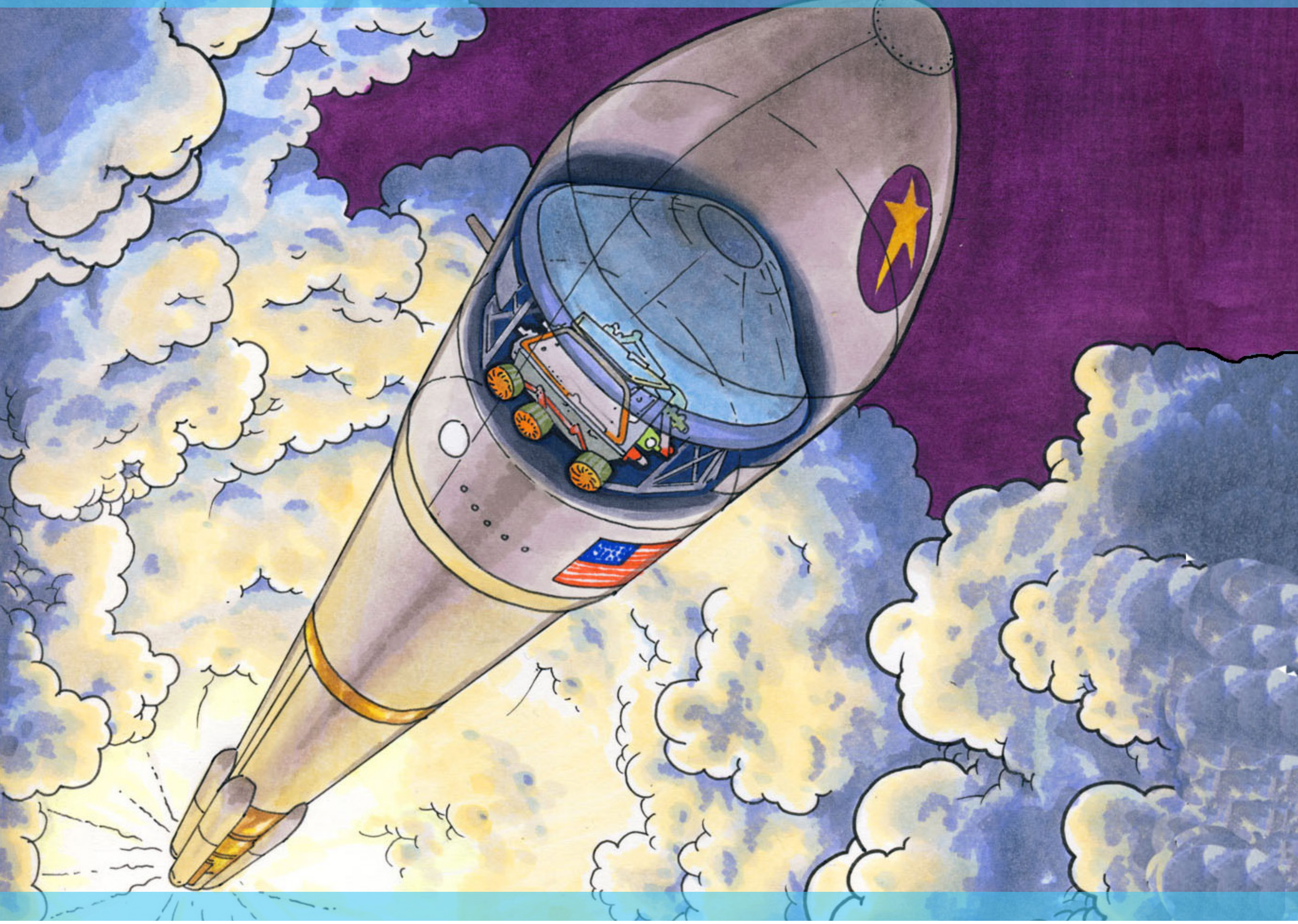
Engineering Adventures®

Liftoff: Engineering Rockets and Rovers

Aerospace Engineering for Out-of-School Time • Grades 3–5



Written by the Engineering is Elementary® Team
Illustrated by Ross Sullivan Wiley and the EiE Team

EiE Engineering is Elementary® | Engineering Adventures®
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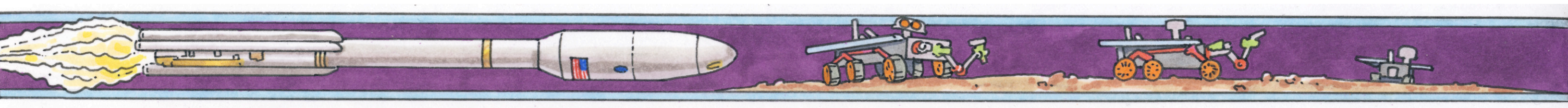

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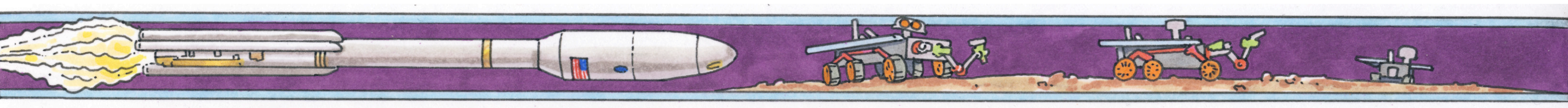
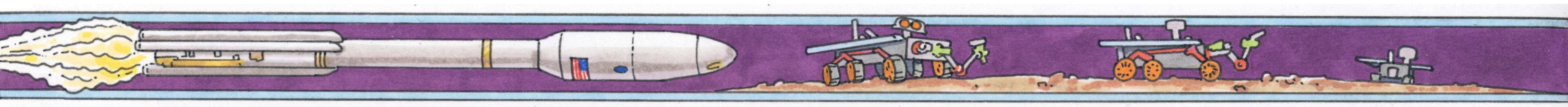


Pilot Sites for Liftoff

This unit would not be possible without valuable feedback from our pilot sites!

A.E. Burdick School, Milwaukee Public Schools Milwaukee, WI
Arboretum Elementary School Waunakee, WI
Bayshore Community Academy Oconto, WI
Boys & Girls Club of La Habra La Habra, CA
Boys & Girls Club of the South Coast Area San Clemente, CA
Boys & Girls Club of Woburn, After the Bell 21st CCLC Woburn, MA
Burnsville Area Learning Center Eagan, MN
City of Healdsburg Parks and Recreation Afterschool Program Healdsburg, CA
The Community Group Lawrence, MA
Columbus Afterschool Program Medford, MA
Edgerly Family South Boston Boys & Girls Club Boston, MA
ESD 105 Migrant Services Yakima, WA
The Frank M. Silvia Elementary School Fall River, MA
Henrico County Public Schools Summer Academy Henrico, VA
The Hockaday School Dallas, TX
Imaginarium Science Center Fort Myers, FL
Informal Science Learning Associates of Laredo Laredo, TX
Jenny Lind School Minneapolis, MN
Minnieland Academy Woodbridge, VA
The Philadelphia Center for Art and Technology Philadelphia, PA
Quaboag Regional School District Warren, MA
Ridgepoint Elementary School Sacramento, CA
Sitton SUN Community School Portland, OR
Somerville Community Schools Somerville, MA
Tucker Elementary Milton, MA
UC Davis School of Education Davis, CA
United South End Settlements Boston, MA
YMCA of Metropolitan Washington Washington, DC



Unit Map

Here is an overview of the adventures in this unit and how they all fit together.

Prep Adventure 1: What is Engineering?
Kids engineer a tower and are introduced to the Engineering Design Process as a problem-solving tool.

→

Prep Adventure 2: What is Technology?
Kids explore the idea that they, as engineers, can design and *improve* technology.

↓

Adventure 1: Out of This World
Kids will be introduced to rockets, rovers, and stomp rocket launchers. They will test how weight affects how rockets fly.

↓

Adventure 2: Boost Your Knowledge
Groups will test rocket variables and share their data.

↓

Adventure 3: Shoot for the Moon
Groups will pick a destination and *create* their rovers.

↓

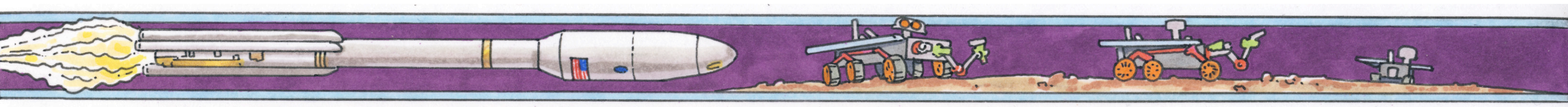
Adventure 4: Create a Rocket
Groups will *plan* and engineer their model rockets.

↓

Adventure 5: Countdown: Improve a Rocket
Groups will offer improvement advice to each other and then *improve* and complete their rockets.

↓

Adventure 6: Engineering Showcase: Liftoff!
Kids present the rockets and rovers they engineered and share their knowledge of the Engineering Design Process.



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Introduction

Adventures

About Engineering is Elementary

Engineering is Elementary® (EiE) fosters engineering and technological literacy among children. Most humans spend over 95% of their time interacting with technology. Pencils, chairs, water filters, toothbrushes, cell phones, and buildings are all technologies—solutions designed by engineers to fulfill human needs or wants. To understand the world we live in, it is vital that we foster engineering and technological literacy among all people, even young children! Fortunately, children are born engineers. They are fascinated with building, taking things apart, and learning how things work. Engineering is Elementary harnesses children's natural curiosity to promote the learning of engineering and technology concepts.

The EiE program has four primary goals:

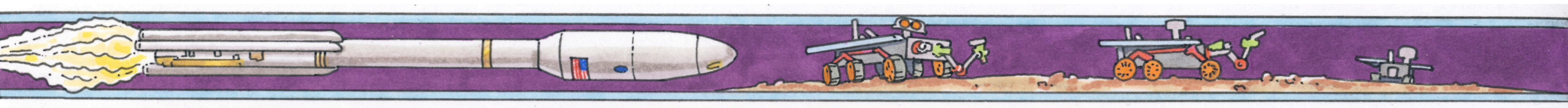
- Increase children's technological literacy.
- Increase educators' abilities to teach engineering and technology.
- Increase the number of schools and out-of-school-time (OST) programs in the U.S. that include engineering.
- Conduct research and assessment to further the first three goals and contribute knowledge about teaching and learning engineering.

The first product developed by the EiE program was the Engineering is Elementary curriculum series. Designed for use in elementary school classrooms, this curriculum is hands-on, research-based, standards-driven, and classroom-tested. For more information about EiE, visit: www.eie.org.

In 2011, EiE began development of Engineering Adventures (EA), a curriculum created for 3rd–5th grade children in OST environments. EA is designed to provide engaging and thought-provoking challenges appropriate for the OST setting. More information about EA can be found online at: www.engineeringadventures.org.

In 2012 the Engineering Everywhere (EE) curriculum was created. EE is designed to empower middle-school-aged children in OST settings to become engineers and solve problems that are personally meaningful and globally relevant. For more information, visit: www.engineeringeverywhere.org.

EiE is a part of The National Center for Technological Literacy (NCTL) at the Museum of Science, Boston. The NCTL aims to enhance knowledge of technology and inspire the next generation of engineers, inventors, and innovators. Unique in recognizing that a 21st-century curriculum must include today's human-made world, the NCTL's goal is to introduce engineering as early as elementary school and continue through high school, college, and beyond. For more information, visit: www.nctl.org.



About Engineering Adventures

The mission of Engineering Adventures (EA) is to create exciting out-of-school-time activities and experiences that allow *all* 3rd–5th grade learners to act as engineers and engage in the Engineering Design Process. Our goal is to positively impact children's attitudes about their ability to engineer by providing materials uniquely appropriate for the varied landscapes of out-of-school-time settings.

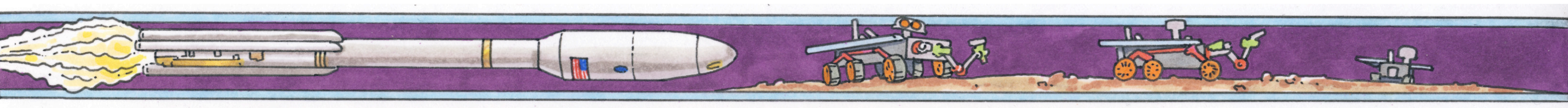
The main ideas that guide the developers of EA are listed below.

We believe kids will best learn engineering when they:
- engage in activities that are fun, exciting, and connect to the world in which they live.
- choose their path through open-ended challenges that have multiple solutions.
- have the opportunity to succeed in engineering challenges.
- communicate and collaborate in innovative, active problem solving.

Through EA units, kids will learn that:
- they can use the Engineering Design Process to help solve problems.
- engineers design technologies to help people and solve problems.
- they have talent and potential for designing and improving technologies.
- they, too, are engineers.

As kids work through their engineering design challenges, they will have the opportunity to build problem-solving, teamwork, communication, and creative thinking skills. Most importantly, this curriculum is designed to provide a fun learning opportunity for kids!

For more information on Engineering Adventures, please visit:
www.engineeringadventures.org.



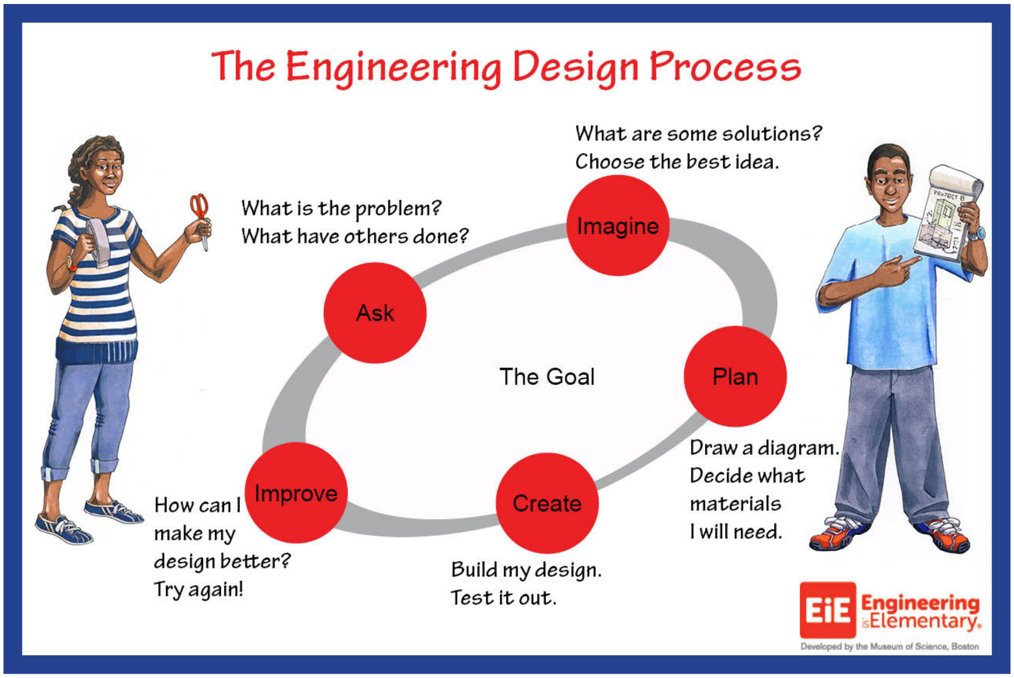
The Engineering Design Process

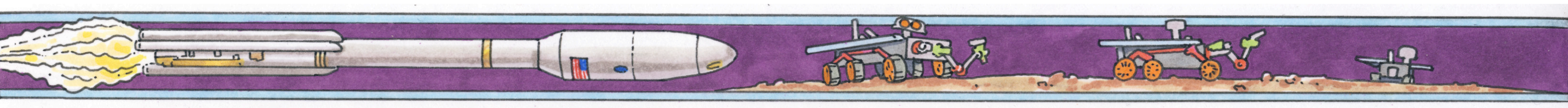
The Engineering Adventures Engineering Design Process (EDP) is the backbone of each Engineering Adventures (EA) unit. It is a five-step process that guides kids in solving engineering challenges. Our goal for each EA unit is for kids to understand the EDP can help them solve problems not only in engineering, but also in other areas of their lives.

While there are many other versions of the EDP that are used in academic and professional settings, the EiE team developed a five-step process that is accessible for elementary school kids. India and Jacob, a fictional world-traveling brother and sister duo, introduce and guide kids through the EDP in each unit. There are also questions for the educator to ask and sections in the Engineering Journal to provide an opportunity for kids to reflect on and discuss the process.

The EDP begins with the goal: the engineering challenge kids are asked to solve. The process is cyclical and flexible; kids can start a challenge at any step and may jump around to steps as they are engineering. For example, it is very common for kids to begin *creating* their technology, but then *ask* questions about materials and *imagine* new ways to *improve* their design. In EA units, kids generally start with the *ask* step, then have time to *imagine* and *plan* their designs, and *create* and *improve* their technologies.

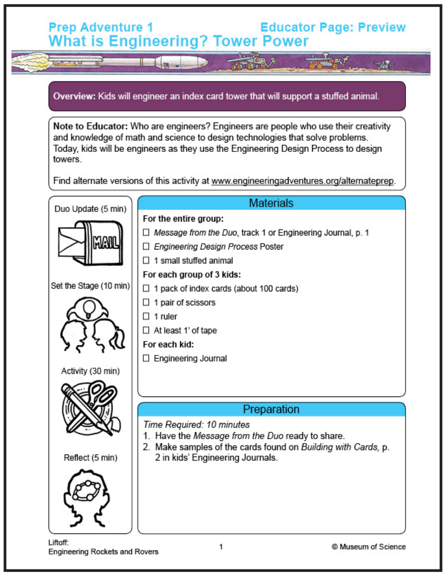
To further highlight the EDP throughout the unit, the steps are italicized in this guide. Below is the EDP used in EA units.





Each Engineering Adventure Includes

Preview pages with relevant background information, materials lists, preparatory instructions, and a preview of the journal pages needed.



Prep Adventure 1 Educator Page: Preview
What is Engineering? Tower Power

Overview: Kids will engineer an index card tower that will support a stuffed animal.

Note to Educator: Who are engineers? Engineers are people who use their creativity and knowledge of math and science to design technologies that solve problems. Today, kids will be engineers as they use the Engineering Design Process to design towers.

Find alternate versions of this activity at www.engineeringadventures.org/alternateprep.

Duo Update (5 min)
Set the Stage (10 min)
Activity (30 min)
Reflect (5 min)

Materials

For the entire group:
- ☐ *Message from the Duo*, track 1 or Engineering Journal, p. 1
- ☐ *Engineering Design Process* Poster
- ☐ 1 small stuffed animal

For each group of 3 kids:
- ☐ 1 pack of index cards (about 100 cards)
- ☐ 1 pair of scissors
- ☐ 1 ruler
- ☐ At least 1' of tape

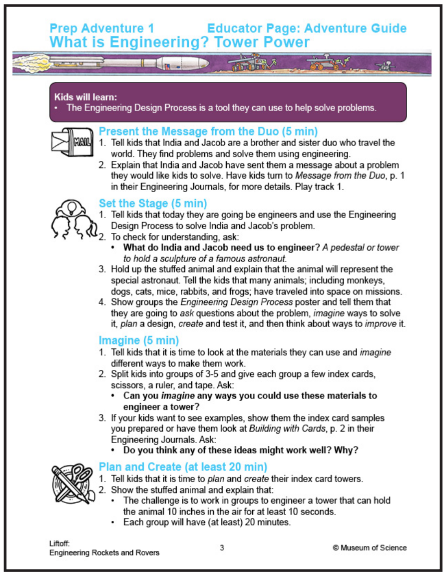
For each kid:
- ☐ Engineering Journal

Preparation

Time Required: 10 minutes
1. Have the *Message from the Duo* ready to share.
2. Make samples of the cards found on *Building with Cards*, p. 2 in kids' Engineering Journals.

Liftoff: Engineering Rockets and Rovers 1 © Museum of Science

An **Adventure Guide** with step-by-step instructions, including discussion questions, extension ideas, and tips.



Prep Adventure 1 Educator Page: Adventure Guide
What is Engineering? Tower Power

Kids will learn:
- The Engineering Design Process is a tool they can use to help solve problems.

Present the Message from the Duo (5 min)
1. Tell kids that India and Jacob are a brother and sister duo who travel the world. They find problems and solve them using engineering.
2. Explain that India and Jacob have sent them a message about a problem they would like kids to solve. Have kids turn to *Message from the Duo*, p. 1 in their Engineering Journals, for more details. Play track 1.

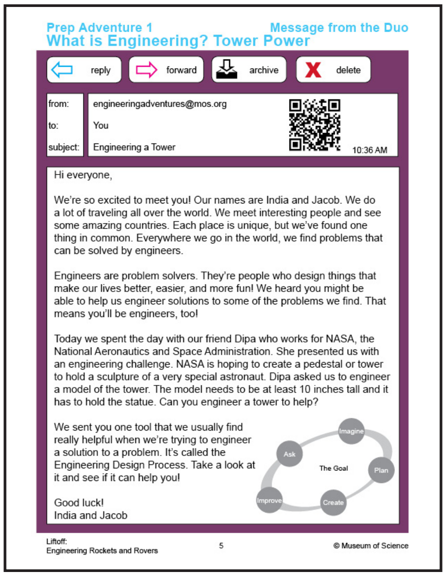
Set the Stage (5 min)
1. Tell kids that today they are going be engineers and use the Engineering Design Process to solve India and Jacob's problem.
2. To check for understanding, ask:
   - **What do India and Jacob need us to engineer?** *A pedestal or tower to hold a sculpture of a famous astronaut.*
3. Hold up the stuffed animal and explain that the animal will represent the special astronaut. Tell the kids that many animals; including monkeys, dogs, cats, mice, rabbits, and frogs; have traveled into space on missions.
4. Show groups the *Engineering Design Process* poster and tell them that they are going to *ask* questions about the problem, *imagine* ways to solve it, *plan* a design, *create* and test it, and then think about ways to *improve* it.

Imagine (5 min)
1. Tell kids that it is time to look at the materials they can use and *imagine* different ways to make them work.
2. Split kids into groups of 3-5 and give each group a few index cards, scissors, a ruler, and tape. Ask:
   - **Can you *imagine* any ways you could use these materials to engineer a tower?**
3. If your kids want to see examples, show them the index card samples you prepared or have them look at *Building with Cards*, p. 2 in their Engineering Journals. Ask:
   - **Do you think any of these ideas might work well? Why?**

Plan and Create (at least 20 min)
1. Tell kids that it is time to *plan* and *create* their index card towers.
2. Show the stuffed animal and explain that:
   - The challenge is to work in groups to engineer a tower that can hold the animal 10 inches in the air for at least 10 seconds.
   - Each group will have (at least) 20 minutes.

Liftoff: Engineering Rockets and Rovers 3 © Museum of Science

A **Message from the Duo**, India and Jacob, with information about the day's activity.



Prep Adventure 1 Message from the Duo
What is Engineering? Tower Power

reply forward archive delete

from: engineeringadventures@mos.org
to: You
subject: Engineering a Tower
10:36 AM

Hi everyone,

We're so excited to meet you! Our names are India and Jacob. We do a lot of traveling all over the world. We meet interesting people and see some amazing countries. Each place is unique, but we've found one thing in common. Everywhere we go in the world, we find problems that can be solved by engineers.

Engineers are problem solvers. They're people who design things that make our lives better, easier, and more fun! We heard you might be able to help us engineer solutions to some of the problems we find. That means you'll be engineers, too!

Today we spent the day with our friend Dipa who works for NASA, the National Aeronautics and Space Administration. She presented us with an engineering challenge. NASA is hoping to create a pedestal or tower to hold a sculpture of a very special astronaut. Dipa asked us to engineer a model of the tower. The model needs to be at least 10 inches tall and it has to hold the statue. Can you engineer a tower to help?

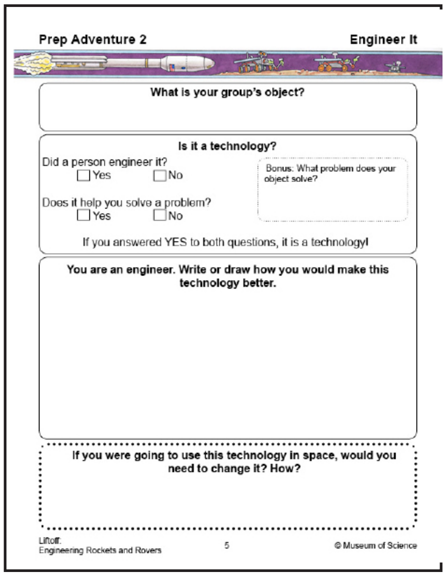
We sent you one tool that we usually find really helpful when we're trying to engineer a solution to a problem. It's called the Engineering Design Process. Take a look at it and see if it can help you!

Good luck!
India and Jacob

Imagine
Ask
The Goal
Plan
Improve
Create

Liftoff: Engineering Rockets and Rovers 5 © Museum of Science

Engineering Journal pages that allow kids to record their findings and reflect on their learning.



Prep Adventure 2 Engineer It

What is your group's object?

Is it a technology?

Did a person engineer it?
☐ Yes ☐ No

Does it help you solve a problem?
☐ Yes ☐ No

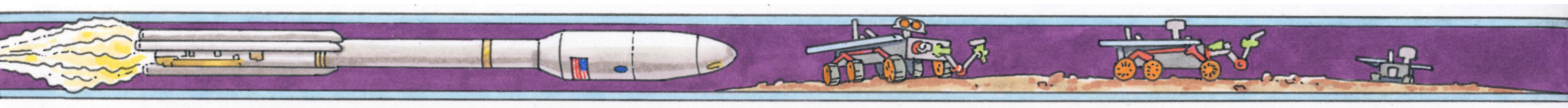
Bonus: What problem does your object solve?

If you answered YES to both questions, it is a technology!

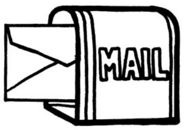
You are an engineer. Write or draw how you would make this technology better.

If you were going to use this technology in space, would you need to change it? How?

Liftoff: Engineering Rockets and Rovers 5 © Museum of Science



The Sections of the Adventures



Messages from the Duo

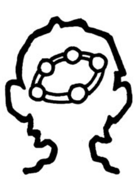
Messages from India and Jacob, a fictional world-traveling brother and sister duo, are provided as a quick, exciting way to present the real-world context for the unit's engineering challenge. Providing a context helps kids to understand the challenge and motivates them to find solutions. If you have access to a CD, MP3 player, or iOS device, we strongly suggest using the audio recordings, although reading the emails aloud will convey the same information.

Set the Stage (Ask)

The Set the Stage, or Ask, part of each adventure provides important information and questions that prepare kids for the main activity. During this section, you might ask questions prompting kids to share their prior knowledge, have them predict what they will find, or remind them of criteria that will help them as they engineer. This sets your kids up to succeed and feel confident in their ability to engineer.

Activities

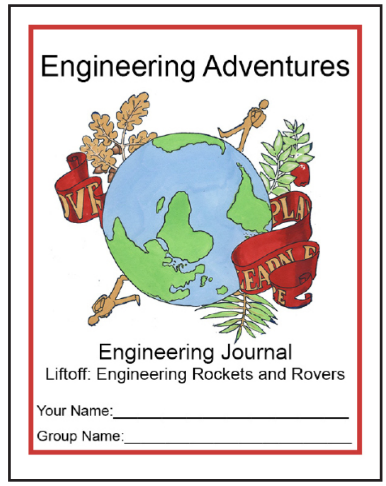
The activities are designed to get kids thinking and working together to solve the unit's engineering design challenge. As the educator, it is your role to guide kids through these activities by encouraging them to pursue and communicate their own ideas, even if you think they may not work. In engineering, there are no right or wrong answers! Every problem has many possible solutions and multiple ways to reach them.



Reflect

Each adventure includes 5-10 minutes at the end for kids to communicate with their peers by sharing their work. This gives kids the chance to discuss new ideas, think about their own work and the work of others, and reflect on what was learned. Group reflection can help reduce competition by encouraging kids to support each other as they move through the Engineering Design Process. For more individual reflection, each adventure also includes time for kids to record thoughts and ideas in their Engineering Journal.

Engineering Journals



Make a copy of the Engineering Journal for each kid as you begin working on this EA unit. The Engineering Journal is a central location for kids to record their thoughts and ideas as they move through the unit. It includes recording pages that will guide kids through the Engineering Design Process, poses questions, and prompts kids to reflect on their learning. The 5-10 minutes kids spend with their journals during each adventure will allow them to create a personalized record of their engineering learning.

There are a few ways you can use the Engineering Journal You may want to have groups share one Engineering Journal as a central recording spot for all group data and findings. This allows group members who enjoy writing and recording to do so. You may also encourage groups to share the responsibility by having group members rotate who records for each adventure.

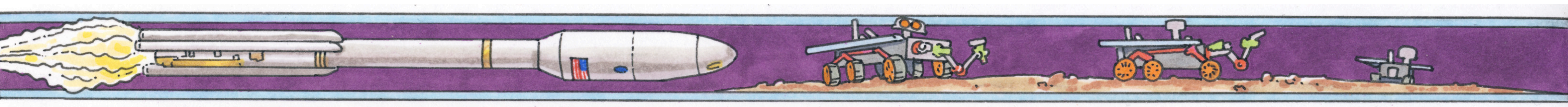
The back page of each Engineering Journal is a passport page from the country or state in which the unit takes place. Kids are encouraged to stamp the passport page when they finish a unit and collect the pages from all of the units they have completed.

Alternate Prep Adventures

The two prep adventures, “What is Engineering?” and “What is Technology?” introduce kids to engineering and technology. “What is Engineering?” gives kids the chance to collaborate, experience a mini hands-on engineering challenge, share their designs, and learn about the Engineering Design Process. This adventure sets the stage for what kids can expect in the rest of the unit.

“What is Technology?” has kids interact with technologies, working with the definition that a technology is anything designed by humans to help solve a problem. Most kids think of technology as things that can be plugged into the wall. They do not realize that the items that they interact with every day—including pencils, paper, and water bottles—are also technologies. This adventure introduces the definition of technology that the kids will refer to as they engineer their own technologies to solve the problem presented in the unit.

There are alternate activities for both of these adventures available online in the Resources section at www.engineeringadventures.org/alternateprep. If kids complete multiple units, you may want to use an alternate activity to refresh the concepts in these activities. There may also be an activity that is more active or would be a better fit for the kids in your program. If you have questions about these activities, please email engineeringadventures@mos.org.



What You Need to Know Before Teaching an EA Unit

Engineering is Fun

The EA team hears this from many OST educators and kids. Engineering is a way of problem solving—a way of thinking about the world—that is very fun and creative. Any time you need to solve a problem in order to reach a goal, you are engineering.

There are No Right or Wrong Answers

There are often many great ways to solve the same problem. Not only is this a good engineering lesson, it is a good life lesson for the kids in your program.

It is Okay to Try It Out

It can be very helpful to try out the engineering challenge yourself—either beforehand or right alongside the kids in your program as they work through the adventures. This can help you understand the challenges the kids might face.

Scheduling the Adventures

Each adventure requires 45-60 minutes of teaching time. We recommend that you budget at least 8-12 hours in order to complete this unit, as some adventures may occasionally go longer than expected.

You can schedule this unit in several ways: once a week, several times a week, or daily. It is also possible to group certain adventures together. The chart below shows which adventures are easily taught together. Use this chart to help you plan your schedule.

Prep Adventure 1: What is Engineering? Tower Power Prep Adventure 2: What is Technology? Technology Detectives	2-3 hours
Adventure 1: Out of This World Adventure 2: Boost Your Knowledge	2-3 hours
Adventure 3: Shoot for the Moon	1-1.5 hours
Adventure 4: Create a Rocket Adventure 5: Countdown: Improve a Rocket	2-3 hours
Adventure 6: Engineering Showcase: Liftoff!	1-1.5 hours

Tips and Tricks for Teaching the Unit

Post a Daily Agenda

Giving kids a sense of the day's adventure will help them to plan ahead and manage their time during the activity.

Facilitate Teamwork

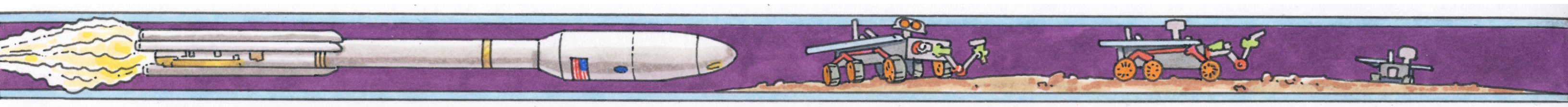
Being able to work well in teams is an important skill for any engineer. You may want to assign team roles to help kids if they struggle with teamwork. Possible roles include: the recorder, the materials gatherer, the tester, and the presenter.

Timing

As groups are working, call out regular time intervals, so kids know how much time they have left to complete their task. This is especially helpful if kids have more than 20 minutes to work on a task. Letting them know when 5-minute increments have passed will allow them to budget their time and reassess where they are in their design.

Invite Others to the Showcase

The Showcase, the last adventure in the unit, is a big deal! This is a chance for kids to highlight the engineering they have done and share their accomplishments with others. Consider inviting families, program staff, and other kids to come to the Showcase.



Mobile Apps

Mobile apps can be a fun way to engage kids in out-of-school-time environments. The Engineering Adventures team has created iOS apps (compatible with most iPhones, iPod Touches, and iPads) that are designed to supplement the hands-on engineering experiences that your program provides.

You can download Engineering Adventures apps onto your personal device or devices that belong to your site. You may also choose to encourage kids to download the apps onto their devices, so they may continue to practice their engineering skills on their own time. Encourage them to receive permission from parents before doing so.

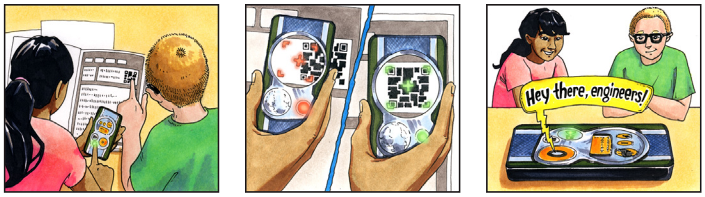
Technology Flashcards

The Technology Flashcards app is designed to be used in conjunction with Prep Adventure 2. The app features a flashcards game that reinforces the idea that a technology is any thing designed by a human to help solve a problem. The game allows kids to learn from their misconceptions in real time by providing them with instant feedback on why selected items are classified as technologies or not.

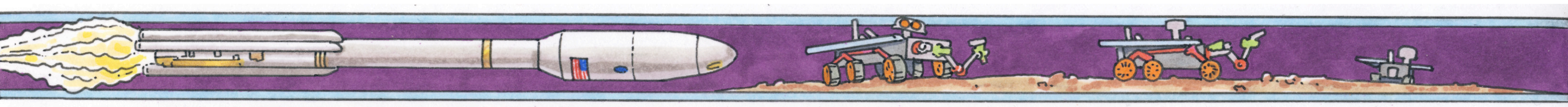
Search for “Technology Flashcards” in the App Store or visit: www.tinyurl.com/flashcardsapp.

Messages from the Duo

The Messages from the Duo app is a new way for kids to listen to the audio communications from India and Jacob at the beginning of each adventure. Kids can use the scanner function in the app to scan the QR code at the top of each Message from the Duo page in the Engineering Journal. The audio of the message will play automatically as if India and Jacob are communicating directly to the kids over walkie-talkie! The app gives kids an opportunity to listen to the messages on their own for enhanced comprehension or to share with others. Educators may also choose to use the app as an alternative to a CD player or reading the messages aloud.



Search for “Messages from the Duo” in the App Store or visit: www.tinyurl.com/MFTDapp.



Background

Aerospace Engineering

Aerospace engineers design technologies that can fly inside and outside of the Earth's atmosphere. Rockets are one example of an aerospace technology and will be the main engineering technology kids will explore in this unit. There are many variables to consider when engineering a vehicle for space flight, so aerospace engineers often focus on one aspect, such as aerodynamics or flight mechanics. Aerospace engineers collaborate with other engineers, scientists, mathematicians, and professionals on other aspects of space technologies.

Modeling is an important tool that aerospace engineers use. Because aerospace engineers design technologies that will be used in locations that could be very different from Earth, they often use models and simulations to test the technologies. There are also many unique criteria and constraints aerospace engineers must contend with because of the varied environments that the technologies are designed for. With their work and dedication, space exploration has reached new heights.

International Space Station and the Jet Propulsion Lab

The International Space Station (ISS) is a research station that is currently in orbit 230 miles above the surface of the Earth. The ISS is an international endeavor that is made possible by the collaboration of 16 countries. It has been under construction in orbit since 1998. NASA focuses its research on the ISS in four major areas: human health and exploration, testing technology, research in life and physical science, and Earth and space science.

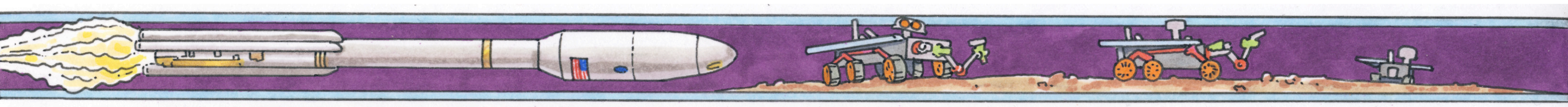
Learn more at: www.tinyurl.com/9q9q3.

The Jet Propulsion Laboratory (JPL) is a NASA center that is located in Pasadena, California, and is operated by the California Institute of Technology. JPL is the location in the United States where rovers are engineered and tested, including the Mars rover *Curiosity,* which landed successfully on Mars in 2012.

Learn more at: www.jpl.nasa.gov.

Core Concepts

1. Context: Exploring space is an amazing and engaging enterprise. In this unit, kids learn about rovers sent to explore different destinations in space, and the rockets that transport them there. Having kids consider the planets and moons that NASA scientists and



engineers are researching engages them in the process of exploring the real-life questions that scientists are trying to answer.

2. Modeling: In this unit, kids focus on creating models of technologies that travel to distant worlds. Aerospace engineers use models in their work too, since they often are not able to test in the destination environments. In this unit, kids create their own models and begin to understand this important aspect of aerospace engineering.

3. Trade-offs and Variables: Aerospace engineers must consider trade-offs and variables in every aspect of their designs. Sometimes optimizing one aspect of a design requires making compromises in another area. When engineering a rocket, for example, engineers might decide to carry fewer scientific instruments on board than they would like in order to lower the weight of the rocket and thus lessen the amount of fuel needed to transport the rocket to its destination. In this unit, kids will choose a destination to explore and will consider what tools they want on their rover, but they are cautioned to choose wisely. Each tool adds more weight to the rover, and therefore to the rocket. Depending on the distance to their destination, the rover or rocket may have to be redesigned.

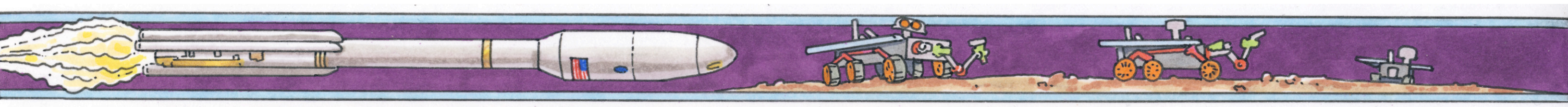
Launching Rockets!

In this unit, the kids will be launching rockets using stomp rocket launchers. The launchers use a push of air to propel the rockets forward. The rockets go far, especially with little or no weight on them. You may want to set up the launcher outside, in a gym, or in a hallway, or you can put the launcher on one side of the classroom and aim it at a far wall. Go over a launching protocol with your kids to make sure that everyone stays safe.

Kids will stomp differently on the rocket launchers. This is a testing variable. To try standardizing this as much as possible, have the kids hop on the air bladder to launch the rockets. You may need to practice with kids when you are getting started to determine the exact protocol.

Educator Resources

For more information about this unit and a list of resources about aerospace engineering, visit: www.eie.org/liftoff.



Vocabulary

Aerospace engineer: An engineer who designs technologies that can fly inside and outside of Earth's atmosphere.

Engineer: Someone who uses his or her creativity and knowledge of math and science to design things that solve problems.

Engineering Design Process: The steps that engineers use to design something to solve a problem.

Mars: Mars is the fourth planet from the sun. It is known as the "Red Planet" due to the rust colored iron oxide on its surface. Several successful rover missions have been sent to Mars, including *Spirit, Opportunity,* and *Curiosity*.

The Moon: The Moon orbits around the Earth. It is the only celestial body other than the Earth that humans have ever set foot on. Future human and rover missions are planned for the Moon.

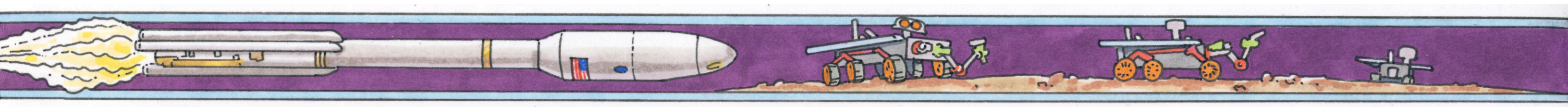
Pluto: Pluto is a dwarf planet that is approximately one-sixth the mass of the Moon. It orbits very far away from the Sun, but its orbit periodically causes Pluto to come closer to the Sun than Neptune. Pluto was classified as a planet from its discovery in 1930 until 2006, when it was reclassified as a dwarf planet.

Technology: Anything designed by humans to help solve a problem.

Titan: Titan is a moon that orbits Saturn, which is the sixth planet from the Sun. The *Huygens* spacecraft landed successfully on Titan in 2005 and sent back pictures that suggest that many of the surface features were formed by flowing liquid sometime in the past.

Trade-off: A situation that involves losing one aspect or quality of a design in exchange for gaining another aspect or quality somewhere else.

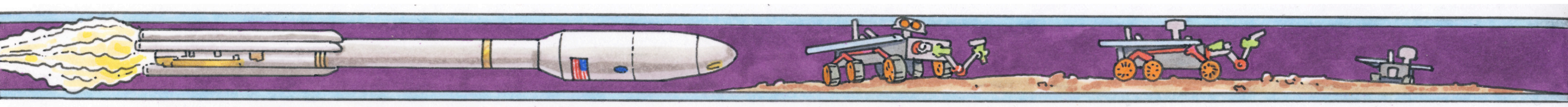
Variable: A characteristic or feature that can be changed. Variables are tested one at a time so the effects of individual variables can be understood.



Materials List

This kit is prepared for 8 groups of 3 kids.

Quantity	Item
Non-Consumable Items	
1	*Engineering Design Process* poster
1	*Messages from the Duo* audio CD, app, or access to a computer
1	stuffed animal toy, about 6” tall
1	tape measure, at least 25’ long
2	protractors
2	stomp rocket launchers with foam rockets
8	rulers, 12”
8 pairs	scissors
10	dowels, wooden, 3/4” diameter
Consumable Items	
8 rolls	tape, masking
20	cups, paper, cone-shaped, 4 oz.
20 sheets	transparency paper
30 sheets	card stock, white
50 sheets	colored foam, 9” x 12”
50	cups, paper, 3 oz.
50	cups, paper, 8 oz.
86	rubber bands
100 sheets	construction paper
100	washers
800	index cards, 3” x 5”
NOT INCLUDED IN KIT	
1	chart paper or white board
1	clock/timepiece for scheduling
1	cloth or bag large enough to cover technologies, see p. 7
1	rock or leaf
8	technologies, see p. 7
30	markers/crayons



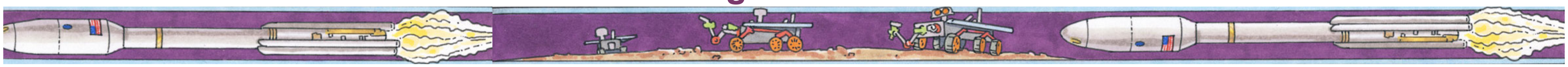
National Education Standards

Engineering Adventures units are written with the goal of teaching engineering skills and critical thinking practices. Many Engineering Adventures units also touch upon a variety of science topics and principles. The engineering standards taught in this unit and the science topic links in this unit are noted below.

		Prep Adventure 1: What is Engineering? Tower Power	Prep Adventure 2: What is Technology? Technology Detectives	Adventure 1: Out of This World	Adventure 2: Boost Your Knowledge	Adventure 3: Shoot for the Moon	Adventure 4: Create a Rocket	Adventure 5: Countdown: Improve a Rocket	Adventure 6: Engineering Showcase: Liftoff!
National Science Education Standards	Science as Inquiry	✓		✓	✓		✓	✓	
	Physical Science			✓	✓		✓	✓	✓
	Life Science								
	Earth and Space Science			✓	✓	✓	✓	✓	✓
	Science and Technology	✓	✓	✓	✓	✓	✓	✓	✓
	Science in Personal and Social Perspectives								
	History and Nature of Science								
ITEEA	The Nature of Technology		✓	✓	✓	✓	✓	✓	✓
	Technology and Society								
	Design	✓		✓	✓	✓	✓	✓	✓
	Abilities for a Technological World	✓		✓	✓	✓	✓	✓	✓
	The Designed World			✓	✓	✓	✓	✓	✓

		Prep Adventure 1: What is Engineering? Tower Power	Prep Adventure 2: What is Technology? Technology Detectives	Adventure 1: Out of This World	Adventure 2: Boost Your Knowledge	Adventure 3: Shoot for the Moon	Adventure 4: Create a Rocket	Adventure 5: Countdown: Improve a Rocket	Adventure 6: Engineering Showcase: Liftoff!
Next Generation Science Standards (Gr. 3–5)	3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.			✓	✓		✓	✓	✓
	5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.			✓	✓		✓	✓	✓
	3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	✓		✓	✓	✓	✓	✓	✓
	3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem	✓		✓	✓		✓	✓	✓
	3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	✓		✓	✓		✓		✓

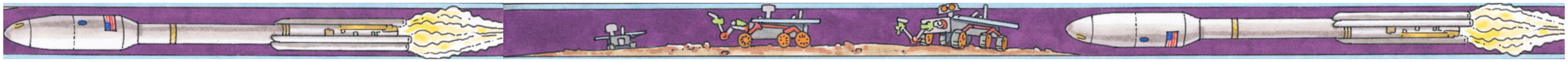
How to Recognize Success Rubric



How do you know if you are leading an Engineering Adventures activity successfully? This tool will help you keep track of your kids' successful moments and will ask you to identify how your own actions enabled your kids to succeed.

Elements of success	What does this look like?	How does the guide help me facilitate this?
Kids were engaged and challenged by the activity. They persisted through difficulties.	• Kids are on-task. • Kids are trying out their ideas. • Kids identify what is working well in their designs. • Kids troubleshoot their own work. • Kids *improve* their designs.	• Use the Message from the Duo to **set a real-world context** that will engage kids in the activity. • Use the bold prompts to **ask open-ended questions** to help kids troubleshoot their work. • Use the bold prompts to **ask kids about what they think is working well** in their designs and what they would like to *improve*. This will help kids feel more confident about their problem-solving abilities.
Kids did most of the talking, sharing their ideas with each other during the entire activity.	• Kids bring their own ideas to the activity and are comfortable sharing them. • Kids brainstorm and debate within their groups. • Kids share their designs with others. • Kids talk about how their ideas are changing over time.	• Use the bold prompts in the guide to **encourage kids to share and explain their thinking**. • Have kids **work in groups** so they can brainstorm and *create* a design together. • Use the bold prompts in the Reflect section to **help kids share their new ideas about designs.**
Kids value their engineering work as a process, not just as the end result.	• Kids go beyond talking about their design to talking about how they thought of it and why they designed it. • Kids use the Engineering Design Process to describe their actions.	• Use the bold prompts in the guide to **ask kids how they use the Engineering Design Process.** Spending time talking and thinking about their process will help kids see the value in it. • Use the bold prompts to **ask all kids about *improving*** their designs, even if their designs are working well. • **Encourage kids to reflect individually** in their Engineering Journals to give them time for their experiences to sink in and be remembered.

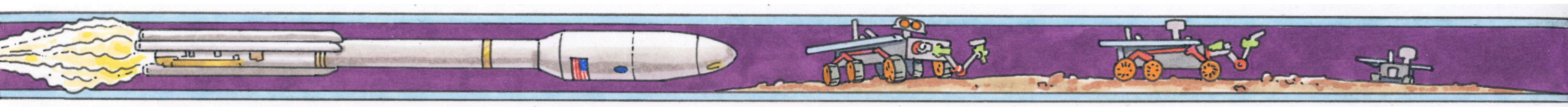
How to Recognize Success Rubric Template



How do you know if you are leading an Engineering Adventures activity successfully? This tool will help you keep track of your kids' successful moments and will ask you to identify how your own actions enabled your kids to succeed.

Date: Adventure:

Elements of success	Evidence: Did I see this during the activity?	What was my role in making this happen?
Kids were engaged and challenged by the activity. They persisted through difficulties.		
Kids did most of the talking, sharing their ideas with each other during the entire activity.		
Kids value their engineering work as a process, not just as the end result.		



Dear Family, Date: _________________

We are beginning an engineering unit called *Liftoff: Engineering Rockets and Rovers*, which is part of the Engineering Adventures curriculum developed by the Museum of Science, Boston. Engineering Adventures is a curricular program that introduces children to engineering and the engineering design process. Throughout this unit, children will learn about aerospace engineering and work to engineer model rockets and rovers. The unit is set in a real-world context: children will learn about the International Space Station, the Jet Propulsion Lab, and some of the work NASA scientists and engineers do.

There are many reasons to introduce children to engineering:

- **Engineering projects reinforce topics children are learning in school.** Engaging students in hands-on, real-world engineering experiences can enliven math, science, and other content areas.
- **Engineering fosters problem-solving skills**, including problem formulation, creativity, planning, and testing alternative solutions.
- **Children are fascinated with building and with taking things apart to see how they work.** By encouraging these explorations, we can keep these interests alive. Describing their activities as "engineering" when children are engaged in the natural design process can help them develop positive associations with engineering, and increase their desire to pursue such activities in the future.
- **Engineering and technological literacy are necessary for the 21st century.** As our society increasingly depends on engineering and technology, our citizens need to understand these fields.

Because engineering projects are hands-on, materials are often required. Several materials necessary for this unit are listed below. If you have any of these materials available, please consider donating them to us.

If you have expertise about aerospace engineering or NASA, or if you have any general questions or comments about the engineering unit we are about to begin, please let me know.

Sincerely,

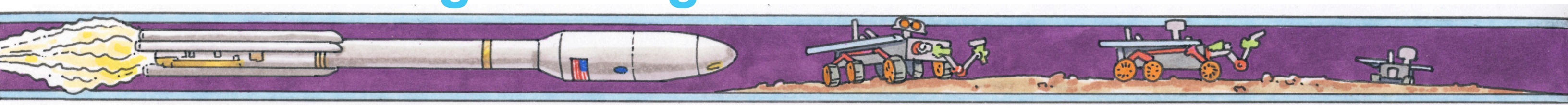
If you have any of the following materials available and would like to donate them, I would greatly appreciate having them by the following date: ______________________ . Thank you!

______________________________ ______________________________

______________________________ ______________________________

______________________________ ______________________________

What is Engineering? Tower Power

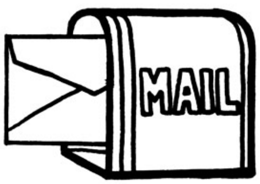


Overview: Kids will engineer an index card tower that will support a stuffed animal.

Note to Educator: Who are engineers? Engineers are people who use their creativity and knowledge of math and science to design technologies that solve problems. Today, kids will be engineers as they use the Engineering Design Process to design towers.

Find alternate versions of this activity at www.engineeringadventures.org/alternateprep.

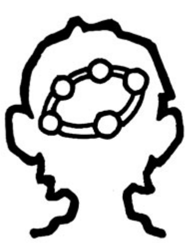
Duo Update (5 min)



Set the Stage (10 min)

Activity (30 min)

Reflect (5 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 1 or Engineering Journal, p. 1
- ☐ *Engineering Design Process* poster
- ☐ 1 small stuffed animal

For each group of 3 kids:

- ☐ 1 pack of index cards (about 100 cards)
- ☐ 1 pair of scissors
- ☐ 1 ruler
- ☐ At least 1’ of tape

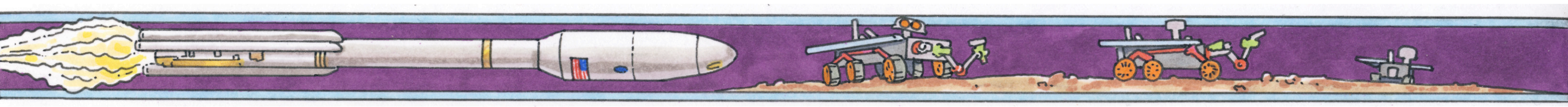
For each kid:

- ☐ Engineering Journal

Preparation

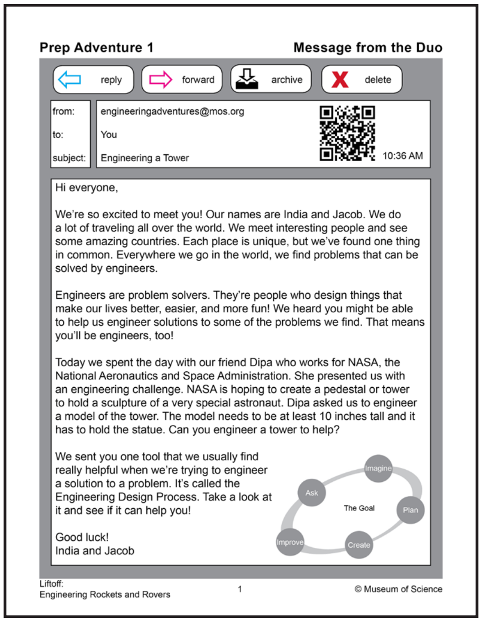
Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Make samples of the cards found on *Building with Cards,* p. 2 in kids’ Engineering Journals.



Journal Pages for Prep Adventure 1

Message from the Duo, p. 1



Prep Adventure 1 — Message from the Duo

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: Engineering a Tower
10:36 AM

Hi everyone,

We're so excited to meet you! Our names are India and Jacob. We do a lot of traveling all over the world. We meet interesting people and see some amazing countries. Each place is unique, but we've found one thing in common. Everywhere we go in the world, we find problems that can be solved by engineers.

Engineers are problem solvers. They're people who design things that make our lives better, easier, and more fun! We heard you might be able to help us engineer solutions to some of the problems we find. That means you'll be engineers, too!

Today we spent the day with our friend Dipa who works for NASA, the National Aeronautics and Space Administration. She presented us with an engineering challenge. NASA is hoping to create a pedestal or tower to hold a sculpture of a very special astronaut. Dipa asked us to engineer a model of the tower. The model needs to be at least 10 inches tall and it has to hold the statue. Can you engineer a tower to help?

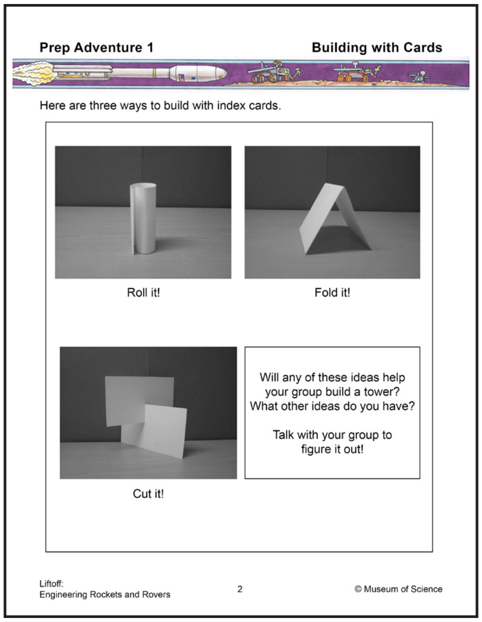
We sent you one tool that we usually find really helpful when we're trying to engineer a solution to a problem. It's called the Engineering Design Process. Take a look at it and see if it can help you!

Imagine, Ask, The Goal, Plan, Improve, Create

Good luck!
India and Jacob

Liftoff: Engineering Rockets and Rovers — 1 — © Museum of Science

Building with Cards, p. 2



Prep Adventure 1 — Building with Cards

Here are three ways to build with index cards.

Roll it!

Fold it!

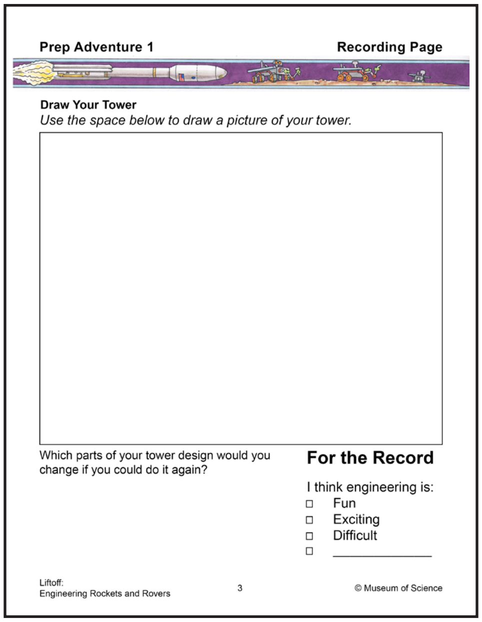
Cut it!

Will any of these ideas help your group build a tower? What other ideas do you have?

Talk with your group to figure it out!

Liftoff: Engineering Rockets and Rovers — 2 — © Museum of Science

Recording Page, p. 3



Prep Adventure 1 — Recording Page

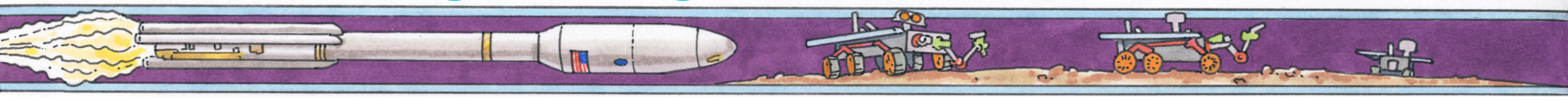
Draw Your Tower
Use the space below to draw a picture of your tower.

Which parts of your tower design would you change if you could do it again?

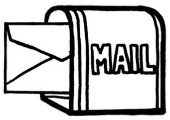
For the Record
I think engineering is:
- ☐ Fun
- ☐ Exciting
- ☐ Difficult
- ☐ ____________

Liftoff: Engineering Rockets and Rovers — 3 — © Museum of Science

What is Engineering? Tower Power

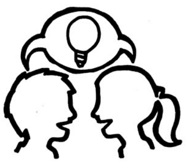


Kids will learn:
- The Engineering Design Process is a tool they can use to help solve problems.



Present the Message from the Duo (5 min)

1. Tell kids that India and Jacob are a brother and sister duo who travel the world. They find problems and solve them using engineering.
2. Explain that India and Jacob have sent them a message about a problem they would like kids to solve. Have kids turn to *Message from the Duo*, p. 1 in their Engineering Journals, for more details. Play track 1.



Set the Stage (5 min)

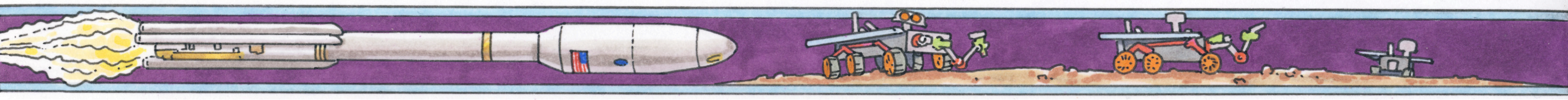
1. Tell kids that today they are going be engineers and use the Engineering Design Process to solve India and Jacob's problem.
2. To check for understanding, ask:
   - **What do India and Jacob need us to engineer?** *A pedestal or tower to hold a sculpture of a famous astronaut.*
3. Hold up the stuffed animal and explain that the animal will represent the special astronaut. Tell the kids that many animals; including monkeys, dogs, cats, mice, rabbits, and frogs; have traveled into space on missions.
4. Show groups the *Engineering Design Process* poster and tell them that they are going to *ask* questions about the problem, *imagine* ways to solve it, *plan* a design, *create* and test it, and then think about ways to *improve* it.

Imagine (5 min)

1. Tell kids that it is time to look at the materials they can use and *imagine* different ways to make them work.
2. Split kids into groups of 3 and give each group a few index cards, scissors, a ruler, and tape. Ask:
   - **Can you *imagine* any ways you could use these materials to engineer a tower?**
3. If your kids want to see examples, show them the index card samples you prepared or have them look at *Building with Cards*, p. 2 in their Engineering Journals. Ask:
   - **Do you think any of these ideas might work well? Why?**

Plan and Create (at least 20 min)

1. Tell kids that it is time to *plan* and *create* their index card towers.
2. Show the stuffed animal and explain that:
   - The challenge is to work in groups to engineer a tower that can hold the animal 10 inches in the air for at least 10 seconds.
   - Each group will have (at least) 20 minutes.



- Groups can only use index cards and tape in the tower. The scissors and rulers cannot be used in the tower.
- Groups can hold the stuffed animal briefly, but they cannot test it on their tower until the 20 minutes are up.

3. Give each group a pack of index cards and let them begin.
4. As groups work, circulate around the room. Ask questions like:
   - **Why do you think your design will work well?**
   - **Which step of the Engineering Design Process are you using right now? How do you know?**

Tip: You may choose to offer unlimited tape, or to challenge groups by limiting the tape to 1 or 2 feet.

Tip: If you can, you may want to offer more time for this challenge.

Tower Showcase (10 min)

1. Have each group present their tower. Ask each group questions like:
   - **Can you tell me about your design?**
   - **Which steps of the Engineering Design Process did your group use?**
2. Use a ruler to measure each group's tower. Give one kid from the group the stuffed animal and have him or her place it on top of their tower. Count to 10 and observe what happens. Whether or not their tower stands, ask:
   - **What parts would you *improve* if you could design your tower again?**

Reflect (5 min)

1. Go through the *Engineering Design Process* poster with kids and have them talk about how they used each step to solve the problem. Ask questions like:
   - **How did you use this step of the Engineering Design Process to solve the problem?** *We* asked *about the challenge; we* imagined *ways to build with cards; we* planned *when we decided what design to use; we* created *and* improved *when we built and fixed the tower.*
   - **Why do you think it is important to use these steps?** *It helps us keep track of our ideas and make sure we are meeting our goals.*
   - **Do you think you are an engineer?**
2. Tell kids that they have just used the same steps that engineers use to solve problems. This means that they are engineers, too! Tell kids they will have the opportunity to engineer solutions to even bigger problems with India and Jacob later on.

What is Engineering? Tower Power

reply forward archive delete

from:	engineeringadventures@mos.org
to:	You
subject:	Engineering a Tower

10:36 AM

Hi everyone,

We're so excited to meet you! Our names are India and Jacob. We do a lot of traveling all over the world. We meet interesting people and see some amazing countries. Each place is unique, but we've found one thing in common. Everywhere we go in the world, we find problems that can be solved by engineers.

Engineers are problem solvers. They're people who design things that make our lives better, easier, and more fun! We heard you might be able to help us engineer solutions to some of the problems we find. That means you'll be engineers, too!

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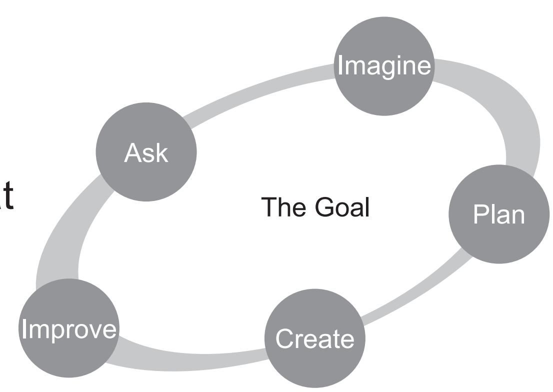
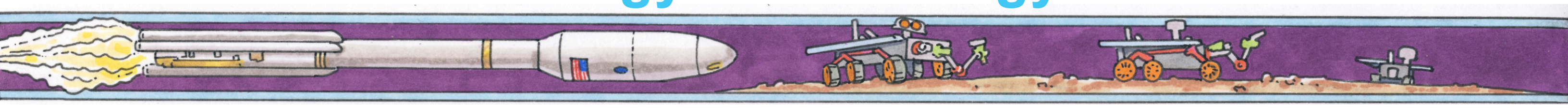


Good luck!
India and Jacob

What is Technology? Technology Detectives

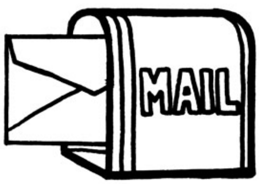


Overview: Kids will examine some technologies and brainstorm ways to *improve* them.

Note to Educator: Many people only think of technologies as things that are electronic or "high-tech." Technology is actually anything designed by humans to help solve a problem.

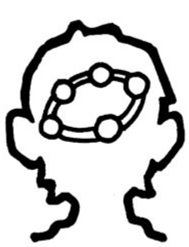
Find alternate versions of this activity at www.engineeringadventures.org/alternateprep.

Duo Update (5 min)



Activity (15 min)

Reflect (20 min)



Materials

For the whole group:

- ☐ *Message from the Duo*, track 2 or Engineering Journal, p. 4
- ☐ *Engineering Design Process* poster
- ☐ cloth or bag large enough to cover technologies
- ☐ large sheet of paper or other writing space
- ☐ rock or leaf

Technologies (choose 8):

- ☐ bag
- ☐ book
- ☐ button
- ☐ construction paper
- ☐ dice
- ☐ electronic device (e.g., phone or calculator)
- ☐ glue stick
- ☐ hair clip
- ☐ hat
- ☐ juicebox
- ☐ key
- ☐ roll of tape
- ☐ ruler
- ☐ scissors
- ☐ spoon
- ☐ stapler
- ☐ stuffed animal
- ☐ sweater
- ☐ water bottle

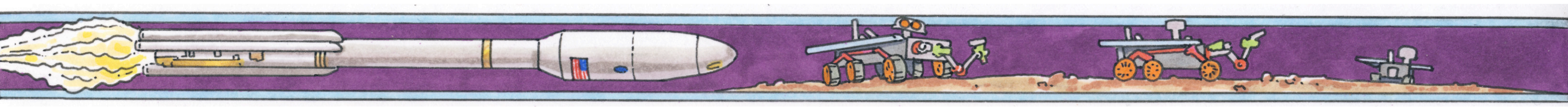
For each kid:

- ☐ Engineering Journal

Preparation

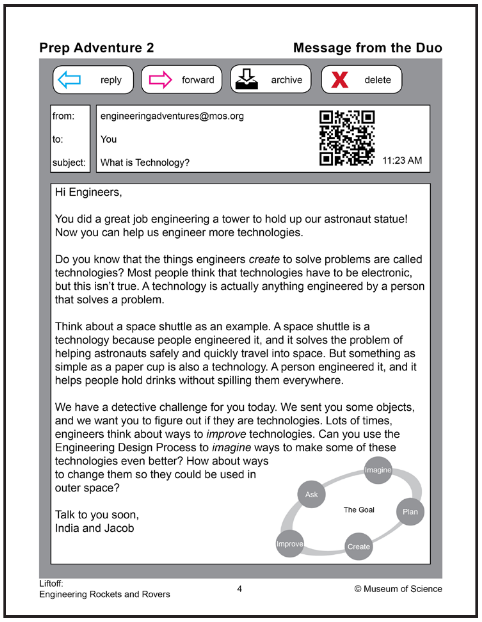
Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Place eight technologies (see above) on a table or floor and cover them with a cloth or bag.
4. On a sheet of large paper, make the *Technology Detective Tool* chart as shown on the next page.



Journal Pages for Prep Adventure 2

Message from the Duo, p. 4



Prep Adventure 2 — Message from the Duo

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: What is Technology?
11:23 AM

Hi Engineers,

You did a great job engineering a tower to hold up our astronaut statue! Now you can help us engineer more technologies.

Do you know that the things engineers *create* to solve problems are called technologies? Most people think that technologies have to be electronic, but this isn't true. A technology is actually anything engineered by a person that solves a problem.

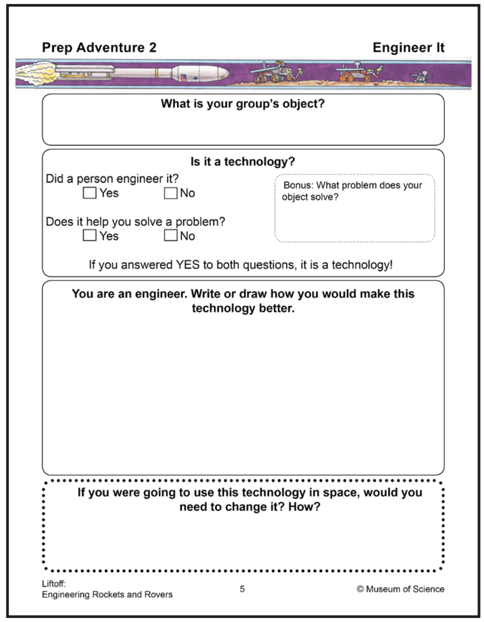
Think about a space shuttle as an example. A space shuttle is a technology because people engineered it, and it solves the problem of helping astronauts safely and quickly travel into space. But something as simple as a paper cup is also a technology. A person engineered it, and it helps people hold drinks without spilling them everywhere.

We have a detective challenge for you today. We sent you some objects, and we want you to figure out if they are technologies. Lots of times, engineers think about ways to *improve* technologies. Can you use the Engineering Design Process to *imagine* ways to make some of these technologies even better? How about ways to change them so they could be used in outer space?

Talk to you soon,
India and Jacob

Liftoff: Engineering Rockets and Rovers — 4 — © Museum of Science

Engineer It, p. 5



Prep Adventure 2 — Engineer It

What is your group's object?

Is it a technology?

Did a person engineer it?
☐ Yes ☐ No

Does it help you solve a problem?
☐ Yes ☐ No

Bonus: What problem does your object solve?

If you answered YES to both questions, it is a technology!

You are an engineer. Write or draw how you would make this technology better.

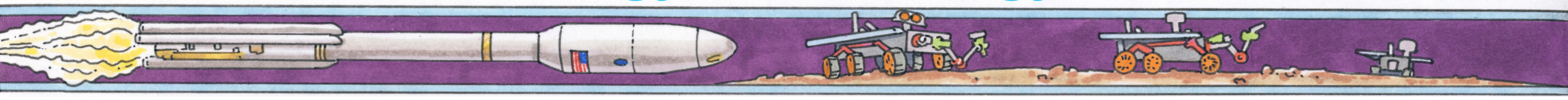
If you were going to use this technology in space, would you need to change it? How?

Liftoff: Engineering Rockets and Rovers — 5 — © Museum of Science

Chart for Prep Adventure 2

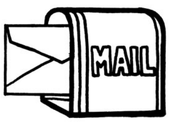
Technology Detective Tool
Did a person engineer it? Does it help you solve a problem? If you answered YES to both, it is a technology!

What is Technology? Technology Detectives



Kids will learn:

- Technology is anything designed by people to help solve a problem.
- Engineers design and *improve* technologies.



Present the Message from the Duo (5 min)

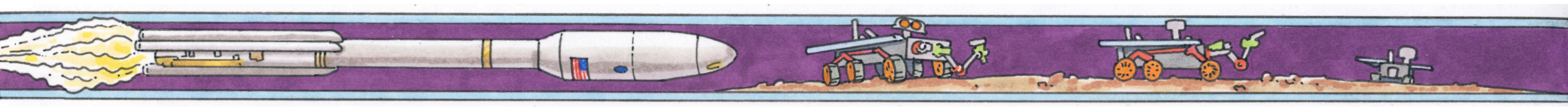
1. Tell kids that India and Jacob sent them a message with more information about what engineers do. Have kids turn to *Message from the Duo,* p. 5 in their Engineering Journals, to follow along. Play track 2.
2. To check for understanding, ask:
   - **India and Jacob said that a technology is anything designed by people to solve a problem. What are some technologies you can think of?** *Accept all answers at this point.*
3. Give the kids about 1 minute to name all the technologies they can think of. If kids are only naming electronics, remind them that India and Jacob mentioned that things like paper cups are also technology.

Tip: You may want to write down what the kids say is technology, so you can refer back to it at the end of the adventure.

Undercover Detectives (15 min)

1. Explain to kids that now they will get the chance to think about more technologies—some that might surprise them.
2. Tell kids that under the cover on the table are some objects that may or may not be technologies. They will use detective skills and teamwork to figure out which objects are technologies and what problems they solve.
3. Split kids into groups of 3.
4. Show them the *Technology Detective Tool* and explain that they can use it to help figure out if the objects are technologies.
5. Pull the cloth and give groups a minute to decide what object they will take.
6. Have each group choose one object they would like to focus on in their groups.
7. Tell kids that they will now think like engineers. They will use the *Technology Detective Tool* to decide whether their object is a technology. Then, they will record ways to *improve* the object they chose.

Tip: If kids are having trouble understanding what it means to engineer something, let them know that words like invent, design, and *improve* have a similar meaning. The more you use the term engineer, the more comfortable they will become with it!



8. Have kids open *Engineer It,* p. 5 in their Engineering Journals. Give groups about 10 minutes to complete the first three boxes. If they are struggling, ask:
   - **How can you make your technology more fun?**
   - **How can you make your technology easier to use?**

Reflect (20 min)

1. Tell kids that they are going to present their ideas about their technologies to their fellow detectives. Encourage them to use the *Technology Detective Tool* chart and the *Engineer It* page in their Engineering Journals to help them present. Ask each group:
   - **What is your technology?**
   - **How do you know it is a technology?** *Refer to the* Technology Detective Tool*.*
2. After all groups have presented, check for understanding about technology. Ask:
   - **Were all the objects you saw technologies? Why or why not?** *Yes, because people engineered them, and they help solve problems.*
3. Tell kids you have one more object for them to think about. Show them the rock/leaf. Ask:
   - **Is this a technology? Why or why not?** *No, because a person did not engineer it.*

Tip: A rock, leaf, or any other natural objects on their own are not technologies. If people turn those objects into tools, however, they could become technologies! For example, using a rock to grind corn or making it into an arrowhead makes the rock a technology.

4. Tell kids that they were engineers today by thinking about technologies that already exist and how to *improve* them. Engineers also think about brand new technologies that no one has thought of before!
5. Have kids think about the engineering they have already done. Ask:
   - **Why do you think the tower you made before was a technology?**
6. Tell kids that in this unit, they will be working in groups to engineer technologies that will help solve a problem.
7. Give kids a few moments to complete the last box on *Engineer It,* p. 5 in their Engineering Journals*.* Thinking about how they might change a technology to use it in space will help kids see themselves as aerospace engineers.

Tip: If you have enough time, encourage kids to share their ideas with a partner before sharing with the whole group.

What is Technology? Technology Detectives

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	What is Technology?

11:23 AM

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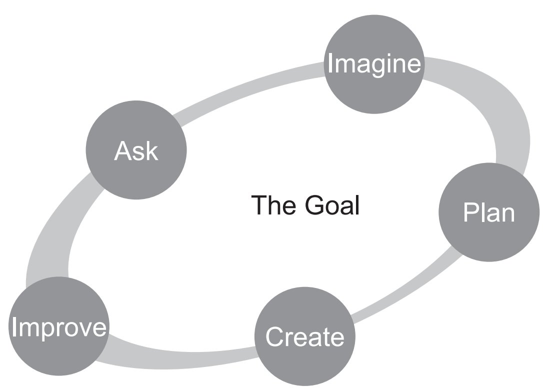
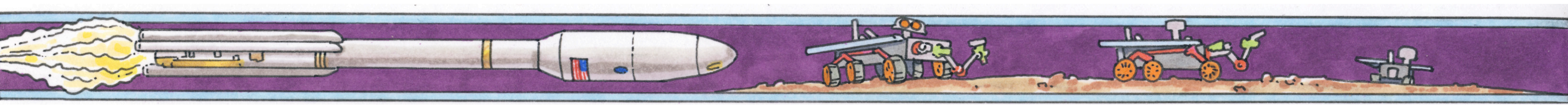


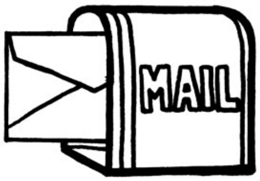
Talk to you soon,
India and Jacob



Overview: Kids will be introduced to rockets, rovers, and stomp rocket launchers.

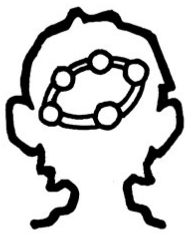
Note to Educator: NASA uses rockets to transport things, like rovers, out of Earth's atmosphere and into outer space. Rovers are the technologies used to explore planets and moons that are difficult for people to get to. There are many great videos, images, and interactive games on the NASA website. Visit www.nasa.gov to learn about and share features that might be interesting to the kids in your program.

Duo Update (5 min)



Ask (30 min)

Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 3 or Engineering Journal, p. 6
- ☐ *Engineering Design Process* poster
- ☐ chart paper and markers or white board
- ☐ masking tape
- ☐ tape measure
- ☐ 2 protractors
- ☐ 2 stomp rocket launcher
- ☐ 4 *Destination Pages*, pp. 19–25 in this guide

For each group of 3 kids:

- ☐ masking tape
- ☐ 1 sheet of construction paper
- ☐ 2 rubber bands
- ☐ 20 washers

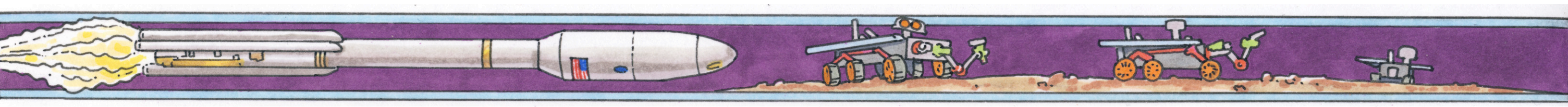
For each kid:

- ☐ Engineering Journal
- ☐ optional: straw with paper package

Preparation

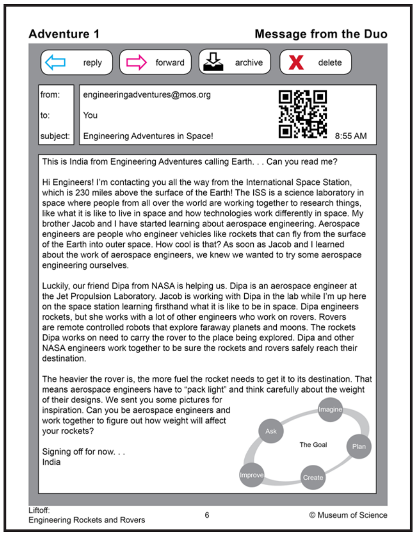
Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Put the launcher outside, in a hallway, gym, or on a far side of a classroom. Tape the stomp rocket launchers to the floor next to each other. The rockets can go far!
4. Tape the *Destination Pages*, pp. 19–25 in this guide, to the floor. Tape the Moon 3 feet, Mars 10 feet, Titan 15 feet, and Pluto 30 feet away from the base of the launcher. (Note: You may want to laminate these sheets to reuse them throughout the unit.)
5. Make an example rocket following directions from *Rocket Testing*, p. 9 in kids' Engineering Journals.



Journal Pages for Adventure 1

Message from the Duo, p. 6



Adventure 1 Message from the Duo

reply forward archive delete

from: engineeringadventures@mos.org
to: You
subject: Engineering Adventures in Space!
8:55 AM

This is India from Engineering Adventures calling Earth. . . Can you read me?

Hi Engineers! I'm contacting you all the way from the International Space Station, which is 230 miles above the surface of the Earth! The ISS is a science laboratory in space where people from all over the world are working together to research things, like what it is like to live in space and how technologies work differently in space. My brother Jacob and I have started learning about aerospace engineering. Aerospace engineers are people who engineer vehicles like rockets that can fly from the surface of the Earth into outer space. How cool is that? As soon as Jacob and I learned about the work of aerospace engineers, we knew we wanted to try some aerospace engineering ourselves.

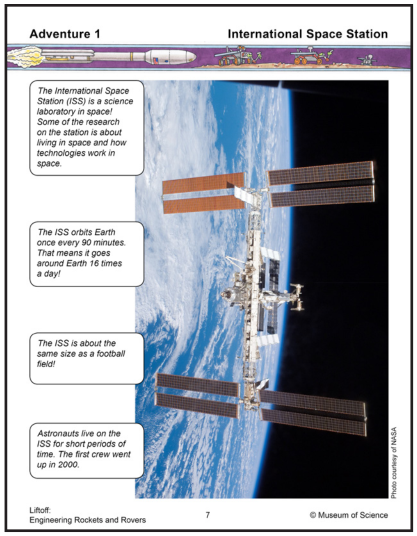
Luckily, our friend Dipa from NASA is helping us. Dipa is an aerospace engineer at the Jet Propulsion Laboratory. Jacob is working with Dipa in the lab while I'm up here on the space station learning firsthand what it is like to be in space. Dipa engineers rockets, but she works with a lot of other engineers who work on rovers. Rovers are remote controlled robots that explore faraway planets and moons. The rockets Dipa works on need to carry the rover to the place being explored. Dipa and other NASA engineers work together to be sure the rockets and rovers safely reach their destination.

The heavier the rover is, the more fuel the rocket needs to get it to its destination. That means aerospace engineers have to "pack light" and think carefully about the weight of their designs. We sent you some pictures for inspiration. Can you be aerospace engineers and work together to figure out how weight will affect your rockets?

Signing off for now. . .
India

Liftoff: Engineering Rockets and Rovers 6 © Museum of Science

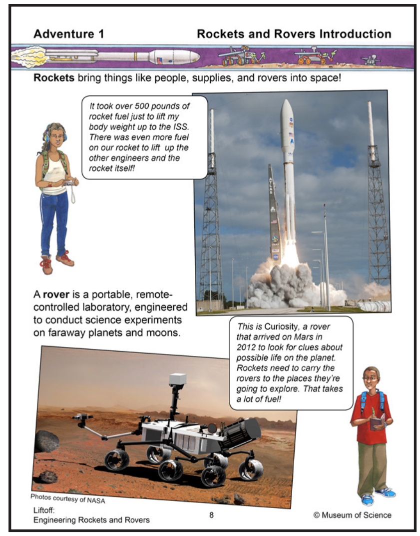
International Space Station, p. 7



Adventure 1 International Space Station

Liftoff: Engineering Rockets and Rovers 7 © Museum of Science

Rockets and Rovers Introduction, p. 8



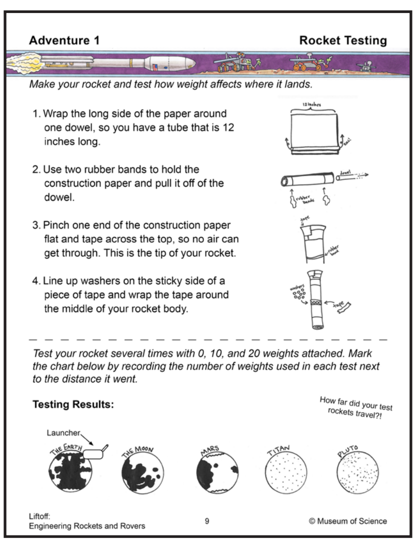
Adventure 1 Rockets and Rovers Introduction

Rockets bring things like people, supplies, and rovers into space!

A **rover** is a portable, remote-controlled laboratory, engineered to conduct science experiments on faraway planets and moons.

Liftoff: Engineering Rockets and Rovers 8 © Museum of Science

Rocket Testing, p. 9



Adventure 1 Rocket Testing

Make your rocket and test how weight affects where it lands.

1. Wrap the long side of the paper around one dowel, so you have a tube that is 12 inches long.
2. Use two rubber bands to hold the construction paper and pull it off of the dowel.
3. Pinch one end of the construction paper flat and tape across the top, so no air can get through. This is the tip of your rocket.
4. Line up washers on the sticky side of a piece of tape and wrap the tape around the middle of your rocket body.

Test your rocket several times with 0, 10, and 20 weights attached. Mark the chart below by recording the number of weights used in each test next to the distance it went.

Testing Results:

Liftoff: Engineering Rockets and Rovers 9 © Museum of Science

Think About It, p. 10

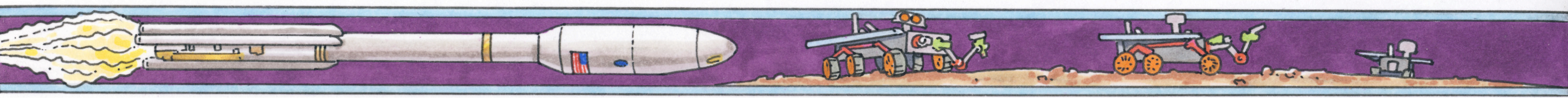
Adventure 1 Think About It

If you could send a rover anywhere in space, what destination would you choose? What would you want to find out there? Draw a picture or write a description below:

Did you know?

It can take a radio message up to 20 minutes to travel from Mars back to Earth!

Liftoff: Engineering Rockets and Rovers 10 © Museum of Science



Kids will learn:

- Aerospace engineers design vehicles like rockets that can fly both inside our atmosphere and in outer space.
- There is a lot to explore about the unique planets and moons in our solar system.

Present the Message From the Duo (5 min)

1. Tell kids that India sent a message about the Duo's mission from the International Space Station. Have kids turn to *Message from the Duo*, p. 6 in their Engineering Journals, to follow along. Play track 3.
2. To check for understanding, ask:
   - **What does India want us to do?** *Be aerospace engineers and figure out how weight will affect our rockets.*
   - **What is Dipa's job as an aerospace engineer?** *She engineers vehicles like rockets that can fly both inside our atmosphere and in outer space.*
3. Point out *International Space Station,* p. 7 in kids' Engineering Journals. Remind them that India is on the International Space Station.

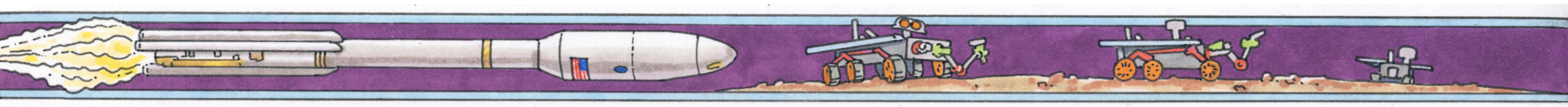
Ask: Rockets and Rovers (5 min)

1. Have kids turn to *Rockets and Rovers Introduction*, p. 8 in their Engineering Journals, to look at some pictures of rockets and rovers. Ask:
   - **What do you think NASA uses rovers for?** *Rovers are used to explore faraway planets and moons, which are difficult for people to get to.*
   - **How do rovers get to the faraway planets and moons they need to explore?** *Rockets get them where they need to go.*

Ask: Stomp Rocket Introduction (25 min)

1. Show kids the target areas representing the different locations they can choose to send their rovers. Let kids know they do not need to land their rocket exactly on the destination paper, just in the general area.
2. Show kids the launchers they will stomp on to launch their rockets.
3. Demonstrate how kids can use the protractors to determine the launch angle of their rockets. Have them try a 45° angle first, then encourage them to experiment with different angles. At the end of the adventure, the group will decide on an angle to use for all tests.
4. Explain that there will be a rocket-launching protocol. To launch a rocket, the launch zone must be clear. The person launching must say

Try It: To model how the launcher works, give each kid a straw with a paper covering. Have kids rip off one side of the paper and then blow through the straw to send the paper sleeve flying.



"LIFTOFF!" and then stomp on the launcher. Demonstrate how the stomp rocket launchers work. Have a volunteer hop on the air bladder, launching the example rocket.

5. Let kids know that each group will make one rocket and have 15 minutes to test how far the rocket will fly with 0, 10, and 20 weights attached. For each test, they will record the number of weights and distance traveled on *Rocket Testing*, p. 9 in their Engineering Journals. Have kids attach weights to the middle of their rockets to standardize that variable.
6. Hold up a dowel and tell kids that the dowel is the same size as the part of the rocket launcher that their rocket will sit on. They can use the dowel to know how tight to roll the construction paper for their rocket. If the rocket fits on the dowel, it will fit on the launcher.
7. Tell kids that the washers represent the weight of the rover on board. Ask:
   - **Which rocket do you predict will go the farthest, one with lots of weight or one with a little weight?** *Accept all answers.*
8. Give groups 15 minutes to test. As groups are testing, make sure that they are using the rocket-launch protocol. Ask groups questions like:
   - **How many weights have you tried on your rocket?**
   - **How does the weight affect the rocket's flight?** *Rockets with more weight do not go as far.*

Reflect (10 min)

1. Gather all of the kids together. Tell kids that, as aerospace engineers, they will engineer a rocket to hold the weight of the rover they design and get the rover to its destination. They have already started gathering data about how weight will affect their rocket designs. Ask:
   - **Do you think aerospace engineers test how weight will affect a rocket? Why?** *Yes, because they need to make sure the rocket can reach its destination with its supplies.*
2. Work with the group to decide which angle they will use for the launcher. Ask:
   - **Which launch angle worked best?** *Decide on an angle to use as a group.*
   - **How did the weight affect your rockets?** *Heavier rockets did not go as far.*
3. Tell kids that in the next adventure, they will investigate more variables that affect the distance rockets can travel. Have kids look at the *Engineering Design Process* poster. Ask:
   - **What steps of the Engineering Design Process did you use today?** *We* asked *about rockets and rovers and how weight affects our rockets.*
4. Give kids time to fill out *Think About It,* p. 10 in their Engineering Journals. Having time to reflect on what they did in this adventure will prepare them for next time.

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Engineering Adventures in Space!

8:55 AM

This is India from Engineering Adventures calling Earth. . . Can you read me?

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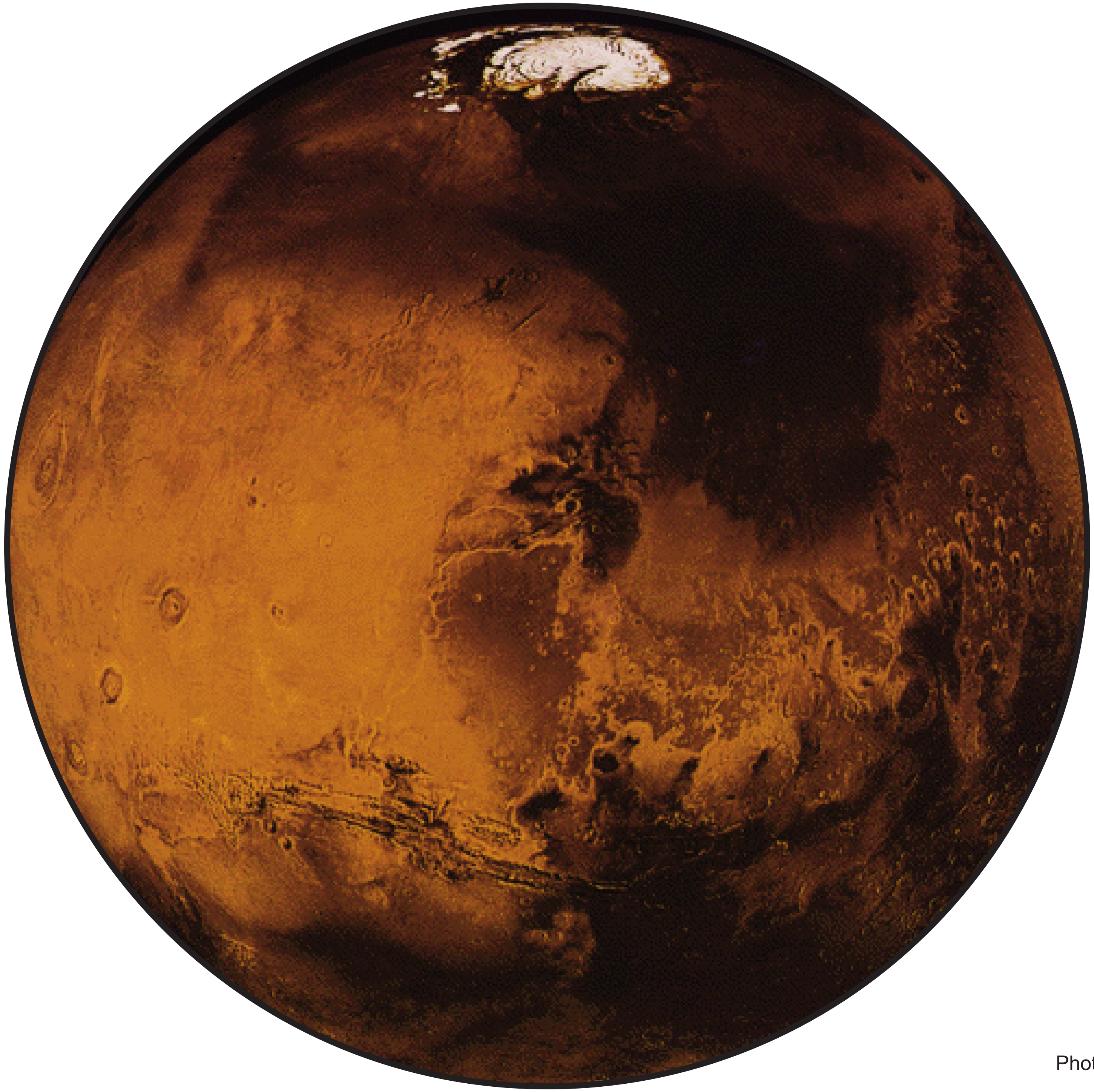
Signing off for now . . .
India

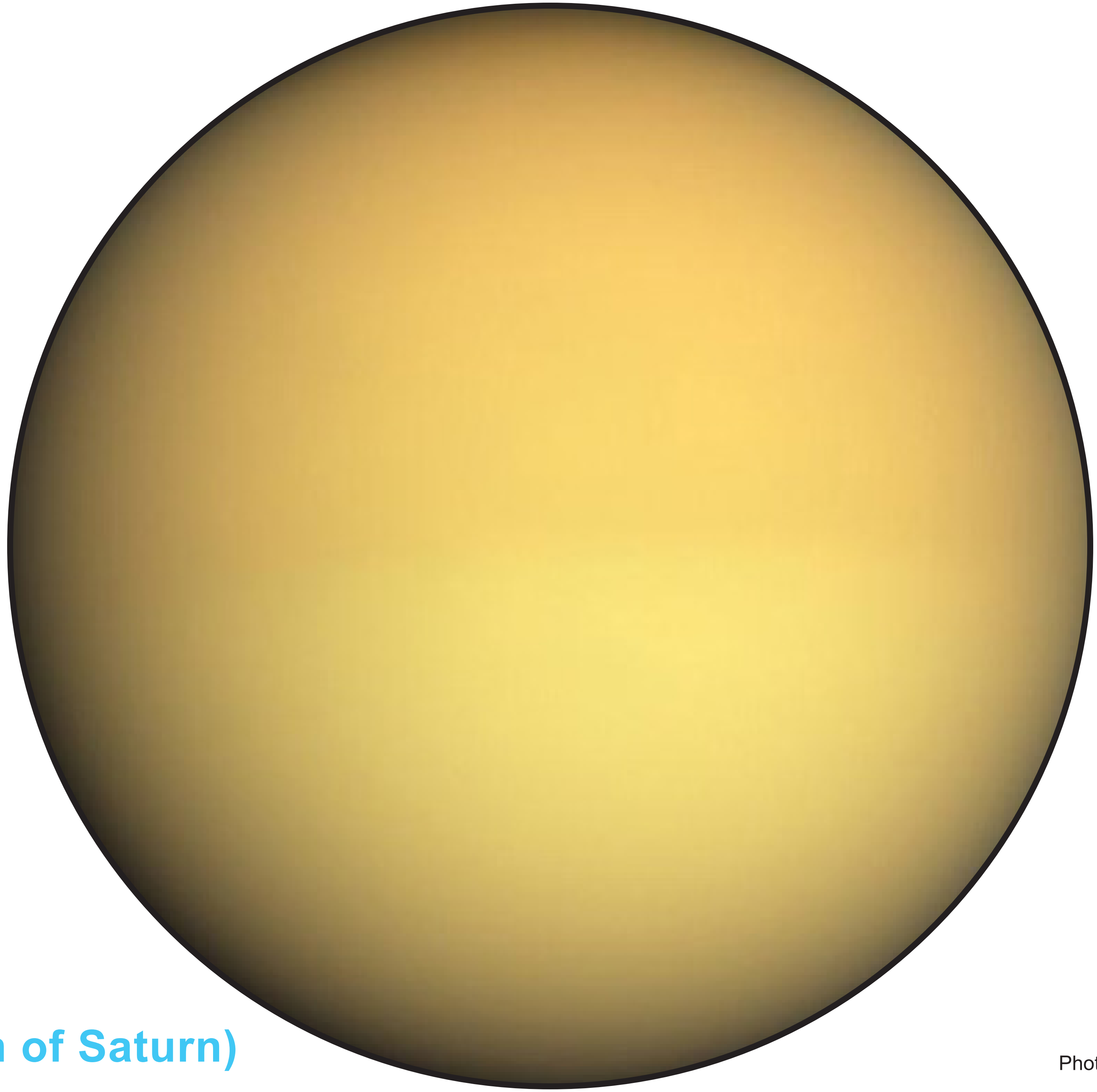
The Moon

Photo courtesy of NASA



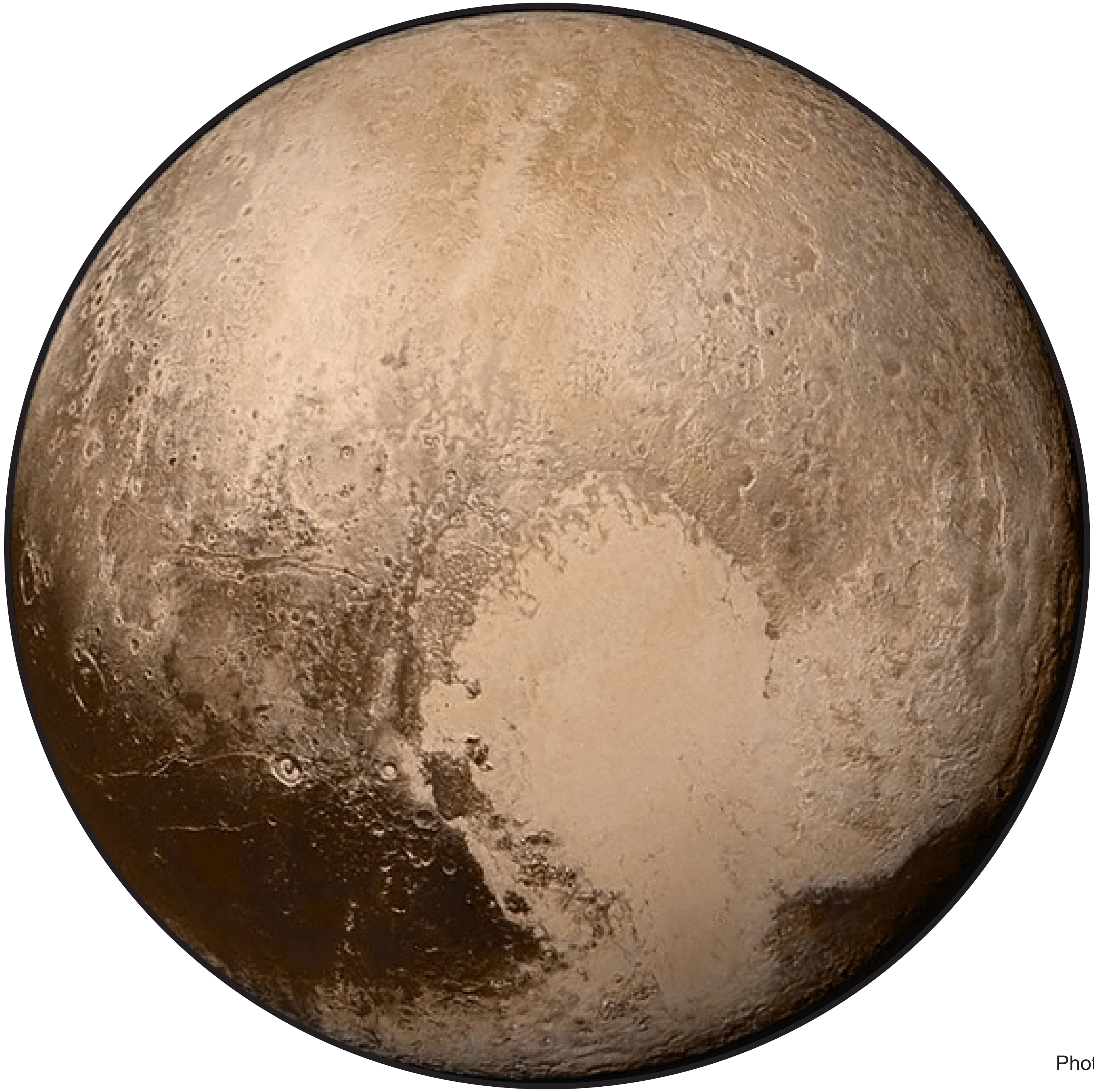
Mars

Photo courtesy of NASA



Titan
(A Moon of Saturn)

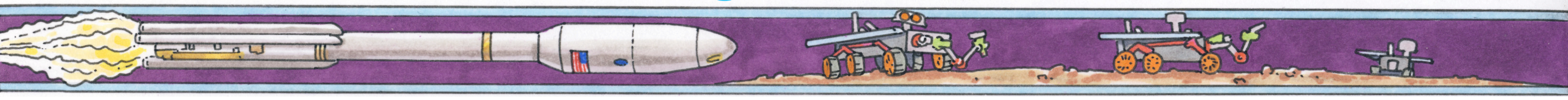
Photo courtesy of NASA



Pluto

Photo courtesy of NASA

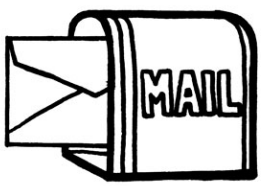
Boost Your Knowledge



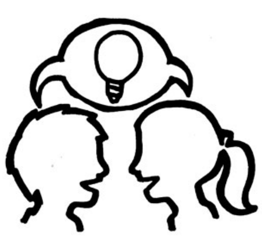
Overview: Kids will test different variables that can affect the flight of a rocket. Each group will focus on one variable and share their findings.

Note to Educator: Groups will be able to refer back to the data they collect in this adventure as they *create* their own rockets in later adventures. There are terms related to aerospace engineering used throughout this unit. You may want to let kids know that there is a glossary of terms on the last page (p. 29) of their Engineering Journals.

Duo Update (5 min)

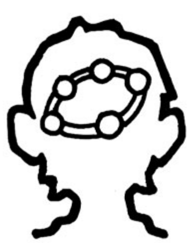


Set the Stage (5 min)



Activity (20 min)

Reflect (15 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 4 or Engineering Journal, p. 11
- ☐ *Engineering Design Process* poster
- ☐ *Destination Pages*, pp. 19–25 in this guide
- ☐ chart paper or white board and markers
- ☐ masking tape
- ☐ tape measure
- ☐ 1 protractor
- ☐ 2 stomp rocket launchers

For each group of 3 kids:

- ☐ directions for the variable they will test, pp. 33–37 in this guide
- ☐ 1 set of variable materials (see preparation box below)

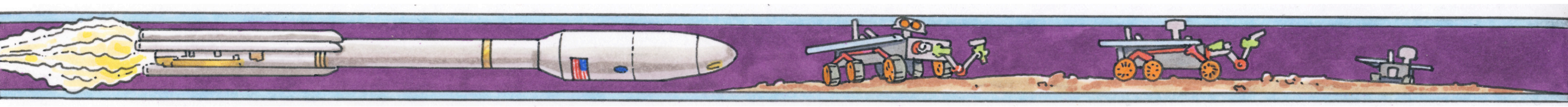
For each kid:

- ☐ Engineering Journal

Preparation

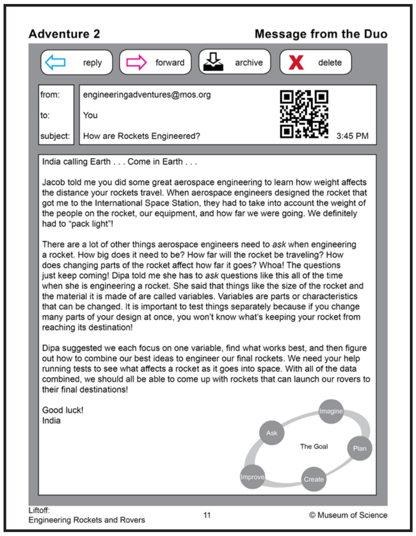
Time Required: 15 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Tape down the stomp rocket launchers. Set them at the angle groups decided on in Adventure 1.
4. Tape the *Destination Pages*, pp. 19–25 in this guide, to the floor. Tape the Moon 3 feet, Mars 10 feet, Titan 15 feet, and Pluto 30 feet away from the base of the launcher.
5. Make the *Results Chart as* shown on the next page.
6. Set aside directions and materials for each variable to be tested.
   - Rocket length: 1 dowel, masking tape, 3 sheets of construction paper, 6 rubber bands
   - Rocket width: 3 dowels, masking tape, 3 sheets of construction paper, 10 rubber bands
   - Rocket material: 1 dowel, masking tape, 1 sheet each of foam, construction paper, and transparency, 6 rubber bands



Journal Pages for Adventure 2

Message from the Duo, p. 11



Adventure 2 Message from the Duo

reply | forward | archive | delete

from: engineeringadventures@mos.org

to: You

subject: How are Rockets Engineered? 3:45 PM

India calling Earth . . . Come in Earth . . .

Jacob told me you did some great aerospace engineering to learn how weight affects the distance your rockets travel. When aerospace engineers designed the rocket that got me to the International Space Station, they had to take into account the weight of the people on the rocket, our equipment, and how far we were going. We definitely had to “pack light”!

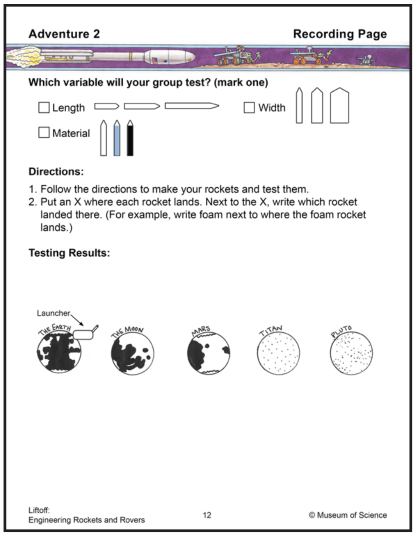
There are a lot of other things aerospace engineers need to *ask* when engineering a rocket. How big does it need to be? How far will the rocket be traveling? How does changing parts of the rocket affect how far it goes? Whoa! The questions just keep coming! Dipa told me she has to *ask* questions like this all of the time when she is engineering a rocket. She said that things like the size of the rocket and the material it is made of are called variables. Variables are parts or characteristics that can be changed. It is important to test things separately because if you change many parts of your design at once, you won’t know what’s keeping your rocket from reaching its destination!

Dipa suggested we each focus on one variable, find what works best, and then figure out how to combine our best ideas to engineer our final rockets. We need your help running tests to see what affects a rocket as it goes into space. With all of the data combined, we should all be able to come up with rockets that can launch our rovers to their final destinations!

Good luck!
India

Liftoff: Engineering Rockets and Rovers 11 © Museum of Science

Recording Page, p. 12



Adventure 2 Recording Page

Which variable will your group test? (mark one)

☐ Length ☐ Width

☐ Material

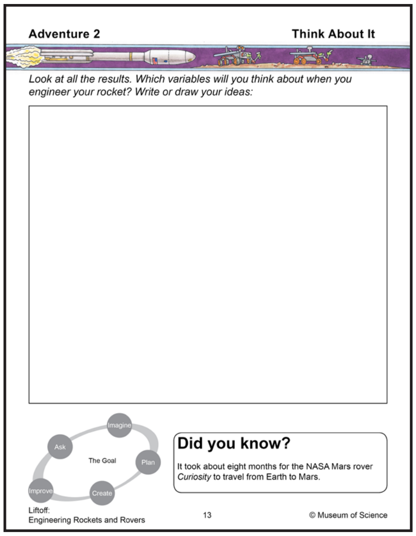
Directions:

1. Follow the directions to make your rockets and test them.
2. Put an X where each rocket lands. Next to the X, write which rocket landed there. (For example, write foam next to where the foam rocket lands.)

Testing Results:

Liftoff: Engineering Rockets and Rovers 12 © Museum of Science

Think About It, p. 13



Adventure 2 Think About It

Look at all the results. Which variables will you think about when you engineer your rocket? Write or draw your ideas:

Did you know?

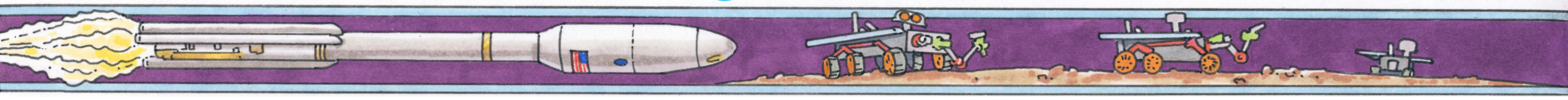
It took about eight months for the NASA Mars rover *Curiosity* to travel from Earth to Mars.

Liftoff: Engineering Rockets and Rovers 13 © Museum of Science

Chart for Adventure 2

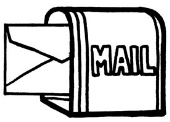
Results Chart		
	Distance	Which traveled the farthest?
Rocket Length Short Medium Long		
Rocket Width Small Medium Large		
Rocket Material Paper Foam Transparency		

Boost Your Knowledge



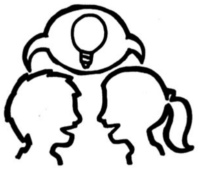
Kids will learn:

- Different variables can affect the way their rockets fly.
- Engineers often work in teams and share ideas with each other.



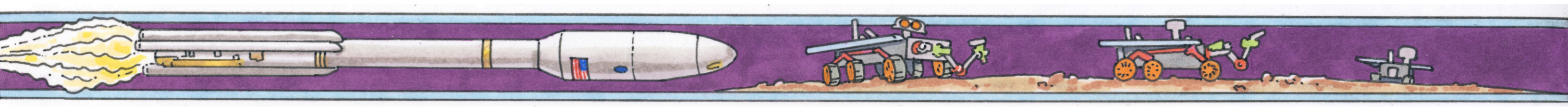
Present the Message From the Duo (5 min)

1. Tell kids that today they will use the *ask* step of the Engineering Design Process to find out more about engineering rockets. India sent a message to tell them more about it.
2. Have kids turn to *Message from the Duo*, p. 11 in their Engineering Journals, to follow along. Play track 4.
3. To check for understanding, ask:
   - **What is India asking you to do?** *Answer questions about how changing different parts of the rocket affects how far it goes.*
   - **What did India say a variable is?** *A characteristic or part you can change.*
4. Remind kids of the rockets they tested in the last adventure. Ask:
   - **What are some parts, or variables, of the rockets you think we could change?** *Length, width, shape, weight, etc.*



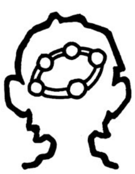
Set the Stage (5 min)

1. Show kids the materials and explain that today each group will be testing one part of the rocket. At the end, they will make one large results chart that groups can use as they engineer their rockets in Adventure 4.
2. Write the word “variable” on the board. Tell kids that India has suggested testing the following variables: material, length, or width.
3. Remind kids that in the first adventure, they tested the variable of weight. Ask:
   - **What did you find out about how weight affects a rocket?** *The less weight, the farther the rocket can go.*
4. Tell kids that in the first adventure they also experimented with different launch angles and decided on a standard angle to use from now on. Ask:
   - **Why is it important that everyone uses the same angle to launch their rockets?** *Because it eliminates a variable that could affect the flight of the rocket.*
   - **Do you have any predictions about which testing variable might be the most important for making your rocket go far?** *Encourage all answers.*



Testing Variables (20 min)

1. Assign each group one variable to focus on. Two groups should test each variable. Multiple groups testing one variable will allow you to compare data at the end of the adventure. If you have less than eight groups, make sure each variable is being tested by at least one group.
2. Remind groups about the testing procedure used in Adventure 1.
3. Hold up a dowel and remind groups that the dowel is about the same size as the part of the rocket launcher that their rocket will sit on. They should use the dowel to check the circumference of rockets they are *creating*. Their rockets should be able to slide onto and off of the dowel easily.
4. Have groups *create* their rockets, following their variable's directions sheet. Groups should mark an "x" where each rocket lands on *Recording Page,* p. 12 in their Engineering Journals.
5. As kids are testing, check in with each group and ask questions like:
   - **Which of your rockets traveled the farthest?**
   - **Has anything surprised you during your testing?**
6. Once all rockets have been tested in a group, have the group put the rocket that went the farthest in a prominent place in the room.



Reflect (15 min)

1. Gather kids around the *Results Chart*. Mark off what each group found and have groups share the rocket that traveled the farthest. Ask:
   - **How do these results compare to your predictions about which variables would be most important for making your rocket go far?**
   - **How will you use the data you gathered about variables when you engineer your own rocket designs?**
   - **Do you think engineers test and share results? Why?** *Yes, because they can get ideas from each other and help each other figure out what to work on for their design.*
   - **Which steps of the Engineering Design Process did you use today?** *We* asked *about rocket variables and* imagined *what we would try.*
2. Tell kids that the results they discovered today will inform their designs later when they begin engineering their final rockets. Let them know that they should try testing different groups of variables together because new combinations may have positive or negative effects. Tell kids that in the next adventure, they will choose the destination they want their rover to explore and decide which tools will go on their rover.
3. Give kids time to fill out *Think About It*, p. 13 in their Engineering Journals. Having kids record their ideas will help them remember what they learned and encourage them to apply it in the next adventure.

Tip: Save the *Results Chart* for later adventures.

reply | forward | archive | delete

from: engineeringadventures@mos.org

to: You

subject: How are Rockets Engineered?

3:45 PM

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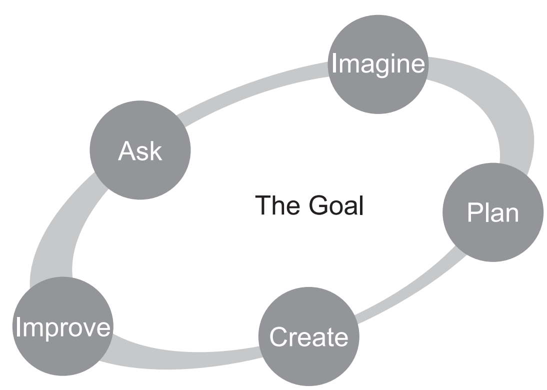
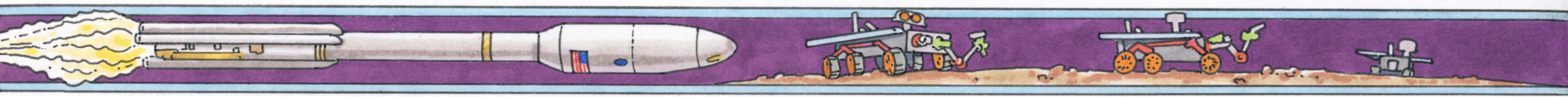
India



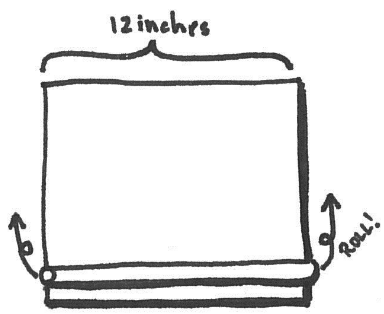
Rocket Length Directions



To test rocket length, follow the directions below.

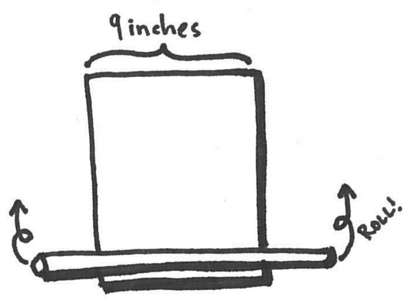
Rocket 1: Long

1. Wrap the long side of the construction paper around the dowel so you have a tube that is 12 inches long.



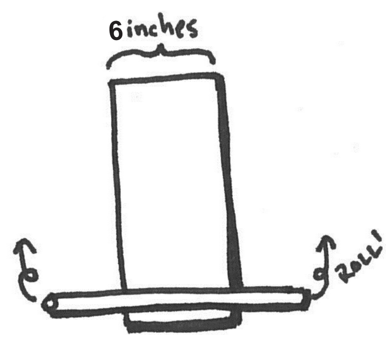
Rocket 2: Medium

1. Wrap the short side of the construction paper around the dowel so you have a tube that is 9 inches long.



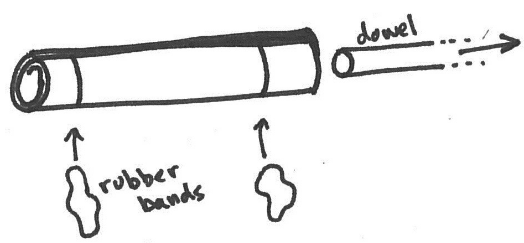
Rocket 3: Short

1. Fold one piece of construction paper in half the long way. Wrap the short side of one piece of the construction paper around the dowel so you have a tube that is 6 inches long.

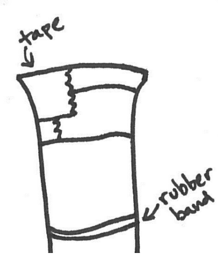


For all:

2. Use two rubber bands to hold the construction paper and pull it off of the dowel.

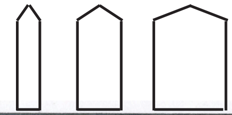


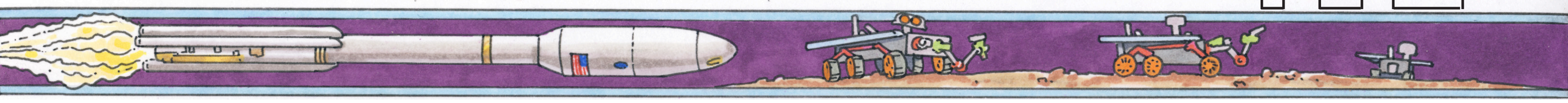
3. Pinch one end of the construction paper flat and tape across the top, so no air can get through. This is the tip of your rocket.



4. Test each rocket. Make sure to record where it lands in your Engineering Journal!

Rocket Width Directions

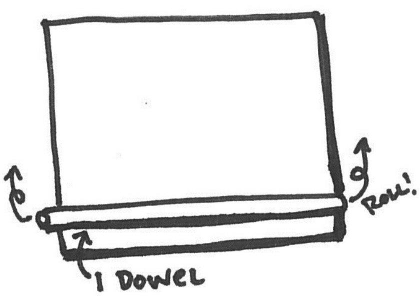




To test rocket width, follow the directions below.

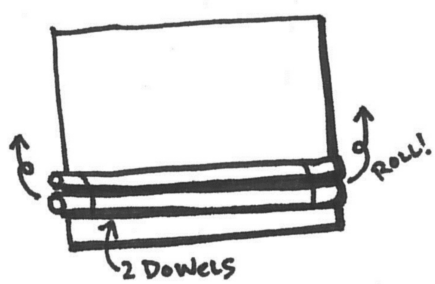
Rocket 1: Small

1. Wrap the long side of the construction paper around **one** dowel so you have a tube that is 12 inches long.



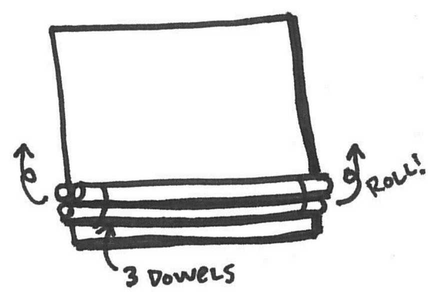
Rocket 2: Medium

1. Use two rubber bands to tie together **two** dowels. Wrap the long side of the construction paper around the dowels so you have a tube that is 12 inches long.



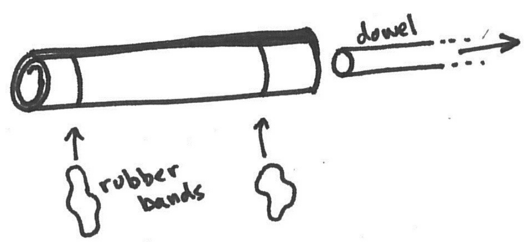
Rocket 3: Large

1. Use two rubber bands to tie together **three** dowels. Wrap the long side of the construction paper around the dowels so you have a tube that is 12 inches long.

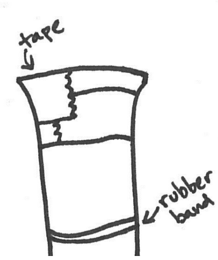


For all:

2. Use two rubber bands to hold the construction paper and pull it off of the dowel.

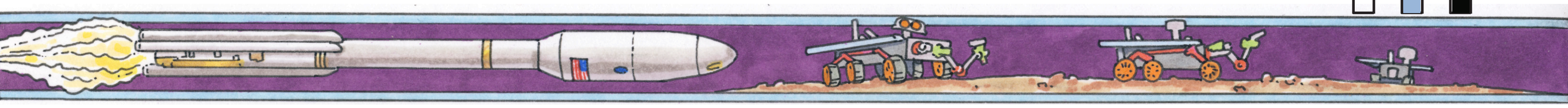


3. Pinch one end of the construction paper flat and tape across the top, so no air can get through. This is the tip of your rocket.



4. Test each rocket. Make sure to record where it lands in your Engineering Journal!

Rocket Material Directions



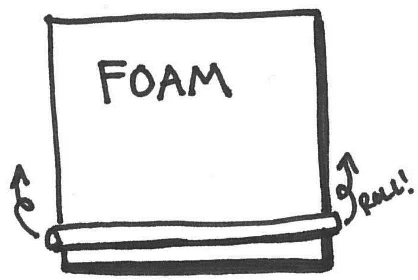
To test rocket material, follow the directions below.

Rocket 1: Construction Paper

1. Wrap the long side of the construction paper around the dowel so you have a tube that is 12 inches long.

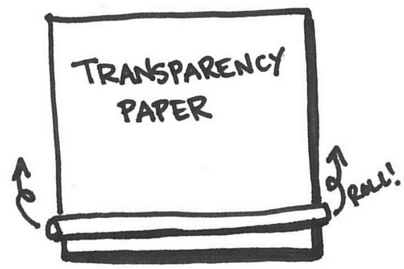
Rocket 2: Foam

1. Wrap the long side of the foam around the dowel so you have a tube that is 12 inches long.



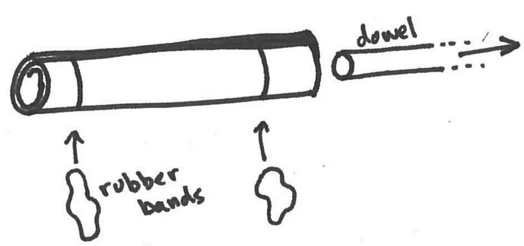
Rocket 3: Transparency Paper

1. Wrap the long side of the transparency paper around the dowel so you have a tube that is 12 inches long.

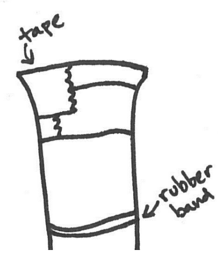


For all:

2. Use two rubber bands to hold the construction paper and pull it off of the dowel.

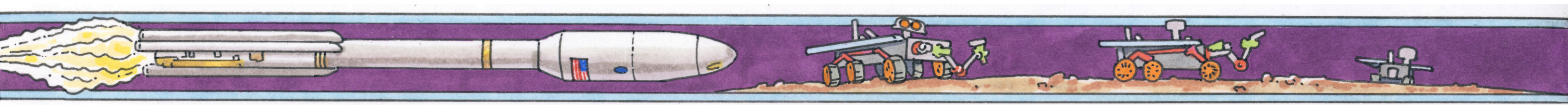


3. Pinch one end of the construction paper flat and tape across the top, so no air can get through. This is the tip of your rocket.



4. Test each rocket. Make sure to record where it lands in your Engineering Journal!

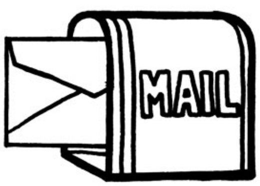
Shoot for the Moon



Overview: Kids will engineer a model rover to explore a moon or planet.

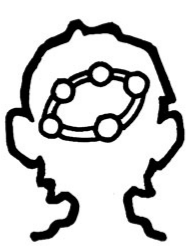
Note to Educator: NASA uses rovers to explore areas of our solar system where it is difficult to send an astronaut. Rovers are engineered to collect data on the surface of another object in Space and are packed with scientific equipment. NASA scientists control rovers remotely from Earth.

Duo Update (5 min)



Create (35 min)

Reflect (5 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 5 or Engineering Journal, p. 14
- ☐ *Engineering Design Process* poster
- ☐ markers or crayons

For each group of 3 kids:

- ☐ 1 *Rover Body* copied onto card stock, p. 45 in this guide
- ☐ 1 *Rover Tools* copied onto card stock, pp. 47–49 in this guide
- ☐ masking tape
- ☐ scissors

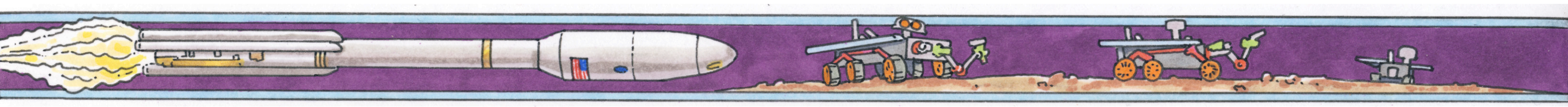
For each kid:

- ☐ Engineering Journal

Preparation

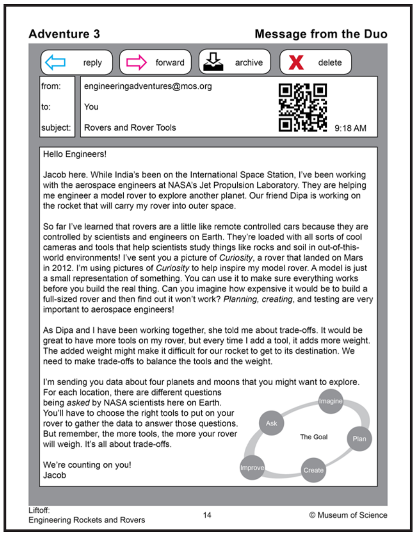
Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Review the picture of example rovers on *Curiosity Rover*, p. 15 in kids' Engineering Journals.
4. Print copies of *Rover Body* onto card stock. There are two rover bodies on one page. Cut along the thick dotted line and have one rover body ready for each group.
5. Print copies of *Rover Tools* onto card stock so each group gets one set of tools.



Journal Pages for Adventure 3

Message from the Duo, p. 14



Adventure 3 Message from the Duo

reply forward archive delete

from: engineeringadventures@mos.org

to: You

subject: Rovers and Rover Tools 9:18 AM

Hello Engineers!

Jacob here. While India's been on the International Space Station, I've been working with the aerospace engineers at NASA's Jet Propulsion Laboratory. They are helping me engineer a model rover to explore another planet. Our friend Dipa is working on the rocket that will carry my rover into outer space.

So far I've learned that rovers are a little like remote controlled cars because they are controlled by scientists and engineers on Earth. They're loaded with all sorts of cool cameras and tools that help scientists study things like rocks and soil in out-of-this-world environments! I've sent you a picture of *Curiosity*, a rover that landed on Mars in 2012. I'm using pictures of *Curiosity* to help inspire my model rover. A model is just a small representation of something. You can use it to make sure everything works before you build the real thing. Can you imagine how expensive it would be to build a full-sized rover and then find out it won't work? *Planning*, *creating*, and testing are very important to aerospace engineers!

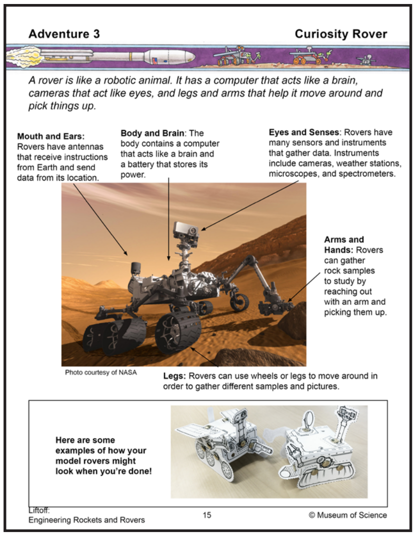
As Dipa and I have been working together, she told me about trade-offs. It would be great to have more tools on my rover, but every time I add a tool, it adds more weight. The added weight might make it difficult for our rocket to get to its destination. We need to make trade-offs to balance the tools and the weight.

I'm sending you data about four planets and moons that you might want to explore. For each location, there are different questions being *asked* by NASA scientists here on Earth. You'll have to choose the right tools to put on your rover to gather the data to answer those questions. But remember, the more tools, the more your rover will weigh. It's all about trade-offs.

We're counting on you!
Jacob

Liftoff: Engineering Rockets and Rovers 14 © Museum of Science

Curiosity Rover, p. 15



Adventure 3 Curiosity Rover

A rover is like a robotic animal. It has a computer that acts like a brain, cameras that act like eyes, and legs and arms that help it move around and pick things up.

Mouth and Ears: Rovers have antennas that receive instructions from Earth and send data from its location.

Body and Brain: The body contains a computer that acts like a brain and a battery that stores its power.

Eyes and Senses: Rovers have many sensors and instruments that gather data. Instruments include cameras, weather stations, microscopes, and spectrometers.

Arms and Hands: Rovers can gather rock samples to study by reaching out with an arm and picking them up.

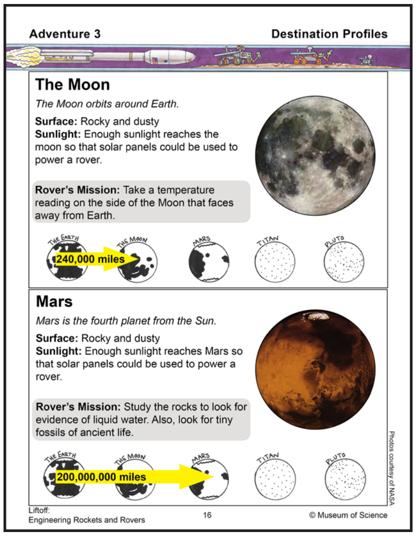
Photo courtesy of NASA

Legs: Rovers can use wheels or legs to move around in order to gather different samples and pictures.

Here are some examples of how your model rovers might look when you're done!

Liftoff: Engineering Rockets and Rovers 15 © Museum of Science

Destination Profiles, p. 16



Adventure 3 Destination Profiles

The Moon

The Moon orbits around Earth.

Surface: Rocky and dusty

Sunlight: Enough sunlight reaches the moon so that solar panels could be used to power a rover.

Rover's Mission: Take a temperature reading on the side of the Moon that faces away from Earth.

Mars

Mars is the fourth planet from the Sun.

Surface: Rocky and dusty

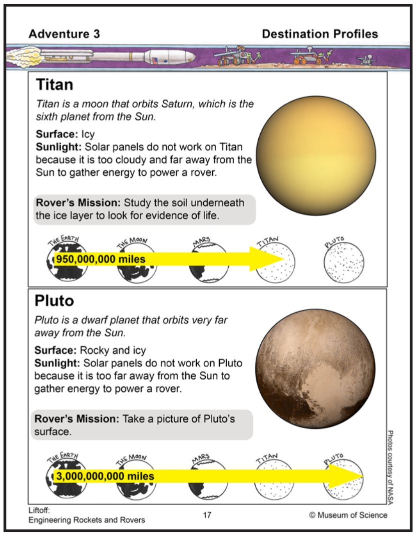
Sunlight: Enough sunlight reaches Mars so that solar panels could be used to power a rover.

Rover's Mission: Study the rocks to look for evidence of liquid water. Also, look for tiny fossils of ancient life.

Photos courtesy of NASA

Liftoff: Engineering Rockets and Rovers 16 © Museum of Science

Destination Profiles, p. 17



Adventure 3 Destination Profiles

Titan

Titan is a moon that orbits Saturn, which is the sixth planet from the Sun.

Surface: Icy

Sunlight: Solar panels do not work on Titan because it is too cloudy and far away from the Sun to gather energy to power a rover.

Rover's Mission: Study the soil underneath the ice layer to look for evidence of life.

Pluto

Pluto is a dwarf planet that orbits very far away from the Sun.

Surface: Rocky and icy

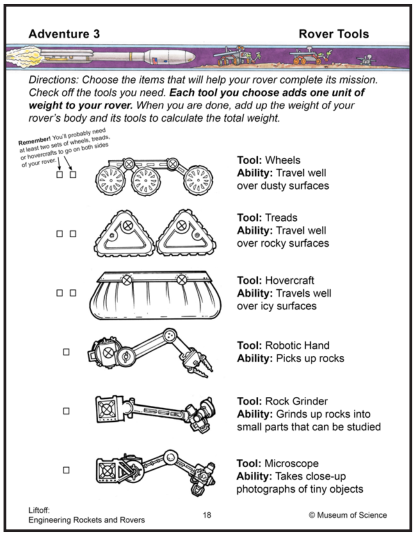
Sunlight: Solar panels do not work on Pluto because it is too far away from the Sun to gather energy to power a rover.

Rover's Mission: Take a picture of Pluto's surface.

Photos courtesy of NASA

Liftoff: Engineering Rockets and Rovers 17 © Museum of Science

Rover Tools, p. 18



Adventure 3 Rover Tools

Directions: Choose the items that will help your rover complete its mission. Check off the tools you need. ***Each tool you choose adds one unit of weight to your rover.*** *When you are done, add up the weight of your rover's body and its tools to calculate the total weight.*

Remember! You'll probably need at least two sets of wheels, treads, or hovercrafts to go on both sides of your rover!

Tool: Wheels
Ability: Travel well over dusty surfaces

Tool: Treads
Ability: Travel well over rocky surfaces

Tool: Hovercraft
Ability: Travels well over icy surfaces

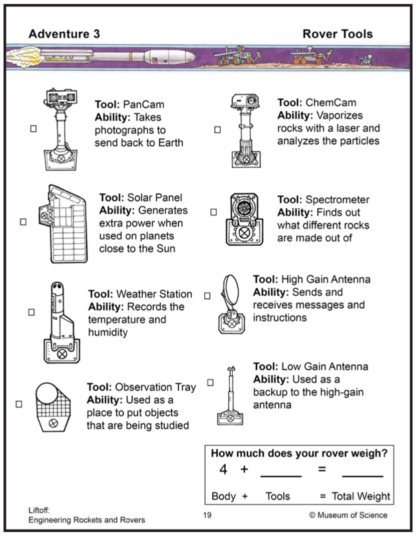
Tool: Robotic Hand
Ability: Picks up rocks

Tool: Rock Grinder
Ability: Grinds up rocks into small parts that can be studied

Tool: Microscope
Ability: Takes close-up photographs of tiny objects

Liftoff: Engineering Rockets and Rovers 18 © Museum of Science

Rover Tools, p. 19



Adventure 3 Rover Tools

Tool: PanCam
Ability: Takes photographs to send back to Earth

Tool: ChemCam
Ability: Vaporizes rocks with a laser and analyzes the particles

Tool: Solar Panel
Ability: Generates extra power when used on planets close to the Sun

Tool: Spectrometer
Ability: Finds out what different rocks are made out of

Tool: Weather Station
Ability: Records the temperature and humidity

Tool: High Gain Antenna
Ability: Sends and receives messages and instructions

Tool: Observation Tray
Ability: Used as a place to put objects that are being studied

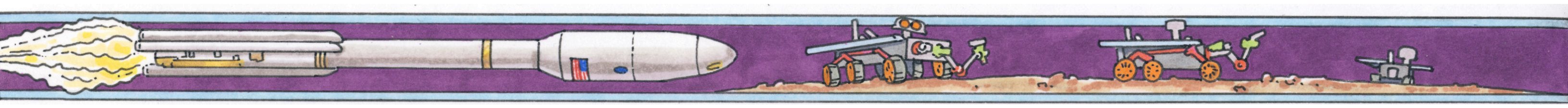
Tool: Low Gain Antenna
Ability: Used as a backup to the high-gain antenna

How much does your rover weigh?

4 + ____ = ____

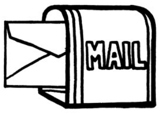
Body + Tools = Total Weight

Liftoff: Engineering Rockets and Rovers 19 © Museum of Science



Kids will learn:

- Rovers need specific tools to be able to gather certain information.
- Models are used to run tests before building a real technology.

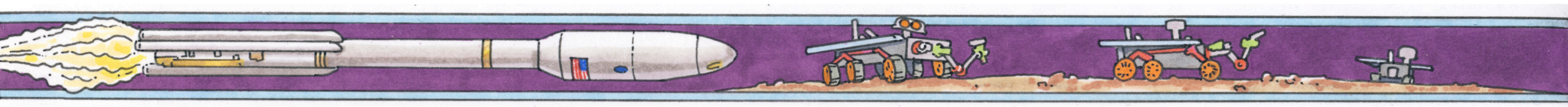


Present the Message From the Duo (5 min)

1. Tell kids that Jacob has sent them a message with information about the rovers their rockets will carry into space.
2. Have kids turn to *Message from the Duo*, p. 14 in their Engineering Journals, to follow along. Play track 5.
3. To check for understanding, ask:
   - **What does Jacob say a model is?** *A model is a small representation of something that is used to make sure everything works before building the real thing.*
   - **Why did Jacob say trade-offs would be important to think about?** *It is good to have more tools on the rover, but it adds more weight that could stop the rocket from going far.*
4. Have kids look at *Curiosity Rover*, p. 15 in their Engineering Journals. Also point out the picture of some example model rovers. Ask:
   - **What are the different tools on the rover for?** *The tools help explore the planet that the rover is on and send information back to Earth.*

Plan: Select a Destination and Tools (10 min)

1. Tell kids that they will work in groups to make a rover that will explore a certain destination in space. Each group will decide which tools will go on their rover.
2. Remind kids that they will need to think about trade-offs. The tools must be chosen carefully so the rover is not too heavy for a rocket to launch its weight.
3. Remind kids that they tested how weight affects a rocket in a previous adventure. Ask:
   - **How did weight affect your rocket?** *The rocket traveled a shorter distance with more weight.*
   - **If you want your rover to go far (like to Pluto), should your rover and rocket be light or heavy?** *If we want it to go far, we need to keep the rover and rocket very light.*
4. Have kids look at *Destination Profiles*, pp. 16–17 in their Engineering Journals.
5. Split kids into groups of 3. Have groups decide which planet or moon their rover will explore and circle the planet or moon in their Engineering Journal. Different groups can explore the same location.



Ask:

- **What are some similarities and differences between the moons and planets?** *Encourage all answers.*

6. Show kids the *Rover Tools*, pp. 18–19 in their Engineering Journals. Each tool has a picture and description. They should note the mission for their destination and make sure the tools they choose will help them complete it. Point out that each rover starts out with a minimum of four weights to account for the weight of the body and the battery.
7. Have groups check off the tools they *plan* to use on their rover.

Create Your Rover (25 min)

1. Have groups present their checked-off rover tools in order to pick up a card stock version of the rover and the tools, scissors, and tape. They should not cut out the pictures from their Engineering Journals!
2. Have groups assemble their rovers by cutting out the tools they chose and attaching them to their rovers with tape. If there is time, they can color in the pieces. If kids change the tools they are working with, remind them to make the changes on the *Rover Tools* page, pp. 18–19 in their Engineering Journals, and recalculate the weight of their rover.
3. Have kids pick up the number of washers that represent the weight of their rovers so they can feel the weight. Remind them that in the next adventure, they will need to engineer a rocket that can carry the weight and still reach their destination!
4. Give kids a minute to come up with a name for their rover, which will become their group name. Tell kids to write their group name on the front cover of their Engineering Journals.

Tip: Tell kids that real rovers and space probes have been named *Curiosity, Spirit*, *Opportunity*, *Pioneer*, and *Voyager*.

Reflect (5 min)

1. Gather kids around the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process did you use today?** *We* imagined *and* planned *our model rovers and the tools they would need based on the location we chose. We then* created *our model rovers.*
   - **What were some trade-offs you made when *creating* your rover?**
   - **How did your group decide which tools to use?** *Encourage kids to explain if they debated any tools in their group and how they came to a decision based on the information they wanted their rover to collect.*
2. Tell kids that next time they will begin to engineer the rocket that will carry their rover to its destination.

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	Rovers and Rover Tools

9:18 AM

Hello Engineers!

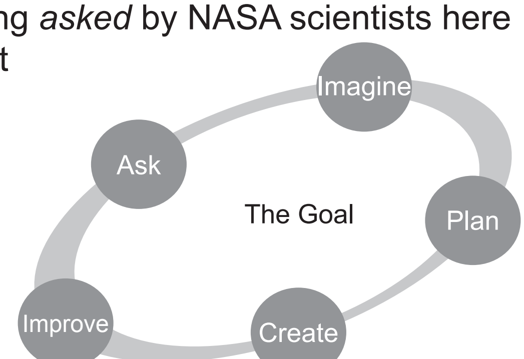
Jacob here. While India's been on the International Space Station, I've been working with the aerospace engineers at NASA's Jet Propulsion Laboratory. They are helping me engineer a model rover to explore another planet. Our friend Dipa is working on the rocket that will carry my rover into outer space.

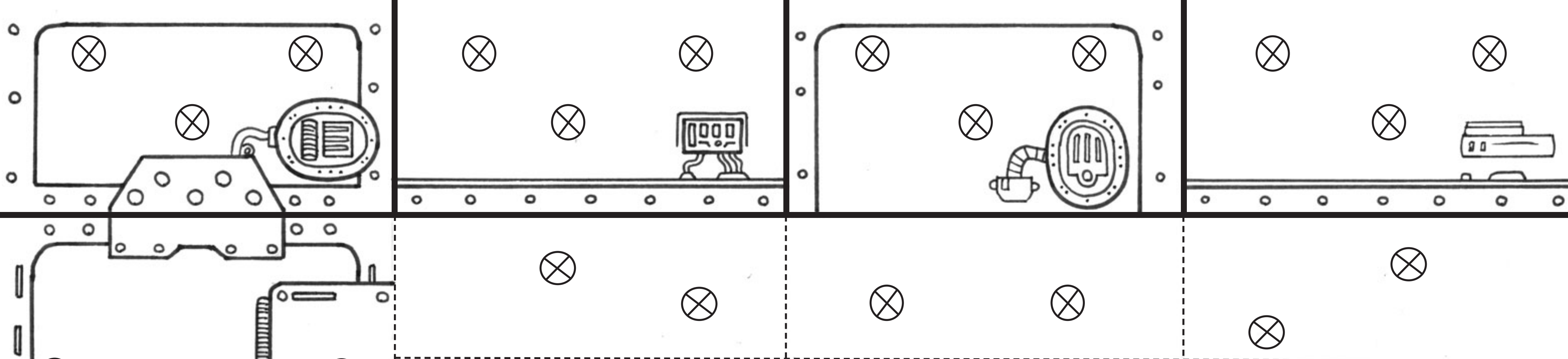
So far I've learned that rovers are a little like remote controlled cars because they are controlled by scientists and engineers on Earth. They're loaded with all sorts of cool cameras and tools that help scientists study things like rocks and soil in out-of-this-world environments! I've sent you a picture of *Curiosity*, a rover that landed on Mars in 2012. I'm using pictures of *Curiosity* to help inspire my model rover. A model is just a small representation of something. You can use it to make sure everything works before you build the real thing. Can you imagine how expensive it would be to build a full-sized rover and then find out it won't work? *Planning, creating*, and testing are very important to aerospace engineers!

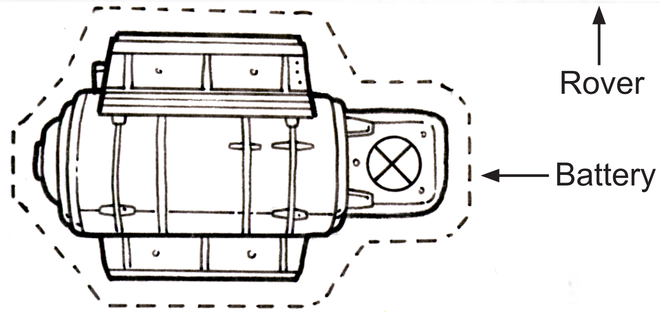
As Dipa and I have been working together, she told me about trade-offs. It would be great to have more tools on my rover, but every time I add a tool, it adds more weight. The added weight might make it difficult for our rocket to get to its destination. We need to make trade-offs to balance the tools and the weight.

I'm sending you data about four planets and moons that you might want to explore. For each location, there are different questions being *asked* by NASA scientists here on Earth. You'll have to choose the right tools to put on your rover to gather the data to answer those questions. But remember, the more tools, the more your rover will weigh. It's all about trade-offs.

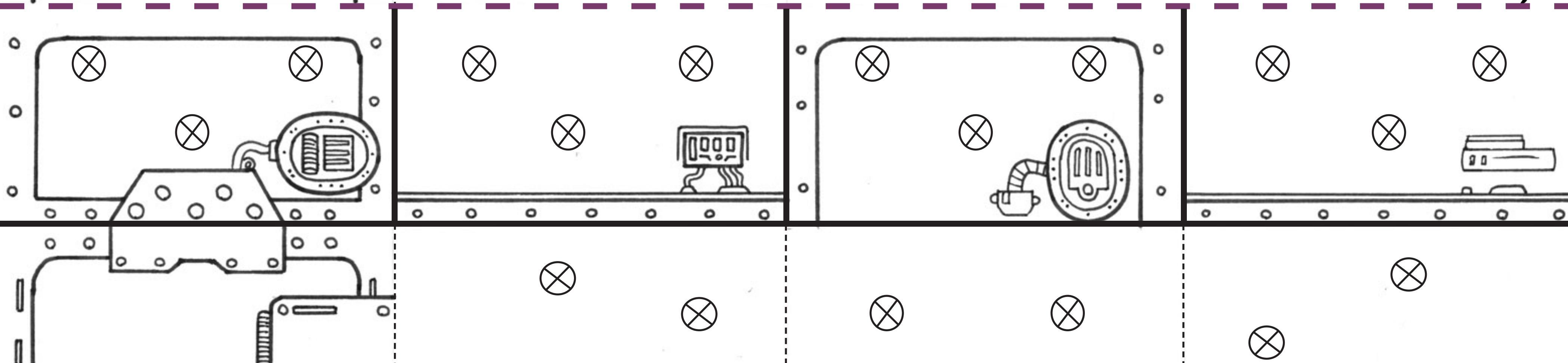
We're counting on you!
Jacob

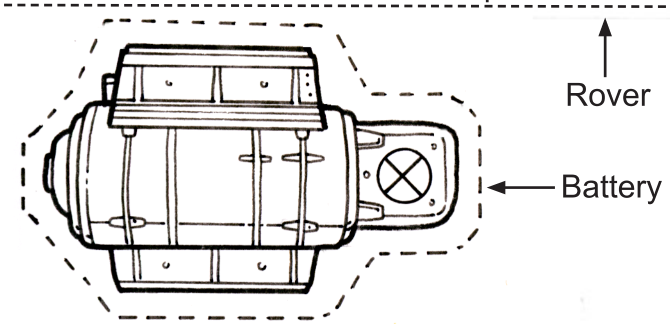






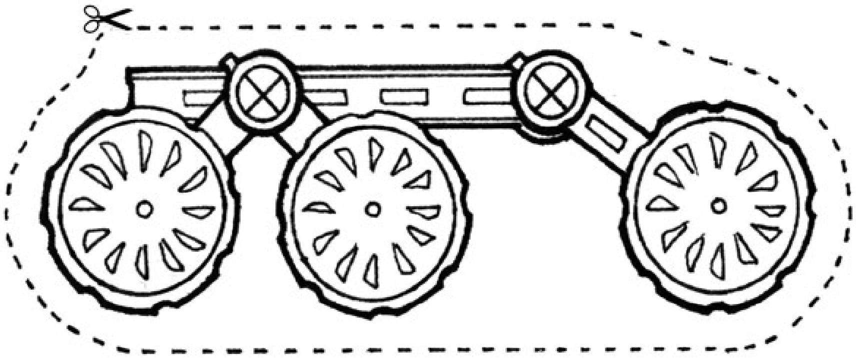
1. Cut on the dotted lines around the rover.
2. Fold in on the dark solid lines.
3. Fold and tape your rover.
4. Cut out and attach your battery.
5. Attach tools!



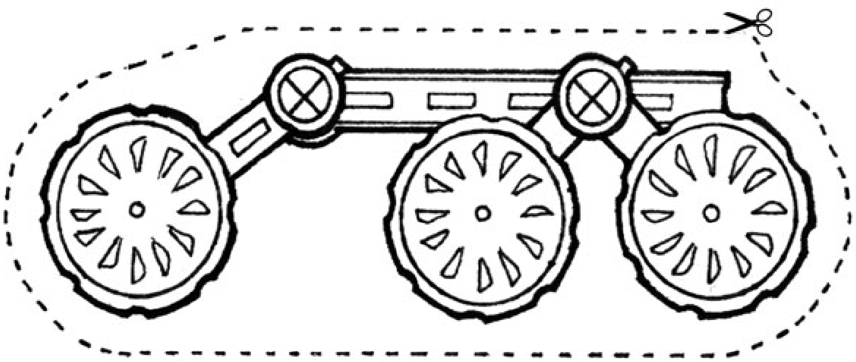


1. Cut on the dotted lines around the rover.
2. Fold in on the dark solid lines.
3. Fold and tape your rover.
4. Cut out and attach your battery.
5. Attach tools!

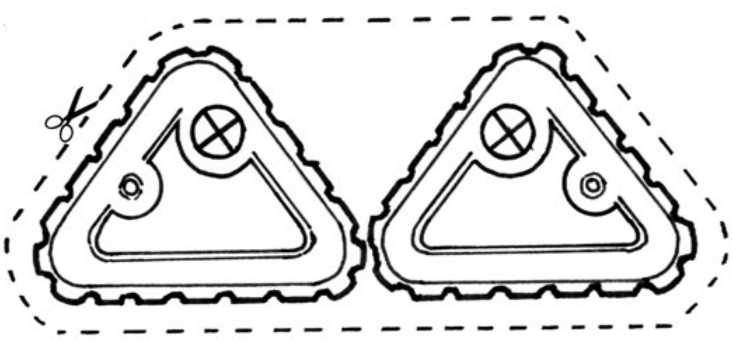
Wheels: Travel well over dusty surfaces



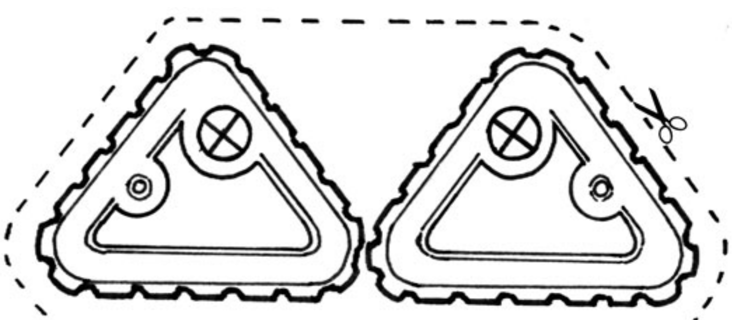
Wheels: Travel well over dusty surfaces



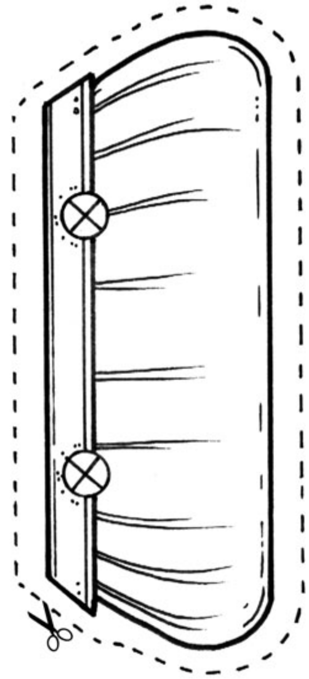
Treads: Travel well over rocky surfaces



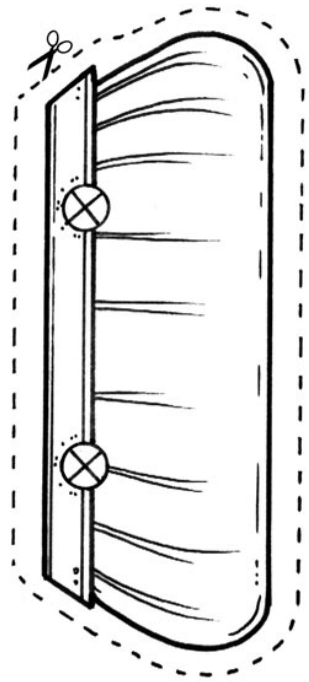
Treads: Travel well over rocky surfaces



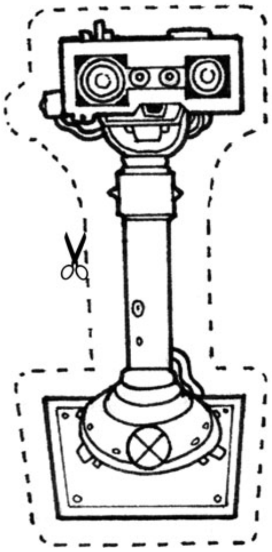
Hovercraft: Travels well over icy surfaces



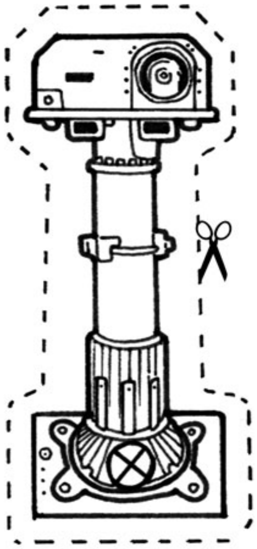
Hovercraft: Travels well over icy surfaces



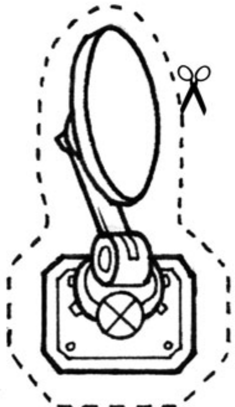
PanCam: takes photographs to send back to Earth



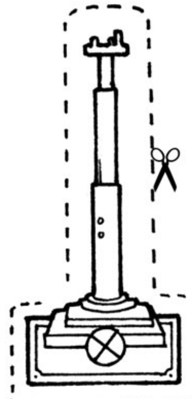
ChemCam: vaporizes rocks with a laser and analyzes the particles



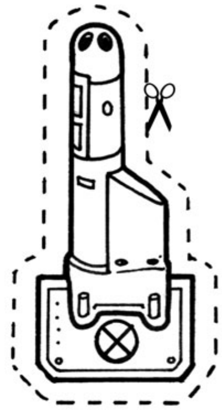
High Gain Antenna: sends and receives messages and instructions



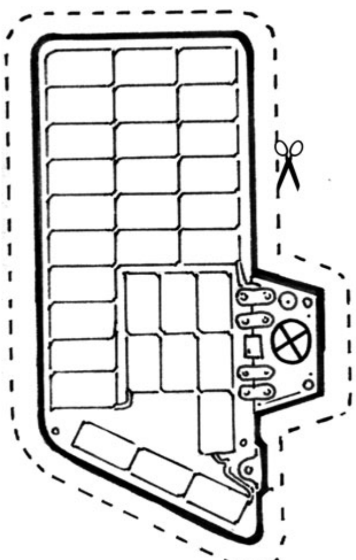
Low Gain Antenna: used as a backup to the high gain antenna

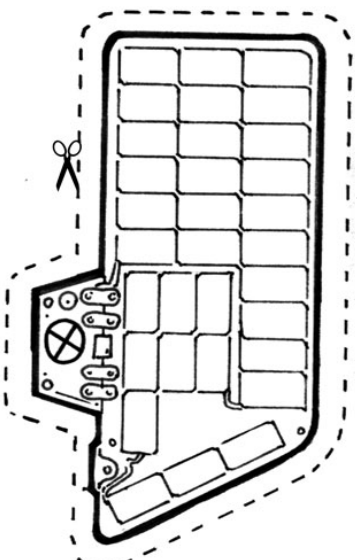


Weather Station: records the temperature and humidity



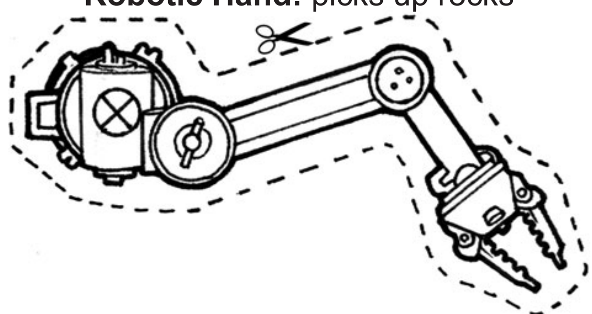
Solar Panel: generates extra power when used on planets close to the Sun



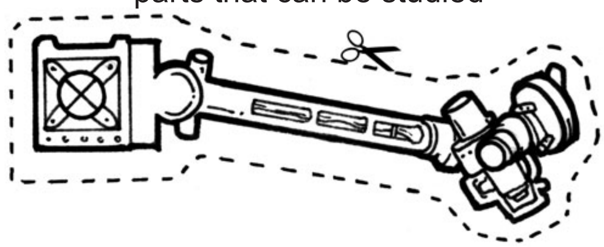


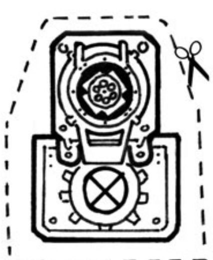
Solar Panel: generates extra power when used on planets close to the Sun

Robotic Hand: picks up rocks



Rock Grinder: grinds up rocks into small parts that can be studied

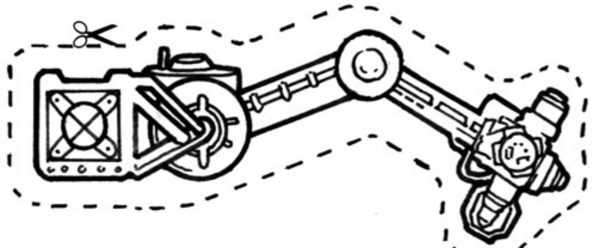




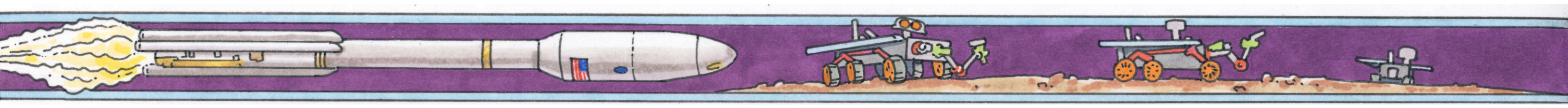
Spectrometer: finds out what different rocks are made out of

Observation Tray: used as a place to put objects that are being studied

Microscope: takes close up photographs of tiny objects



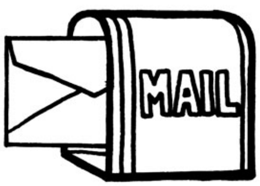
Create a Rocket



Overview: Kids will engineer their rockets.

Note to Educator: Be sure to save the rockets that the kids engineer for Adventures 5 and 6.

Duo Update (5 min)



Activity (35 min)

Reflect (10 min)

Materials

For the entire group:

- ☐ *Message from the Duo*, track 6 or Engineering Journal, p. 20
- ☐ *Engineering Design Process* poster
- ☐ *Results Chart*
- ☐ masking tape
- ☐ tape measure
- ☐ 1 protractor
- ☐ 2 stomp rocket launchers

Materials Store

- ☐ 20 cone-shaped paper cups
- ☐ 20 sheets of transparency paper
- ☐ 50 colored foam sheets
- ☐ 50 cups, 3 oz.
- ☐ 50 cups, 8 oz.
- ☐ 50 rubber bands
- ☐ 100 sheets of construction paper
- ☐ 100 washers

For each group of 3 kids:

- ☐ dowel
- ☐ masking tape
- ☐ scissors

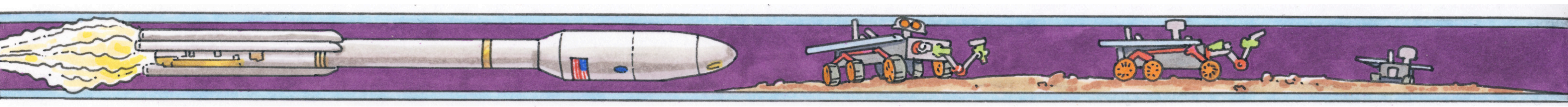
For each kid:

- ☐ Engineering Journal

Preparation

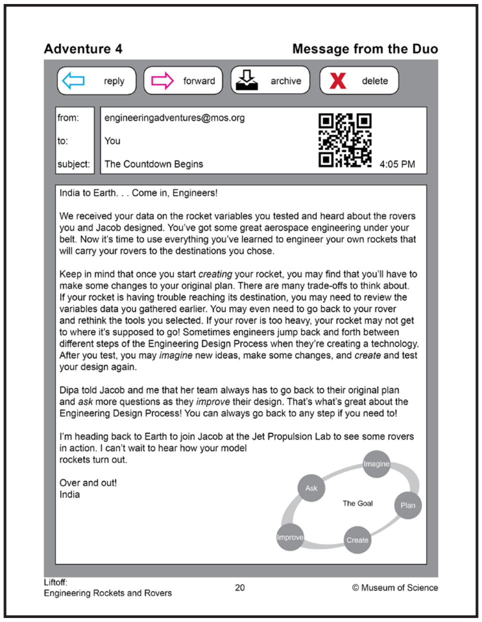
Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Post the *Results Chart* from Adventure 2.
4. Tape the stomp rocket launchers to the floor. Use the protractor to angle them the way the group decided.
5. Tape the *Destination Pages*, pp. 19–25 in this guide, to the floor. Tape the Moon 3 feet, Mars 10 feet, Titan 15 feet, and Pluto 30 feet away from the base of the launcher.



Journal Pages for Adventure 4

Message from the Duo, p. 20



Adventure 4 | Message from the Duo

reply | forward | archive | delete

from: engineeringadventures@mos.org

to: You

subject: The Countdown Begins | 4:05 PM

India to Earth. . . Come in, Engineers!

We received your data on the rocket variables you tested and heard about the rovers you and Jacob designed. You've got some great aerospace engineering under your belt. Now it's time to use everything you've learned to engineer your own rockets that will carry your rovers to the destinations you chose.

Keep in mind that once you start *creating* your rocket, you may find that you'll have to make some changes to your original plan. There are many trade-offs to think about. If your rocket is having trouble reaching its destination, you may need to review the variables data you gathered earlier. You may even need to go back to your rover and rethink the tools you selected. If your rover is too heavy, your rocket may not get to where it's supposed to go! Sometimes engineers jump back and forth between different steps of the Engineering Design Process when they're creating a technology. After you test, you may *imagine* new ideas, make some changes, and *create* and test your design again.

Dipa told Jacob and me that her team always has to go back to their original plan and *ask* more questions as they *improve* their design. That's what's great about the Engineering Design Process! You can always go back to any step if you need to!

I'm heading back to Earth to join Jacob at the Jet Propulsion Lab to see some rovers in action. I can't wait to hear how your model rockets turn out.

Over and out!
India

Ask
Imagine
The Goal
Plan
Create
Improve

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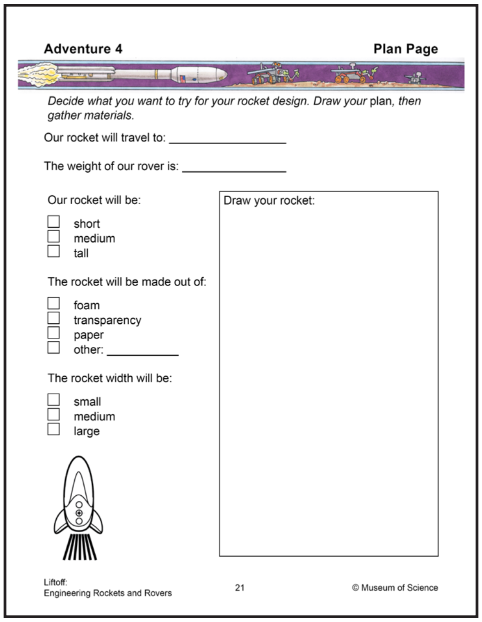
Engineering Rockets and Rovers | 20 | © Museum of Science

Plan Page, p. 21



Adventure 4 | Plan Page

Decide what you want to try for your rocket design. Draw your plan, then gather materials.

Our rocket will travel to: ______________

The weight of our rover is: ______________

Our rocket will be:

- ☐ short
- ☐ medium
- ☐ tall

The rocket will be made out of:

- ☐ foam
- ☐ transparency
- ☐ paper
- ☐ other: __________

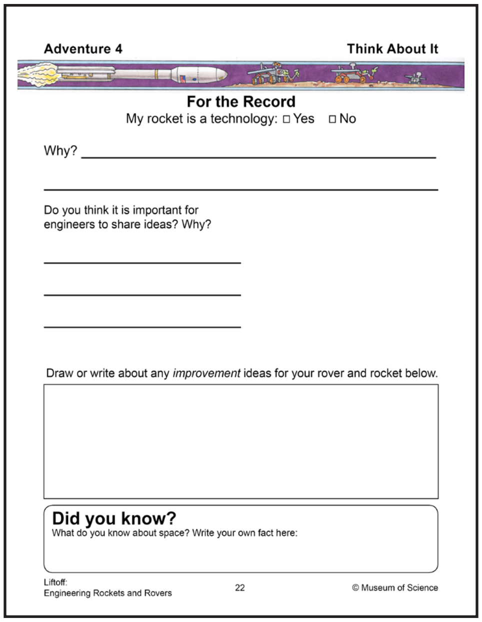
The rocket width will be:

- ☐ small
- ☐ medium
- ☐ large

Draw your rocket:

Liftoff:
Engineering Rockets and Rovers | 21 | © Museum of Science

Think About It, p. 22



Adventure 4 | Think About It

For the Record

My rocket is a technology: ☐ Yes ☐ No

Why? ____

____

Do you think it is important for engineers to share ideas? Why?

____

____

____

Draw or write about any *improvement* ideas for your rover and rocket below.

Did you know?
What do you know about space? Write your own fact here:

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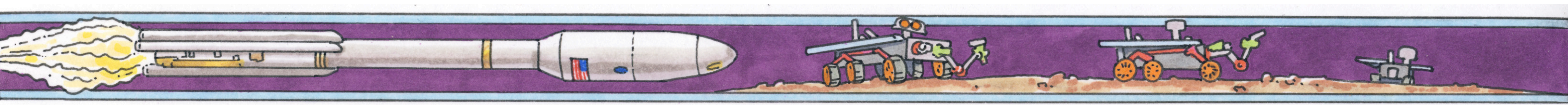
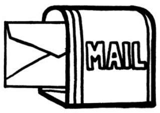
Engineering Rockets and Rovers | 22 | © Museum of Science

Adventure 4
Create a Rocket

Educator Page: Activity Guide



Kids will learn:
- All the testing of variables they have done will help them engineer their rockets.
- Engineers often test, retest, and redesign.



Present the Message From the Duo (5 min)

1. Tell kids that India has sent another message.
2. Have kids turn to *Message from the Duo*, p. 20 in their Engineering Journals, to follow along. Play track 6.
3. To check for understanding, ask:
   - **What is India asking us to do?** *Work together to engineer a rocket that can get our rover and all of its tools to the location we chose.*

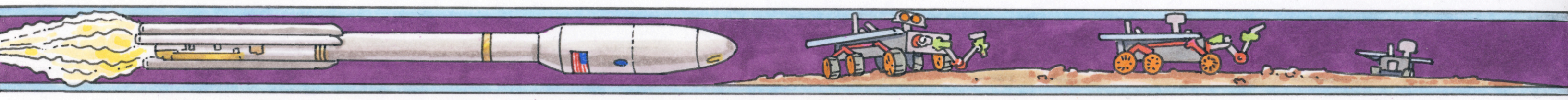
Plan Your Rocket (15 min)

1. Have kids turn back to *Destination Profiles*, pp. 16–17 in their Engineering Journals. Have groups review the destination they chose and its features. Ask a few groups to share:
   - **What is your rover's mission when it reaches your planet or moon?**
   - **How heavy is your rover?**
2. Have all groups share the weight of their rover based on the tools they added. The final weight should be recorded on *Plan Page*, p. 21 in their Engineering Journals. Remind kids that they will be adding washers to their rockets to account for the rover weight and they may need to make some trade-offs. Ask:
   - **What can you do if the washers are too heavy for your rocket?** *Remove unnecessary tools from your rover to lighten the load.*
3. Have kids turn back to *Think About It*, p. 13 in their Engineering Journals, and look at what they wanted to try after testing all the variables in Adventure 2.
4. Review what worked well for each variable in Adventure 2 by looking at the Results Board.
5. Show kids the materials they will be able to use to engineer their rockets.
6. On *Plan Page*, p. 21 in kids' Engineering Journals, have groups look at their individual ideas from Adventure 2 and draw or write a plan for their group's rocket, labeling the parts and materials.

Engineer Your Rocket (20 min)

1. Tell kids that it is now time to engineer the rocket that will carry their rover to its destination.

Tip: Remind groups they can use the dowel as a reminder of the size of the stomp rocket launcher nozzle.



2. As kids work on their rockets, encourage them to test, and ask:
    - **What is working well?**
    - **What needs to be *improved*?**
    - **How can you make sure your rocket reaches its destination?**
3. As groups are getting ready to test, remind kids about the launching protocol of calling out “LIFTOFF!” and making sure everyone is out of the way before launching rockets.
4. Point out the destinations on the floor and remind kids that they want their rockets to land in the area of the destination they chose.

Tip: Encourage groups to experiment with where they place the weights, especially if they are adding a lot of weight to their rockets. Does their rocket fly differently if weights are on a different part of the rocket?

Reflect (10 min)

1. Tell kids that they will have an opportunity to continue *planning, creating,* testing*,* and *improving* their rockets in the next adventure.
2. Ask:
    - **Did any group need to make trade-offs today? Can you share what happened?**
3. Show kids the *Engineering Design Process* poster. Ask:
    - **Which steps of the Engineering Design Process were the most helpful to you today?** *Accept all answers, but encourage kids to think about how they* planned, created, *and* improved.
4. Congratulate kids on using the Engineering Design Process and sharing their engineering ideas.
5. Give kids time to record their thoughts on *Think About It*, p. 22 in their Engineering Journals. Having kids record their ideas will help them remember what they learned and apply it in the next adventure.

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	The Countdown Begins

4:05 PM

India to Earth. . . Come in, Engineers!

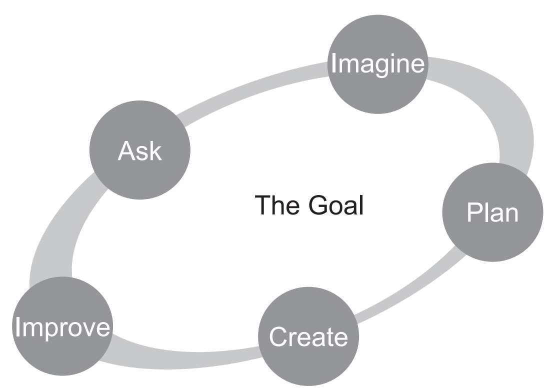
We received your data on the rocket variables you tested and heard about the rovers you and Jacob designed. You've got some great aerospace engineering under your belt. Now it's time to use everything you've learned to engineer your own rockets that will carry your rovers to the destinations you chose.

Keep in mind that once you start *creating* your rocket, you may find that you'll have to make some changes to your original plan. There are many trade-offs to think about. If your rocket is having trouble reaching its destination, you may need to review the variables data you gathered earlier. You may even need to go back to your rover and rethink the tools you selected. If your rover is too heavy, your rocket may not get to where it's supposed to go! Sometimes engineers jump back and forth between different steps of the Engineering Design Process when they're creating a technology. After you test, you may *imagine* new ideas, make some changes, and *create* and test your design again.

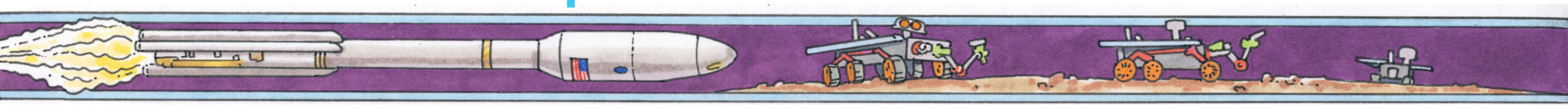
Dipa told Jacob and me that her team always has to go back to their original plan and *ask* more questions as they *improve* their design. That's what's great about the Engineering Design Process! You can always go back to any step if you need to!

I'm heading back to Earth to join Jacob at the Jet Propulsion Lab to see some rovers in action. I can't wait to hear how your model rockets turn out.

Over and out!
India



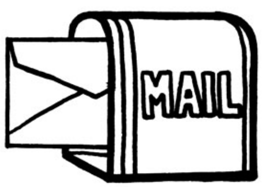
Countdown: Improve a Rocket



Overview: Kids will *improve* and complete their rockets.

Note to Educator: Be sure to save the rockets and rovers kids design for Adventure 6.

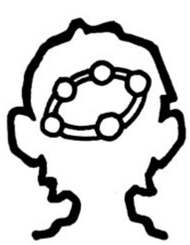
Duo Update (5 min)



Ask (5 min)

Activity (25 min)

Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 7 or Engineering Journal, p. 23
- ☐ *Engineering Design Process* poster
- ☐ masking tape
- ☐ tape measure
- ☐ 1 protractor
- ☐ 2 stomp rocket launchers

For each group of 3 kids:

- ☐ dowel
- ☐ masking tape
- ☐ scissors

For each kid:

- ☐ Engineering Journal

Materials Store (remaining materials from Adventure 4):

- ☐ 20 cone-shaped paper cups
- ☐ 20 transparency paper sheets
- ☐ 50 colored foam sheets
- ☐ 50 cups, 3 oz.
- ☐ 50 cups, 8 oz.
- ☐ 50 rubber bands
- ☐ 100 construction paper sheets
- ☐ 100 washers

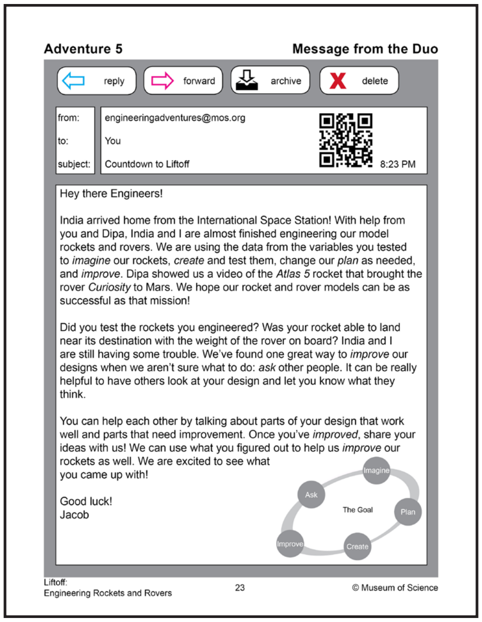
Preparation

Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Tape the stomp rocket launchers to the floor at the angle decided on by the group.
4. Tape the *Destination Pages*, pp. 19–25 in this guide, to the floor. Tape the Moon 3 feet, Mars 10 feet, Titan 15 feet, and Pluto 30 feet away from the base of the launcher.

Journal Pages for Adventure 5

Message from the Duo, p. 23



Adventure 5 **Message from the Duo**

reply forward archive delete

from:	engineeringadventures@mos.org
to:	You
subject:	Countdown to Liftoff 8:23 PM

Hey there Engineers!

India arrived home from the International Space Station! With help from you and Dipa, India and I are almost finished engineering our model rockets and rovers. We are using the data from the variables you tested to *imagine* our rockets, *create* and test them, change our *plan* as needed, and *improve*. Dipa showed us a video of the *Atlas 5* rocket that brought the rover *Curiosity* to Mars. We hope our rocket and rover models can be as successful as that mission!

Did you test the rockets you engineered? Was your rocket able to land near its destination with the weight of the rover on board? India and I are still having some trouble. We've found one great way to *improve* our designs when we aren't sure what to do: *ask* other people. It can be really helpful to have others look at your design and let you know what they think.

You can help each other by talking about parts of your design that work well and parts that need improvement. Once you've *improved*, share your ideas with us! We can use what you figured out to help us *improve* our rockets as well. We are excited to see what you came up with!

Good luck!
Jacob

Liftoff:
Engineering Rockets and Rovers 23 © Museum of Science

Letter to the Duo, p. 24

Adventure 5 **Letter to the Duo**

India and Jacob, the Duo
c/o Museum of Science, EiE
1 Science Park
Boston, MA 02114

Dear India and Jacob,

We finished engineering our rocket to send our rover to ________________. When engineering my rocket, I found out some things that work well, which may help you *improve* your design. I found that ____________________________
_______________________________________.

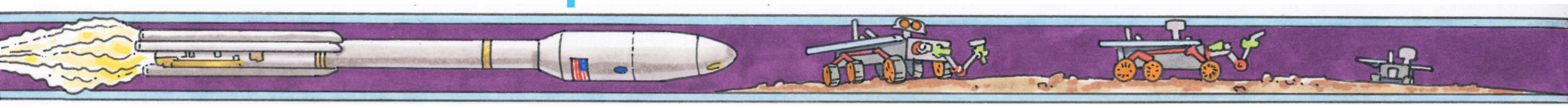
Here is a picture of my group's final design:

Sincerely,

____

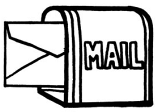
Liftoff:
Engineering Rockets and Rovers 24 © Museum of Science

Countdown: Improve a Rocket



Kids will learn:

- Sharing findings and offering advice to other groups, just as real engineers do, can be helpful.
- Engineers have to *improve* a design many times before it is complete.



Present the Message From the Duo (5 min)

1. Tell kids that Jacob has sent a message.
2. Have kids turn to *Message from the Duo*, p. 23 in their Engineering Journals, to follow along. Play track 7.
3. To check for understanding, ask:
   - **What is Jacob asking you to do?** *Jacob is asking us to share our designs and give each other advice to* improve*.*

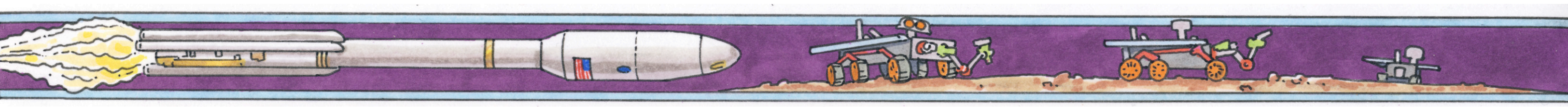
Advice Exchange (5 min)

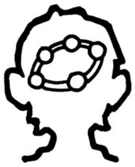
1. Pair up two groups. Have the groups share with each other any technical problems they are having with their rockets, as well as the parts that are working really well. As one group shares, the other will act as consulting engineers and offer ideas about what the group may be able to do to *improve* their rocket.
2. You may want to suggest that the consultants ask the other group things like:
   - **What is working well about your design?**
   - **Are you having any trouble reaching your destination?**
   - **What are you going to do to *improve* your rocket?**

Improve (25 min)

1. Have groups *improve* their rockets. Encourage them to test along the way using the proper launch protocol. Remind kids that if they change their rover, they need to recalculate the weight and change the number of washers on their rocket.
2. As groups are working, ask the questions from above and:
   - **Which parts still need work?**
   - **Which variables have you focused on?**
   - **Which steps of the Engineering Design Process are you using to help you *improve*?**

Tip: If any groups have a successful rocket early on, you may suggest they color their rover, see if they can get their rocket to land directly on the planet or moon page, or try to have their rocket reach two destinations with slight alterations to their design.





Reflect (10 min)

1. Tell kids that they will present their rovers and rockets and launch their rockets in the next adventure.
2. Show kids the *Engineering Design Process* poster. Ask:
   - **How did you use the Engineering Design Process to *improve* your rocket designs?** *We went back and* asked *questions to figure out how to* improve *our rockets, and then we made a* plan *before going back to* create *and finish our model.*
   - **Did you use any of the advice offered by another group?**
   - **Were there any trade-offs you had to consider as you were engineering?** *We wanted lots of tools on our rovers, but that made our rovers heavy and sometimes it was hard for the rocket to launch them a far distance. There were trade-offs to be made between the weight and the distance.*
3. Congratulate kids on using the Engineering Design Process.
4. Give kids time to fill out *Letter to the Duo*, p. 24 in their Engineering Journals. Having kids write what they worked on and share advice will help them consolidate some of the key points they learned as they engineered.

Countdown: Improve a Rocket

reply forward archive delete

from:	engineeringadventures@mos.org
to:	You
subject:	Countdown to Liftoff

8:23 PM

Hey there Engineers!

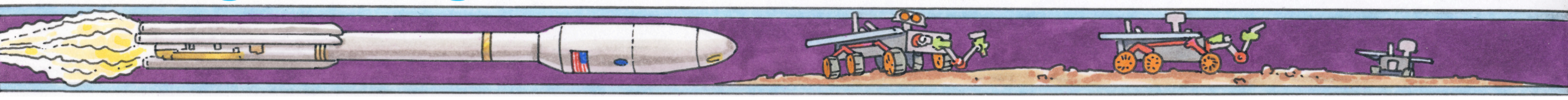
India arrived home from the International Space Station! With help from you and Dipa, India and I are almost finished engineering our model rockets and rovers. We are using the data from the variables you tested to *imagine* our rockets, *create* and test them, change our *plan* as needed, and *improve*. Dipa showed us a video of the *Atlas 5* rocket that brought the rover *Curiosity* to Mars. We hope our rocket and rover models can be as successful as that mission!

Did you test the rockets you engineered? Was your rocket able to land near its destination with the weight of the rover on board? India and I are still having some trouble. We've found one great way to *improve* our designs when we aren't sure what to do: *ask* other people. It can be really helpful to have others look at your design and let you know what they think.

You can help each other by talking about parts of your design that work well and parts that need improvement. Once you've *improved*, share your ideas with us! We can use what you figured out to help us *improve* our rockets as well. We are excited to see what you came up with!

Good luck!
Jacob

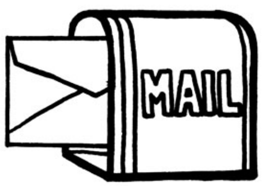
Engineering Showcase: Liftoff!



Overview: Kids will present their rockets and rovers and explain how they used the Engineering Design Process to engineer their rockets.

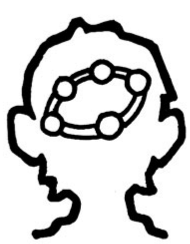
Note to Educator: This is a time for your group to share all of their hard work with family and friends! Consider inviting guests to the Engineering Showcase and encourage kids to share the specific challenges that their group worked on and overcame.

Duo Update (5 min)



Activity (30 min)

Reflect (10 min)



Materials

For the entire group:

- ☐ *Message from the Duo*, track 8 or Engineering Journal, p. 25
- ☐ *Engineering Design Process* poster
- ☐ masking tape
- ☐ tape measure
- ☐ 1 protractor
- ☐ 2 stomp rocket launchers

For each group of 3 kids:

- ☐ completed rockets and rovers

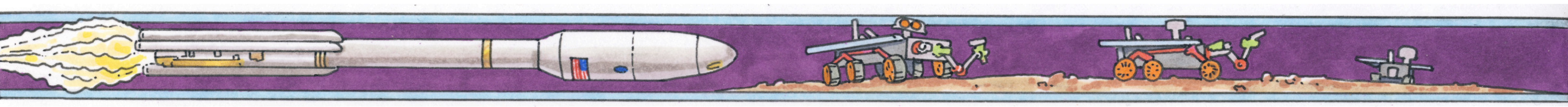
For each kid:

- ☐ Engineering Journal

Preparation

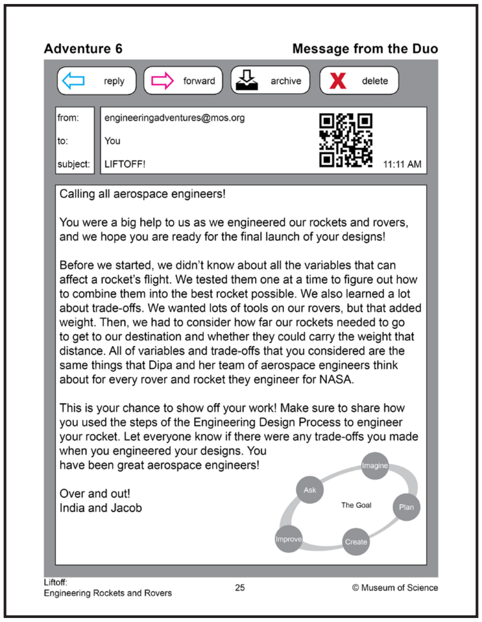
Time Required: 10 minutes

1. Post the *Engineering Design Process* poster.
2. Have the *Message from the Duo* ready to share.
3. Tape the stomp rocket launchers to the floor at the angle the group decided on.
4. Tape the *Destination Pages*, pp. 19–25 in this guide, to the floor. Tape the Moon 3 feet, Mars 10 feet, Titan 15 feet, and Pluto 30 feet away from the base of the launcher.



Journal Pages for Adventure 6

Message from the Duo, p. 25



Adventure 6 **Message from the Duo**

reply | forward | archive | delete

from: engineeringadventures@mos.org
to: You
subject: LIFTOFF!
11:11 AM

Calling all aerospace engineers!

You were a big help to us as we engineered our rockets and rovers, and we hope you are ready for the final launch of your designs!

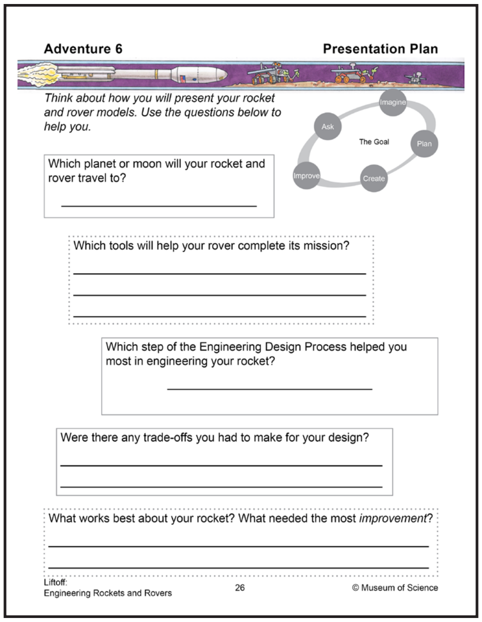
Before we started, we didn't know about all the variables that can affect a rocket's flight. We tested them one at a time to figure out how to combine them into the best rocket possible. We also learned a lot about trade-offs. We wanted lots of tools on our rovers, but that added weight. Then, we had to consider how far our rockets needed to go to get to our destination and whether they could carry the weight that distance. All of variables and trade-offs that you considered are the same things that Dipa and her team of aerospace engineers think about for every rover and rocket they engineer for NASA.

This is your chance to show off your work! Make sure to share how you used the steps of the Engineering Design Process to engineer your rocket. Let everyone know if there were any trade-offs you made when you engineered your designs. You have been great aerospace engineers!

Over and out!
India and Jacob

Liftoff: Engineering Rockets and Rovers 25 © Museum of Science

Presentation Plan, p. 26



Adventure 6 **Presentation Plan**

Think about how you will present your rocket and rover models. Use the questions below to help you.

Which planet or moon will your rocket and rover travel to?

Which tools will help your rover complete its mission?

Which step of the Engineering Design Process helped you most in engineering your rocket?

Were there any trade-offs you had to make for your design?

What works best about your rocket? What needed the most *improvement*?

Liftoff: Engineering Rockets and Rovers 26 © Museum of Science

My Next Engineering Adventure, p. 27

Adventure 6 **My Next Engineering Adventure**

What do you want to engineer next?

Draw your technology here!

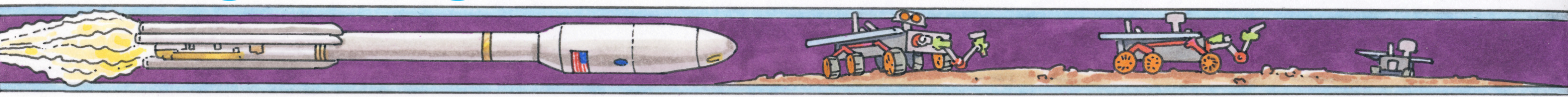
My engineering checklist:

- ☐ Find friends to work with.
- ☐ **Ask** questions about how to start.
- ☐ **Imagine** lots of ideas.
- ☐ Make a **Plan**.
- ☐ **Create** and test the plan.
- ☐ **Improve** until you think it is ready.

What materials will you use?

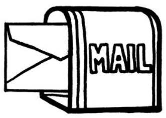
Liftoff: Engineering Rockets and Rovers 27 © Museum of Science

Engineering Showcase: Lift Off!



Kids will learn:

- Models and trade-offs are important in engineering.
- The Engineering Design Process can be used to engineer a rocket, and many other things!



Present the Message From the Duo (5 min)

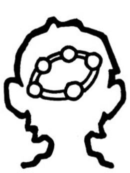
1. Tell kids that today they will show off the rockets and rovers they engineered and then launch their rockets. Let them know that India and Jacob sent a message to tell them more.
2. Have kids turn to *Message from the Duo*, p. 25 in their Engineering Journals. Play track 8.
3. To check for understanding, ask:
   - **What are India and Jacob asking you to do?** *Share how we used the Engineering Design Process, present our rockets and rovers, and launch!*

Prepare/Plan (5 min)

1. Have groups discuss how they will present their rocket and rover. They should use *Presentation Plan*, p. 26 in their Engineering Journals, to see what questions they will be asked. They can use this page to take notes on if they would like.

Showcase (25 min)

1. Have each group take a turn presenting their rocket and rover. Before they launch their rocket, use prompts like:
   - **Tell us about your design.**
   - **Which tools did you decide to put on your rover? How will these tools help the rover when it reaches your destination?**
   - **How did you use the steps of the Engineering Design Process to engineer your rocket?**
   - **Were there any trade-offs you had to consider as you engineered?**



Reflect (10 min)

1. After the final launch, gather kids together and ask:
   - **Why do you think aerospace engineering is important?** *Aerospace engineers work on rockets and other objects that can help explore space.*
2. Show kids the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process helped you most?**
   - **Do you think you will use this process again?**
3. Have kids fill out *My Next Engineering Adventure,* p. 27 in their Engineering Journals. This activity reinforces that they are successful engineers and can use the Engineering Design Process to solve many other problems!

Adventure 6 — Message from the Duo
Engineering Showcase: Lift Off!

reply | forward | archive | delete

from:	engineeringadventures@mos.org
to:	You
subject:	LIFTOFF!

11:11 AM

Calling all aerospace engineers!

You were a big help to us as we engineered our rockets and rovers, and we hope you are ready for the final launch of your designs!

Before we started, we didn't know about all the variables that can affect a rocket's flight. We tested them one at a time to figure out how to combine them into the best rocket possible. We also learned a lot about trade-offs. We wanted lots of tools on our rovers, but that added weight. Then, we had to consider how far our rockets needed to go to get to our destination and whether they could carry the weight that distance. All of variables and trade-offs that you considered are the same things that Dipa and her team of aerospace engineers think about for every rover and rocket they engineer for NASA.

This is your chance to show off your work! Make sure to share how you used the steps of the Engineering Design Process to engineer your rocket. Let everyone know if there were any trade-offs you made when you engineered your designs. You have been great aerospace engineers!

Over and out!
India and Jacob