for the CEV to launch the same distance each time than for the CEV to be launched the farthest.

## CREATE

- Challenge the students to build a Reusable Launcher based on their designs.

## EXPERIMENT

- Conduct two sets of tests: 3 launches, each using three different set-ups. Record data.

## IMPROVE

- Students *improve* the Reusable Launcher based on results of the tests.

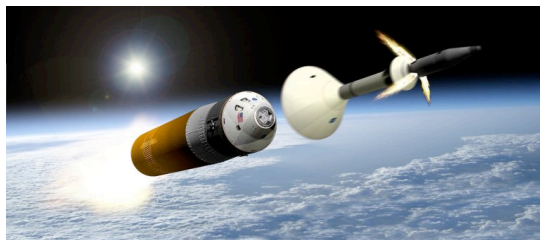
## CHALLENGE CLOSURE

Ask the students

- Why was it important that the launcher be reusable?
- Why was it important that your results were repeatable?

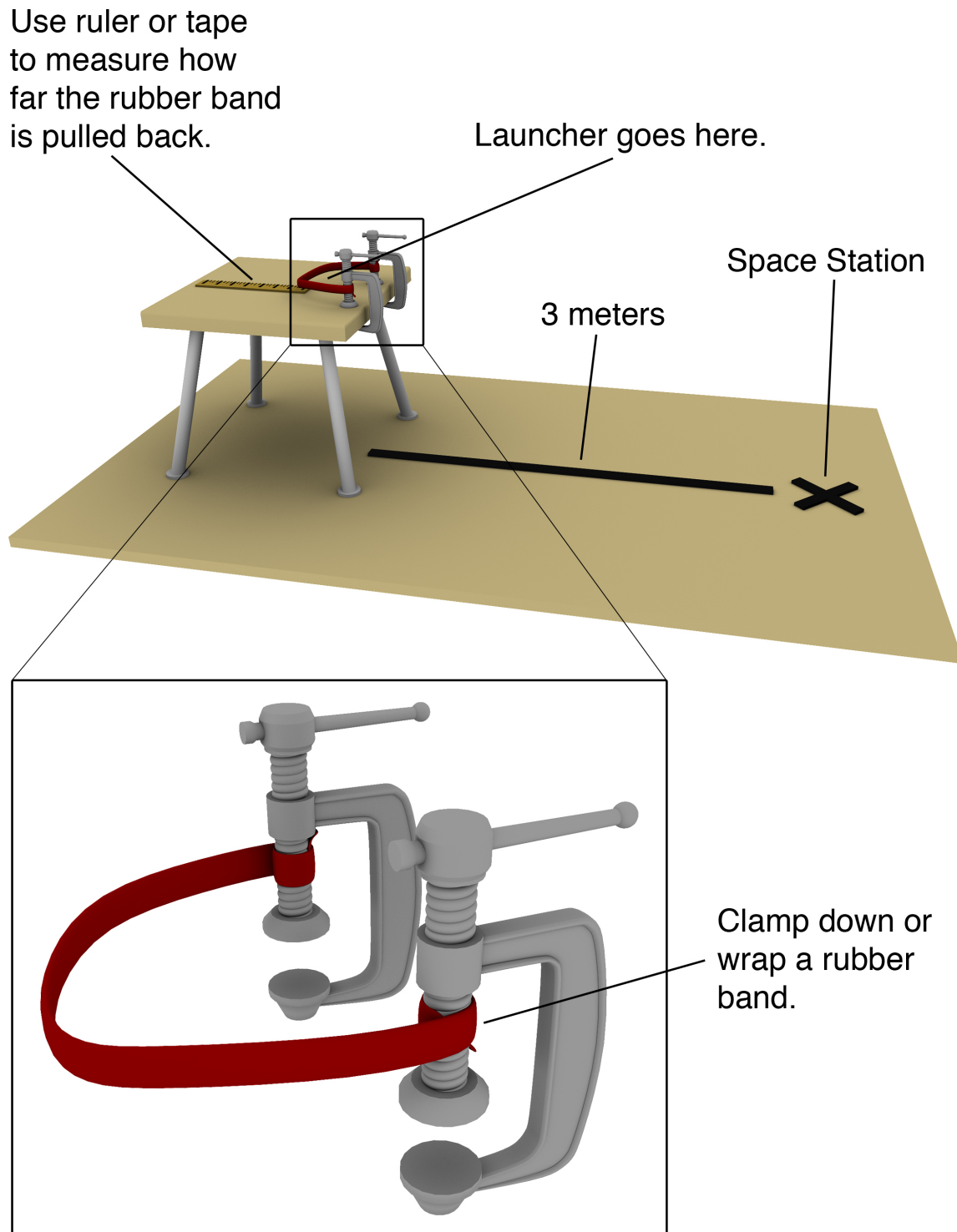
## PREVIEWING NEXT SET OF ACTIVITIES

The Moon is a very harsh environment. There is no atmosphere to protect astronauts and their equipment from solar radiation and the extreme temperature swings between night and day. Next session, we will begin to find ways to protect astronauts from those extreme temperature changes.



**Pre Activity Set Up** - See next page.

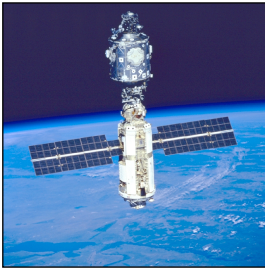
# LAUNCHER SET-UP



## DESIGN CHALLENGE

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### *It's Time to Launch into Space!*



Last session, you built a model of a Crew Exploration Vehicle. During this session, you must design and build a Reusable Launcher. You will then launch your CEV! On the way to the Moon, your CEV is going to rendezvous with the International Space Station to pick up some supplies. When you launch your CEV, the goal is to get into orbit close to the International Space Station.

**The Challenge:** To design and build a Launcher that meets the following **constraints**:

1. *Launch the CEV into orbit so that it may rendezvous with the International Space Station. The goal is to launch the CEV 3 meters.*
2. *Be reusable.*
3. *Demonstrate a repeatable outcome. If you set up the Launcher the same way twice, the CEV should travel the same distance both times. It is more important that the CEV is launched the same distance using the same setup than it is to get the CEV to launch the farthest distance.*

## IMAGINE AND PLAN

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What job does a Reusable Launcher do?

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What components must a Reusable Launcher have to do the job?

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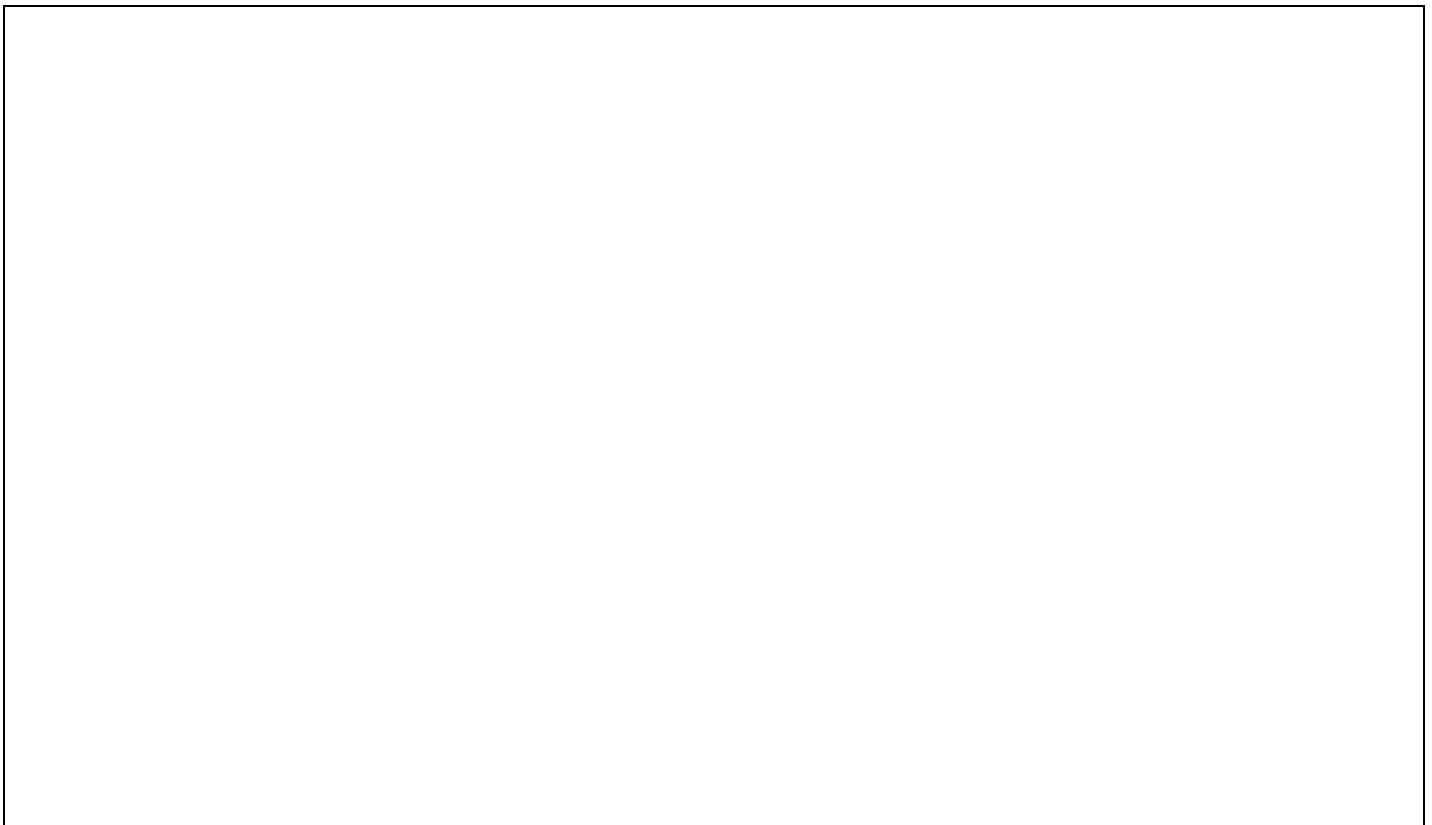
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What do you need to build your Launcher?

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Draw a picture of your team's Reusable Launcher:



## EXPERIMENT AND RECORD

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If you change how far back you pull the rubber band, how will it affect the launch?

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Measure how far back you pull the rubber band. Enter that in the first two boxes of column one. Pull the rubber band back farther and measure the new distance. Record it in the second two boxes. Change it again for the third set.

**CEV Launch Data Table**

Trial	Distance rubber band is pulled back	Dependent Variables	
		Distance traveled (m)	Distance from target (m)
1	Setup A: _____ cm		
2	Setup A: _____ cm		
1	Setup B: _____ cm		
2	Setup B: _____ cm		
1	Setup C: _____ cm		
2	Setup C: _____ cm		

# FILTER THE DUST

## OBJECTIVE

To demonstrate an understanding of Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

The team mission is to design a reusable air-filter system that will identify optimal materials that could be used to filter the air on the Moon.

## PROCESS SKILLS

Measuring, counting, designing, evaluating

## MATERIALS

General building supplies and tools

Pinwheel

Paper towel tube

Hairdryer (cool setting)

Masking tape

Crayons

Air filter materials (cheesecloth, coffee filter, fabric)

Lunar dust (2 cups of dirt or sand)

Plastic spoon

## WORKSHEETS

Imagine and Plan

Experiment and Record

## MOTIVATE

- Ask students to provide examples of air filters and how they are used on Earth.
- Lead students to discuss why it would be important to filter air on the Moon, for example, in a lunar habitat or a vehicle.

## SET THE STAGE: ASK, IMAGINE, PLAN

- Share the *Design Challenge* with the students
- Discuss the word “measure” and ask students to give examples of ways they could measure how far away something is from them.
- Ask students to make measurements of the drawings on the *Imagine and Plan* worksheet.

## CREATE

- Challenge the students to build an air filter device based on their plans. Remind them to keep within specifications.
- While each group is working, the teacher should set up the pinwheel at the end of a desk.

## EXPERIMENT

- Using the cool setting on a hairdryer, teams will test their design by placing the paper towel tube to the hairdryer and holding their design in the middle of the tube
- Students will test the lunar dust flow and record their data.

## IMPROVE

- If there is time, have students inspect their designs and the experiment results. Allow teams to rework their design if needed.

## CHALLENGE CLOSURE

- Engage the students in the following questions:
  - Which material would not filter enough lunar dust?
  - Which material would filter the lunar dust but not let much air pass through?
  - Which filter material would work best on the Moon? Why?

## PREVIEWING NEXT WEEK

Next session students will learn about the principles of energy transfer. When humans go to the Moon, we will need to protect our bodies from the extreme differences in temperature. Have students think of examples their families use for thermal protection, such as if they go camping!



### Lunar Dust Buster

Have you ever opened a fragile item packed in a box filled with Styrofoam peanuts? If you plunge your hands into the foam peanuts to search for the item, when you pull it out foam peanuts are clinging to your arms. Try to brush them off, and they won't fall off—instead, they seem to hop away, only to cling to your legs or elsewhere. The smaller peanuts seem to cling even tighter. In fact, if you break a foam peanut into bits, the tiny lightweight bits are almost impossible to brush off. This behavior is classic static cling. It's also the behavior of lunar dust and possibly also Martian dust.

The dozen Apollo astronauts who landed on the Moon between 1969 and 1972 found moon dust to be an unexpected challenge. Not only was it so rough that it wore partially through the outer gloves of their space suits, but also it stuck to everything. The more they tried to brush it away, the more it worked its way into the space suits' fabric. Lunar dust can be unsafe for humans to breathe and it is now a challenge to find a way to filter the air. NASA astronauts will need proper air filters to allow them to live and work on the Moon.

**The Challenge:** *Your mission is to design a reusable air-filter that will identify materials that could be used to filter the air on the Moon. The challenge is to identify which material allows the right amount of airflow. Your team must design an air filter that tests three different materials. The design must meet the following constraints:*

- 1. The filter must be reusable. You may not use glue or tape to attach it to the paper towel tube.*
- 2. Air must pass through your filter. You will test this by using a hairdryer and a pinwheel as you count the number of rotations it makes with each material.*
- 3. Filter materials must block out a large amount of lunar dust. You will test this by gently shaking dirt through each material and measuring the before and after amounts.*

## IMAGINE AND PLAN

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### Using Crayons to Practice Measurement

How many crayons long is each picture? Write a number next to each picture to show the length in crayon measurements. Remember to keep using the same crayon!

1. The arrow is \_\_\_\_\_ crayons long.



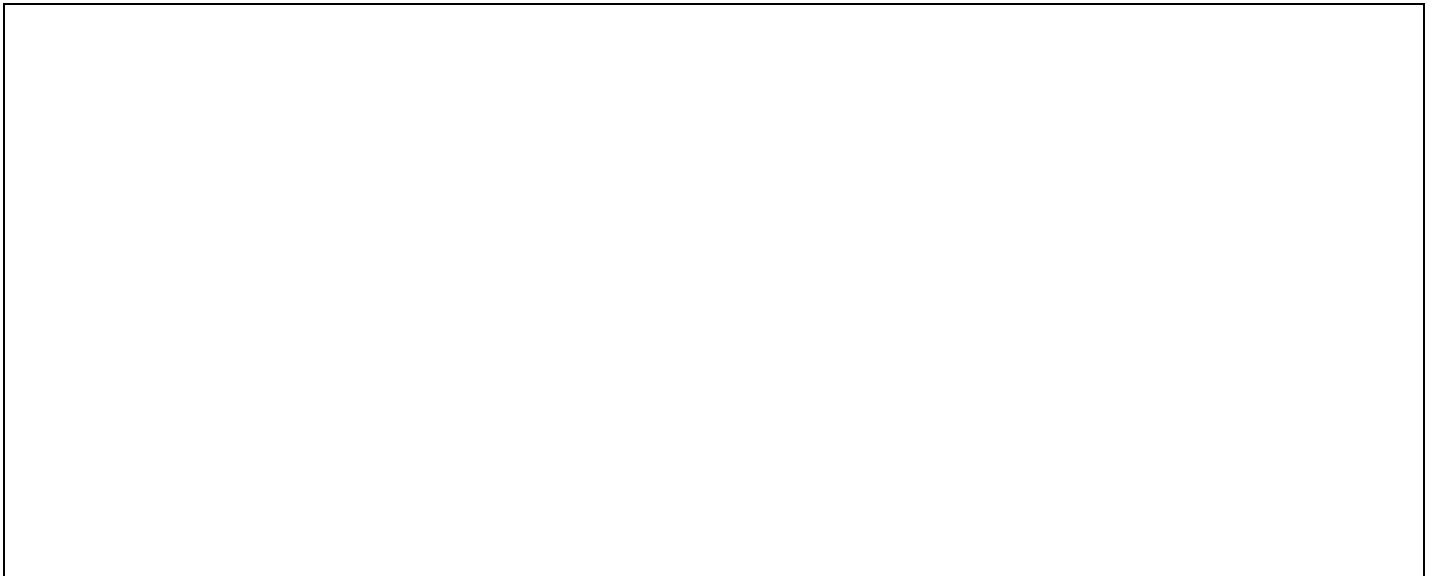
2. The row of rocks is \_\_\_\_\_ crayons long.



3. The row of leaves is \_\_\_\_\_ crayons long.



Draw a picture to show how you will attach each filter material to the tube.



What type of fabric will you use as your third material choice?

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## EXPERIMENT AND RECORD

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Your teacher should already have the pinwheel attached to the end of the desk. Use a piece of masking tape to mark one blade on your pinwheel. This will help you count how many times the pinwheel spins for each filter test.

Turn on the hairdryer and try different positions of the filter from the pinwheel. Using your crayons, measure the distance between your filter and the pinwheel. Identify the farthest distance that the filter can be held from the pinwheel and still make it spin. Record that distance in the table below.

Using a stopwatch, count the number of times the pinwheel rotates in 15 seconds. Record the data below.

Filter Material	Distance of Filter from Pinwheel (Number of crayon lengths)	Number of Pinwheel Rotations in 15 seconds
Cheesecloth		
Coffee Filter		
Fabric		

## EXPERIMENT AND RECORD (continued)

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Now you will test each filter material to find out how much lunar dust will pass through.

1. Test only one material at a time. Place the cheesecloth flat on the desk or table. Add two scoops of dirt into the middle of the filter.
2. Pick up both sides of each filter and hold it over a plate or piece of paper. Gently shake it for 5 to 10 seconds to allow the dirt to pass through the filter material.
3. Draw a picture in the correct box below to show how much dirt passed through each filter.
4. Repeat steps 1-3 for the coffee filter and fabric and record the data in the table below.

Cheesecloth	Coffee Filter	Fabric

# IS IT HOT OR COLD UP THERE?

## OBJECTIVE

To demonstrate an understanding of Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

The team mission is to gather and analyze data in order to understand the relationships between temperature and energy.

## PROCESS SKILLS

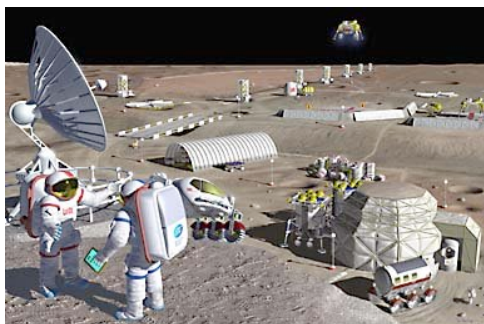
Scientific inquiry, measuring, data analysis

## MATERIALS

Thermometers  
plastic cups  
glow sticks  
hot and cold tap water

## WORKSHEETS

Imagine and Plan  
Experiment and Record



## MOTIVATE

- Let students pretend to be molecules. First have them stand still and close together. Then have the students wiggle and then walk and move around to demonstrate more thermal energy entering the system. Have them move faster and jump up and down as even more thermal energy enters the system. Then have the students stop to notice where they are standing. (Note: They should be much farther apart and should feel much warmer than they were originally.)

## SET THE STAGE: ASK, IMAGINE, PLAN

- Share the *Design Challenge* with the students

## CREATE

- Students should gather their materials and set up for the experiment. Remind them that heat is the results of more movement from molecules. Have students predict what they think might happen to the glow sticks.

## EXPERIMENT

- Have students follow the directions on the *Experiment and Record* worksheet to complete their experiment.

## IMPROVE

- If there is time, have students explore ideas of other ways they could investigate the relationship between temperature and energy.

## CHALLENGE CLOSURE

- Engage the students in the following questions:
  - Explain what happened to the glow stick when placed in hot water? In cold water?
  - What was happening to the molecules inside of the glow stick with each type of water? Were they moving faster or slower?

## PREVIEWING NEXT WEEK

The Moon is a very harsh environment. There is no atmosphere to protect astronauts and their equipment from solar radiation and the extreme temperature swings between night and day. Next session, we will begin to find ways to protect astronauts from those extreme temperature changes by experimenting with insulation.

## DESIGN CHALLENGE

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### Oh, to not have an atmosphere!

There is no atmosphere on the Moon, so temperatures fluctuate through a very wide range. In the shadowed areas of the Moon, the temperature ranges from as low as  $-180^{\circ}\text{C}$  (or  $-300^{\circ}\text{F}$ ), and in the sunlit areas it is about  $100^{\circ}\text{C}$  (or  $212^{\circ}\text{F}$ ), which is the boiling point for water! These are serious extremes for human beings! Furthermore, there are spots on the Moon that are permanently exposed to the Sun, and others permanently in shadow. It is in the permanently shadowed areas of some craters that scientists believe may have water ice.

Anyone living on the Moon, even for a short while, will have to deal with this temperature variation and be protected properly from damaging effects. Thus we must understand how heat moves. So how can we prevent heat from being transferred to or from our bodies? In other words, how can we insulate ourselves from the wide variations of temperature in the lunar environment?

**The Challenge:** Your mission is to complete an experiment that will help you understand how heat, or **thermal energy**, moves, and what factors affect the rate of temperature change.

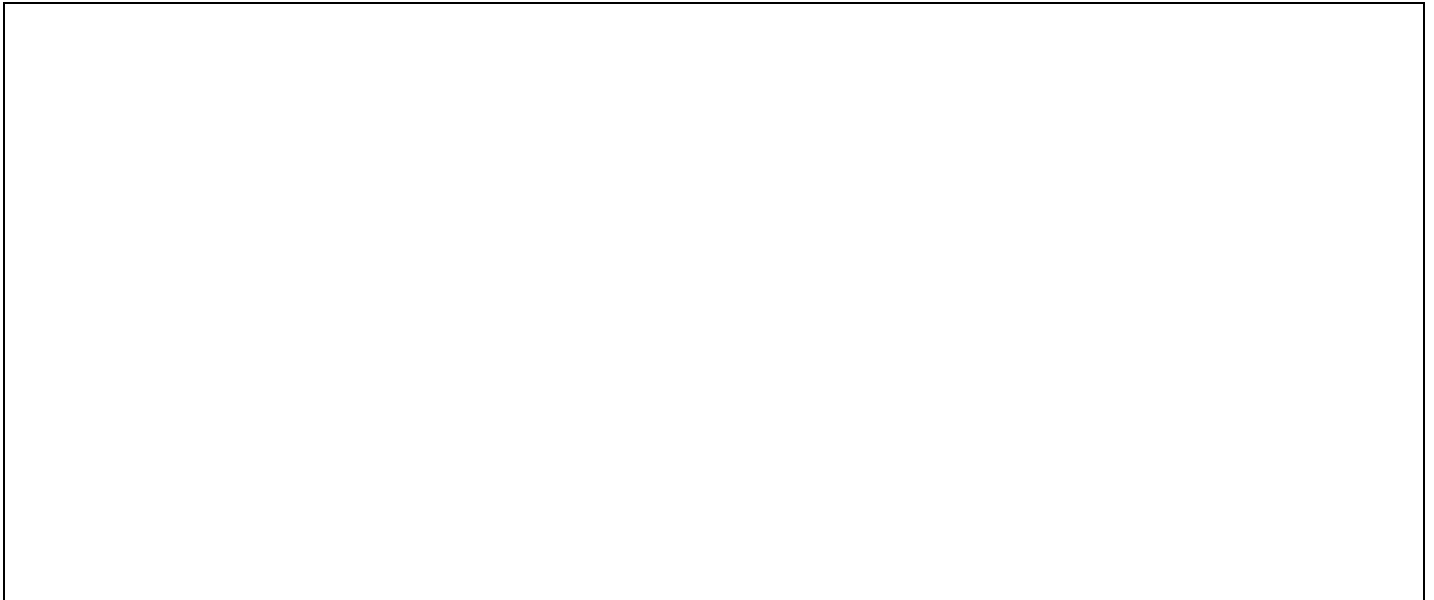
Follow these steps to complete the experiment:

1. *Assign each group member a job for this experiment: Materials Manager, Recorder, and Thermometer Reader.*
2. *The Materials Manager must collect necessary materials for experiment and label the outsides of each plastic cup so you know which cup is the hot water and which is the cold water.*
3. *Remove a glowstick from its wrapper and activate it as directed on the wrapper.*
4. *Using a graduated cylinder, collect 50 mL of cold tap water and pour it into one plastic cup. Repeat for hot water.*
5. *The thermometer reader should place the thermometer into the cups and let the Recorder know the starting temperature for each cup of water.*
6. *Place the glowsticks into both cups and record your observations.*

## IMAGINE AND PLAN

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Take a few minutes and discuss with your team members a definition of HEAT and TEMPERATURE. Draw some objects that come to mind when you use these two words.



Draw out the experimental set-up as your teacher explained in the Design Challenge. Make sure to label everything.



## EXPERIMENT AND RECORD

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1. Collect necessary materials for experiment and label the outsides of each plastic cup so you know which cup is the hot water and which is the cold water.
2. Using a graduated cylinder, collect 50 mL of cold tap water and pour it into one plastic cup. Repeat for hot water (from the tap).
3. Record the temperature for each cup of water in the table below.
4. Place the activated glow sticks into each cup of water and turn off the lights in the room.

Cup	Temperature (°C)	Glowstick Observation
Hot		
Cold		

# BUILD A LUNAR THERMOS

## OBJECTIVE

To demonstrate an understanding of Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

The team mission is to apply the understanding of thermal transfer to design a Lunar Thermos that will hold 100ml of water constant to within 5° over 5 minutes.

## PROCESS SKILLS

Experimental design, measuring, graphing and data analysis

## MATERIALS

General building supplies

Thermometers

Stopwatches

Graduate cylinders

Small and large plastic/styrofoam cups

Insulating materials (e.g. bubble wrap, paper, towels, sand, water, foil, etc)

## WORKSHEETS

Imagine and Plan

Experiment and Record



## MOTIVATE

- Ever wonder how much is involved in today's spacesuits? Check out this interactive site to learn about NASA's spacesuits: [http://www.nasa.gov/audience/foreducators/spacesuits/home/clickable\\_suit.html](http://www.nasa.gov/audience/foreducators/spacesuits/home/clickable_suit.html)

## SET THE STAGE: ASK, IMAGINE, PLAN

- Share the *Design Challenge* with the students
- Have students first recall what thermal energy transfer is and draw a picture that depicts a warm human standing on the Moon during a cold, lunar night. Then have the students draw the opposite, a "cool" human standing in the extreme heat of a hot lunar day.

## CREATE

- Have students practice measuring temperature on the thermometer.
- Challenge the students to devise a system to keep water at a constant temperature.

## EXPERIMENT

- Have students follow the directions on the *Experiment and Record* worksheet to complete their experiment.

## IMPROVE

- If there is time, have students inspect their designs and the experiment results. Allow teams to rework their design if needed.

## CHALLENGE CLOSURE

- Engage the students in the following questions:
  - Did your thermos keep the cold water at a constant temperature for 5 minutes?
  - What would have been different if you were trying to keep hot water from cooling off instead of keeping cold water from warming up?
  - How would you make your thermos more effective?

## PREVIEWING NEXT WEEK

This session we were trying to stop the transfer of heat energy using insulation. What if we needed to capture heat energy? Why would we need to capture heat energy if we wanted to live on the Moon?

## DESIGN CHALLENGE

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### Protecting humans while exploring the Moon

When we go to the Moon, we will need to protect our bodies from the extreme differences in temperature (remember, the Moon's surface temperature can go from  $-180^{\circ}\text{C}$  to  $100^{\circ}\text{C}$  in just one day!). Just think about the number of layers you would wear when going outside on a very cold winter's day. We want to keep our bodies at a fairly constant temperature. Since humans are mostly composed of water, how can we keep from losing or gaining too much heat energy?

**The Challenge:** Your mission is to find an insulating material that can help keep humans at a steady temperature while working on the Moon. Your team will need to keep 100 ml of water at a relatively constant temperature by designing and building a "Lunar Thermos". Your "Thermos" should change by no more than  $5^{\circ}$  over 5 minutes. You can use any combination of materials to use as your insulation.

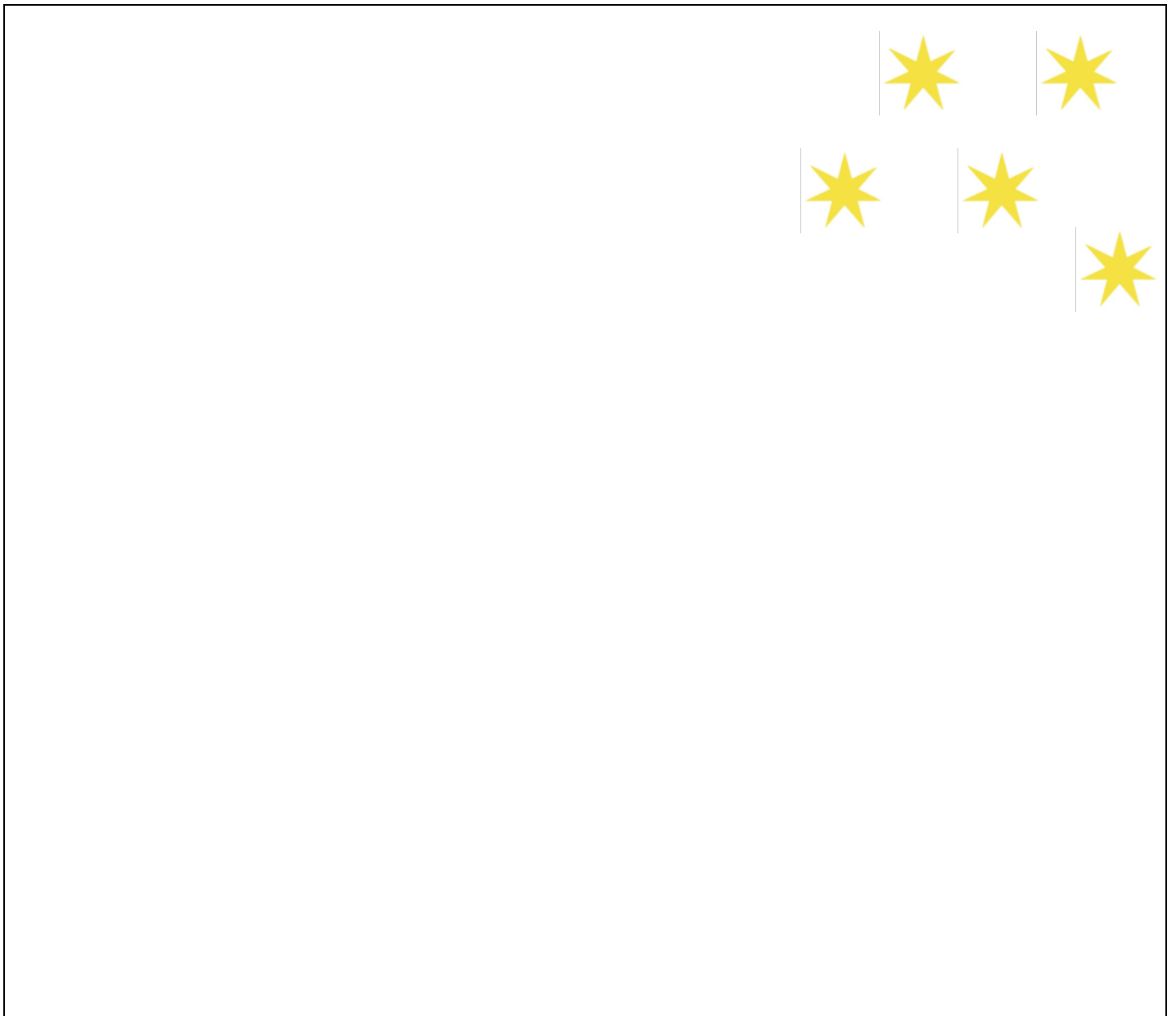




## IMAGINE AND PLAN

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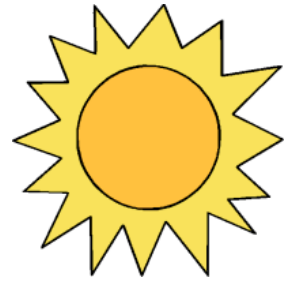
Draw a picture of a warm human standing on the Moon in the cold, lunar night. In your picture, show how heat moves between the human and the air around him or her. Make sure to label the arrows warm and cool.



## *IMAGINE AND PLAN (continued)*

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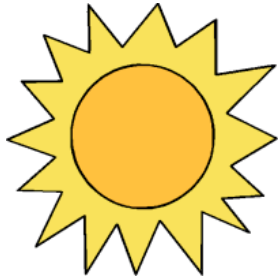
Now imagine that the sun comes up, and the human is standing on the hot lunar surface. Draw a picture showing how heat moves between the human and the air around him or her. Make sure to label the arrows warm and cool.



## *IMAGINE AND PLAN (continued)*

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Now, imagine a method for keeping the human not too warm, not too cool, but just right! Draw a showing a method for keeping the human at an ideal temperature for the cold nights and hot days.



## EXPERIMENT AND RECORD

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1. Collect necessary materials and insulate your cup.
2. Record the temperature of the room: \_\_\_\_\_ °C
3. Using a graduated cylinder, collect 100 mL of warm tap water and pour it into the insulated plastic cup.
4. Record the temperature of the water every 30 seconds for 5 minutes total. Record your results below.

Time Min:sec	Warm Water Temperature °C
0:00	
0:30	
1:00	
1:30	
2:00	
2:30	
3:00	
3:30	
4:00	
4:30	
5:00	

# BUILD A SOLAR OVEN

## OBJECTIVE

To demonstrate an understanding of Engineering Design Process while utilizing each stage to successfully complete a team challenge.

## CHALLENGE

The team mission is to design and build a solar box cooker, and test it out to see if it works well enough to make S'mores!

## PROCESS SKILLS

Experimental design, measuring, graphing and data analysis

## MATERIALS

Thermometer

Timers

Cardboard box

Aluminum pans

Aluminum foil

Black construction paper

One piece of plexiglass big enough to cover the box or plastic wrap

Sunshine, OR gooseneck lamp with 100 W bulb

S'mores fixin's (graham crackers, marshmallows and chocolate)

Oven mitts

## WORKSHEETS

Imagine and Plan

Experiment and Record

## MOTIVATE

- Have students watch the video "Living on the Moon":

<http://svs.gsfc.nasa.gov/goto?10515>

## SET THE STAGE: ASK, IMAGINE, PLAN

- Share the *Design Challenge* with the students
- Tell students that if they succeed in their design, a tasty treat will be had!

## CREATE

- Hand out the materials to the students and challenge them to build their own solar ovens.

## EXPERIMENT

- Have students follow the directions on the *Experiment and Record* worksheet to complete their experiment.
- Once the oven is built, students should place a S'more and the thermometer in the box and close the plexiglass lid.
- Place the box in direct sunlight (they may have to tilt the box so that there are no shadows inside). If it is a cloudy day, use a goose neck lamp with the 100W bulb.
- Ensure students use oven mitts when moving the plexiglass lid or removing items from the solar oven once exposed to the sun.

## IMPROVE

- If there is time, have students inspect their designs and the experiment results. Allow teams to rework their design if needed.

## CHALLENGE CLOSURE

- Engage the students with the following questions:
  - Whose oven got to the highest temperature?
  - Whose oven melted the marshmallows and the chocolate?
  - Does it make a difference to use actual sunlight compared to light from a lamp? Why or why not?
  - What else could you cook using a solar oven?

## END OF PROGRAM

This session concludes the NASA Beginning, Engineering, Science and Technology activities. Students now should have a firm grasp of the Engineering Design Process and how it is applied in real applications of our quest to travel to the Moon, Mars and beyond. Fill out a certificate for each student for completing all the steps to becoming a NASA BEST student (p.?).



## DESIGN CHALLENGE

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### Can we cook while on the Moon?

While we might have to bring just about everything with us when we establish a habitat on the Moon, one thing we won't need is solar energy. There may be no atmosphere, no climate nor weather on the Moon, but that all means it DOES make it an ideal place to collect solar energy. The majority of the Moon is exposed to sunlight constantly, except briefly during a rare lunar eclipse. If that energy could be harnessed, we could use it to power most everything in our habitat...including that most important device that helps us cook our food – an oven!



**The Challenge:** Your mission is to design and build a solar oven to cook your own S'mores simply using a cardboard box, aluminum foil, black paper and some plastic wrap. Your solar oven must meet the following specifications:

1. *It must have a "footprint" of no more than 40 cm x 40 cm.*
2. *In 10 minutes, the temperature inside the box must increase by 10°C.*
3. *You may use any available materials to line the bottom and inside of box.*

## IMAGINE AND PLAN

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Place a piece of white paper and a piece of black construction paper outside in the sun or under a lamp. Place a thermometer on top of each piece of paper. Let it sit for 5 minutes.

Which piece of paper had a higher temperature on the thermometer?

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Which paper absorbed most heat energy?

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How can using aluminum foil increase the temperature?

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Using the answers above, design your solar oven:

## EXPERIMENT AND RECORD

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1. Using the materials provided, build you solar oven based on your design.
2. Place one S'more in the middle of the oven (1 graham cracker, 1 piece of chocolate, 1 marshmallow) and the thermometer. Cover with plastic wrap and begin cooking.
3. Record the temperature in the table below. Make sure to use oven mitts when manipulating anything inside the oven!

Time Min:sec	Oven Temperature °C
0:00	
1:00	
2:00	
3:00	
4:00	
5:00	

Did your S'mores melt? \_\_\_\_\_

If you could make changes to your solar oven, what would you do?

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# ALIGNMENT TO NATIONAL STANDARDS

## SCIENCE

### Science as Inquiry

Develop abilities necessary to do scientific inquiry.

Develop understanding about scientific inquiry.

### Science and Technology

Develop abilities to technological design.

Develop understanding about science and technology.

### History of Nature and Science

Develop understanding of science as a human endeavor.

## TECHNOLOGY & ENGINEERING

### Creativity and Innovation

Apply existing knowledge to generate new ideas, products or processes.

Create original works as a means of personal or group expression.

Use models and simulations to explore complex systems and issues.

### Research and Information Fluency

Locate, organize, analyze, evaluate, synthesize and ethically use information from a variety of sources and media.

Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.

### Critical Thinking, Problem Solving, and Decision Making

Identify and define authentic problems and significant questions for investigation.

### Digital Citizenship

Exhibit a positive attitude toward using technology that supports collaboration, learning and productivity.

K	1	2
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓

## MATHEMATICS

	K	1	2
<b>Numbers and Operations</b>			
Understand numbers, ways of representing numbers, relationships among numbers and number systems.		✓	✓
Compute fluently and make reasonable estimates.		✓	✓
Count with understanding and recognize "how many" in sets of objects.	✓	✓	✓
Connect number words and numerals to the quantities they represent, using various physical models and representations.	✓	✓	✓
<b>Measurement</b>			
Understand measureable attributes of objects and the units, systems, and processes of measurement.	✓	✓	✓
Apply appropriate techniques, tools, and formulas to determine measurements.	✓	✓	✓
<b>Data Analysis and Probability</b>			
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.			✓
Develop and evaluate inferences and predictions that are based on data.			✓
<b>Problem Solving</b>			
Build new mathematical knowledge through problem solving.	✓	✓	
Solve problems that arise in mathematical and in other contexts.	✓	✓	
Apply and adapt a variety of appropriate strategies to solve problems.	✓	✓	
<b>Communication</b>			
Communicate mathematical thinking coherently and clearly to peers, teachers and others.	✓	✓	✓
Analyze and evaluate the mathematical thinking and strategies of others.	✓	✓	✓
Use the language of mathematics to express mathematical ideas precisely.	✓	✓	✓
<b>Connections</b>			
Recognize and apply mathematics in contexts outside of mathematics.	✓	✓	✓

## ORIGINATING MATERIAL

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*Build a Satellite to Orbit the Moon* adapted from

[www.lpi.usra.edu/education/explore/moon/lro.shtml](http://www.lpi.usra.edu/education/explore/moon/lro.shtml)

*Launch Your Satellite* adapted from **Rockets Educator Guide**

[www.nasa.gov/pdf/58269main\\_Rockets.Guide.pdf](http://www.nasa.gov/pdf/58269main_Rockets.Guide.pdf)

*Prepare for a Mission* adapted from **Principles of Remote Exploration** at

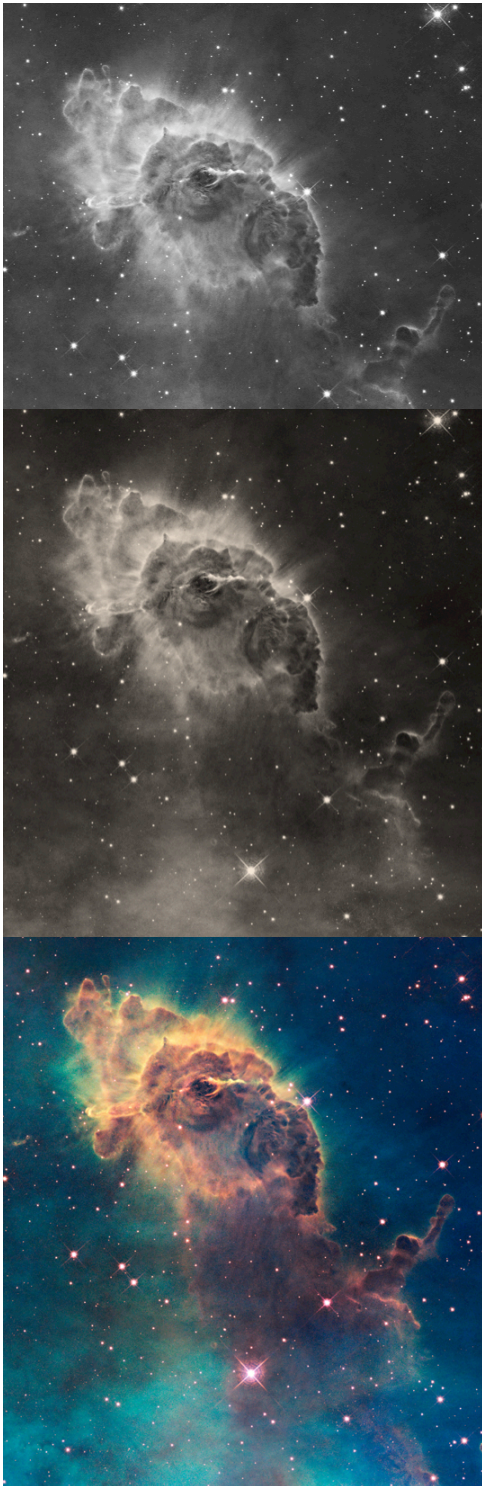
[learners.gsfc.nasa.gov/PREP/](http://learners.gsfc.nasa.gov/PREP/)

*Design the new Crew Exploration Vehicle!* adapted from **NASA's KSNN™ 21st Century Explorer newsbreak “What will replace the space shuttle?”** at

[education.jsc.nasa.gov/explorers/pdf/p5\\_educator.pdf](http://education.jsc.nasa.gov/explorers/pdf/p5_educator.pdf)

*Build a Solar Oven* was adapted from **Lunar Nautics**, but is also a very popular activity found in many science textbooks.

[www.nasa.gov/audience/foreducators/topnav/materials/listbytype/  
Lunar\\_Nautics\\_Designing\\_a\\_Mission.html](http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Lunar_Nautics_Designing_a_Mission.html)



National Aeronautics and Space Administration



**This certifies that**

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**is officially a NASA BEST STUDENT!**

**For the achievement in understanding and  
applying the Engineering Design Process.**

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