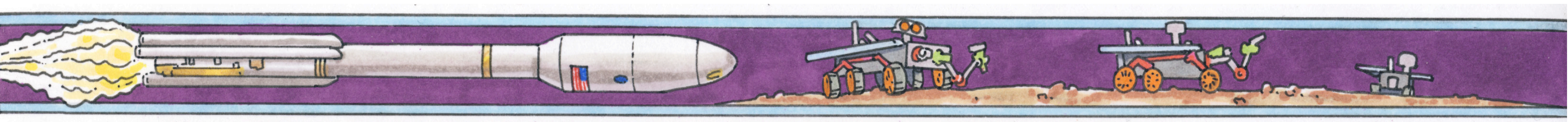
Engineering Adventures

Engineering Journal

Liftoff: Engineering Rockets and Rovers

Your Name:_______________________________

Group Name:_____________________________



reply forward archive delete

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

10:36 AM

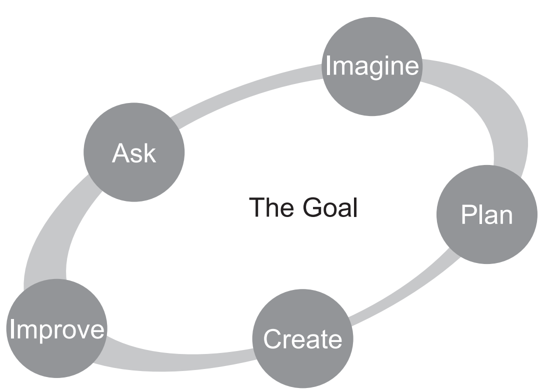
Hi everyone,

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.

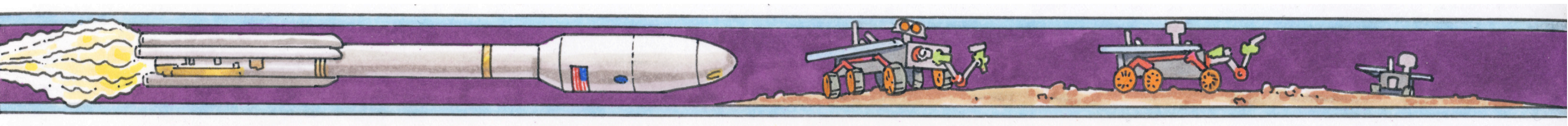
Engineers are problem solvers. They're people who design things that make our lives better, easier, and more fun! We heard you might be able to help us engineer solutions to some of the problems we find. That means you'll be engineers, too!

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!

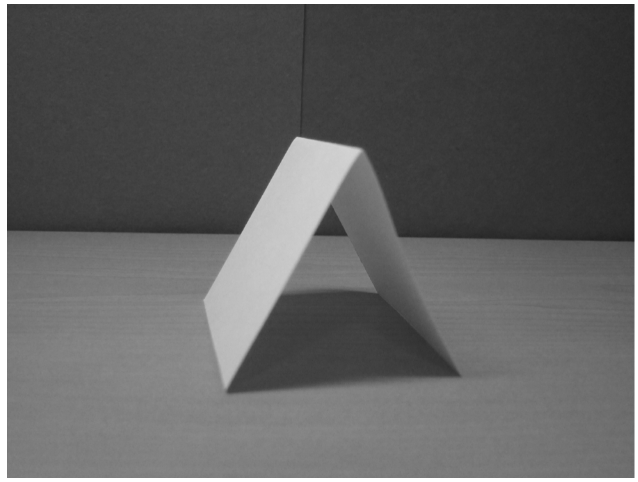


Good luck!
India and Jacob

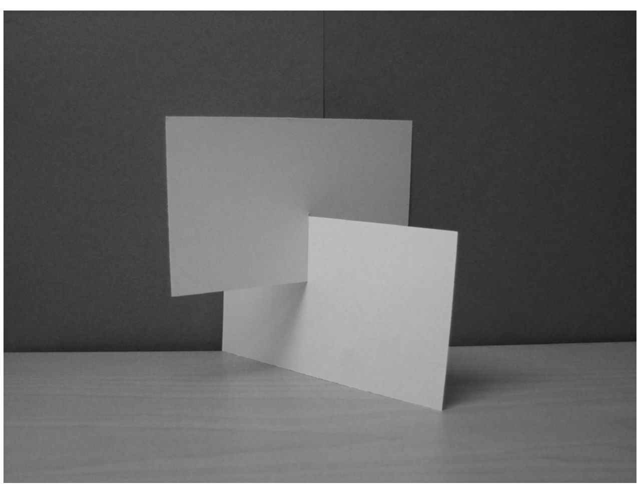


Here are three ways to build with index cards.

Roll it!



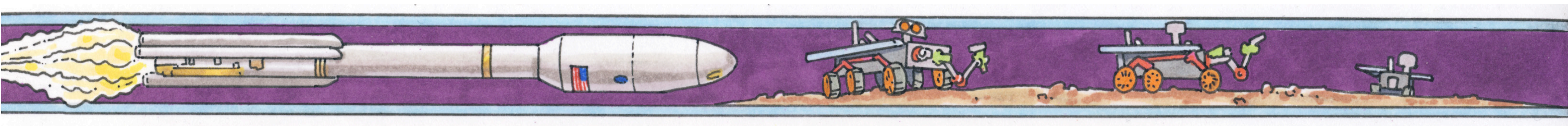
Fold it!



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!



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
- ☐ ________________

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,

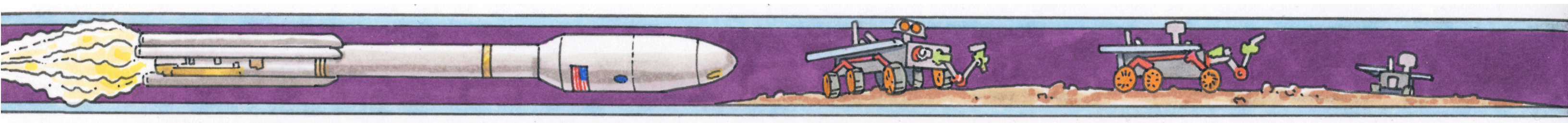
You did a great job engineering a tower to hold up our astronaut statue! Now you can help us engineer more technologies.

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



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?

reply | forward | archive | delete

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

8:55 AM

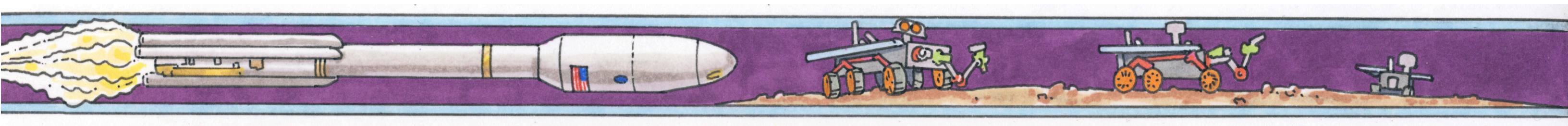
This is India from Engineering Adventures calling Earth. . . Can you read me?

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



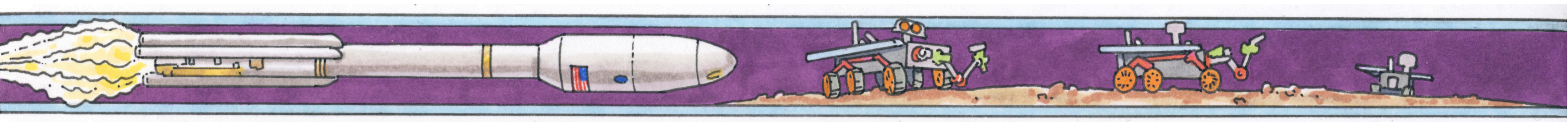
The International Space Station (ISS) is a science laboratory in space! Some of the research on the station is about living in space and how technologies work in space.

The ISS orbits Earth once every 90 minutes. That means it goes around Earth 16 times a day!

The ISS is about the same size as a football field!

Astronauts live on the ISS for short periods of time. The first crew went up in 2000.

Photo courtesy of NASA

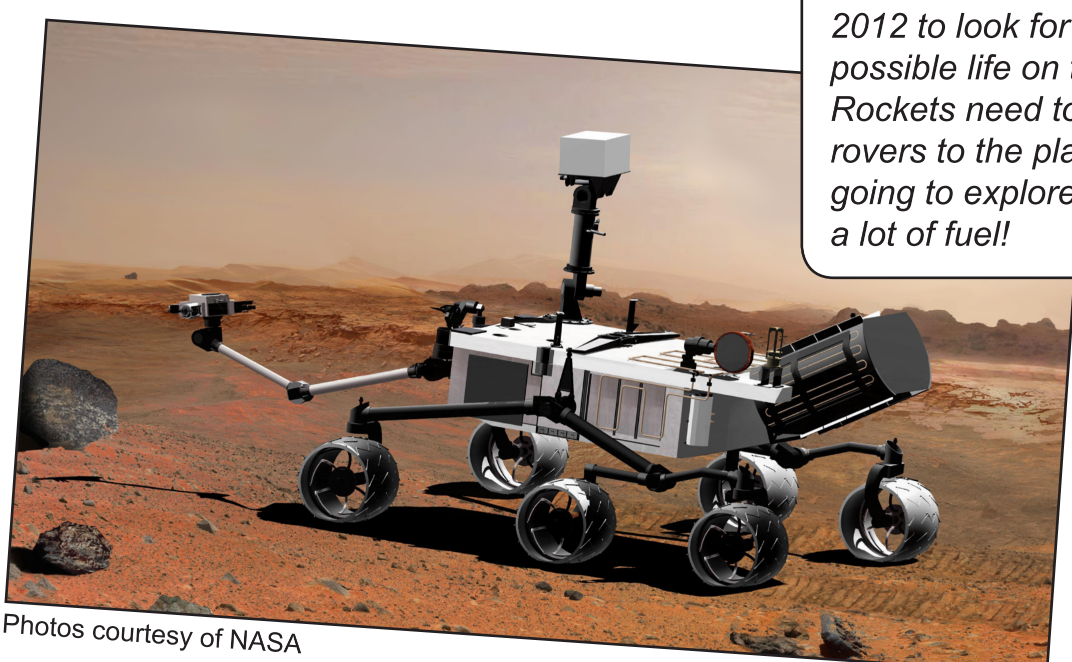


Rockets bring things like people, supplies, and rovers into space!

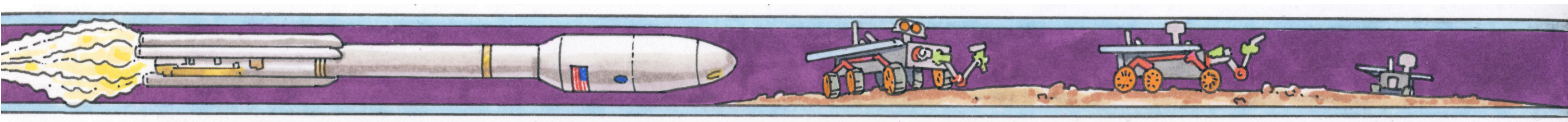
It took over 500 pounds of rocket fuel just to lift my body weight up to the ISS. There was even more fuel on our rocket to lift up the other engineers and the rocket itself!

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

This is Curiosity*, a rover that arrived on Mars in 2012 to look for clues about possible life on the planet. Rockets need to carry the rovers to the places they're going to explore. That takes a lot of fuel!*

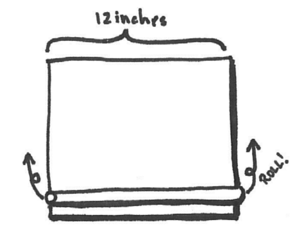


Photos courtesy of NASA

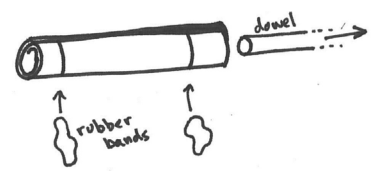


Make your rocket and test how weight affects where it lands.

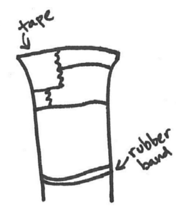
1. Wrap the long side of the paper around one dowel, so you have a tube that is 12 inches long.



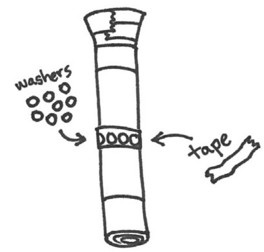
2. Use two rubber bands to hold the construction paper and pull it off of the dowel.



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.



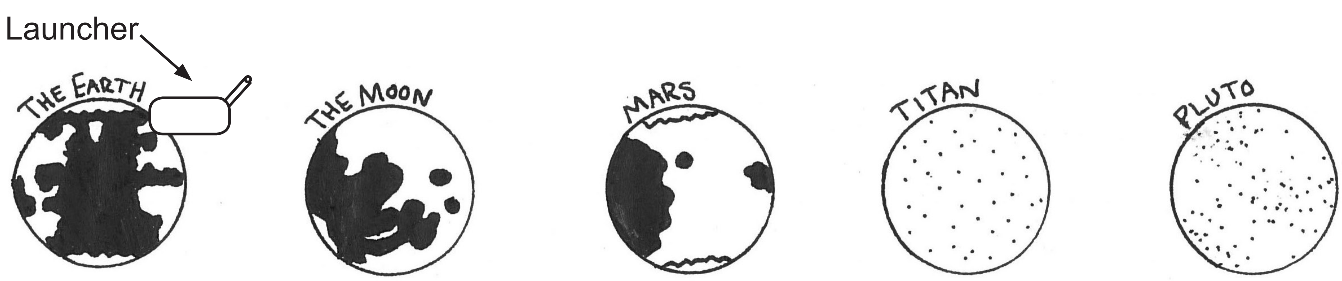
4. Line up washers on the sticky side of a piece of tape and wrap the tape around the middle of your rocket body.

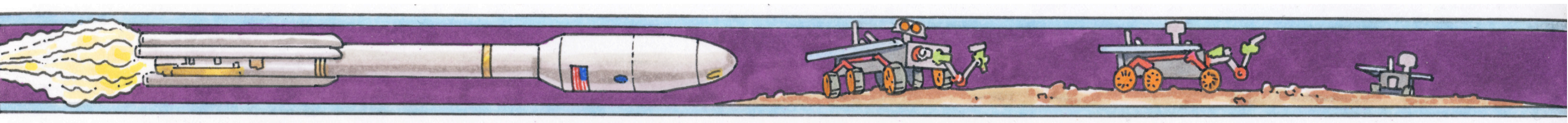


Test your rocket several times with 0, 10, and 20 weights attached. Mark the chart below by recording the number of weights used in each test next to the distance it went.

Testing Results:

How far did your test rockets travel?!





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!

reply | forward | archive | delete

from: engineeringadventures@mos.org

to: You

subject: How are Rockets Engineered?

3:45 PM

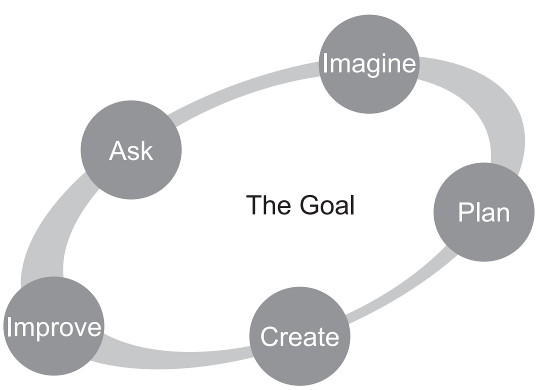
India calling Earth . . . Come in Earth . . .

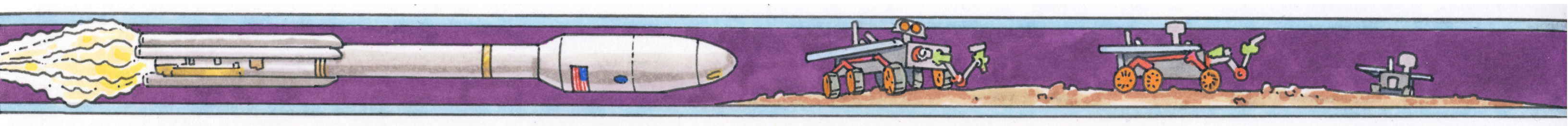
Jacob told me you did some great aerospace engineering to learn how weight affects the distance your rockets travel. When aerospace engineers designed the rocket that got me to the International Space Station, they had to take into account the weight of the people on the rocket, our equipment, and how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

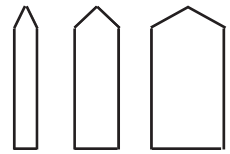
Dipa suggested we each focus on one variable, find what works best, and then figure out how to combine our best ideas to engineer our final rockets. We need your help running tests to see what affects a rocket as it goes into space. With all of the data combined, we should all be able to come up with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

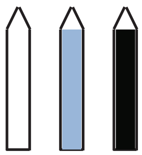
Good luck!
India





Which variable will your group test? (mark one)

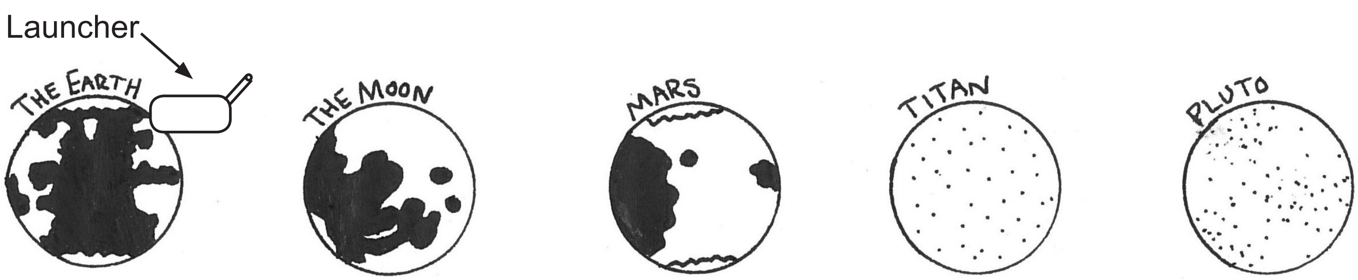
☐ Length  ☐ Width 

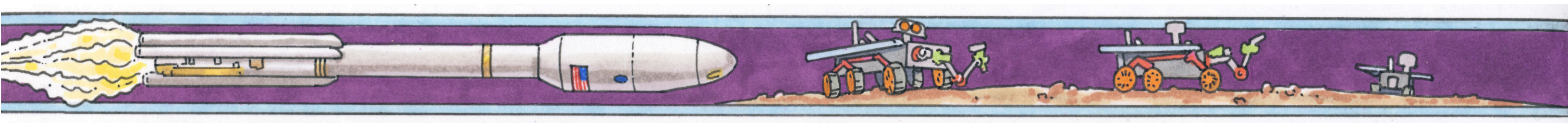
☐ Material 

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:





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.

reply forward archive delete

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

9:18 AM

Hello Engineers!

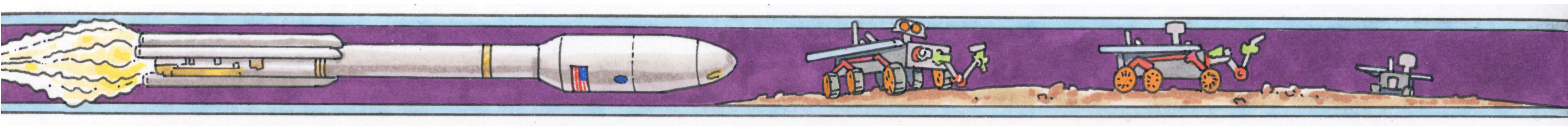
Jacob here. While India's been on the International Space Station, I've been working with the aerospace engineers at NASA's Jet Propulsion Laboratory. They are helping me engineer a model rover to explore another planet. Our friend Dipa is working on the rocket that will carry my rover into outer space.

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

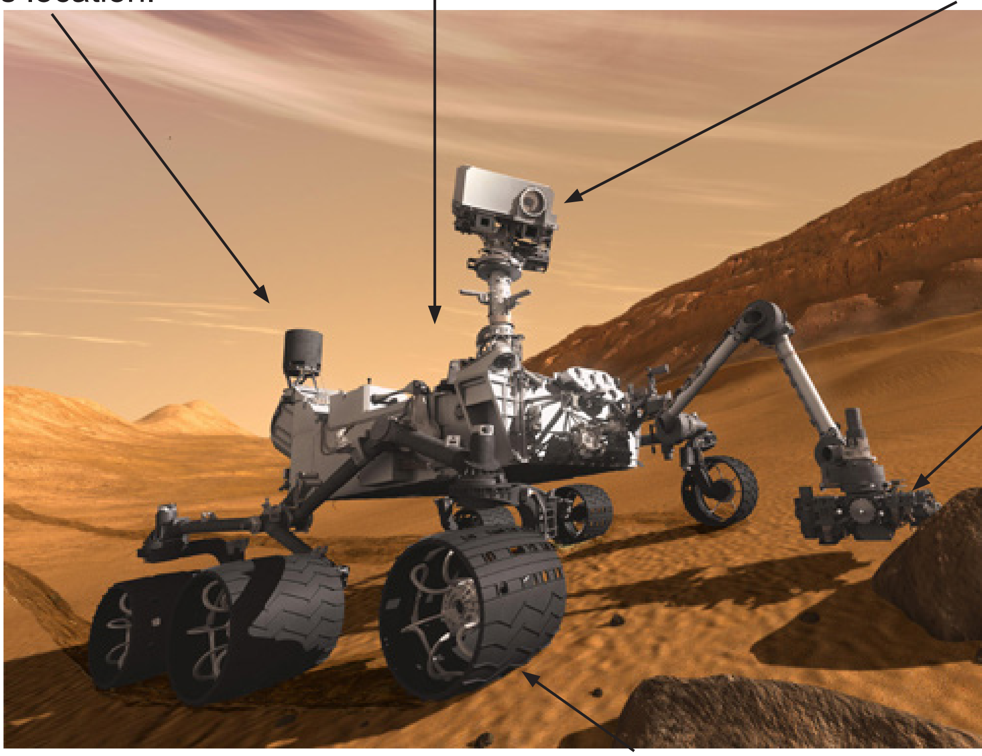


A rover is like a robotic animal. It has a computer that acts like a brain, cameras that act like eyes, and legs and arms that help it move around and pick things up.

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.

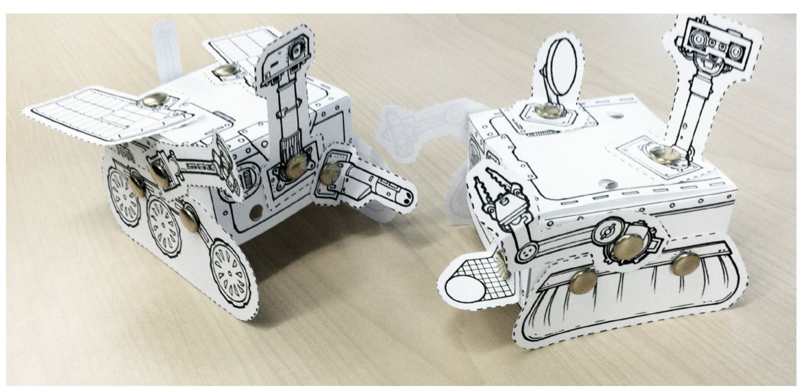


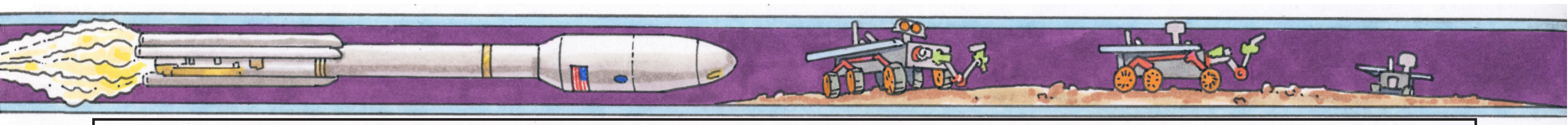
Arms and Hands: Rovers can gather rock samples to study by reaching out with an arm and picking them up.

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!



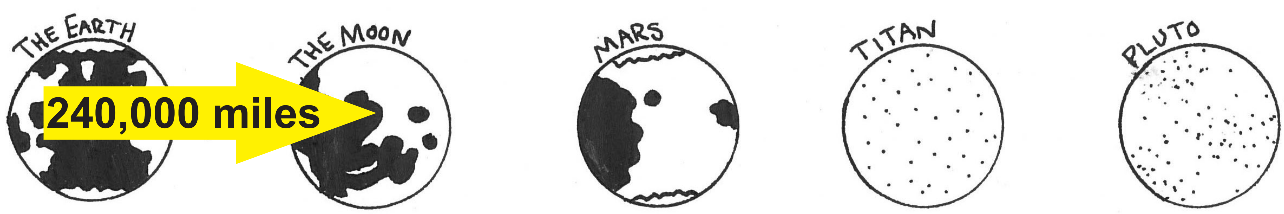


The Moon

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.

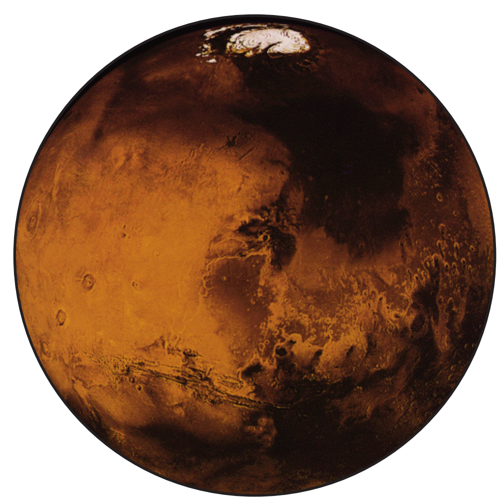
Rover's Mission: Take a temperature reading on the side of the Moon that faces away from Earth.



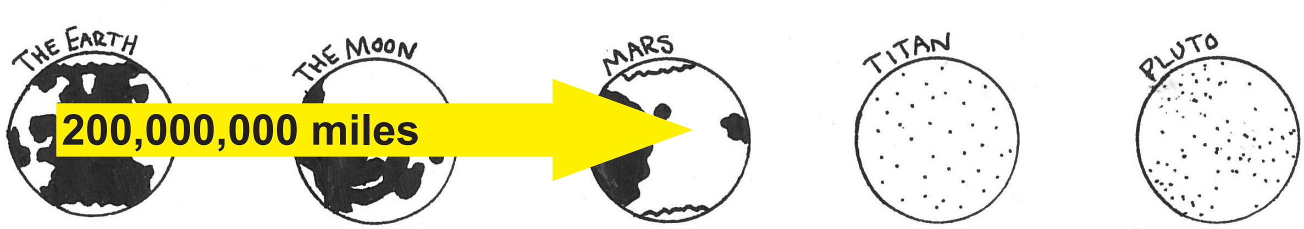
Mars

Mars is the fourth planet from the Sun.

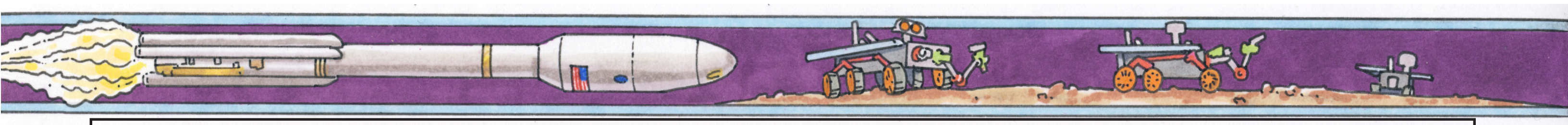
Surface: Rocky and dusty
Sunlight: Enough sunlight reaches Mars so that solar panels could be used to power a rover.



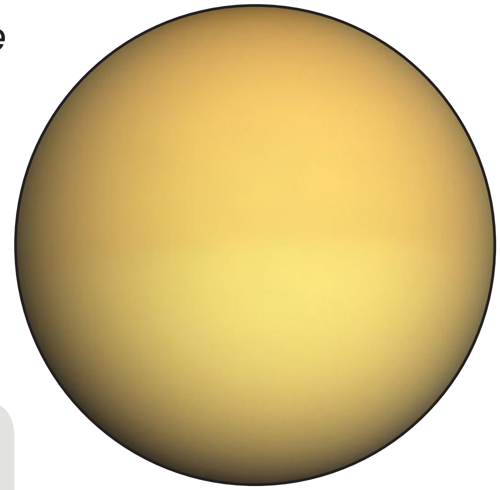
Rover's Mission: Study the rocks to look for evidence of liquid water. Also, look for tiny fossils of ancient life.



Photos courtesy of NASA



Titan

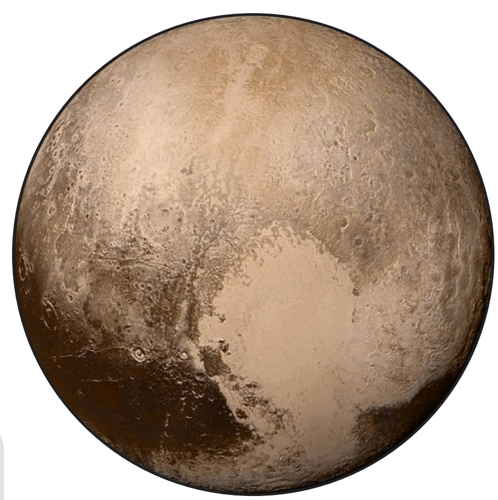


Titan is a moon that orbits Saturn, which is the sixth planet from the Sun.

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.

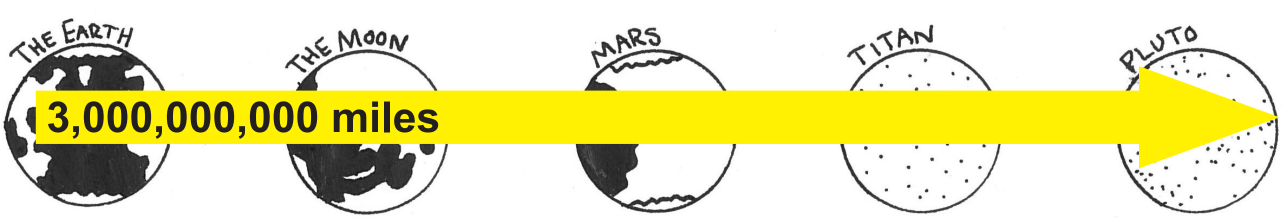
Pluto



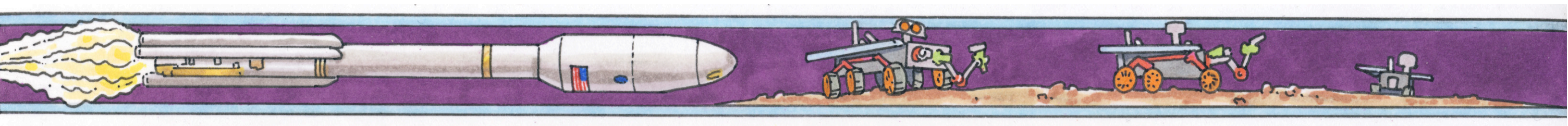
Pluto is a dwarf planet that orbits very far away from the Sun.

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.



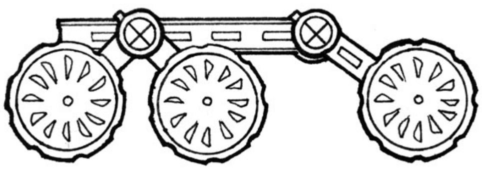
Photos courtesy of NASA



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.*

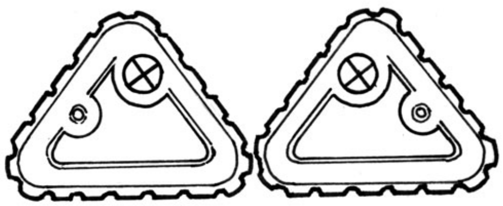
Remember! You'll probably need at least two sets of wheels, treads, or hovercrafts to go on both sides of your rover.

☐ ☐



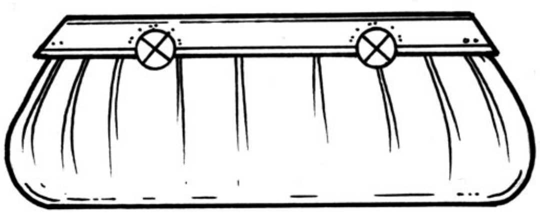
Tool: Wheels
Ability: Travel well over dusty surfaces

☐ ☐



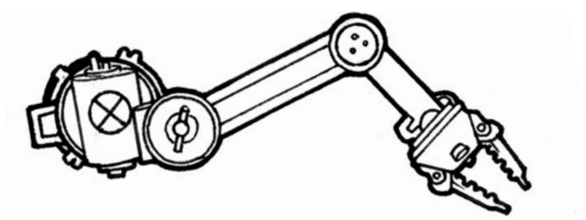
Tool: Treads
Ability: Travel well over rocky surfaces

☐ ☐



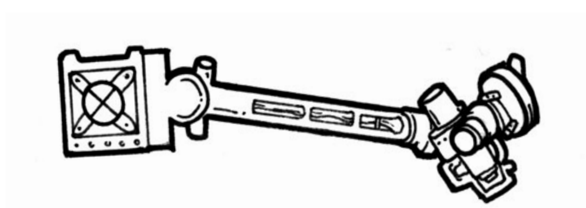
Tool: Hovercraft
Ability: Travels well over icy surfaces

☐



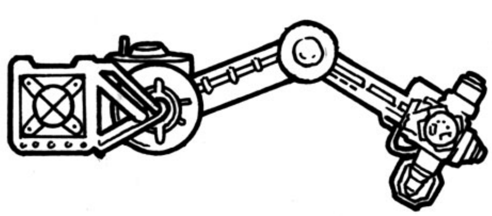
Tool: Robotic Hand
Ability: Picks up rocks

☐

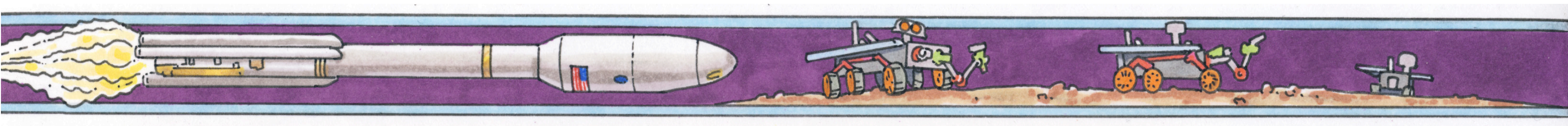


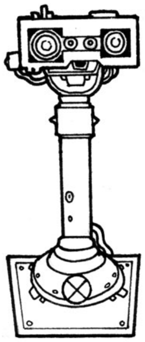
Tool: Rock Grinder
Ability: Grinds up rocks into small parts that can be studied

☐

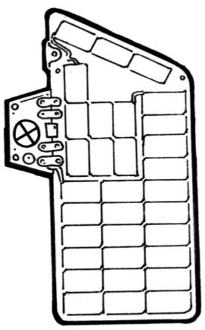


Tool: Microscope
Ability: Takes close-up photographs of tiny objects

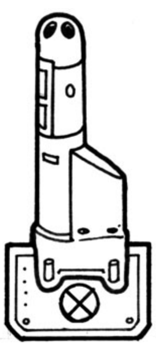


☐ 

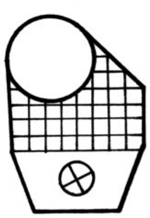
Tool: PanCam
Ability: Takes photographs to send back to Earth

☐ 

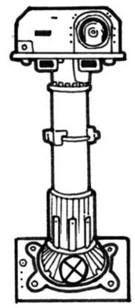
Tool: Solar Panel
Ability: Generates extra power when used on planets close to the Sun

☐ 

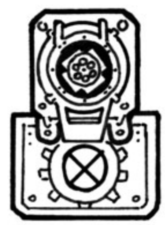
Tool: Weather Station
Ability: Records the temperature and humidity

☐ 

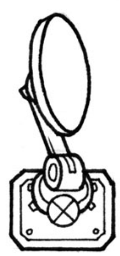
Tool: Observation Tray
Ability: Used as a place to put objects that are being studied

☐ 

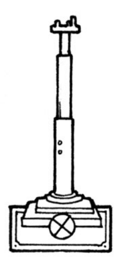
Tool: ChemCam
Ability: Vaporizes rocks with a laser and analyzes the particles

☐ 

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

☐ 

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

☐ 

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

reply | forward | archive | delete

from: engineeringadventures@mos.org

to: You

subject: The Countdown Begins

4:05 PM

India to Earth. . . Come in, Engineers!

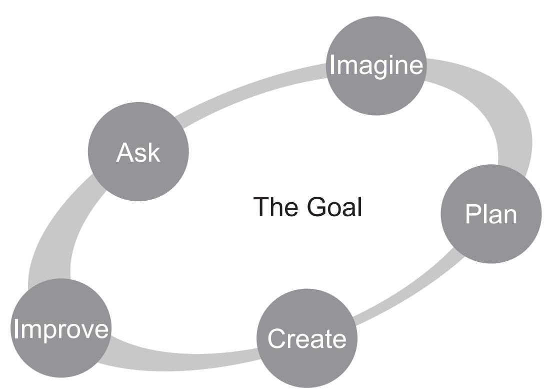
We received your data on the rocket variables you tested and heard about the rovers you and Jacob designed. You've got some great aerospace engineering under your belt. Now it's time to use everything you've learned to engineer your own rockets that will carry your rovers to the destinations you chose.

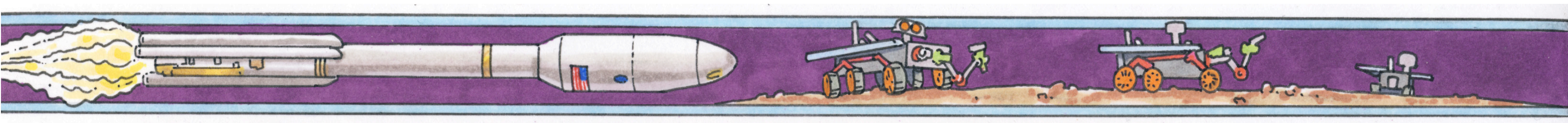
Keep in mind that once you start *creating* your rocket, you may find that you'll have to make some changes to your original plan. There are many trade-offs to think about. If your rocket is having trouble reaching its destination, you may need to review the variables data you gathered earlier. You may 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





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:

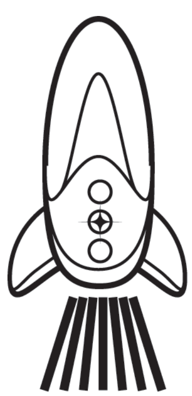
☐ short
☐ medium
☐ tall

The rocket will be made out of:

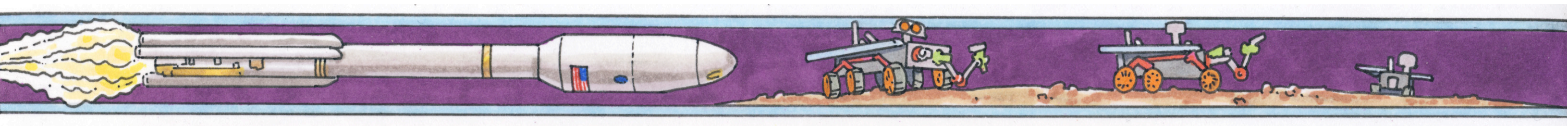
☐ foam
☐ transparency
☐ paper
☐ other: ____________

The rocket width will be:

☐ small
☐ medium
☐ large



Draw your rocket:



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:

reply | forward | archive | delete

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

8:23 PM

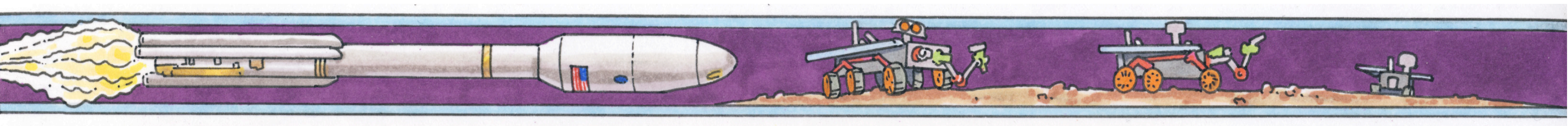
Hey there Engineers!

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



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,

____

reply forward archive delete

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

11:11 AM

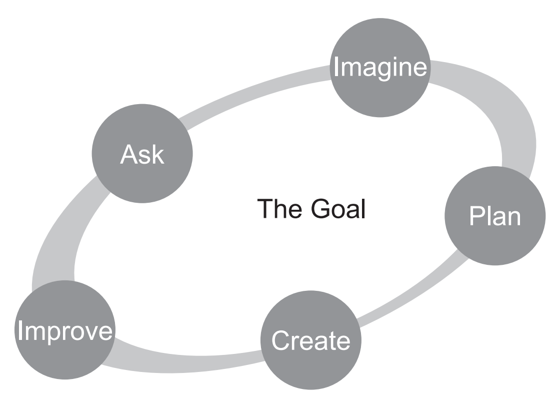
Calling all aerospace engineers!

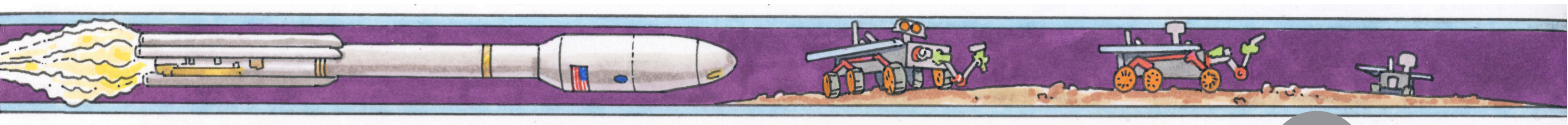
You were a big help to us as we engineered our rockets and rovers, and we hope you are ready for the final launch of your designs!

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





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?

____

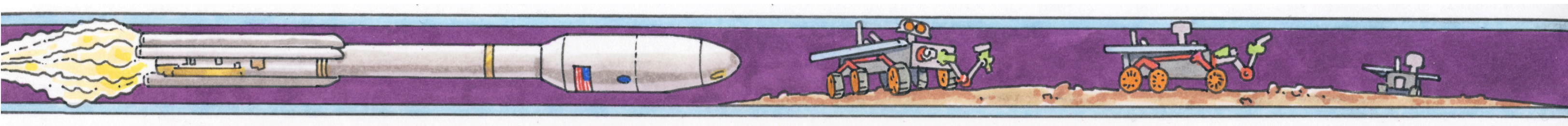
____

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

____

____

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?

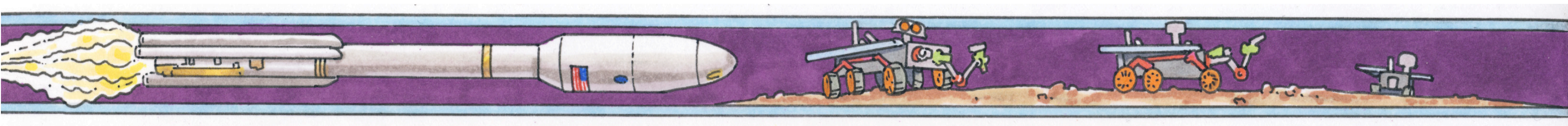
____

____

____

____

Glossary



Aerospace engineer: An engineer who designs technologies that can fly from Earth into outer space.

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

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

Mars: Mars is the fourth planet from the sun. It is known as the “Red Planet” because there is rust-colored iron oxide on its surface. Several 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.

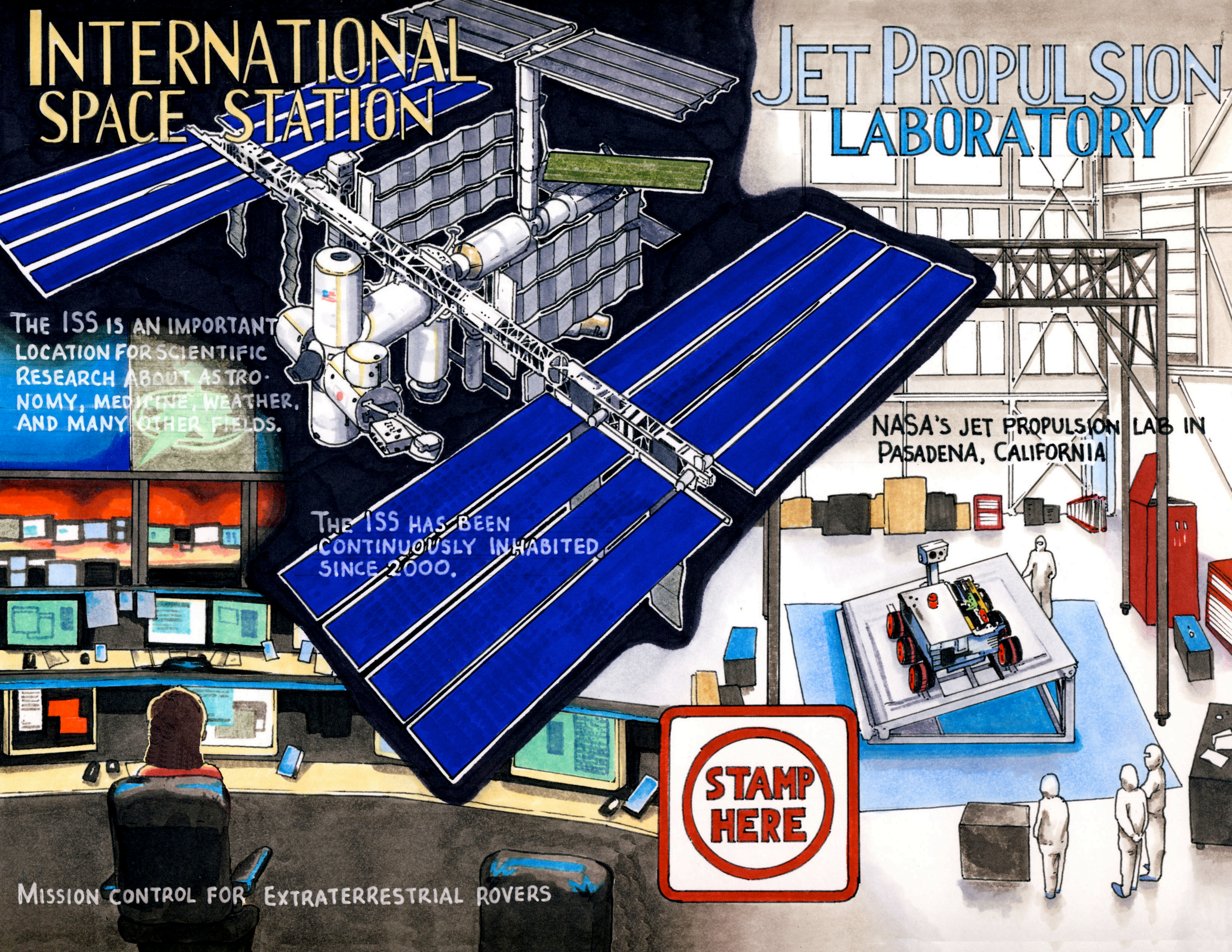
Pluto: Pluto is a dwarf planet that is about one-sixth the mass of the Moon. It orbits very far away from the Sun, but parts of its orbit move it closer to the Sun than Neptune. Pluto was classified as a planet from its discovery in 1930 until 2006. Then it was reclassified as a dwarf planet.

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 on Titan in 2005 and sent back pictures. The pictures made scientists think there may have been liquid flowing on the surface of Titan many years ago.

Trade-off: A situation that requires compromising the quality of one part of a design to gain more quality somewhere else.

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


INTERNATIONAL SPACE STATION
JET PROPULSION LABORATORY
THE ISS IS AN IMPORTANT LOCATION FOR SCIENTIFIC RESEARCH ABOUT ASTRONOMY, MEDICINE, WEATHER, AND MANY OTHER FIELDS.
THE ISS HAS BEEN CONTINUOUSLY INHABITED SINCE 2000.
NASA'S JET PROPULSION LAB IN PASADENA, CALIFORNIA
STAMP HERE
MISSION CONTROL FOR EXTRATERRESTRIAL ROVERS